INTERNATIONAL STANDARD

ISO 2063-1

First edition
2017-09

Thermal spraying — Zinc, aluminium and their alloys —

Part 1: Design considerations and quality requirements for corrosion protection systems

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Projection thermique — Zinc, aluminium et alliages de ces métaux —

Partie 1: Considérations de conception et exigences de qualité pour les systèmes de protection contre la corrosion

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Reference number
ISO 2063-1:2017(E)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*.

This document, together with ISO 2063-2:2017, cancels and replaces ISO 2063:2005, which has been technically revised.

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A list of all the parts in the ISO 2063 series can be found on the ISO website.

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Introduction

In order to protect iron- and steel-based structures (e.g. for steel construction, bridge construction, steel structures for water construction, onshore and offshore wind energy constructions, petrol and natural gas industry) against corrosion, protective coatings are usually deposited. Corresponding to type, shape and required functionality of the part, numerous procedures are available. The deposition of corrosion protection coatings or coating systems can be done by applying hot-dip galvanizing, organic coatings or thermal spraying of zinc, aluminium and their alloys. Using combinations of metallic and organic coatings, duplex corrosion protection coating systems can be produced.

Thermal-sprayed corrosion protection coatings made of zinc, aluminium and their alloys can be sprayed onto all steels which make up the components used in the relevant industrial application. This may be carried out on-site, as well as in the workshop, regardless of the article's size. Due to the usually low heat input into the surface of the part, only a slight thermal loading of the substrate occurs, so that changes in steel properties and deformation of the part do not occur.

Corrosion protection coatings can be used as repairs or rework of defects of other coatings (e.g. uncoated hot-dip zinc galvanized areas) or worn coatings where thermal spraying can be applied on the spot. Due to relative low investment costs, thermal spraying can also be economically applied for single parts.

The ISO 2063 series applies to thermal-sprayed metallic coatings to protect iron and steel against corrosion by deposition of zinc, aluminium or their alloys onto the uncoated surface to be protected.

This document targets designers of components. It covers the planning engineering of the corrosion protection system and deals with the basic rules for planning of corrosion protection systems and for the constructive design of the components to be protected, if the protection system is based upon a thermal-sprayed metallic coating.

ISO 2063-2 targets manufacturers of corrosion protection systems. It deals with the requirements for the execution of the corrosion protection works by thermal spraying in the workshop and on-site.

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Thermal spraying — Zinc, aluminium and their alloys —

Part 1: Design considerations and quality requirements for corrosion protection systems

1 Scope

This document specifies requirements for the protection of iron and steel surfaces against corrosion by applying thermal-sprayed metallic coatings of zinc, aluminium or their alloys.

In this document, requirements for the planning of the corrosion protection system and for the constructive design of the component to be protected are specified, where thermal spraying is intended to be the process for the deposition of the metallic corrosion protection.

Some field-related basic terms are defined and instructions for corrosion behaviour of the zinc and aluminium materials under different environment conditions are provided.

Characteristic properties of the coating, e.g. coating thickness, minimum adhesive strength and surface appearance, are specified and test procedures for thermal-sprayed corrosion protection coatings of zinc, aluminium or their alloys are determined.

This document is valid for applying thermal-sprayed zinc and aluminium protection coatings against corrosion in the temperature range between –50 °C to +200 °C, taking into consideration the service conditions of any sealants used. Heat-resistant protective coatings of aluminium are covered by ISO 17834 and are not in the scope of this document.

Other corrosion protection processes, e.g. hot-dip galvanizing (galvanic coating), sherardizing, electroplating or selection and deposition of organic coatings/paints are not in the scope of this document.

Requirements for the manufacturing of thermal-sprayed coatings are specified in ISO 2063-2.

