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Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures —

Part 3:
Sherardizing

Revêtements de zinc — Lignes directrices et recommandations pour la protection contre la corrosion du fer et de l’acier dans les constructions —

Partie 3: Shérardisation

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Contents

Page

Foreword iv
Introduction v
1 Scope 1
2 Normative references 1
3 Terms and definitions 1
4 Design for sherardizing 2
4.1 General 2
4.2 Surface preparation 2
4.3 Design considerations 3
4.4 Clearances of threaded components 3
5 Storage and transport 4
5.1 General 4
5.2 Recommendations for storage and transport 4
6 Effects of article condition on quality of sherardizing 4
6.1 Composition 4
6.2 Surface condition 4
6.3 Influence of steel surface roughness on the sherardized coating thickness 5
6.4 Internal stresses in the base material 5
6.4.1 General 5
6.4.2 Distortion cracking 5
6.4.3 Hydrogen embrittlement 6
6.5 Large objects and thick steels 6
7 Effect of sherardizing process on the article 6
7.1 Processing circumstances 6
7.2 Coating properties influenced by the sherardizing process 6
7.2.1 Sherardizing practice 6
7.2.2 Surface properties of the finished article 6
8 After-treatments 7
Bibliography 8

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 4, *Hot dip coatings (galvanized, etc.)*.

This second edition cancels and replaces the first edition (ISO 14713-3:2009), of which it constitutes a minor revision following the publication of ISO 17668 with the following changes:

— ISO 17668 has replaced EN 13811;

— Table 1 has been amended to align coating classes with ISO 17668.

A list of all parts in the ISO 14713 series can be found on the ISO website.

Introduction

Sherardizing is a thermal diffusion process in which articles are heated in the presence of a sherardizing mixture consisting of zinc dust with or without an inert material.

The process is carried out in a slowly rotating closed container at temperatures ranging from about 300 °C to 500 °C. The normal processing temperature is below the melting point of zinc (419 °C).

During the process, zinc/iron alloys are built up on the surface of the ferrous articles. A coating thickness of 10 µm to 75 µm (and higher if required) can be achieved. The coating thickness is accurately controlled by the amount of zinc dust, the processing time and temperature. The coating closely follows the contours of the basis material, and uniform coatings are produced on articles, including those of irregular shape.

After sherardizing, the containers are cooled down. A screening process separates the sherardized articles from the unused sherardizing mixture. The articles, with the zinc/iron-alloyed layer, are normally post-treated by phosphating, chromating or another suitable passivation process (conversion coating) resulting in a dust-free and clean passivated surface.

Most steel and iron articles can be sherardized.

Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures —

Part 3: Sherardizing

1 Scope

This document provides guidelines and recommendations regarding the general principles of design that are appropriate for articles to be sherardized for corrosion protection.

The protection afforded by the sherardized coating to the article will depend upon the method of application of the coating, the design of the article and the specific environment to which the article is exposed. The sherardized article can be further protected by application of additional coatings (outside the scope of this document), such as organic coatings (wet paints or powder coatings). When applied to sherardized articles, this combination of coatings is often known as a “duplex system”.

General guidance on this subject can be found in ISO 12944-5 and EN 13438.

The maintenance of corrosion protection in service for steel with sherardized coatings is outside the scope of this document.

Specific product-related requirements (e.g. for sherardized coatings on fasteners or tubes, etc.) will take precedence over these general recommendations.

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

3 Terms and definitions

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

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

3.1
sherardizing
thermal diffusion process in which articles are heated in close contact with a sherardizing mixture, consisting of zinc dust with or without an inert material, in a closed container, usually rotated

3.2
sherardized coating
coating consisting of zinc/iron alloys obtained by the sherardizing process, and normally post-treated by phosphating, chromating or another suitable passivating process (conversion coating)

Note 1 to entry: “Sherardized coating” is referred to in this document as “coating”.

4 Design for sherardizing

4.1 General

It is essential that the design of any article required to be finished should take into account not only the function of the article and its method of manufacture but also the limitations imposed by the finish.

Sherardizing is a process developed to protect components of various sizes, but mainly small articles, against corrosion and wear. No jig marks are visible after sherardizing. Normal sherardizing equipment has containers with nominal dimensions of 2 000 mm × 480 mm × 400 mm. Specialized equipment has been developed to treat large tubes for the gas and oil industry and large articles of complex shape for the automotive industry.

