INTERNATIONAL STANDARD

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Metallic coatings — Electroplated coatings of nickel for engineering purposes

Revêtements métalliques — Dépôts électrolytiques de nickel pour usages industriels

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 4526 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 3, *Electrodeposited coatings and related finishes*.

This second edition cancels and replaces the first edition (ISO 4526:1984), which has been technically revised.

Introduction

Engineering nickel coatings are specified for various applications such as improved hardness, wear and corrosion resistance, load-bearing characteristics, heat-scaling resistance, corrosion fatigue resistance and other improvements in surface properties. Electrodeposited nickel is also, used in engineering applications to salvage worn or incorrectly machined manufactured articles, and function as diffusion barriers in combination with other metallic coatings. Engineering nickel coatings usually contain greater than 99 % nickel and are most frequently electrodeposited from additive-free Watts or nickel sulfamate solutions. Typical solution compositions, operating conditions and mechanical properties of electrodeposits from these solutions are given in Annex A.

When increased hardness, greater wear resistance, modified deposit internal stress values and enhanced levelling characteristics are required, particles of organic additives such as silicon carbide, tungsten carbide, aluminium oxide, chromium carbide and other substances may be introduced into these solutions. The use of sulfur-containing organic additives to increase hardness and to lower residual internal stress is feasible only when the end-use involves exposure to low or moderate temperatures. High temperature exposure of nickel coatings that contain sulfur may result in embrittlement and cracking of the coating. The effect is time-dependent and may become evident at 150 °C if the time of heating is sufficiently long.

A notable trend is the growing utilisation of nickel alloy electroplating processes for engineering applications. These include binary alloys of nickel with cobalt, iron, manganese, molybdenum, phosphorus and tungsten.

Metallic coatings — Electroplated coatings of nickel for engineering purposes

1 Scope

This International Standard specifies requirements for electroplated nickel and nickel alloy coatings applied to ferrous and non-ferrous basis metals for engineering purposes.

Binary nickel alloys in which nickel is a minor constituent are outside the scope of this International Standard.

The designation provides a means of specifying the type and thickness of nickel and nickel alloy coatings appropriate for engineering applications.

2 Normative references

The following referenced documents are indispensable for the application 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 2064, *Metallic and other inorganic coatings — Definitions and conventions concerning the measurement of thickness*

ISO 2079, *Surface treatment and metallic coatings — General classification of terms*

ISO 2080, *Electroplating and related processes — Vocabulary*

ISO 2177, *Metallic coatings — Measurement of coating thickness — Coulometric method by anodic dissolution*

ISO 2361, *Electrodeposited nickel coatings on magnetic and non-magnetic substrates — Measurement of coating thickness — Magnetic method*

ISO 2819, *Metallic coatings on metallic substrates — Electrodeposited and chemically deposited coatings — Review of methods available for testing adhesion*

ISO 3497, *Metallic coatings — Measurement of coating thickness — X-ray spectrometric methods*

ISO 3543, *Metallic and non-metallic coatings — Measurement of thickness — Beta backscatter method*

ISO 3882, *Metallic and other inorganic coatings — Review of methods of measurement of thickness*

ISO 4516, *Metallic and other inorganic coatings — Vickers and Knoop microhardness tests*

ISO 4519, *Electrodeposited metallic coatings and related finishes — Sampling procedures for inspection by attributes*

ISO 8401, *Metallic coatings — Review of methods of measurement of ductility*

ISO 9220, *Metallic coatings — Measurement of coating thickness — Scanning electron microscope method*

ISO 9587, *Metallic and other inorganic coatings — Pretreatments of iron or steel to reduce the risk of hydrogen embrittlement*

ISO 9588, *Metallic and other inorganic coatings — Post-coating treatments of iron or steel to reduce the risk of hydrogen embrittlement*

ISO 10289, *Methods for corrosion testing of metallic and other inorganic coatings on metallic substrates — Rating of test specimens and manufactured articles subjected to corrosion tests*

ISO 10587, *Metallic and other inorganic coatings — Test for residual embrittlement in both metallic-coated and uncoated externally-threaded articles and rods — Inclined wedge method*

ISO 12686, *Metallic and other inorganic coatings — Automated controlled shot-peening of metallic articles prior to nickel, autocatalytic nickel or chromium plating, or as a final finish*

ISO 15724, *Metallic and other inorganic coatings — Electrochemical measurement of diffusible hydrogen in steels — Barnacle electrode method*

EN 12508, *Corrosion protection of metals and alloys — Surface treatment, metallic and other inorganic coatings — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2064, ISO 2079, ISO 2080 and EN 12508 apply.

