Cold reduced tinmill products — Electrolytic tinplate and electrolytic chromium/chromium oxide coated steel

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee ISE/29, Tinplate and blackplate, which has the responsibility to:

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— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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Amendments issued since publication

<table>
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<th>Amd. No.</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
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<td>14845</td>
<td>19 December 2003</td>
<td>Indicated by a sideline</td>
</tr>
</tbody>
</table>

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ISBN 0 580 37204 9
Cold reduced tinmill products — Electrolytic tinplate and electrolytic chromium/chromium oxide coated steel

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Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 26, Tinmill products — Qualities, dimensions, tolerances and specific tests, the Secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by September 2001, and conflicting national standards shall be withdrawn at the latest by September 2001.


This European Standard revises and combines EN 10202:1989, Cold reduced electrolytic chromium/chromium oxide coated steel, and EN 10203:1991, Cold reduced electrolytic tinplate. EN 10203 is withdrawn.

It is intended that the third European Standard in the present series, EN 10205:1992, Cold reduced blackplate in coil form for the production of tinplate or electrolytic chromium/chromium oxide coated steel, will be withdrawn.

COCOR (Coordinating Commission of ECISS) approved the work item to revise EN 10202:1989 at its meeting in November 1996. The following countries agreed to participate: Belgium, France, Germany, Italy, Netherlands, Norway and the United Kingdom.

The annexes A, F, G, H and I are informative; the annexes B, C, D and E are normative. This European Standard also contains a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies requirements for tinmill products in the form of sheets or coils for subsequent cutting into sheets. Tinmill products consist of single and double reduced low carbon mild steel electrolytically coated with either tin (tinplate) or chromium/chromium oxide (ECCS).

Single reduced tinmill products are specified in nominal thicknesses that are multiples of 0,005 mm from 0,17 mm up to and including 0,49 mm. Double reduced tinmill products are specified in nominal thicknesses that are multiples of 0,005 mm from 0,13 mm up to and including 0,29 mm.

This European Standard applies to coils and sheets cut from coils in nominal minimum widths of 600 mm.

NOTE Standard width coils for specific uses, e.g. tabstock, may be slit into narrow strip for supply in coil form.
2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate points 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. In the case of undated references, the most recent edition of the publications referred to applies (including amendments).

EN 610:1996, Tin and tin alloys — Ingot tin

EN 10002-1:1989, Metallic materials — Tensile testing — Part 1: Methods of test (at ambient temperature)


3 Terms and definitions

For the purposes of this standard the following terms and definitions apply:

3.1 electrolytic tinplate
cold rolled low carbon mild steel sheet or coil coated on both surfaces with tin that is applied in continuous electrolytic operation

3.2 differentially coated electrolytic tinplate
electrolytic tinplate, one surface of which carries a heavier tin coating than the other. In some cases one surface may have no tin coating

3.3 electrolytic chromium/chromium oxide coated steel (ECCS)
cold rolled low carbon mild steel sheet or coil electrolytically treated to produce on both surfaces a duplex film of metallic chromium adjacent to the steel substrate with a top layer of hydrated chromium oxides or hydroxides

3.4 single cold reduced
term used to describe those products where the steel substrate has been reduced to the desired thickness in a cold reduction mill and subsequently annealed and temper rolled

3.5 double cold reduced
term used to describe those products in which the steel substrate, after annealing, has had a second reduction in excess of 5 %, using a lubricant

3.6 temper rolling
secondary rolling process, in which the reduction is less than or equal to 5 %, normally carried out dry

3.7 standard grade
material in sheet form that, having passed line inspection, is suitable under normal conditions of storage, for established lacquering and printing over the entire surface of the sheet and does not contain any defect that renders the material unsuitable for its intended use (see line inspection 3.25)
3.8 second grade
material that represents the best sheets rejected from the standard grade but may contain sheets exhibiting
defects in surface appearance and shape of limited extent. Suitability for established lacquering and printing
over the entire surface of the sheet is not assured. Not normally available in ECCS