Some internal stresses in the articles to be sherardized will be relieved during the sherardizing process and this may cause deformation of the coated article. Normally, the sherardizing is carried out between 320 °C and 419 °C.

The purchaser should seek the advice of the sherardizer before designing or manufacturing a product that is subsequently to be sherardized, as it may be necessary to adapt the construction of the article for the sherardizing process, especially when very fragile components are sent for sherardizing. These components may be liable to damage and distortion during processing. The sherardizer may be able to recommend a design modification.

4.2 Surface preparation

The design and the materials used should permit good surface preparation. This is essential for the production of a high-quality coating. Sherardizing is only effective on surfaces free of oil, grease, and rust, scale or other surface contaminants. It is recommended to avoid lacquers, wax, paint, oil and grease-based markings. Surfaces should be free from defects to ensure a coating of good appearance and serviceability.

Grit blasting is the preferred surface preparation for sherardizing because

— the abraded surface responds very well to the sherardizing process, and

— the risk of hydrogen embrittlement to spring steels and to high-tensile steels, or damage to free-cutting steels, is avoided.

In case alkaline degreasing is applied, the articles should be dried before being grit blasted, if necessary, or before being sherardized.

Sintered materials should be free of oil and resins before they are sent for sherardizing.

For castings, grit blasting is essential to remove moulding sand.

In special cases, e.g. to remove scale, hydrochloric acid pickling can be considered. However, it is recommended to remove scale from articles before the final machining, so that the articles are not damaged in the pretreatment stage of the sherardizing process to provide a coating of good appearance and serviceability. The purchaser should seek the advice of the sherardizer in case such a pretreatment is required.

4.3 Design considerations

Articles to be sherardized are limited in size, since most of the containers used in the sherardizing process have nominal dimensions of 2 000 mm × 480 mm × 400 mm. Articles that are too large for such a container cannot be sherardized partially. When jointed assemblies on fabrications (not welded assemblies) have dimensions larger than the dimensions of the sherardizing containers, it should be considered to sherardize the unassembled parts and assemble the parts after sherardizing.

Internal threads or recesses can be cut before the articles are sent for sherardizing. The uniform zinc alloy layers closely follow the contours of the articles to be sherardized. Tubes and hollow articles can be sherardized. Special measures, e.g. prefilling the hollow sections with the sherardizing mixture, can be taken to ensure that the inside of these products is coated as well.

Springs and high-tensile steels are also suitable for sherardizing. To prevent affecting the integrating properties of such articles, the sherardizing should be carried out at appropriate temperatures, depending on the hardening and tempering temperatures of these articles. Springs should preferably be sherardized unassembled in a free and unloaded state. Depending on the heat treatment of these articles before finishing, the sherardizing can be carried out at lower temperatures between 320 °C and 380 °C. The processing time, however, will be extended when sherardizing at lower temperatures.

Articles having soft-soldered or resin-bonded joints should not be sent for sherardizing, as joints of this nature are affected by the sherardizing process.

Welding is preferable before sherardizing. All welds should be free of slag. Spot welding is possible after the articles are sherardized; ideally, thinner coatings, less than 15 µm in thickness, are desired.

On mating surfaces and holes, extra clearance should be provided to allow for the thickness of the coating material specified (see ISO 17668).

For the clearance recommendations for threaded components, see 4.4.

4.4 Clearances of threaded components

Although sherardizing gives a uniform coating without any significant changes in the profile of threads, there shall be adequate clearance between external and internal threads before sherardizing.

The recommended clearances are given in Table 1.

Table 1 — Clearances recommended for bolts and nuts to be sherardized

Minimum coating thickness µm	**Coating class according to ISO 17668**	**ISO metric, UNF and UNC threads** µm
10	Class 10	120
15	Class 15	180
30	Class 30	360
45	Class 45	540
60	Class 60	720
75	Class 75	900

If only the external thread is to be sherardized and then used with a standard uncoated internal thread (or *vice versa*), then half the clearance shown in Table 1 is required on the thread to be sherardized.

It is recommended to sherardize both bolts and nuts. Whenever possible, nuts and bolts sent for sherardizing should be forwarded to the sherardizer together, so that the clearance can be checked.

