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BSI Standards Publication

Aerospace series — Zinc-Nickel (12-16 % Ni) plating of steels with specified tensile strength ≤ 1 450 MPa, copper alloys, nickel alloys and aluminium alloys for parts and fasteners

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National foreword

This British Standard is the UK implementation of EN 4826:2014.

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

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Aerospace series - Zinc-Nickel (12 %-16 % Ni) plating of steels with specified tensile strength ≤ 1 450 MPa, copper alloys, nickel alloys and aluminium alloys for parts and fasteners

Série aérospatiale - Dépôt électrolytique Zinc-Nickel (12 %-16 % Ni) sur aciers de résistance ≤ 1 450 MPa, sur alliages de cuivre, alliages de nickel et alliages d'aluminium pour pièces et éléments de fixation

Luft- und Raumfahrt - Zink-Nickel (12 % bis 16 % Ni) Stahlbeschichtung mit festgelegter Zugfestigkeit ≤ 1 450 MPa, Kupfer-, Nickel- und Aluminiumlegierungen für Verbindungsteile und Verschlüsse

This European Standard was approved by CEN on 28 June 2014.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 4826:2014) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

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of an identical text or by endorsement, at the latest by June 2015, and conflicting national standards shall be withdrawn at the latest by June 2015.

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1 Scope

This European Standard specifies the plating of a Zinc-Nickel (12 % to 16 %) alloy on mechanical parts and fasteners in steels (R_m ≤ 1 450 MPa), stainless steels (R_m ≤ 1 450 MPa), copper alloys, nickel alloys and aluminium alloys (not applicable for electrical components), as well as the passivation and lubricant finishing that can be associated to them. The Zinc-Nickel process is an electrolytic plating process under controlled current allowing to deposit a Zinc-Nickel layer from, most often, an alkaline electrolyte. Alkaline Zinc-Nickel is only considered in this standard.

The purpose of this standard is to give technical and quality requirements of Zinc-Nickel plating. It doesn't give complete in-house process instructions, these shall be given in the manufacturers detailed process instructions.

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 2832, *Aerospace series — Hydrogen embrittlement of steels — Notched specimen* test

EN 4473, *Aerospace series — Aluminium pigmented coatings for fasteners — Technical specification*

EN 9100, *Quality Management Systems — Requirements for Aviation, Space and Defence Organizations*

EN ISO 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method* (ISO 1463)

EN ISO 2409, *Paints and varnishes — Cross-cut test* (ISO 2409)

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

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

EN ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests* (ISO 9227)

ISO 2812 (all parts), *Paints and varnishes — Determination of resistance to liquids*

NASM 1312-5, *Fastener test methods — Method 5: Stress durability* [1)]

NASM 1312-14, *Fastener test methods — Method 14: Stress durability internally threaded fasteners* [1)]

ASTM F 519, *Standard test method for mechanical hydrogen embrittlement evaluation of plating/coating processes and service environments* [2)]

1) Published by: AIA National (US) Aerospace Industries Association of America http://www.aia-aerospace.org/

2) Published by: ASTM National (US) American Society for Testing and Materials http://www.astm.org/

3 Terms and definitions

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

3.1
batch
unless otherwise specified, it comprises parts of the same type (shape, size, material), processed at the same time in the same bath with the same de-embrittlement conditions

3.2
pre-production part
part representative of future production

3.3
electro-plating
electrolytical metal deposition

3.4
passivation
conversion performed on metal electro-deposition in order to improve corrosion resistance

3.5
lubricant top coat /finishing
additional thin organic or inorganic resin based layer in order to improve functional properties: friction

3.6
Zinc-Nickel coating system
Zinc-Nickel coating including:

- possible undercoat as strike,
- supplementary treatments as passivation and/or lubricant top coat.

See 6.1: type 1 to type 4.

3.7
substrate
material upon which a coating is directly deposited, in the case of a single or first coating, the substrate is identical with the basis metal and for a subsequent coating, the intermediate coating is the substrate

3.8
UTS
R_m
Ultimate Tensile Strength

3.9
nodule
rounded projection formed on a cathode during electrode position (2.5) that may be seen without magnification

4 Purpose of process

The aim of the Zinc-Nickel plating is to ensure a protection against corrosion for steels or to reduce the effects of galvanic coupling of less noble materials in contact with the plated substrates. For improving corrosion, a passivation is performed on Zinc-Nickel coating. The Zinc-Nickel plating has also electrical conductivity properties and may also provide anti-galling properties when associated with an appropriate lubricant finishing.