3.9 batch (box) annealed (BA)
process in which the cold reduced strip is heated in tight coil form, within a controlled atmosphere, for a
pre-determined time/temperature cycle

3.10 continuously annealed (CA)
process in which cold reduced coils are unwound and heated in strip form within a controlled atmosphere for
a pre-determined time/temperature cycle

3.11 finish
surface appearance of tinmill products is determined by the surface characteristics of the steel base together
with the condition of the coating which, in the case of tinplate, can be either flow-melted or unflow-melted

3.11.1 flow-melting
process by which the ‘as deposited’ tin is heated above its melting point of 232 °C and is quickly quenched in
cool water resulting in a composite coating iron/tin alloy and free tin which exhibits a bright reflective
appearance

3.11.2 bright finish
finish resulting from the use of temper mill work rolls that have been ground to a high degree of polish and, in
the case of tinplate, together with a flow-melted tin coating

3.11.3 stone/fine stone finishes
finishes characterized by a directional pattern, resulting from the use of final mill work rolls that have been
ground to a lower degree of polish than those used for the bright finish, in the case of tinplate together with a
flow-melted tin coating

3.11.4 shot blast
finish resulting from the use of temper mill work rolls that have been shot blasted

3.11.5 silver finish
tinplate product resulting from the use of shot blasted temper mill work rolls and with a flow-melted tin
coating

3.11.6 matt finish
tinplate product resulting from the use of shot blasted temper mill work rolls and with an unflow-melted tin
coating

3.12 coil
rolled flat strip product which is wound into regularly superimposed laps so as to form a coil with almost flat
sides

3.13 bow
residual curvature in sheet or coil such that the distance between the edges is less than the appropriate
sheet or coil dimension
3.13.1
**longitudinal (line) bow**
residual curvature in the strip remaining along the direction of rolling

3.13.2
**transverse (cross) bow**
mode of curvature in the sheet such that the distances between its edges parallel to the rolling direction is less than the sheet width

3.14
**centre fullness (full centre, centre buckle)**
intermittent vertical displacement occurring other than at the edge of the sheet or coil when the material is laid on a flat horizontal surface

3.15
**short pitch camber**
devention of the coil from a straight line forming its chord

3.16
**edge wave**
intermittent vertical displacement occurring at the edge of a sheet or a sample from a coil when laid on a flat horizontal surface

3.17
**feather edge (transverse thickness profile)**
variation in thickness, characterized by a reduction of thickness close to the edges, at right angles to the rolling direction

3.18
**burr**
metal displaced beyond the plane of the surface of the strip by shearing action

3.19
**rolling width**
width of the strip perpendicular to the rolling direction

3.20
**consignment**
quantity of material of the same specification made available for despatch at the same time

3.21
**bulk package, or bulk**
packaging unit comprising a stillage platform, the sheets and packaging material

3.22
**stillage platform**
platform on which sheets are stacked to facilitate packing and ready transportation

3.23
**skid**
base platform on which a coil is placed to facilitate ready transportation

3.24
**sample unit**
750 m of coil cut into sheets, for the purposes of sampling

3.25
**line inspection**
final inspection of the finished product performed by instruments and/or by visual examination at normal production line speeds
3.26
anvil effect
effect which a hard anvil can produce on the numerical hardness value obtained when a hardness test is performed on very thin sheet supported on such an anvil

3.27
S.I.T.A.
area of 100 m$^2$ of material (a total surface area of 200 m$^2$)

4 Information to be supplied by the purchaser

4.1 General
The following information shall be given on the enquiry and order to assist the manufacturer in supplying the correct material:

a) the designation as given in clause 5;
b) the quantity expressed as an area (S.I.T.A.’s) or mass (tonnes);
c) the maximum and minimum mass and/or outside diameter of coils;
d) marking requirements for differentially coated tinplate (see clause 11);
e) any further special requirements e.g. special surface property requirements for packaging white or citrus fruits;
f) the type of annealing i.e. BA or CA.