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 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method*

ISO 2063-2:2017, *Thermal spraying —Zinc, aluminium and their alloys — Part 2: Execution of corrosion protection systems*

ISO 2178, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method*

ISO 4624, *Paints and varnishes — Pull-off test for adhesion*

ISO 8044, *Corrosion of metals and alloys — Basic terms and definitions*

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*

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ISO 8501-3, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 3: Preparation grades of welds, edges and other areas with surface imperfections*

ISO 12671, *Thermal spraying - Thermally sprayed coatings - Symbolic representation on drawings*

ISO 14232-1, *Thermal spraying — Powders — Part 1: Characterization and technical supply conditions*

ISO 14916, *Thermal spraying — Determination of tensile adhesive strength*

ISO 14917, *Thermal spraying — Terminology, classification*

ISO 14919, *Thermal spraying — Wires, rods and cords for flame and arc spraying — Classification — Technical supply conditions*

ISO 14923, *Thermal spraying — Characterization and testing of thermally sprayed coatings*

EN 10163-2, *Delivery requirements for surface conditions of hot-rolled steel plates, wide flats and sections — Part 2: Plate and wide flats*

EN 10163-3, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 3: Sections*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14917, ISO 8044 and the following apply.

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

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

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

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3.1
service life
expected lifetime of a product (e.g. a structure, component or part) or the acceptable period of use in service

Note 1 to entry: It is also the time that any manufactured item can be expected to be serviceable.

3.2
design life
period of time during which the item (e.g. a structure, component, part or product) is expected by its designers to work within its specified parameters

Note 1 to entry: In the case of series production, it is the period of time between the putting into service of a single item and that item's onset of wearing out.

3.3
life to first maintenance
durability
expected life of a coating system until first maintenance

Note 1 to entry: It is also the time interval that elapses after the initial coating before coating deterioration reaches the point that maintenance is necessary to restore protection of the base metal in accordance with ISO 12944-1.

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3.4
protective coating system
sum total of the coats of metal materials and/or paints (duplex coatings) or related products which are to be applied or which have been applied to a substrate to provide corrosion protection in accordance with ISO 12944-1

3.5
pre-fabrication primer
fast-drying paint that is applied to blast-cleaned steel to provide temporary protection during fabrication while still allowing welding and cutting in accordance with ISO 12944-5

Note 1 to entry: In many languages, the term "pre-fabrication primer" does not have the same meaning in English.

3.6
maintenance
sum of all measures to ensure that function of protection of the steel structure against corrosion is maintained

Note 1 to entry: Maintenance includes, but is not limited to, paintwork. Such paintwork can be patch painting (repair included spots/areas of the coating system), patch painting followed by over-painting of the structure or total repairing in accordance with ISO 12944-8.

4 Criteria for corrosion and corrosion protection by thermal-sprayed coatings

4.1 General

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Thermal-sprayed coatings of zinc, aluminium and their alloys can significantly increase the effectiveness of the corrosion protection and the service life of the parts. Thermal-sprayed coatings are to be applied preference, if a long time effective corrosion protection is required.

4.2 Corrosivity categories and environment conditions

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The corrosivity category provides a basic rule for selecting materials and corrosion protection measures in relation to requirements for the individual application, especially for the service life. Definitions of corrosivity categories and environment conditions are given in ISO 9223 and ISO 12944-2. Additional notes for measuring relevant environment parameters are given in ISO 9225.

Annex A contains a list of typical environments related to the estimation of corrosivity categories.

4.3 Corrosion rate

The corrosion rate of a material is given by the medium and by the exposure time of moisture, air pollution, temperature and contamination of the surface.

ISO 9224 contains information about corrosion rates for different metals. Additional information for metallic materials related to the likelihood of corrosion in the atmosphere environment is given in ISO 9223.

4.4 Coating materials and corrosion behaviour

4.4.1 General

The coating material and the required coating thickness are to be selected and specified in relation to the expected corrosivity, the required design life and construction design.

The corrosion rate of metals and alloys, are not constant over the course of the exposure time. For most metals and alloys, it decreases with time of the exposure due to the accumulation of corrosion products on the surface of the exposed metal.

