

Specification for

Electrolytically zinc coated cold rolled steel flat products — Technical delivery conditions

The European Standard EN 10152:1993 has the status of a
British Standard

UDC 669.146.91.5-41-122.2:620.1

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National foreword

This British Standard has been prepared under the direction of the Iron and Steel Policy Committee and is the English language version of EN 10152 *Electrolytically zinc coated and cold rolled steel flat products*. It supersedes BS 6687:1986 which is withdrawn.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Descriptors: Iron and steel products, cold rolled products, metal bars, steels, galvanizing, electrodeposited coatings, designation, delivery, chemical composition, mechanical properties, adhesion, appearance, quality classes, inspection, marking

English version

Electrolytically zinc coated cold rolled steel flat products — Technical delivery conditions

Produits plats en acier, laminés à froid,
revêtus de zinc par voie électrolytique —
Conditions techniques de livraison

Elektrolytisch verzinkte kaltgewalzte
Flacherzeugnisse aus Stahl — Technische
Lieferbedingungen

This European Standard was approved by CEN on 1993-10-15. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Foreword

This European Standard has been drawn up by ECISS/TC 27, Surface coated flat products, the Secretariat of which is held by Normenausschuß Eisen und Stahl (FES) im DIN.

The European Standard EN 10152 supersedes EURONORM 152-80 *Electrolytic zinc coated steel flat rolled products*

At a meeting of ECISS/TC 27 held on 7 July 1992 in Düsseldorf the text was agreed for circulation for formal vote within CEN. The following countries were represented at this meeting: Austria, Belgium, Finland, France, Germany and United Kingdom.

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 April 1994, and conflicting national standards shall be withdrawn at the latest by April 1994.

In accordance with the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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1 Scope

1.1 This European Standard specifies requirements for continuously electrolytic zinc coated cold rolled flat products of low carbon steels suitable for cold forming according to Table 1 in rolled widths ≥ 600 mm and thicknesses from 0,35 mm up to and including 3 mm, delivered as strip (in coil form), sheet, slit strip or cut lengths obtained from slit strip or sheet.

1.2 This European Standard may also be applied to continuously electrolytic zinc coated cold rolled flat products of

- a) steels according to EN 10139 (cold rolled strip in rolled widths < 600 mm);
- b) other types of low carbon steel for cold forming;
- c) steels normally characterized by minimum yield strength values in addition to formability parameters, e.g.
 - steels with high yield strength and improved formability according to Euronorm 149-4, or other microalloyed steels;
 - phosphorous alloyed steels and bake-hardening steels;
 - general purpose structural steels.

1.3 By special agreement at the time of ordering this European Standard may be applied to continuously electrolytic zinc coated hot-rolled steel flat products (e.g. according to EN 10025, Euronorm 111, Euronorm 149-1 to Euronorm 149-3 etc.).

1.4 The coating masses, surface qualities and surface finishes are given in **5.9**, **5.11** and Table 2. As the mass of the zinc coating applied is relatively small, the material is not intended to withstand outside exposure without further chemical treatment and painting.

1.5 This European Standard is not applicable to

- hot-dip zinc coated steel sheet and strip (see EN 10142 and EN 10147);
- continuously organic coated steel flat products (see EN 10169).

2 Normative references

This European Standard incorporates by dated or undated reference provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of testing (at ambient temperature)*.

EN 10002-2, *Metallic materials — Tensile testing — Part 2: Verification of the force measuring system of the tensile testing machines*.

EN 10002-4¹⁾, *Metallic materials — Tensile testing — Part 4: Verification of extensometers used in uniaxial testing*.

EN 10021¹⁾, *General technical delivery requirements for steel and steel products*.

EN 10025, *Hot rolled products of non-alloy structural steels; technical delivery conditions*.

EN 10027-1, *Designation systems for steel — Part 1: Steel names; principal symbols*.

EN 10027-2, *Designation systems for steel — Part 2: Numerical system*.

EN 10079¹⁾, *Definition of steel products*.

EN 10130, *Cold rolled low carbon steel flat products for cold forming; technical delivery conditions*.

EN 10131, *Cold-rolled non-coated flat products in low carbon steel for cold forming; tolerances on dimensions and shape*.

EN 10139¹⁾, *Cold rolled uncoated low carbon steel strip for cold forming; Technical delivery conditions*.

EN 10204, *Steel and iron and steel products — inspection documents*.

ECISS Information Circular IC 10¹⁾, *Designation systems for steel; Additional symbols for steel names*.

Euronorm 12 (1955)²⁾, *Bend test for steel sheet and strip less than 3 mm thick*.

Euronorm 111 (1977)²⁾, *Hot rolled non coated mild unalloyed steel and strip for cold forming; quality standard*.

¹⁾ At present at the stage of draft.

²⁾ Until they are transformed into European Standards, either the Euronorms referred to or the corresponding national standards may be applied.