5 Applicability and limitations of the process

This standard applies whenever referenced.

It is applicable on parts with or without threads, and fasteners, and on:

— low alloys steels and stainless steels R_m ≤ 1 450 MPa,

— copper alloys,

— nickel alloys,

— aluminium alloys.

The electrolytic Zinc-Nickel plating process must not be used in the following cases:

— welded parts likely to entrap electrolyte,

— cavities, holes, recesses for which processing limitations may result in uncontrolled or incomplete,

— coverage,

— springs with diameter ≤ 1 mm.

Zinc-Nickel plating can withstand the following service temperatures:

— 120 °C for parts coated with lubricant top coat,

— 250 °C for parts coated with trivalent chromium passivation.

6 Coating system classification

6.1 System types

Zinc-Nickel coating system is classified by the four following types, depending on the supplementary finishing:

Type 1 (T1): Zinc-Nickel (12 % to 16 %) alloy as plated.

Type 2 (T2): Zinc-Nickel (12 % to 16 %) alloy as plated and trivalent chromium passivation in order to improve corrosion resistance.

Type 3 (T3): Zinc-Nickel (12 % to 16 %) alloy as plated, trivalent chromium passivation and friction control lubricant for improving corrosion resistance and reaching consistent coefficient of friction of 0.08 to 0.14.

Type 4 (T4): Zinc-Nickel (12 % to 16 %) alloy as plated, trivalent chromium passivation and friction control lubricant for improving corrosion resistance and reaching consistent coefficient of friction of 0.12 to 0.18.

6.2 Coating thicknesses

Unless otherwise specified in the product standard or definition document, the coating thicknesses are as follows:

— Class A: 4 µm to 7 µm [typical thickness for screws with diameter < 3,5 mm and tight fits (bushes)].

— Class B: 7 µm to 13 µm (typical thickness for parts with tigh tolerances or threaded, and screws with diameter > 3,5 mm).

— Class C: 10 µm to 20 µm (typical thickness for other cases for maximum corrosion resistance).

— It is permissible that thicknesses obtained on parts exceed the maximum thickness values given above provided that the final sizes required by the plan and drawings are satisfied and that the thickness is not exceeding 20 % of the maximum thickness.

— For internally threaded parts, a maximum limit of 13 µm (class B) above the minimum shall be allowed on the external surfaces.

— The thickness tolerances are those of the Zinc-Nickel electrolytic plating (type 1) and/or Zinc-Nickel coating system (type 2, 3 and 4): Possible undercoat (e.g. strike in order to improve adhesion on stainless steels), Passivation and lubricant finishing thicknesses are considered to be insignificant. For fasteners, the possible undercoat, the passivation or lubricant finishing thicknesses shall not alter mountability, see dimensional test, subclause 8.3.

7 Requirements

7.1 Process requirements

7.1.1 Information for the processor

— process designation, see Clause 9;

— bare substrate standard reference and heat treatment;

— areas to be plated;

— plated thickness measuring points;

— duration and temperature of stress relief and de-embrittlement treatments;

— electrical contact points or areas where these are not permitted;

— specification for testing on parts and/or samples.

7.1.2 Condition of parts prior to the treatment

Welding, soldering/brazing, mechanical operations and heat treatments shall have been completed.

Stress relief may be required for parts which have been cold worked or machined after the heat treatment operation.

When shot peening is specified, it shall be performed after the stress relief operations.

Unless otherwise specified, the stress relief heat treatment conditions for parts in steel shall conform to Table 1.

Table 1 — Stress relief heat treatment of parts in steel

R_m MPa	Stress relief heat treatment
≤ 1 100	Not necessary
> 1 100 and ≤ 1 450	(190 to 230) ± 10 °C, 1 h min.

A slight discoloration of the surface by oxidation is admissible after stress relief.

7.1.3 Process conditions

a) Tooling

The tools, bars, electrical contact systems, and metal masking tooling must be protected against corrosion, and/or free of corrosion or any other damage which may be detrimental to the treatment during use. The part racks and tools must be designed and set up in such a manner as to:

— avoid any retention of air or treatment solution in the parts,

— facilitate neutralization and removal of solutions during rinsing operations,

— assure electrical contact for the electrolytic baths,

— avoid the treatment any accidental contact between the parts to be treated and the tank equipments or electrodes, and between the different parts.