NOTE Appropriate grades are suitable for shaping operations such as stamping, drawing, folding, beading, bending and assembly work such as joint forming, soldering and welding. The end use should be borne in mind when the grade is selected.

4.2 Delivery conditions
The product shall be supplied on the following basis, unless the purchaser specifies otherwise on the enquiry and order:

a) in the case of tinplate with cathodic surface passivation treatment using a dichromate salt of an alkali metal (see 6.3);
b) where differential tin coatings are ordered the heavier coated surface shall be indicated by continuous parallel lines spaced at 75 mm intervals (see clause 11);
c) for double reduced tinmill products: with a stone surface finish (see note 1 to Table 1);
d) for coils: the location of each weld shall be indicated by a piece of non-rigid material and a punched hole (see 10.3);
e) for coils, the coils shall be dispatched with their cores vertical (see 14.1.1);
f) for sheets: the direction of the runners of the stillage platform is at the discretion of the producer but shall be consistent within a consignment (see 14.2);
g) for sheets: the rolling width shall be either of the two specified dimensions (see 4.3);
h) in the case of tinplate with a coating of DOS (see 6.4) or in the case of ECCS with a coating of either DOS or BSO.
4.3 Additional information

In addition to the information in 4.1 and 4.2 the purchaser shall provide further information to the supplier to ensure that the order requirements are consistent with the end use of the product.

The purchaser shall inform the supplier of any modifications to his fabrication operations that will significantly affect the way in which the tinmill products are used.

NOTE 1 It should be noted that double cold reduced tinmill products are relatively less ductile than single cold reduced products and have very distinct directional properties, so for some uses, e.g. for three-piece can bodies, the direction of rolling should be stated.

NOTE 2 When double cold reduced products are used for three-piece can bodies, the rolling direction should be around the circumference of the can so as to minimize the hazard of flange cracking.

5 Designation

For the purposes of this European Standard, tinmill products are classified based on tensile properties as given in Table 4.

Single and double reduced products covered by this European Standard shall be designated by the following characteristics in the sequence given:

a) a description of the material (either tinplate coil or sheet or ECCS coil or sheet);

b) the number of this European Standard (EN 10202);

c) the symbol for tinmill products (T);

d) the mechanical property grade (see Table 4);

e) the type of annealing (see 8.1.3);

f) the type of finish (see 6.2);

g) in the case of tinplate, the coating masses and their combinations, E (for equally coated) or D (for differentially coated) described in clause 11; in the case of ECCS coil or sheet, the letters ECCS;

h) in the case of tinplate, the coating tolerance (see Table 2);

i) in the case of tinplate, the passivation (see 6.3);

j) the dimensions in mm:

— for coils: thickness \times \text{rolling width};

— for sheets: thickness \times \text{rolling width} \times \text{cut length}.
Example: single cold reduced tinplate sheet in accordance with this European Standard of steel grade TS275, batch annealed, stone finish, equally coated with a coating mass of 2.8 g/m² for high speed welding, passivation 300 with a thickness of 0.22 mm, a rolling width of 800 mm and cut length of 900 mm shall be designated:

    tinplate sheet EN 10202-TS275-BA-ST-E2,8/2,8-HS-300-0,22×800×900

or double cold reduced tinplate coil in accordance with this European Standard, of steel grade TH620, continuously annealed, stone finish, differentially coated with coating masses of 8.4 g/m² and 5.6 g/m² for standard use, passivation 311 with a thickness of 0.18 mm and a rolling width of 750 mm shall be designated:

    tinplate coil EN 10202-TH620-CA-ST-D8,4/5,6-SP-311-0,18×750

or double cold reduced ECCS coil in accordance with this European Standard, of steel grade TH620, continuously annealed, fine stone finish, with a thickness of 0.185 mm and a rolling width of 750 mm shall be designated:

    ECCS coil EN 10202-TH620-CA-FS-ECCS-0,185×750

NOTE The designation does not cover variations in all material properties. Further detailed product definition may be required.