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The corrosion rates of thermal-sprayed coatings are different from bulk materials and other types of metallic coatings due to porosity of thermal-sprayed coatings.

4.4.2 Zinc and zinc alloys

Zinc possesses a high resistance to corrosion due to its passive behaviour against atmospheric attack. However, the corrosion rate per year is affected by the composition of the atmosphere.

The rate of corrosion of zinc or zinc coatings in water depends mainly on the pH value, the carbon dioxide value and the salt and oxygen content of the water. In neutral or slightly alkaline water, zinc corrodes insignificantly only.

Alloying of aluminium up to a content of 15 mass % to the zinc base metal generates a higher corrosion resistance in maritime atmosphere compared to pure zinc metal in the case of lower pH values. It is evidently shown that the passive protection of the aluminium due to its oxidation can be combined with the cathodic protection of zinc.

NOTE Many applications of zinc and zinc alloys in the atmosphere indicate their favourable corrosion behaviour, e.g. the frequent use of thermal-sprayed zinc and zinc alloys for coatings on steel structures in industrial and marine environments and also in form of solid material for roofs and gutters and cast tubes in soils.

Details of the corrosion behaviour of zinc materials (Zn99,99 and ZnAl15) are shown in Annex B.

Further details for zinc, zinc alloys and their corrosion behaviour can be taken from ISO 14713-1.

4.4.3 Aluminium and aluminium alloys

The corrosion behaviour of aluminium materials is characterized by the protection behaviour of the electrical isolating aluminium oxide layer, which is rebuilt spontaneously even after mechanical damage to the surface. Aluminium shows a very high corrosion resistance in slightly acidic to slightly basic media and is particularly suitable for the corrosion protection of steel structures in SO_2-containing industrial atmospheres, as well as in marine environments.

Further details for aluminium, aluminium alloys and their corrosion behaviour in sea water and maritime atmosphere are to be taken from the literature.

A summary of the details for the corrosion behaviour of aluminium materials (Al and AlMg5) are shown in Annex B.

NOTE Aluminium coatings are successfully used in the building industry, where they are applied by electrolytic anodizing or thermal spraying. They have been proven in industrial and marine environments, as well as in seawater immersion.

5 Requirements for the corrosion protection systems and their planning

5.1 General rules — Technical requirements

Application of the thermal-sprayed corrosion protection system requires counter-intuitive design considerations as compared to other coating processes such as hot-dip galvanizing, which are not in the scope of this document. The most adequate corrosion protection system for the specific application should be specified according to the material used and the coating process before starting the design at any time. In the case of a more serious corrosion attack, an additional organic coating should be applied to the spray coating (duplex system), which can increase the corrosion protection significantly.

The following points of view shall be considered and stipulated in a specification, where required.

a) The corrosion protection system, e.g. a thermal-sprayed coating, sealed and covered by an organic coating, shall be selected in such a way that it complies with the required design life of the component. This is especially valid for surfaces, which are not accessible after assembly. A coating

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protection system, which is intended to survive the required design life of the construction with appropriate maintenance, shall be applied.

b) If there is no protection system available that is likely to survive for the full expected design life, the corrosion protection system shall be planned not to corrode or only corrode insignificantly until the first maintenance is planned. In that way, only the organic coating shall be renewed during maintenance. The adequate period of time to first maintenance shall be stipulated.

c) Thermal-sprayed metallic corrosion protection coatings may be sealed. The sealant to be used shall be stipulated in the coating specification or the manufacturing instructions. Comparability with further organic coatings and the thermal-sprayed metallic coating shall be considered.

d) Because thermal spraying can be applied in the workshop, as well as on-site, instructions as to the place of coating application shall be given, if applicable.

e) If bimetallic corrosion is possible, adequate organic coatings or foils as a barrier are to be stipulated. Organic coating systems can be chosen relative to the corrosivity category in accordance with ISO 12944-5.

f) ISO 12944-5 provides guidance for the selection of organic coating materials which are also suitable as topcoats for thermally sprayed coatings.