Avoid any galvanic damage between tools and parts.

b) Masking

The parts shall be previously degreased prior to masking.

Component areas which must not be coated shall be masked with suitable material.

c) Surface pre-treatment

Surface preparation means any method able to completely eliminate all surface contaminations.

Methods which may result in hydrogen embrittlement of the material shall be avoided.

The surface preparation prior to Zinc-Nickel plating that guides the plating adhesion depends on the metallic substrate; for aluminium alloys, copper alloys and stainless steels a strike undercoat may be performed.

d) Zinc-Nickel plating

The Zinc-Nickel shall be deposited in accordance with an approved electrolyte and processor to produce coatings containing 12 % to 16 % nickel.

The composition of the bath as well as the process parameters shall be chosen such that the requirements for the Zinc-Nickel coating specified by this standard (see 7.2) could be met.

Addition agents shall have no negative effect on the hydrogen embrittlement behaviour.

Treatment can be performed by racking or barrel. Before part immersion, it is essential to ensure that the electrical contacts are correct (cleanliness of bars and contacts). During part immersion in bath, power supply shall be switched off.

e) Passivation

Items shall be passivated immediately after plating or after baking if applicable. The supplementary passivation for corrosion performance shall be if possible chromate free.

f) De-embrittlement

De-embrittlement shall be carried out within 4 h after Zinc-Nickel plating, in accordance with Table 2.

Table 2 — De-embrittlement

Substrate	**Temperature** [a] °C	**Minimum duration** [a] h
Steels 1 100 MPa $< R_m \leq$ 1 450 MPa	(190 to 230) $\pm$ 10 °C	8
Other materials $R_m \leq$ 1 100 MPa	Not required	
[a] Other conditions may be used subject to agreement between the processor and the purchaser.		

NOTE When the strength resistance is defined by a range (for example 1 000 MPa to 1 150 MPa), the value to be considered for de-embrittlement conditions, is the highest one of the range (1 150 MPa in the case of the example).

g) Lubricant finishing

It should be applied by immersion or by spray on clean items. The lubricant is applied after de-embrittlement or passivation within the delay allowing to avoid the damage of the passivation layer. Electrical properties might be affected by the lubricant finishing.

h) Stripping

Both electrochemical and chemical processes may be applied. The stripping variants used, however, shall not deteriorate the dimensions, surface finish and mechanical properties of parts. In particular, it shall not result in embrittlement of the metallic substrate.

Reprocessing of parts depends on the material and may only be carried out following confirmation and requirements by the manufacturer.

7.2 Main technical engineering requirements

7.2.1 General

The final coating is expected to meet the following main requirements:

— adequate appearance of Zinc-Nickel plating, of passivation and of lubricant finishing when applicable,

— a good adhesion of Zinc-Nickel coating to the substrate, of lubricant finishing on Zinc-Nickel plating when applicable, of the subsequent paint to the Zinc-Nickel coating system,

— adequate thickness according required range on drawing,

— a good corrosion protection of substrate and of the Zinc-Nickel coating system,

— a composition of 12 % to 16 % in nickel,

— no crack of substrate due to embrittlement,

— electrical conductivity.

7.2.2 Appearance

The surface shall be satin, uniform in appearance, and free from:

— rough, burnt or powdery areas,

— pits,

— exfoliations, nodule,

— blisters or other defects.

The colour of the coating shall be:

— T1: metallic grey,

— T2: yellow-blue iridescent,

— T3 or T4: semi glossy or mat grey.

7.2.3 Adhesion

— of the Zinc-Nickel plating: After test by scribe and adhesive tape (3M 250 or 3M 2525 or equivalent) or thermal shock (agreed between processor and purchaser) according EN ISO 2819, a visual inspection shall not show any pulling off of the coating at the surface of the substrate or other lack of adhesion to the substrate,

— of lubricant finishing and organic finishing when applicable: When tested by scribe and adhesive tape (3M 250 or 3M 2525 or equivalent) according EN ISO 2409 and ISO 2812 (at initial stage and after immersion 14 days in water), a visual inspection shall not show any pulling off of the organic coating or other lack of adhesion to the Zinc-Nickel plating,

7.2.4 Coating thickness

When tested by appropriate method (that provides accuracy of measurement better than 10 % of the thickness being measured – For examples: X-ray fluorescence method (EN ISO 3497), micrographic cross section per EN ISO 1463, metrological control etc.), the thickness of Zinc-Nickel coating system shall be in the range required according 6.2. Areas (holes, small openings …) where the coating thickness cannot be measured shall show evidence of coating; no bare areas are permitted.