Table 1 — Chemical composition and mechanical properties of electrolytically zinc coated mild steel flat products^a

| Steel grade | | Definition and classification according to EN 10020 | Deoxidation | Validity of mechanical properties | Surface appearance | Absence of stretcher strain marks | R_e | R_m | A_{80} | r_{90} | n_{90} | Chemical composition (ladle analysis, % max.) | | | | | |
|------------------------|--------------|---|---------------------------|-----------------------------------|--------------------|-----------------------------------|-------------------------|-------------------|----------|-----------------------|---------------------|---|-------|-------|------|------------------|----|
| Steel name | Steel number | | | | | | N/mm ² | N/mm ² | % | min. d | min. d e | min. d | C | P | S | Mn | Ti |
| | | | | | | | b | | min. c | | | | | | | | |
| DC01 + ZE ^f | 1.0330 | Non alloy quality steel ^g | Manufacturer's discretion | — — | A B | — 3 months | ^h j —/280 | 270/410 | 28 | — | — | 0,12 | 0,045 | 0,045 | 0,60 | | |
| DC03 + ZE | 1.0347 | Non alloy quality steel ^g | Fully killed | 6 months 6 months | A B | 6 months 6 months | ^h —/240 | 270/370 | 34 | 1,3 | — | 0,10 | 0,035 | 0,035 | 0,45 | | |
| DC04 + ZE | 1.0338 | Non alloy quality steel ^g | Fully killed | 6 months 6 months | A B | 6 months 6 months | ^h —/220 | 270/350 | 37 | 1,6 | 0,160 | 0,08 | 0,030 | 0,030 | 0,40 | | |
| DC05 + ZE | 1.0312 | Non alloy quality steel ^g | Fully killed | 6 months 6 months | A B | 6 months 6 months | ^h —/190 | 270/330 | 39 | 1,9 | 0,190 | 0,06 | 0,025 | 0,025 | 0,35 | | |
| | | | | | | | | | | \bar{r} d e min. | \bar{n} d min. | | | | | | |
| DC06 + ZE | 1.0873 | Alloy quality steel | Fully killed | 6 months 6 months | A B | no limit no limit | ⁱ —/190 | 270/350 | 37 | 1,8 | 0,200 | 0,02 | 0,020 | 0,020 | 0,25 | 0,3 ^k | |

Notes to Table 1

^a The mechanical properties apply only to skin-passed products.

^b The values of yield stress shall be the 0,2 % proof stress ($R_{p\,0,2}$) for products which do not present a definite yield point and the lower yield stress (R_{eL}) for the others.

When the thickness is less than or equal to 0,7 mm but greater than 0,5 mm the values for yield stress shall be increased by 20 N/mm². For thicknesses less than or equal to 0,5 mm the values shall be increased by 40 N/mm².

^c When the thickness is less than or equal to 0,7 mm but greater than 0,5 mm the minimum values for elongation shall be reduced by 2 units. For thicknesses less than or equal to 0,5 mm the minimum values shall be reduced by 4 units.

^d The values of r_{90} and n_{90} or \bar{r} and \bar{n} (see annexes A and B) only apply to products of thickness equal to or greater than 0,5 mm.

^e When the thickness is over 2 mm the value for r_{90} or \bar{r} is reduced by 0,2.

^f It is recommended that products in grade DC01 + ZE should be formed within 6 weeks from the time of their availability.

^g Unless otherwise agreed at the time of the enquiry and order DC01 + ZE, DC03 + ZE, DC04 + ZE and DC05 + ZE may be supplied as alloy steels (for example with boron or titanium).

^h For design purposes the lower limit of R_e for grades DC01 + ZE, DC03 + ZE, DC04 + ZE and DC05 + ZE may be assumed to be 140 N/mm².

ⁱ For design purposes the lower limit of R_e for grade DC06 + ZE may be assumed to be 120 N/mm².

^j The upper limit of R_e of 280 N/mm² for grade DC01 + ZE is valid only for 8 days from the time of the availability of the product.

^k Titanium may be replaced by niobium. Carbon and nitrogen shall be completely bound.

EURONORM 149 (1980)³⁾, *Flat products in high yield strength steels for cold forming; wide flats, sheet/plate, wide and narrow strip* — Part 1: *General requirements* — Part 2: *Specific requirements for thermomechanically treated hot rolled products* — Part 3: *Specific requirements for normalized hot rolled products* — Part 4: *Specific requirements for cold rolled products*.

ISO 9513, *Metallic materials — Verification of extensometers used in uniaxial testing*.

Table 2 — Electrolytic zinc coatings
(see also 5.9.4 and 5.9.5)

| Coating designation | Nominal zinc coating values for each surface ^a | | Minimum zinc coating values for each surface ^b | |
|---------------------|---|--------------------------|---|--------------------------|
| | Thickness μm | Mass g/m ² | Thickness μm | Mass g/m ² |
| ZE25/25 | 2,5 | 18 | 1,7 | 12 |
| ZE50/50 | 5,0 | 36 | 4,1 | 29 |
| ZE75/75 | 7,5 | 54 | 6,6 | 47 |
| ZE100/100 | 10,0 | 72 | 9,1 | 65 |

^a A coating mass of 50 g/m² corresponds to a coating thickness of approximately 7,1 μm.
^b See 6.4.4 and 6.5.4.