6 Manufacturing features

6.1 Manufacture

For tinplate the purity of tin used to produce the coating shall be not less than 99.85 % (see EN 610).

The methods of manufacture of tinmill products are the responsibility of the manufacturer and are not specified in this European Standard.

The purchaser shall be informed if any alteration is made to the method of manufacture that will affect the properties of the product.

The manufacturer shall supply to the purchaser details of the manufacturing process to ensure efficient use of the product by the purchaser.

NOTE Information on the types and chemical composition of steels for tinmill products is provided in annex A.

6.2 Finish

The recognized finishes of tinmill products including surface roughness of the steel base, shall be as in Table 1.
## Recognized finishes

<table>
<thead>
<tr>
<th>Product finish</th>
<th>Code</th>
<th>Steel base</th>
<th>Tinplate/ECCS</th>
<th>Flow-melted</th>
<th>Nominal surface roughness of the steel base μm Ra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bright</td>
<td>BR</td>
<td>Smooth</td>
<td>TPL</td>
<td>Yes</td>
<td>≤ 0,35</td>
</tr>
<tr>
<td>Fine stone</td>
<td>FS</td>
<td>Fine stone</td>
<td>TPL</td>
<td>Yes</td>
<td>0,25 – 0,45</td>
</tr>
<tr>
<td>Fine stone</td>
<td>FS</td>
<td>Fine stone</td>
<td>ECCS</td>
<td>-</td>
<td>0,25 – 0,45</td>
</tr>
<tr>
<td>Stone</td>
<td>ST</td>
<td>Stone</td>
<td>TPL</td>
<td>Yes</td>
<td>0,35 – 0,60</td>
</tr>
<tr>
<td>Stone</td>
<td>ST</td>
<td>Stone</td>
<td>ECCS</td>
<td>-</td>
<td>0,35 – 0,60</td>
</tr>
<tr>
<td>Silver</td>
<td>SG</td>
<td>Shot blast</td>
<td>TPL</td>
<td>Yes</td>
<td>≥ 0,90</td>
</tr>
<tr>
<td>Matt</td>
<td>MM</td>
<td>Shot blast</td>
<td>TPL</td>
<td>No</td>
<td>Various</td>
</tr>
</tbody>
</table>

**NOTE 1** Double reduced product is only supplied as stone finish.

**NOTE 2** For guidance on the measurement of surface roughness, refer to EN ISO 4288.

**NOTE 3** The appearance is governed by:

a) the surface characteristics of the steel base which principally result from controlled preparation of the work rolls used during the final stages of temper rolling;

b) the mass of the coating applied;

c) whether the tin layer is flow-melted or unflow-melted.

**NOTE 4** For de-tinning prior to testing for surface roughness, see annex B.

### 6.3 Passivation

Under normal conditions of transport and storage, tinmill products shall be suitable for surface treatments such as established lacquering and printing operations.

ECCS is not subject to a passivation treatment.

After tinning, tinplate is subject to a passivation treatment in which chromium and chromium oxides are deposited on to each surface to improve resistance to oxidation and improve suitability for lacquering and printing. There are two tinplate passivation processes in common use:

a) Code 311, which is the most widely used and is a process of cathodic treatment in a solution of sodium dichromate;

b) Code 300, which is a simple chemical dip treatment in a sodium dichromate solution.

Code 311 will normally be supplied unless otherwise specified.

Values per surface for total chromium shall be as follows:

- **Code 311**: 3,5 to 9,0 mg/m²
- **Code 300**: 1,0 to 3,0 mg/m²

The preferred method of measurement is the diphenylcarbazide method (see annex C).
6.4 Oiling

Tinmill products, coils and sheets, shall be supplied with an oil coating. The oil shall be recognized (i.e. by the relevant national or international authority) as suitable for food packaging. Unless otherwise agreed at the time of order (see 4.2 h)) the oils used shall be dioctyl sebacate (DOS) for tinplate and either DOS or butyl stearate oil (BSO) for ECCS.