For surfaces that cannot be touched by a 19 mm sphere, including internal threads, no thickness requirements are established, but such areas shall show evidence of coating. There shall be no bare areas, except for areas beyond a hole depth of 2,0 times the hole diameter.

NOTE The thickness of Zinc-Nickel coating system shall be uniform in thickness on surfaces that can be touched by a 20 mm sphere except that slight build-up on exterior corners and edges will be permitted provided the finished engineering drawing dimensions are met.

7.2.5 Corrosion resistance

After minimum exposure to salt spray (EN ISO 9227 – NSS test – see Table 3 for duration dependant of coating system), the visual inspection of the specimens shall show no evidence of bare metal corrosion (red corrosion on steels). The amount of white corrosion products should be minimal; 96 h is the common duration of white corrosion appearance, but is not a rejection criteria.

Table 3 — Minimum NSS exposure before corrosion depending on coating system performed on low carbon steel and alloy steel

		Coating system T1	**Coating systems** T2	**Coating systems** T3/T4
		Red corrosion	Red corrosion	Red corrosion
Class A	4 µm to 7 µm	96 h	120 h	336 h
Class B	7 µm to 13 µm	120 h	336 h	750 h
Class C	10 µm to 20 µm	168 h	750 h	750 h

7.2.6 Nickel content

When tested by X-Ray fluorescence or other applicable methods, the alloy composition shall be within the limits of 12 % to 16 %. This Zinc-Nickel content shall be uniform in the thickness and on all over the part coated.

7.2.7 Hydrogen embrittlement of steels

Unless otherwise specified, these tests are applicable to steels of $R_m \geq 1\,100$ MPa.

— For parts

  — no rupture within 200 h after static tensile test according (see EN 2832 or ASTM F 519), on steel Zinc-Nickel plated and de-embrittled according the manufacturers detailed process instructions.

— For fasteners:

  — externally threaded fasteners shall be tested as specified in NASM 1312-5;

  — internally threaded fasteners shall be tested as specified in NASM 1312-14.

The minimum test load shall be 85 % of the minimum ultimate tension load specified in the end product specification. The load shall be sustained for not less than 72 h. The fasteners shall be examined and shall be free of crack or fracture.

8 Quality requirements

8.1 Approval of the processor

See EN 9100.

8.2 Process approval

The processor shall carry out:

— the plating on pre-production parts and/or samples determined by agreement between the processor and the purchaser;

— the tests specified in this standard, unless otherwise agreed between the processor and the purchaser.

The process chart defined in the manufacturers process instructions shall not be changed without any previous agreement from the purchaser.

8.3 General points

During all the process operations, the operating conditions must be within the parameters defined in the manufacturers detailed process instructions.

Regular controls must be performed on the facilities and the products used and on conformance of the application process conditions to the requirements of this document and of the manufacturers detailed process instructions.

All records of process parameters, tests and inspection results shall be registered under the control of the quality assurance of the workshop.

All process operators shall be adequately trained.

In order to verify the above specified design requirements and maintain the process with appropriate performances, the process needs to be checked by:

— periodic tests on samples coated under the same conditions as the parts,

— periodic bathes chemical analysis,

— parts acceptance controls.

The minimum tests and controls are defined in the paragraphs below. The frequency and nature of other tests shall be determined by agreement between the processor and the purchaser.

8.4 Periodic tests

The Table 4 below synthesizes all the periodic tests on samples.