Details for applying the sealing and deposition of the organic coating to a thermal-sprayed coating can be taken from 6.5 and 6.6.

5.2 Used spray materials and coating thickness

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5.2.1 Spray materials

Primarily, spray materials of zinc, aluminium or their alloys for applications covered in this document are applied in wire form. In the case of smaller areas and for repairs, spray powders are also used. Usual spray materials are available

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— in wire form:

  — Zn99,99 in accordance with ISO 14919, code number 2.1;

  — ZnAl15 in accordance with ISO 14919, code number 2.3;

  — Al99,5 in accordance with ISO 14919, code number 3.2;

  — AlMg5 in accordance with ISO 14919 , code number 3.3;

— in powder form:

  — Al 99 in accordance with ISO 14232-1;

  — Zn 99,5 in accordance with ISO 14232-1;

  — ZnAl15 (no standard available).

The spray material to be used shall be specified in the manufacturing instructions.

5.2.2 Coating thickness

Depending upon the service conditions of the construction, the corrosivity of the environment, the requested service life and the expected corrosion resistance of the coating, the composition of the coating and the thickness of the sprayed coating are critical considerations.

In relation to the corrosivity and the selection of the spray material, the minimum coating thickness mentioned in Table C.1 for coatings of zinc, aluminium or their alloys are recommended. The minimum coating thickness shall be specified in the manufacturing instructions.

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5.3 Construction design requirements for iron and steel components for thermal spraying

5.3.1 General

The corrosion protection system should be stipulated. This should be the most appropriate for a particular application. The coating should be specified before the design work is started. The design of the part and the specification of the coating should fulfil the instructions of this document and correspond to the recommendations in accordance with ISO 12679.

5.3.2 Recommendations for the design of the part — Avoidance of corrosion creating areas

Components, structures and constructions intended for spray metallizing should be designed considering the general possibilities for operation and limits of the thermal spray processes. The main principles are shown in Table D.1.

Favourable and unfavourable examples of the design for thermal spraying are shown in Figures D.1 to D.4. Further instructions for thermal spraying-related design are provided in Annex D or can be taken from ISO 12679. Further advice for general accessibility can be taken from ISO 12944-3.

5.3.3 Requirements for welding in combination with thermal-sprayed protective coatings

Welding works shall be done prior to thermal spraying. If a construction shall be welded later, the weld zone shall be masked and not be coated up to a distance of about 100 mm from the weld bevel.

If the welding can be applied after thermal spraying, only the area of the weld zone shall be prepared, in accordance with ISO 8501-3, and coated locally. The coating process, e.g. thermal spraying, zinc powder coating, deposition of solder, or an organic coating only, shall be stipulated in the manufacturing instructions.

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5.3.4 Thermal spraying of corrosion protected fastenings

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The corrosion protection for screws, nuts and other sorts of load-carrying fastenings shall be compatible with the corrosion protection system of the part and should be balanced for the required design life. The current product standards contain specific requirements.

6 Pre-conditions and requirements for the manufacturing process

6.1 General — Requirements

The surface to be corrosion protected by a thermal-sprayed coating shall be unambiguously indicated on the drawing resp. described in the manufacturing instructions. Also, the required minimum thickness and the final conditions of the surface, including the sealing, shall be indicated preferably in accordance with ISO 12671. If further organic coatings shall be deposited, instructions for the organic coating and its application shall be specified in the manufacturing instructions.

6.2 Reference areas

Coated reference areas shall show the durability of the coating system over the service life. Using these guidelines for inspection, the state of the coating shall be evaluated in this area in the presence of an independent supervisor, after a certain or specified service time has elapsed.

In case of spraying very large component surfaces, several reference areas can be required. Location and size of such areas shall be specified by the planning engineering. Selection of the reference area, thermal spraying of the metallic coating and its sealing should be carried out in the workshop, where the final organic coating can be applied on-site. Application of the entire coating work shall be

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