General practice for threaded bolts and nuts to be sherardized is either of the following:

a) the bolts are manufactured to the tolerances laid down in the appropriate specifications, without allowance being made for sherardizing; the nuts are then tapped up to the oversize mentioned in Table 1, before sherardizing; or

b) the bolts are oversized to a level mentioned in Table 1, so that standard threads on sherardized nuts can be used in all cases.

A coating thickness of 10 µm is recommended for small threaded articles of dimensions less than M10.

The purchaser should seek the advice of the sherardizer before designing or manufacturing threaded materials to be sherardized.

5 Storage and transport

5.1 General

The coating has a matt grey appearance, the natural colour of the zinc/iron alloy layer of the surface after sherardizing, and is normally post-treated by phosphating, chromating or another suitable passivation process (conversion coating). This prevents wet-storage stains on the coating, so-called “white rust”, during storage in humid conditions or during transport and increases the life time in service.

Due to the zinc/iron alloy composition of the coating, it may acquire, during outside exposure, a dark orange-brown patina. This is not to be confused with corrosion of the base material, but results from the initial colour change of the zinc/iron alloy by normal oxidation when exposed to humid conditions outside.

This discolouration is not detrimental to the coating properties and the use of the coated article. On continued exposure, the surface becomes darker in colour and the coating has a normal life depending on the coating thickness.

5.2 Recommendations for storage and transport

If possible, sherardized tubes and other hollow articles should be stored vertically and loosely pending the use, thus preventing water or any other corrosive fluids from being trapped. Bulk articles should be stored in dry conditions. Special care should be taken to store (large) threaded materials to avoid damaging the threads.

Outdoor transport of bulk articles should be carried out in dry conditions, if possible in (closed) containers or bags.

6 Effects of article condition on quality of sherardizing

6.1 Composition

Unalloyed carbon steels, low-alloy steels, sintered materials, and malleable grey and cast iron are suitable for sherardizing. Spring steel and high-tensile steel can be satisfactorily sherardized. Depending on the hardening and tempering temperature of these parts, the sherardizing process is carried out at appropriate temperatures ranging from 320 °C to 380 °C.

The chemical composition of the steel has no practical influence on the composition or on the thickness of the coating.

6.2 Surface condition

The surface of the base material should be clean before sherardizing.

Surface contamination that cannot be removed by grit blasting should be removed prior to the mechanical pretreatment process. The responsibility of removing the contamination should be agreed between the sherardizer and purchaser.

6.3 Influence of steel surface roughness on the sherardized coating thickness

Surface roughness has no practicable influence on the sherardized coating structure or the properties of the coating.

It is recommended that flame-cut, laser-cut and plasma-cut surfaces should be ground off by the fabricator.

6.4 Internal stresses in the base material

6.4.1 General

The sherardizing process can be carried out at temperatures ranging from 300 °C to 500 °C. The articles to be sherardized are slowly heated up to the processing temperature, normally below 419 °C. The processing time will be approximately 1 h to 2 h to form the coating by thermal diffusion. After sherardizing, the articles are cooled down slowly to room temperature.

This processing does not cause internal stresses in the base material, except for steels that have tempering temperatures that fall within the processing temperature range.

For these steels, it is necessary to carry out the sherardizing process at the lower end of the processing temperature range (320 °C to 380 °C). However, for steels with a tempering temperature below 320 °C, it is hard to sherardize without affecting the properties of these steels.

The sherardizer cannot be responsible for deformation of the steel work during sherardizing (as the specific state of stress in the article at the time of processing is not within his control) unless the distortion has occurred through faulty processing.

6.4.2 Distortion cracking

Hardened and/or high-tensile steels may contain internal stresses of such a magnitude that sherardizing may increase the risk of cracking of the steel during sherardizing. The risk of cracking can be reduced by sherardizing at lower temperatures and/or by stress relieving before sherardizing. Specialist advice should be sought when sherardizing such steels.

NOTE High-tensile steels feature a yield strength greater than or equal to 650 MPa.

A stress-relieving heat treatment should be planned at the design stage and should be executed at the fabrication stage subsequently to cold-working welding, oxy-cutting or drilling. The reduction of the residual stresses, inherently associated with cold forming, may be obtained with a stress-relieving heat treatment, typically at 600 °C.

However, if 600 °C is significantly exceeded due to poor control of the thermal cycle, a lowering of the mechanical properties of steel might be observed. Therefore, stress-relieving heat treatments should be based on a specialist's advice.