Table 4 — Minimum periodic tests requirements

Minimum periodicity	Material, samples types	Number of samples per test	Characteristics	Tests		Criteria
				Type	Standard	
Twice-monthly	– low alloy carbon steel 15CDV6 or equivalent Area: 1dm^2 minimum – or fasteners	3 specimens	Appearance	Visual		Subclause 7.2.2
			Adhesion	Scribe and tape or thermal shock test (agreed between processor and purchaser)	EN ISO 2819	Subclause 7.2.3
			Thickness	Subclause 7.2.4 X-ray fluorescence method (EN ISO 3497)		
			Nickel content	Subclause 7.2.6 X-ray fluorescence method (EN ISO 3497)		
			Corrosion	Salt spray test	EN ISO 9227	Subclause 7.2.5
Quaterly	– Low alloy carbon steel 35NCD16 or equivalent R_m > 1 800 MPa – or fasteners	3 specimens	De-embrittlement	Static tensile test Stress durability test	EN 2832, ASTM F 519 type 1a.1 NASM 1312-5 and NASM 1312-14	Subclause 7.2.7

8.5 Periodic chemical analysis

The bathes composition shall be in the limit as specified in the Manufacturers detailed process Instruction. The periodicity of the analysis shall be defined considering the ageing, contamination and the efficiency of the bathes, the production rate and the re-adjustment or refilling of the bathes.

8.6 Parts acceptance controls

8.6.1 Controls before treatment

A visual inspection must be performed in order to ensure that the parts to be treated have no defects as: cracks, stripes, pits, corrosion … or other defects can be harmfull for parts, for coating appearance and performance.

8.6.2 Controls during treatment

At the end of the degreasing phases, the rinsing phase must be followed by the water break test to evaluate the wettability (and therefore the cleanliness) of the surfaces (not applicable to barrel plating).

This test consists in covering the parts with an uniform water film. This water film must cover the parts during at least 30 s without any film discontinuity; otherwise, degreasing phases have to be repeated. If successive degreasing many result in hydrogen embrittlement, the number of successive degreasing must be limited according the manufacturer process instruction.

8.6.3 Controls after Zinc-Nickel plating + passivation

The Table 5 below synthesizes all the lot acceptance tests on parts.

Table 5 — Minimum parts controls

Type	Frequency	Method and criteria
Visual inspection	100 % critical parts 10 % minimum others with a minimum of 2 parts or on 3 fasteners *	Subclause 7.2.2.
Adhesion	10 % minimum others with a minimum of 2 parts or on 3 fasteners *	Tape test – Fix firmly the scotch tape (scotch tape 3M 250 or 3M 2525 or equivalent) and pull off sharply. No unsticking or coating tearing are allowed after test. – Choose the most suspicious areas i.e. areas evaluated as sensitive to unsticking, for example due to a complex geometry of the part.
Thickness	One sample or 3 fasteners* per batch	Subclause 7.2.4.
Nickel content	10 % minimum others with a minimum of 2 parts per batch when applicable or on sample per batch or on 3 fasteners*	Subclause 7.2.6.
* According to the EN 4473, Subclause 5.2.		

8.6.4 Controls after lubricant finishing

Presence of topcoat (if applicable):

Exposed to UV, type 3 and type 4 coatings system types shall give a typical bluish fluorescence. If the test indicates the absence of the film on threaded areas the items will be rejected.

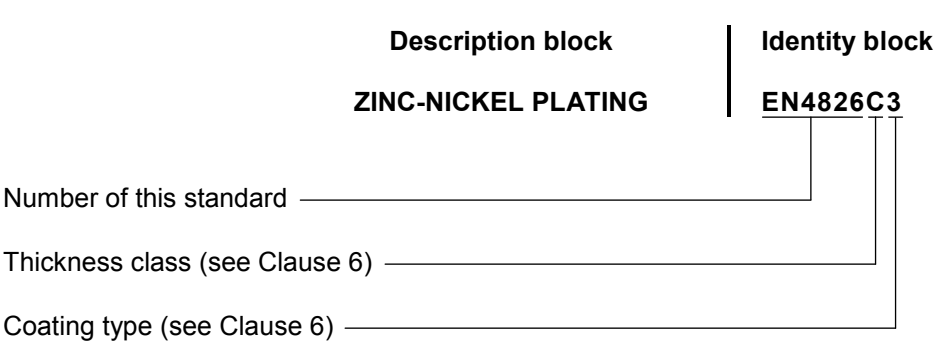
— single sampling plan for more stringent inspection,

— acceptable quality level (AQL) 1,5.

The frequency and nature of other tests (for instance torque/tension test) shall be determined by agreement between the processor and the purchaser.

9 Designation

EXAMPLE ZnNi 12-16 Class C T3.



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