Oil shall be applied uniformly across the surface in quantities which, where applicable, are compatible with lacquering, printing and handling operations and cause no de-wetting or excessive dust pick up.

7 Coatings

7.1 Electrolytic tinplate

7.1.1 Properties

Values for tin coatings for single surfaces shall be as shown in Table 2. The values shown shall apply to single spot measurements.

NOTE Guidance on the marking and identification of differentially coated tinplate is provided in clause 11.

The mass per unit area for equally and differentially coated tinplate shall be determined on test pieces taken from samples selected in accordance with clause 12 and tested in accordance with 7.1.2. In cases of dispute the referee method given in annex D shall be used.

<table>
<thead>
<tr>
<th>Nominal coating g/m²</th>
<th>High speed welding applications HS</th>
<th>Other applications SP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g/m² min</td>
<td>g/m² max</td>
</tr>
<tr>
<td>1,00</td>
<td>0,75</td>
<td>1,80</td>
</tr>
<tr>
<td>1,40</td>
<td>1,10</td>
<td>2,30</td>
</tr>
<tr>
<td>2,00</td>
<td>1,60</td>
<td>3,00</td>
</tr>
<tr>
<td>2,80</td>
<td>2,30</td>
<td>3,90</td>
</tr>
<tr>
<td>4,00</td>
<td>3,35</td>
<td>5,30</td>
</tr>
<tr>
<td>5,00</td>
<td>4,20</td>
<td>6,50</td>
</tr>
<tr>
<td>5,60</td>
<td>4,70</td>
<td>7,20</td>
</tr>
<tr>
<td>8,40</td>
<td>7,15</td>
<td></td>
</tr>
<tr>
<td>11,20</td>
<td>9,55</td>
<td>No technical requirement</td>
</tr>
<tr>
<td>14,00</td>
<td>11,95</td>
<td></td>
</tr>
<tr>
<td>15,10</td>
<td>12,90</td>
<td></td>
</tr>
</tbody>
</table>

1) Continuous electrical resistance welding at speeds greater than 30 m/min.
7.1.2 Test method

7.1.2.1 Test pieces
From each sheet selected in accordance with clause 12, two test pieces (one per surface), each of an accurately determined area not less than 2 500 mm$^2$, and preferably in the form of discs, shall be carefully prepared. The test pieces shall be taken not less than 25 mm from the edges.

7.1.2.2 Method of determination

The tin coating mass shall be expressed in grams of tin per square metre to the nearest 0.1 g/m$^2$.

For routine quality control purposes the coating masses may be determined by any of the recognized and acceptable analytical methods but, in case of dispute and for all retests, the method described in annex D shall be the referee method.

The tin coating mass of a consignment shall be taken as the average of all the results.

7.2 ECCS

7.2.1 General

ECCS shall be lacquered on both surfaces before use.

NOTE ECCS is not suitable for soldering or welding.

Total chromium and chromium in oxide coating masses shall be as in Table 3 and the values shown shall apply to the average of three single spot measurements.

The mass per unit area shall be determined on test pieces taken from samples selected in accordance with clause 12 and tested in accordance with clause 7.2.2.

<table>
<thead>
<tr>
<th>Table 3 — ECCS masses</th>
<th>Coating mass (mg/m$^2$) each surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>Total chromium</td>
<td>50</td>
</tr>
<tr>
<td>Chromium in oxides</td>
<td>7</td>
</tr>
</tbody>
</table>

NOTE Total chromium is the sum of the metallic chromium and chromium content of the oxides and hydroxides.