Residual stresses and hardening are created in the welded areas or the areas affected by oxy-cutting. Their magnitude depends on different factors, e.g. length and thickness of welds and welding procedures.

Residual stresses and hardening in the fabricated element may be responsible for damage or deformation of the coated article. Therefore, residual stresses and hardening shall be minimized by adequate design and welding procedures. Critical constructional details may be subjected to an additional heat treatment for stress-relief. Similar recommendations may also be followed for drilling and stamping processes.

6.4.3 Hydrogen embrittlement

Structural steels are not normally embrittled by the absorption of hydrogen during pickling, and if there is any hydrogen remaining, it does not, in general, affect structural steels.

If steels are harder than approximately 34 HRC, 340 HV or 325 HB (see ISO 18265), care is necessary to minimize hydrogen absorption during surface preparation by pickling with hydrochloric acid. The welds and the heat-affected zones (HAZ) of structural steels do not normally exceed a hardness value of 340 HV. Therefore, these zones should not normally be embrittled by the absorption of hydrogen during surface preparation.

During sherardizing, the articles are slowly heated up to the processing temperature (normally between 320 °C and 419 °C). The eventually absorbed hydrogen is available for discharge before the coating layer has developed.

6.5 Large objects and thick steels

The thickness and dimensions of the steel articles have no effect on the development of the coating, the coating composition and the properties of the coating.

7 Effect of sherardizing process on the article

7.1 Processing circumstances

The coating follows very closely the contours of the article to be sherardized. However, for threaded components, a clearance allowance should be made on mating threads to accommodate the thickness of the coating. The recommended clearances are given in Table 1.

High-tensile steel articles, such as bolts and nuts up to Class 12.9, are suitable for sherardizing. Special care should be taken for such products in the pretreatment process. The purchaser should seek the advice of the sherardizer in case such parts are sent for sherardizing.

Sherardizing does not give rise to hydrogen embrittlement (see 6.4.3), or liquid metal assisted cracking LMAC (liquid metal embrittlement LME), as the process is a dry thermal diffusion process and the steel articles are normally not in contact with molten zinc when sherardizing takes place below 419 °C.

Materials that will be adversely affected by the heat of the sherardizing process should not be sherardized. For steels whose tempering temperature falls in the processing temperature range of 300 °C to 500 °C, it is necessary to carry out the sherardizing process at the lower end of the processing temperature range. However, for steels with a tempering temperature below 320 °C, it is hard to sherardize these steels without affecting the properties (see 6.4.1).

Heat-treated or cold-worked steels may be tempered by the heat in the sherardizing process and lose some of any increased strength obtained by heat treatment or cold working. The purchaser should seek the advice of the sherardizer in case such parts are sent for sherardizing.

7.2 Coating properties influenced by the sherardizing process

7.2.1 Sherardizing practice

Small additions to the sherardizing mixture can be used, as part of the processing technique of sherardizers, to improve the coating quality.

7.2.2 Surface properties of the finished article

The sherardized surface is built up of zinc/iron alloys containing mainly zinc. The surface shows a certain roughness. Due to the iron content of the surface alloy layer, the coating derives a special property, abrasion resistance and high hardness, typically 350 HV, enabling it to withstand mechanical abrasion and rough handling. Sherardizing is, in particular, used to finish, for example, scaffolding fittings, nails and chains.

The rather rough passivated surface is a good surface for paint and organic powder coating adhesion, as well as for rubber or rubber-like bonded steel components.

8 After-treatments

To minimize the possible formation of wet-storage stains on the surface, the coating can be post-treated, by means of phosphating, chromating or another suitable passivation process (conversion coating) as part of the sherardizing process.

Sherardized articles might be treated with a lubricant to regulate the coefficient of friction of the surface. This is used to great effect on threaded articles and hinge pins.

If the articles are to be painted or powder coated after sherardizing (duplex systems), the purchaser should inform the sherardizer before the article is sherardized. In most cases, no pretreatment of the sherardized surface is needed before painting or powder coating.

Proprietary products are available for preparation of sherardized coatings for painting or powder coating.

For the application of duplex systems involving the use of paints, requirements on surface treatment, painting systems, coating thickness, application technologies, etc., have to be defined by agreement between the customer and the purchaser. More information is given in ISO 12944-5.

For the application of duplex systems involving the use of powder coatings, recommendations on coating powders, pretreatments, application and system performance can be found in EN 13438 and EN 15773.

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