3 Definitions

For the purposes of this European Standard the following definitions apply.

3.1

flat products, strip, sheet, cut length. See EN 10079

3.2

electrolytic zinc coating is understood to be a coating of zinc applied by electrolysis on a suitably prepared steel surface from an aqueous zinc salt solution by the use of an electric current

flat products may have a zinc coating on one or both surfaces. If both surfaces are zinc coated, a different coating thickness may be applied on each side (this process being referred to as differential zinc coating)

4 Designation

4.1 The steel names are allocated in accordance with EN 10027-1 and ECISS Information Circular IC 10; the steel numbers are allocated in accordance with EN 10027-2.

4.2 The products covered by this European Standard shall be designated as follows in the order given:

- type of product (e.g. strip, sheet, cut length);
- number of this standard (EN 10152);
- steel name or steel number (see Table 1);
- numbers denoting the nominal coating thickness on each surface (e.g. 50/50 = nominal coating thickness of 5,0 μm on each side, see Table 2 and 5.9.2);
- letters A or B indicating the surface quality (see 5.11.2);
- letters denoting the surface treatment (see 5.12 and Table 3).

Table 3 — Surface treatment

| Symbol | Type of treatment |
|--------|---|
| P | Phosphated |
| PC | Phosphated and chemically sealed |
| C | Chemically passivated |
| PCO | Phosphated, chemically sealed and oiled |
| CO | Chemically passivated and oiled |
| PO | Phosphated and oiled |
| O | Oiled |
| U | As coated, i.e. untreated |

Examples

Designation of strip made of steel DC03 + ZE, electrolytically zinc coated with a nominal thickness of 5,0 μm on each surface (50/50), surface quality A, surface treatment phosphated (P):

Strip EN 10152 – DC03 + ZE50/50 – AP

Designation of sheet made of steel DC05 + ZE electrolytically zinc coated with a nominal thickness of 7,5 μm on one surface and of 2,5 μm on the other surface (75/25), surface quality B, surface treatment phosphated and oiled (PO):

Sheet EN 10152 – DC05 + ZE 75/25 – BPO

4.3 Where appropriate, additional information to the designation as specified in 4.2 shall be given to describe clearly the delivery requirements (see clause 10).

5 Requirements

5.1 General

The requirements according to 5.2 to 5.8 and 5.13 apply to products made of the steel grades given in Table 1.

³⁾ Until they are transformed into European Standards, either the EURONORMS referred to or the corresponding national standards may be applied.

For other steels used as substrate for electrolytically deposited coatings of zinc (see 1.2 and 1.3) the requirements shall be based on the appropriate quality standard for the non-coated steel product.

5.2 Steelmaking and manufacturing processes

Unless otherwise agreed at the time of ordering, the steelmaking and manufacturing processes are left to the discretion of the manufacturer. The purchaser shall be informed of these processes, if he requires it.

5.3 Deoxidation

The method of deoxidation shall be in accordance with that specified in Table 1.

5.4 Chemical composition

The chemical composition based on ladle analysis shall be as given in Table 1.

5.5 Delivery condition

The products specified in this European Standard are normally supplied in the skin-passed condition. By agreement at the time of the enquiry and order non skin-passed products may be supplied.

5.6 Choice of properties

The products covered by this European Standard shall comply with the requirements of Table 1. By agreement they may be delivered as suitable for making a particular part; in this case a maximum percentage of scrap may be agreed and acceptance on the basis of mechanical properties is not applicable.

5.7 Mechanical properties

5.7.1 The mechanical properties are given in Table 1; they apply only to skin-passed products.

NOTE The properties in Table 1 are those specified for cold rolled non-coated low carbon steel flat products according to EN 10130 with the exception of the R_e , A_{80} and n_{90} values for the grades DC04 + ZE, DC05 + ZE and DC06 + ZE which have been altered with respect to the influence of the electrolytical treatment on those properties.

The mechanical properties are valid for the period specified in Table 1 from the date on which the products are made available. The date of availability shall be notified to the purchaser with reasonable prior notice compatible with the validity of the mechanical properties. Prolonged storage of products of grade DC01 + ZE could result in some change in the mechanical properties leading to a reduction in formability.

5.7.2 The tensile test values apply to transverse samples and relate to the test piece cross-section without zinc coating.

5.8 Stretcher strain marks

All products are generally subjected to a light skin-pass after annealing at the manufacturer's works to avoid the formation of stretcher strain marks.

The tendency to form such marks reappears a certain time after the skin-pass. It is therefore in the purchaser's interest to form the products as soon as possible.

Products of grade DC06 + ZE do not exhibit stretcher strain marks whether delivered skin passed or non-skin-passed. For skin-passed products the manufacturer shall ensure the absence of stretcher strain marks:

- for 6 months after products of grades DC03 + ZE, DC04 + ZE and DC05 + ZE are made available, for surface qualities A and B;
- for 3 months after products of DC01 + ZE are made available, for surface quality B.