4 Information to be supplied to the electroplater

4.1 Essential information

When ordering articles to be electroplated, in accordance with this International Standard, the purchaser shall provide the following information in writing, e.g. in the contract or purchase order, or on engineering drawings.

a) The designation (see Clause 5).

b) The requirements for special test specimens (see 6.1).

c) The significant surface, indicated by drawings of the articles or by suitably marked samples (see 6.2).

d) The final surface finish, e.g. as-plated, ground, machined or polished. Alternatively, samples showing the required finish shall be supplied or approved by the purchaser, and used for comparison purposes (see 6.2 and 6.3).

e) The type and size of defects with the number of defects that can be tolerated per item, for the surface or per square decimetre of surface (see 6.2).

f) Additional portions of the surface where minimum thickness requirements apply (see 6.4).

g) The test methods to be used to measure thickness, adhesion and porosity and, if required, those for internal stress and ductility (see 6.4, 6.6, 6.7, 6.11 and 6.12, respectively).

h) The tensile strength of parts and the requirement for stress relief heat treatment before electroplating (see 6.8).

i) The requirement for hydrogen embrittlement relief after electroplating, and the hydrogen embrittlement test methods (see 6.9).

j) The sampling plan and acceptance levels (see Clause 7).

4.2 Additional information

The following additional information may be provided by the purchaser, when appropriate:

a) the nominal composition or specification, and metallurgical condition of the basis metal including hardness (see 5.3);

NOTE In the case of reclaimed articles, it may not be possible to supply this information, and it may, therefore, be difficult to guarantee the quality of the coating.

b) the necessity for peening before or after electroplating (see 6.10);

c) any special requirements for, or restrictions on, pre-treatment, e.g., vapour blasting instead of acid pre-treatment;

d) requirements for undercoats and/or overcoats (see 5.5);

e) where appropriate, any special requirements for surface finish, hardness and adhesion (see 6.3, 6.5 and 6.6, respectively).

5 Designation

5.1 General

The designation shall appear on engineering drawings, in the purchase order, the contract or in the detailed product specification.

The designation specifies, **in the order given**, the basis material, its standard designation (optional), stress relief requirements, the type and thickness of undercoats, the type and thickness of the nickel or nickel alloy coating, the type and thickness of coatings applied over the nickel or nickel alloy coating, and post-treatments including heat treatment.

5.2 Components

The designation shall comprise the following:

a) the term, “Electrodeposited coating”;

b) the number of this International Standard, i.e ISO 4526;

c) a hyphen;

d) the chemical symbol of the basis metal (see 5.3);

e) a solidus (/);

f) symbols for the nickel or nickel alloy coating, as well as coatings applied prior to and after electroplating, separated by solidi (/) for each stage in the coating sequence in the order of application. The coating designation shall include the thickness of the coatings in micrometres (see 5.5) as well as heat treatment requirements (see 5.4). Double solidi or separators (//) shall be used to indicate that a step has been omitted or is not a requirement.

NOTE It is recommended that the specific alloy be identified by its standard designation following the chemical symbol of the basis metal; e.g., its UNS number, or the national or regional equivalent may be placed between the symbols < >.

EXAMPLE Fe<G43400> is the UNS designation for a high-strength steel.

See [1] to [5].

5.3 Designation of the basis metal

The basis metal shall be designated by its chemical symbol or, if an alloy, its principal constituent.

For example;

a) Fe for iron and steel;

b) Zn for zinc alloys;

c) Cu for copper and copper alloys;

d) Al for aluminium and aluminium alloys.

NOTE To ensure proper surface preparation and hence adherence of the coating to the substrate, it is important to identify the specific alloy and its metallurgical condition (tempered, nitrided, etc.).