7.2.2 Test method

7.2.2.1 Test pieces
From each sheet selected in accordance with clause 12, four discs, each of area not less than 2 500 mm$^2$, shall be taken from each of the three sets of positions. The test area of each disc shall be of an accurately determined area not less than 2 000 mm$^2$. The edge test pieces shall be taken not less than 25 mm from the edges.
Two of the four discs (two per surface) from each position shall be used for the separate determinations of the masses of chromium in the metallic chromium layer and the chromium oxide layer on one surface of the sheet and the other two discs shall be used for the corresponding determinations on the other surface.

7.2.2.2 Method of determination
The masses of metallic chromium and chromium in oxide shall be expressed in milligrams per square metre to the nearest 1 mg/m².

For routine test purposes the coating masses may be determined by any of the recognized and acceptable analytical methods but, in cases of dispute and for all retests, the method described in annex E shall be the referee method.

Any tests carried out using the test in annex E shall be performed on untreated material, in the as produced state.

8 Mechanical properties

8.1 Classification

8.1.1 General
A number of different mechanical properties may be determined for tinmill products.

No single mechanical test can measure all the factors which may affect their fabrication characteristics, nor is it possible to apply any single test satisfactorily to the range of tinmill products currently produced.

Individual mechanical properties can significantly influence the performance of tinplate in processing and subsequent intended use and will vary depending on the steel type and the methods of casting, annealing and temper rolling employed.

NOTE 1 The term “temper” when applied to tinmill products, summarizes a combination of interrelated properties.

The test considered to provide the best guide to mechanical properties is the tensile test which measures yield or proof strength and tensile strength. For the purpose of this European Standard these tests form the basis of the classification shown in Table 4. In cases of dispute, the tensile test shall be the referee method.

NOTE 2 The tensile test is a laboratory test which is not always available to users. Tests which are suitable for in plant evaluation of tinmill products are the Rockwell hardness test (see annex F) and Springback test (see annex G). The Rockwell hardness test is suitable for use with SR materials and the Springback test for DR. The Rockwell hardness test should be used as a means of fault diagnosis for DR material only in the absence of suitable samples and equipment for the preferred tests.

NOTE 3 Samples used for Rockwell hardness testing shall be de-tinned and for CA products, adequately aged. Artificial ageing will normally be necessary where the material has not been pre-stoved through a lacquering or printing process and this can be achieved by heating the specimen to 200 °C for 20 minutes.

8.1.2 Test method for tensile properties

8.1.2.1 Test pieces
For each sheet selected in accordance with clause 12, cut two rectangular test pieces approximately 200 mm × 25 mm wide, with the rolling direction parallel to the length of the test piece, at the position marked Z in Figure 1. Ensure that the edge test pieces clear the edges of the sheet by a minimum of 25 mm. Before carrying out the tensile test, artificially age the test pieces at 200 °C for 20 minutes.
8.1.2.2 Test method

Determine the 0.2 % proof strength as described in EN 10002-1 using the conditions specified in annex A of EN 10002-1 for thin products.

Carry out one test on each of the test pieces, i.e. two tests per sheet selected.

Calculate the representative proof strength for the consignment as the arithmetic mean of all the proof strength results on all the sample sheets taken from the consignment.

NOTE The tensile test is a laboratory test which is not always available to users. Tests which are suitable for in plant evaluation of tinmill products are the Rockwell hardness test (see annex F) and Springback test (see annex G). The Rockwell hardness test is suitable for use with SR materials and the Springback test for DR. The Rockwell hardness test should be used as a means of fault diagnosis for DR material only in the absence of suitable samples and equipment for the preferred tests.

8.1.3 Annealing for tinplate

Annealing for tinplate shall be either batch annealing or continuous annealing and shall be specified by the purchaser at the time of enquiry and order. (see 4.1 f))

NOTE The forming properties of tinmill products will differ depending on the type of annealing employed.

8.2 Mechanical properties of tinmill products

When tested as described in 8.1.2.2 the mechanical properties shall be as given in Table 4.