5.9 Coatings

5.9.1 Zinc coatings as given in Table 2 are applicable for equally coated products.

5.9.2 In the designation the coating is expressed as ten times the nominal coating thickness in μm , indicated separately for either surface of the product [see 4.1 d)].

5.9.3 The coatings shall be checked by determining the mass of zinc per square metre on each surface (see 6.4.4 and 6.5.4). Each result shall meet the requirements for the minimum coating mass according to Table 2.

5.9.4 Differential coatings based upon a combination of the coatings mentioned in Table 2 may be available, subject to agreement between manufacturer and purchaser. They shall be designated as follows: ZE75/25 etc.

When differential coatings are supplied the manufacturer shall indicate which surface has the greater coating thickness, i.e. the top or the bottom surface of the sheets, inside or outside of the coil.

5.9.5 Material may be supplied, subject to agreement between manufacturer and purchaser, with coating on one surface only. Such coatings shall be designated as follows: ZE25/00 etc.

Slight zinc coatings may appear at the edge areas of the uncoated surface.

5.9.6 A maximum value (single spot test) for the coating mass per surface of the product may be agreed upon for each coating designation.

5.10 Adhesion of coating

The adhesion of the coating shall be tested using the method specified in **6.5.3**. After bending, the coating shall show no signs of flaking, but an area of 6 mm from each edge of the specimen shall be disregarded in order to exclude the effect of the cutting. Crazeing and toughening are permissible.

5.11 Surface characteristics

5.11.1 General

The surface characteristics consist of the surface quality and the surface finish. The surface quality and finish shall be specified by the purchaser at the time of the order (see **4.2**).

5.11.2 Surface quality

5.11.2.1 The products shall be supplied with either of the surface qualities A or B.

— Surface quality A:

defects such as pores, slight indentations, small marks, minor scratches and slight colouring which do not affect formability or the application of subsequent surface coatings are permitted.

— Surface quality B:

The better of the two surfaces shall be virtually free from surface imperfections liable to impair the uniform appearance of a high-quality paint finish. For one-sided coating, this requirement shall apply for the uncoated surface unless otherwise agreed. The other surface shall at least conform to surface quality A.

Unless otherwise agreed, a single surface of the sheet shall be inspected and shall comply with the requirements.

The other surface shall be such that during subsequent treatment it does not have a deleterious effect on the surface inspected.

5.11.2.2 When supplying strip in coils, there is greater risk of surface defects than if sheet and cut lengths are supplied as it is not possible for the manufacturer to eliminate all the defects in a coil. This shall be taken into account by the purchaser when evaluating the products.

5.11.3 Surface finish

By agreement at the time of the enquiry and order ranges for surface roughness (R_a values) may be specified for specific end uses.

5.12 Surface treatment (surface protection)

Electrolytically zinc coated strip and sheet may be supplied in one of the surface treatment conditions listed in Table 3. Surface treatment reduces the risk of corrosion occurring during transport and storage, which is mainly due to humidity and gives rise to wet storage stain (white rust). The phosphated, chemically sealed and oiled treatment condition normally offers the best corrosion protection. Since this type of protection is, however, not permanent the transport and storage conditions shall be selected to suit the material concerned.

A surface treatment also improves the adherence and protective effect of a coating applied by the processor who is, however, to ensure that pretreatment and coating systems are compatible with each other. Chemically sealed or passivated material is not recommended for products which will subsequently be phosphated. Discoloration as a result of chemical treatment does not impair further processing.

Phosphating in conjunction with a suitable lubricating agent may improve workability. Products are supplied without surface treatment (U, as in Table 3) only if the purchaser so wishes. In such cases, corrosion damage to the product may occur even when stored for short periods or during transport. Untreated products are also susceptible to fretting corrosion and are easily scratched.

In the case of oiled surfaces, it shall be possible to remove the oil layer with suitable detergents not attacking the zinc coating. It is assumed that the processor has all the equipment necessary for degreasing the products.

5.13 Applications

5.13.1 Welding

The product is suitable for welding under conditions laid down for the base metal. However, precautions may be necessary to overcome the presence of the zinc and, where applied, the phosphate on the surface of the product.

5.13.2 Painting

Zinc coated steel is a suitable base for paint, but the first treatment may be different from those used for uncoated steel. Pre-treatment primers, chemical conversion coatings and primers specially formulated for direct application to zinc surfaces are all appropriate first treatments for electrolytically zinc coated steel.

In drawing up a surface preparation and painting schedule, consideration should be given by the purchaser as to whether the material should be supplied chemically passivated or phosphated and/or oiled (see also 5.12).

5.13.3 Forming

Electrolytic zinc coatings are usually tightly adherent even when used for difficult formings. However, powdering can occur if the product is overformed or "coined" during fabrication. Care should be taken to ensure that the speed of forming and the clearance of dies is carefully controlled.

5.14 Mass, tolerances on dimensions and shape

5.14.1 The product mass shall be calculated taking the density of the steel as 7,85 kg/dm³ and the density of the zinc coating as 7,15 kg/dm³.