5.4 Designation of heat treatment requirements

The heat treatment requirements shall be in brackets and designated as follows:

a) the letters SR, for heat treatment for stress relief purposes; the letters ER, for heat treatment for the purpose of reducing susceptibility to hydrogen embrittlement; the letters, HT, for heat treatment for other purposes;

b) in parentheses, the minimum temperature, in degrees centigrade;

c) the duration of the heat treatment, in hours.

EXAMPLE [SR(210)1] designates stress relief heat treatment at 210 °C for 1 h.

When heat treatment is specified, the requirements shall be included in the designation. See the last example in 5.6.

5.5 Type and thickness of metal layers

The electroplated nickel shall be designated by the chemical symbol for nickel, Ni, followed by a number giving the specified minimum local thickness of the coating in micrometres. The type of nickel shall be designated by the symbols given in Table 1 placed after the number that designates coating thickness.

In the case of nickel alloy coatings, the symbols for the alloy coating given in Table 2 shall be followed by a whole number in parentheses giving the nominal composition of the alloy coating, followed by a number giving the specified minimum local thickness of the coating, in micrometres.

EXAMPLE NiCo(35)25 designates a nickel-cobalt alloy coating containing 35 % mass fraction cobalt and which is 25 µm thick.

Metallic undercoats and overcoats deposited electrolytically or by other means shall be designated by the chemical symbol(s) for the deposited metal(s) followed by a number specifying the minimum local thickness of the layer in micrometres.

Table 1 — Symbols, sulfur content and ductility of different types of nickel coatings

Type of nickel	Symbol	Sulfur content % mass fraction	Ductility %
Sulfur-free	sf	< 0,005	> 8
Sulfur-containing	sc	> 0,04	—
Sulfur-free nickel containing particles dispersed throughout the nickel matrix	pd	< 0,005	> 8

Table 2 — Symbols and nominal compositions of electrodeposited binary nickel alloys

Nickel alloy	Symbol	Nominal compositions % mass fraction
Nickel-cobalt	NiCo	5 to 50 cobalt
Nickel-iron	NiFe	10 to 30 iron
Nickel-manganese	NiMn	Approximately 0,5 manganese
Nickel-molybdenum	NiMo	5 to 40 molybdenum
Nickel-tungsten	NiW	5 to 40 tungsten
Electroplated nickel-phosphorus	NiP	1 to 30 phosphorus

NOTE Nickel coatings for engineering purposes are most often electrodeposited from Watts and nickel sulfamate solutions, typical compositions of which are given in Annex A. The symbol, sf, refers to nickel electroplated from solutions not containing hardeners, brighteners or stress-reducing agents, the deposits from which are sulfur-free. The symbol, sc, refers to nickel electrodeposits that may contain sulfur or other co-deposited elements or compounds that are present to increase the hardness, refine the grain structure or to control the internal stress of the electrodeposited nickel. Watts and nickel sulfamate solutions can be modified in order to deposit alloys of nickel with cobalt, iron, manganese or phosphorus. The solutions for depositing nickel alloy coatings with either molybdenum or tungsten however, are significantly different from Watts or sulfamate solutions. Proprietary solutions for electrodepositing nickel-molybdenum and nickel-tungsten alloy coatings are reportedly available. For additional technical information on nickel alloy electroplating, see [6] and [7].

5.6 Examples of designations

An engineering nickel coating that has a minimum local nickel thickness of 50 µm, that is sulfur-free and that is electrodeposited on carbon steel is designated as follows:

Electrodeposited coating ISO 4526 - Fe//Ni50sf

An engineering nickel coating that has a minimum local thickness of 75 µm, that is sulfur-free, that contains co-deposited silicon carbide particles dispersed throughout the nickel, and that is electrodeposited on an aluminium alloy is designated as follows:

Electrodeposited coating ISO 4526 - Al//Ni75pd

An engineering nickel coating that has a minimum local thickness of 25 µm, that is sulfur-free and that is deposited on a high strength steel that is stress relieved prior to electroplating at 210 °C for 2 h and is also heat treated for embrittlement relief purposes at 210 °C for 22 h is designated as follows:

Electrodeposited coating ISO 4526 - Fe/[SR(210)2]/Ni25sf/[ER(210)22]