NOTE For routine testing of double reduced products the proof strength may be determined using the springback test as described in annex G. However, in cases of dispute, the method given in 8.1.2.2 is used.
Table 4 — Mechanical properties of tinmill products

<table>
<thead>
<tr>
<th>New grades</th>
<th>Steel number</th>
<th>Nominal values</th>
<th>Dev.</th>
<th>Aim values</th>
<th>Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS230</td>
<td>1.0371</td>
<td>230</td>
<td>± 50</td>
<td>325</td>
<td>± 50</td>
</tr>
<tr>
<td>TS245</td>
<td>1.0372</td>
<td>245</td>
<td>± 50</td>
<td>340</td>
<td>± 50</td>
</tr>
<tr>
<td>TS260</td>
<td>1.0379</td>
<td>260</td>
<td>± 50</td>
<td>360</td>
<td>± 50</td>
</tr>
<tr>
<td>TS275</td>
<td>1.0375</td>
<td>275</td>
<td>± 50</td>
<td>375</td>
<td>± 50</td>
</tr>
<tr>
<td>TS290</td>
<td>1.0381</td>
<td>290</td>
<td>± 50</td>
<td>390</td>
<td>± 50</td>
</tr>
<tr>
<td>TS350</td>
<td>1.0385</td>
<td>550</td>
<td>± 50</td>
<td>575</td>
<td>± 50</td>
</tr>
<tr>
<td>TH415</td>
<td>1.0377</td>
<td>415</td>
<td>± 50</td>
<td>435</td>
<td>± 50</td>
</tr>
<tr>
<td>TH435</td>
<td>1.0378</td>
<td>435</td>
<td>± 50</td>
<td>460</td>
<td>± 50</td>
</tr>
<tr>
<td>TH520</td>
<td>1.0384</td>
<td>520</td>
<td>± 50</td>
<td>540</td>
<td>± 50</td>
</tr>
<tr>
<td>TH550</td>
<td>1.0373</td>
<td>550</td>
<td>± 50</td>
<td>570</td>
<td>± 50</td>
</tr>
<tr>
<td>TH580</td>
<td>1.0382</td>
<td>580</td>
<td>± 50</td>
<td>590</td>
<td>± 50</td>
</tr>
<tr>
<td>TH620</td>
<td>1.0374</td>
<td>620</td>
<td>± 50</td>
<td>625</td>
<td>± 50</td>
</tr>
</tbody>
</table>

NOTE 1 Steel grades TH520, TS550, TH550, TH580 and TH620 are usually delivered double reduced, all other grades are delivered single reduced.

NOTE 2 Table 4 represents the grades in common use. Other grades are available for specific end uses.

NOTE 3 TS260 is a new grade introduced as an intended replacement for TS245, as it has a wider range of applications.

NOTE 4 The deviations shown refer to measurements of individual samples.

NOTE 5 The deviation of ± 50 shown in Table 4 represents the normal range within the specified grades. For special requirements a tolerance of ± 40 can be supplied.

NOTE 6 The tensile testing of tinmill products is being reviewed. The above values are therefore intended as a guide based on the values currently available.

NOTE 7 Batch annealed grades should be designated with the letter S. Continuous annealed grades should be designated with the letter H.

NOTE 8 Informative annex I gives a list of former designations.

9 Tolerances on dimensions and shape

9.1 General

Tolerances on dimensions and shape shall be as specified in 9.2 to 9.4, together with appropriate methods of measurement. The tolerances shall apply to materials sampled in accordance with clause 12.

9.2 Thickness and feather edge

9.2.1 Thickness

The thickness of the material shall conform to the following:

a) the deviation from the agreed thickness measured at the centre line of the strip shall not exceed ± 5 %;

b) the deviation from the agreed thickness measured at any point not within 6 mm of the mill trimmed edge shall be within +5 % to −8 %;

c) the average thickness shall not deviate from the nominal thickness by more than ± 2 % for consignments comprising more than 10 000 sheets (or metre equivalent when in coil form).