5.14.2 For the tolerances on dimensions and shape EN 10131 applies. The application of other dimensional standards shall be specially agreed at the time of enquiry and order.

6 Testing

6.1 General

6.1.1 The purchaser shall specify at the time of the enquiry and order his requirements for

- type of testing: specific or non-specific (see EN 10021);
- type of inspection document (see EN 10204).

6.1.2 Specific testing shall be carried out in accordance with 6.2 to 6.6.

6.1.3 Specific testing may not be specified either for the product analysis or the surface finish. However by agreement at the time of enquiry and order the manufacturer may supply a certificate of compliance with the order

6.2 Test units

The test unit consists of 20 t or a fraction of 20 t of electrolytically zinc coated flat products of the same grade and nominal thickness, coating type and surface characteristics. In the case of strip, a coil with a mass of more than 20 t is regarded as one test unit.

6.3 Number of tests

One series of tests shall be carried out per test unit as specified in 6.2 to determine

- the mechanical properties (see 6.5.1);
- the r - and n -values if specified in Table 1 (see 6.5.2);
- the adhesion of the coating (see 6.5.3); and
- the coating mass (see 6.5.4).

6.4 Sampling

6.4.1 In the case of strip, the samples shall be taken from the beginning or end of the coil. In the case of sheet and cut lengths, the selection of the sample shall be left to the discretion of the inspector carrying out the inspection tests.

6.4.2 The sample for the tensile test (see 6.5.1) shall be taken transversely to the direction of rolling at a distance of at least 50 mm from the edges of the product.

6.4.3 The sample for the bend test to determine the adhesion of the coating (see 6.5.3) may be taken in any direction. The distance from the product edges shall be at least 50 mm. The size of the sample shall be such that the length of the folded edge is at least 100 mm.

6.4.4 One sample for testing the coating mass (see 6.5.4) with an area of at least 5 000 mm² shall be taken at a distance of at least 50 mm from the edges of the product.

6.4.5 All the samples shall be taken and machined, if necessary, in such a way that the results of the tests are not affected.

6.5 Test methods

6.5.1 The tensile test shall be carried out as described in EN 10002-1 using type 2 test pieces (original gauge length $L_0 = 80$ mm, width $b = 20$ mm) as described in EN 10002-1 (see also 5.7.2).

6.5.2 The determination of the plastic strain ratio r and the strain hardening exponent n shall be carried out in accordance with annex A and annex B of this European Standard.

6.5.3 The bend test to determine the adhesion of the coating (see also 5.10 and 6.4.3) shall be carried out as described in EURONORM 12.

The diameter D of the mandrel or bending roll shall be 0 (flat on itself) for the steels covered by Table 1 and shall be by agreement between the manufacturer and the purchaser for other steel types.

The angle of bend shall be 180° in all cases.

When pressing together the two legs of the test piece, care shall be taken that the coating is not damaged.

6.5.4 The coating mass shall be determined from the difference in mass of the sample before and after the coating has been removed chemically.

Other methods — e.g. non-destructive tests — may be used for continuous checks at the manufacturer's works.

In cases of dispute, the method described in annex C of this European Standard shall be used.

6.6 Retests

The requirements of EN 10021 shall apply. In the case of coils, the retest specimens shall be taken from a distance of at least one lap away, but with a maximum of 20 m from the end of the coil.

6.7 Inspection documents

If agreed at the time of ordering, one of the inspection documents specified in EN 10204 shall be supplied.

7 Marking

7.1 A label shall be attached to each coil or bundle containing at least the following information:

- name or mark of the manufacturer's works;
- full designation (see 4.2);
- nominal dimensions of the product;
- identification number;
- order number;
- mass of the lot, coil or bundle.

7.2 Marking of the products by branding may be agreed upon at the time of ordering.

8 Packing

The packing requirements for the product shall be agreed at the time of ordering.

9 Storage and transportation

9.1 Moisture, in particular condensation between the sheets, laps of the coil or other adjacent parts made of electrolytically zinc coated flat products may lead to the formation of matt grey to white deposits (white rust). The possible types of surface protection are given in 5.12. However, if there is lengthy contact with moisture, the corrosion protection may be reduced locally. As a precaution, the product should be transported and stored dry and protected from moisture.

9.2 During transportation, dark spots may appear on the zinc coated surfaces as a result of friction. Generally, they only impair the appearance. Friction is reduced by oiling the products. However, the following precautionary measures should be taken: secure packing, laid flat, no local pressure spots.

10 Information to be supplied by the purchaser

The following information is required from the purchaser so that the manufacturer may supply the products to conform with the requirements:

- a) product type (strip, sheet, cut length);
- b) nominal dimensions (thickness, width and, in the case of sheet and cut lengths, length);
- c) quantity;
- d) complete designation (see 4.2);
- e) limiting mass and sizes of the coils and individual bundles of sheets;
- f) properties of steels other than those covered by Table 1 (see 5.1, 5.14.2 and 6.5.3);
- g) any products suitable for making a particular part (see 5.6);
- h) any requirement for a maximum value of the coating mass (see 5.9.6);
- i) any requirement on surface roughness (see 5.11.3);
- j) if required type of testing and inspection document (see 6.1.1 and 6.7);
- k) any marking desired by branding of the product (see 7.2);
- l) any requirement for packing (see clause 8).

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Annex A (normative)
Method of determination of the plastic strain ratio *r*

NOTE This annex is based upon the procedures being developed by ISO/TC164/SC2.

A.1 Definitions, symbols and designations
A.1.1 Plastic strain ratio *r* is defined as the ratio of true width and thickness strains in a test piece that has been submitted to uniaxial tensile stress.

$$r = \frac{\epsilon_b}{\epsilon_a}$$

where

- ϵ_a is the true thickness strain
- ϵ_b is the true width strain

The plastic strain shall be homogeneous.
A.1.2 Since measurements of length are more easily made than of thickness changes the following relationship derived from the law of constancy of volume before and after plastic strain is normally used for calculation of *r*:

$$r = \frac{\ln \frac{b_0}{b}}{\ln \frac{Lb}{L_0b_0}}$$

The symbol *r* shall be completed by index figure *x* giving the orientation of the test piece relative to the rolling direction and by index figure *y* giving the strain level, for example *r*_{45/20} (see Table A.1).
A.1.3 The weighted average *r*_{*x/y*} value is calculated using the formula

$$\bar{r} = \frac{r_0 + r_{90} + 2r_{45}}{4}$$

A.1.4 Symbols and designations used in measurement and calculations for determining the plastic strain ratio *r* are given in Table A.1.

Table A.1

| Symbol | Designation | Unit |
|--------------------------------|---|------|
| <i>b</i> ₀ | Original gauge width of the test piece | mm |
| <i>b</i> | Gauge width of the test piece after straining to a specified elongation | mm |
| <i>L</i> ₀ | Original gauge length | mm |
| <i>L</i> | Gauge length after straining to a specified elongation | mm |
| <i>r</i> | Plastic strain ratio | |
| <i>r</i> _{<i>x/y</i>} | Plastic strain ratio in direction <i>x</i> (in degrees) relative to the rolling direction for the strain level <i>y</i> % | |
| \bar{r} | Weighted average of <i>r</i> _{<i>x/y</i>} values | |
| ϵ_a | True thickness strain | |
| ϵ_b | True width strain | |

^a In some countries *r* is used instead of \bar{r} .

A.2 Principle
The method involves carrying out a tensile test to a specified strain level of 20 % and of determining the plastic strain ratio by calculation from measurements of the changes in length and width for a given test piece. As the determination shall be carried out in the range of homogeneous deformation, then if the uniform elongation of the tested material is lower than 20 %, strain values of 15 % to 20 % can be applied. The strain level shall be given as index *y*. The orientation of the test piece relative to the rolling direction shall be given as index *x* (see A.1.2).

A.3 Testing equipment
A.3.1 The testing machine and method of gripping shall comply with the requirements of EN 10002-1 and EN 10002-2.
A.3.2 When the gauge length and width are determined by an extensometer, the class of the extensometer shall be 1 or better according to ISO 9513.

A.4 Test piece
A.4.1 The sampling and preparation of the test piece shall be in accordance with EN 10002-1. The test piece type shall be No 2 (80/20 mm).

A.4.2 The gauge length shall be between 50 mm and 80 mm but preferably 80 mm. The gauge length shall be measured within $\pm 0,01$ mm and the test piece width shall be measured within $\pm 0,005$ mm, using devices having adequate accuracy.

A.5 Procedure

A.5.1 In general, the test is carried out at ambient temperature between 10 °C and 35 °C. Tests carried out under controlled conditions shall be made at a temperature of $23\text{ °C} \pm 5\text{ °C}$.

A.5.2 If the measurement is made manually, the original width of the test piece shall be measured in at least three evenly distributed places within the gauge length (one measurement at each end of the gauge length). The mean value of the width shall be taken for calculations of plastic strain ratio r .

A.5.3 If the measurements are made automatically, the original gauge length and at least one width measurement shall be set according to the requirements of class 1 extensometers or better as specified by ISO 9513.

A.5.4 The speed of the machine, as defined by the speed of separation of cross-heads of the machine, expressed as a percentage of the parallel length per minute, shall in no case exceed 50.

A.5.5 Mount the test piece in the grips of the testing machine and apply the load in accordance with **A.5.4**:

- a) to achieve the prescribed strain (manual determination);
- b) to determine the width values at the prescribed strain level (automatic determination).

A.5.6 For manual determination after removing the load measure the gauge length L and gauge width b in the same manner and to the same tolerance as for original values.

A.5.7 For automatic determination the measurements of length and width at prescribed strain level are made according to **A.4.2**.

A.5.8 For manual determination calculate the plastic strain ratio in accordance with **A.1.2**.

A.5.9 For automatic determination the plastic strain ratio is obtained direct using an automatic tensile testing machine and data processing program. The elastic strains (in both width and length directions) shall be considered.

A.5.10 Calculate the weighted average r in accordance with **A.1.3**.

A.6 Interpretation of results

A.6.1 Determined values of plastic strain ratio r shall be rounded to 0,05.

A.6.2 If the test piece shows any transverse bow, which could influence the test results, the test shall be considered invalid and a new test shall be carried out.

A.6.3 If the plastic strain was inhomogeneous, the test results shall be considered invalid and a new test shall be carried out.

A.6.4 In case of dispute the testing shall be carried out with three test pieces of the specified orientation relative to the rolling direction. The average value of the 3 tests shall be considered.

A.7 Test report

The orientation of the applied strain relative to the rolling direction shall be added as an index figure x . The applied strain value, if not 20 %, shall be given as an index figure y .

Annex B (normative)

Method of determination of the strain hardening exponent n

NOTE This annex is based upon the procedures being developed by ISO/TC 164/SC2.

B.1 Definitions, symbols and designations

B.1.1 Symbols and designations used in determining the strain hardening exponent are given in Table B.1.

B.1.2 The strain hardening exponent n is defined as an exponent in the mathematical equation of the relation between true stress and true strain (during uniaxial application of the force):

$$\sigma = K\epsilon^n \quad 1)$$

or in the logarithmic form:

$$\ln\sigma = \ln K + n \ln\epsilon \quad 2)$$

B.1.3 The symbol n shall be completed by an index figure x giving the orientation of the test piece relative to the rolling direction and by an index figure y giving the upper limit of the strain range if the latter is not the standard value of 20 %.

i.e $n_{45/18}$

Table B.1

| Symbol | Designation | Unit |
|------------------------|--|-------------------|
| L_0 | Original extensometer gauge length of the test piece | mm |
| L | Instantaneous gauge length of the test piece after instantaneous action of the force F | mm |
| S_0 | Original cross-section of the gauge part of the test piece | mm ² |
| S | Instantaneous cross-section of the gauge part of the test piece after instantaneous action of the force F | mm ² |
| | $S = S_0 \frac{L_0}{L}$ | |
| ϵ | Instantaneous true strain after instantaneous action of the force F | |
| | $\epsilon = \ln \frac{L}{L_0}$ | |
| σ | Instantaneous true stress after instantaneous action of the force F | N mm ² |
| | $\sigma = \frac{F}{L_0} \cdot \frac{L}{S_0}$ | |
| F | Instantaneous force applied to the test piece | N |
| n | Strain hardening exponent | |
| K | Strength coefficient | N mm ² |
| $n_{x/y}$ | Strain hardening exponent ratio in direction x (in degrees) relative to the rolling direction for the strain level y % | |
| \bar{n} ^a | Weighted average of n_x values | |
| N | Number of measurements for determination of strain hardening exponent | |

^a In some countries n_m is used instead of \bar{n} .

B.1.4 The weighted average of n_x – values is calculated using the formula

$$\bar{n} = \frac{n_0 + n_{90} + 2 n_{45}}{4}$$

B.2 Principle

The test involves uniaxial tensile straining of the test piece at the prescribed rate in the interval including the region of the uniform plastic strain.

The strain hardening exponent is determined within the strain range of 10 % to 20 %. As the determination shall be carried out in the range of homogeneous deformation, then if the uniform elongation of the tested material is lower than 20 %, values for the upper limit of the strain range of 15 % to 20 % can be applied. In this case the upper strain limit shall be given as index y (see **B.1.3**).

B.3 Testing equipment

B.3.1 The testing machine and method of gripping shall comply with the requirements of EN 10002-1 and EN 10002-2.

B.3.2 The accuracy of the extensometer used shall be class 1 or better according to ISO 9513.

B.4 Test piece

B.4.1 The sampling and preparation of the test piece shall be in accordance with EN 10002-1, the test piece type is No 2 (80 mm/20 mm).

B.4.2 The gauge length shall be between 50 mm and 80 mm but preferably 80 mm. The gauge length shall be measured within $\pm 0,01$ mm using a device having adequate accuracy.

B.5 Procedure

B.5.1 In general, the test is carried out at ambient temperature between 10 °C and 35 °C. Tests carried out under controlled conditions shall be made at a temperature of $23 \text{ °C} \pm 5 \text{ °C}$.

B.5.2 The test piece shall be mounted in the testing machine so that the force can be applied axially in accordance with EN 10002-1.

B.5.3 The speed of the machine, as defined by the speed of separation of the cross heads of the machine, expressed as a percentage of the parallel length per minute, shall in no case exceed 50. This speed shall be kept constant in the time interval over which the tensile hardening exponent is calculated.

B.5.4 The force and the corresponding strain shall be recorded at a minimum of 5 points, distributed at equal distances within the strain range of 10 % – 20 % (10 % – 15 % 18 %, refer to **B.2**) for which the strain hardening exponent is calculated.

B.5.5 From the values of the force corresponding strain, the true stress shall be calculated using the formula

$$\sigma = \frac{F}{S_0} \cdot \frac{L}{L_0}$$

and the true strain shall be calculated using the formula

$$\varepsilon = \ln \frac{L}{L_0}$$

and the logarithms of these values shall be obtained.

B.5.6 The n value is calculated using the formula given below, the standard formula for calculating the inclination of a straight line using the statistical method of least squares:

$$n = \frac{N \sum x_i y_i - \sum x_i \sum y_i}{N \sum x_i^2 - \left(\sum x_i \right)^2}$$

where

$$y = Ax + B$$

with $y = \ln \sigma$

$$x = \ln \varepsilon$$

$$A = n$$

$$B = \ln K$$

B.5.7 Calculated values of the strain hardening exponent, n , shall be rounded to 0,005.

B.5.8 In case of dispute the testing shall be carried out with three test pieces of the specified orientation relative to the rolling direction. The average value of the 3 tests shall be considered.

B.6 Test report

The orientation of the applied strain relative to the rolling direction shall be added as an index figure x , the upper limit of the applied strain range, if not 20 %, shall be given as an index figure y .

Annex C (normative)

Reference method for determination of the zinc coating mass

C.1 Principle

The sample shall be at least 5 000 mm² in area. Using a sample with a surface area of 5 000 mm², the loss of mass in grams when the coating is dissolved, multiplied by 200, will represent the zinc mass in grams per square metre on each surface of the product.

C.2 Reagent and preparation of the solution

Reagent:

- Hydrochloric acid (HCl $\rho_{20} = 1,19$ g/cm³)
- Hexamethylenetetramine

Preparation of the solution:

The hydrochloric acid is diluted with deionized or distilled water in the ratio one part pure HCl to one part water (50 % dilution).

Hexamethylenetetramine is then added, stirring, in the ratio of 3,5 g per litre of dilute hydrochloric acid solution.

This prepared solution permits the execution of numerous successive dissolutions under satisfactory conditions of attack of the coating, both from the point of view of speed and accuracy.

C.3 Apparatus

Balance capable of weighing samples to an accuracy of 0,01 g. For the test, use a take-off device.

C.4 Procedure

The following operations are applied to the sample:

- a) if necessary, degrease the sample with an organic solvent which will not attack the zinc, then dry the sample;
- b) protect one surface of the sample against the attack of the solution by coating with a suitable lacquer;
- c) weigh the sample to an accuracy of 0,01 g;

d) place the sample in the hydrochloric acid solution with hexamethylenetetramine inhibitor at ambient temperature (20 °C to 25 °C). Leave the sample immersed in the solution until the release of hydrogen ceases or only a few bubbles are released;

e) after the attack, the tested surface of the sample is washed and brushed under running water, dried with a cloth and then by heating to around 100 °C and cooled and dried by blowing with warm air;

f) weigh the sample again to an accuracy of 0,01 g;

g) determine the difference between the mass of the coated sample and that of the sample without its coating. This difference, calculated in grams, represents the mass of the coating on the tested surface;

h) remove the lacquer from the other surface [see C.4 b)] and continue as mentioned above under c) to g).

National annex NA (informative)

Committees responsible

The United Kingdom participation in the preparation of this European Standard was entrusted by the Iron and Steel Standards Policy Committee (ISM/-) to Technical Committee ISM/10 upon which the following bodies were represented:

British Railways Board
British Steel Industry
Cold Rolled Sections Association
Society of Motor Manufacturers and Traders Limited

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Welded Steel Tube Association
Coated Metals Limited
Department of the Environment (Property Services Agency)
International Tin Research Institute
Metal Roof Deck Association
National Association of Steel Stockholders
National Centre of Tribology
Paintmakers Association of Great Britain Ltd.
Zinc Development Association

National annex NB (informative)

Cross-references

| Publication referred to | Corresponding British Standard |
|-------------------------|---|
| | BS EN 10002 <i>Tensile testing of metallic materials</i> |
| EN 10002-1:1990 | Part 1:1990 <i>Method of test at ambient temperature</i> |
| EN 10002-2:1991 | Part 2:1992 <i>Verification of the force measuring system of the tensile testing machine</i> |
| EN 10025:1990 | BS EN 10025:1990 <i>Specification for hot rolled products of non-alloy structural steels and their technical delivery conditions</i> |
| | BS EN 10027 <i>Designation systems for steel</i> |
| EN 10027-1:1992 | Part 1:1992 <i>Steel names, principal symbols</i> |
| EN 10027-2:1991 | Part 2:1992 <i>Steel numbers</i> |
| EN 10130:1991 | BS EN 10130:1991 <i>Specification for cold rolled low carbon steel flat products for cold forming: technical delivery conditions</i> |
| EN 10131:1991 | BS EN 10131:1991 <i>Cold-rolled uncoated low carbon and high yield strength steel flat products for cold forming. Tolerances on dimensions and shape</i> |
| EN 10142:1990 | BS EN 10142:1991 <i>Specification for continuously hot-dip zinc coated low carbon steel sheet and strip for cold forming: technical delivery conditions</i> |
| EN 10204:1991 | BS EN 10204:1991 <i>Metallic products. Types of inspection documents</i> |
| EN 10147:1991 | BS EN 10147:1992 <i>Specification for continuously hot-dip zinc coated structural steel sheet and strip. Technical delivery conditions</i> |

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