NOTE The agreed thickness will normally be the ordered thickness.
9.2.2 Test method for thickness
Thickness shall be measured using a spring loaded micrometer accurate to 0.001 mm. The micrometer shall have a ball ended shank of approximately 3 mm diameter, and a curved surface base anvil of approximately 25 mm radius.

Measurements shall be made to the nearest 0.001 mm.

Thickness at individual points shall not be measured within 6 mm of an edge.

9.2.3 Feather edge
Feather edge is the thinning of material along the mill trimmed coil edge. For both sheet and coil, the thickness when measured at a distance of 6 mm from the mill trimmed edge shall not vary by more than 6 % from the centre thickness measured at right angles to the trimmed edge.

9.2.4 Test method for feather edge
The measurement of feather edge on sheet or coil, three individual points shall be measured on the same straight line at right angles to the rolling direction using a spring loaded micrometer as previously described.

The three measurements shall be made along the stated line at the centre of the rolling width and 6 mm from each trimmed rolling width edge.

9.3 Linear dimensions

9.3.1 Width and length
A rectangle of the ordered dimension shall be available from within each sheet. The rolling width shall not differ from the ordered dimension, by more than 3 mm. The sheared length of a sheet shall not differ from the ordered dimension by more than 3 mm.

9.3.2 Out-of-squareness of sheets
Out-of-squareness is the deviation of an edge from a straight line drawn at a right angle to the other side of the sheet, touching one corner and extending to the opposite edge (see Figure 2).

The out-of-squareness expressed as a percentage is calculated as follows:

\[
\text{out-of-squareness (\%)} = \left( \frac{\text{deviation (A)}}{\text{sheet dimension (B)}} \right) \times 100
\]

For each sheet in the sample, the out-of-squareness shall not exceed 0.15 %.

![Figure 2 — Out-of-squareness of sheets](image-url)
9.3.3 Short pitch camber (lateral weave) of coils

Short pitch camber is measured as the maximum deviation of the mill trimmed edge from a straight line forming a chord to it over a relatively short distance (see Figure 3).

Short pitch camber, measured over a chord length of 1 metre, shall not exceed 0,3 mm when measured prior to shearing.

9.3.4 Test method for short pitch camber

The selected sample is placed against a straight edge and short pitch camber ($D$) is determined by using a gauge of 0,3 mm diameter. Where the gauge will fit between the straight edge and the sample, the product is deemed to be out of specification.

9.4 Shape

9.4.1 Edge wave

The wave height ($h$) at any point shall not exceed 2,5 mm (see Figure 4). No more than six waves in excess of 1,5 mm shall be present over a cut length of 1 m.

9.4.2 Test method for edge wave

To measure edge wave each sample is laid on a flat horizontal surface which is larger than the sheet. Wave heights are determined by using bars of standard diameters in increments of 0,25 mm.

The wave height shall be given as the bar diameter that just fits under the wave at the edge of the sheet.
9.4.3 Bow

Bow is the residual curvature in sheet or coil such that the distance between the edges is less than the appropriate sheet or coil dimension. Bow may be either convex or concave face uppermost on the bulk package. The normal convention is to express convex bow uppermost as a positive (+) value and concave bow as a negative (−) value (see Figure 5).

![Figure 5 — Bow](image)

The individual values of both longitudinal and transverse bow shall not exceed 30 mm. When purchased as coil, this shall apply after normal levelling operations.

Where both convex and concave bowed sheets are present in the same bulk package, the sum of the maximum values of each, ignoring the sign (+/−), shall not exceed 30 mm.

9.4.4 Test method for bow

When selecting the sample it is necessary to identify the upper and lower surface of each sheet with respect to the bulk package.

The maximum value of longitudinal or transverse bow is measured by hanging the sample sheet from one horizontal edge against a rigid vertical surface, noting whether the upper or lower surface is against the vertical surface, so that the bow causes the bottom edge of the sheet to stand away from that surface.

The sample sheet shall be evenly supported along the top to a depth not exceeding 25 mm from the sheet edge. The maximum distance the bottom edge stands away from the vertical (a in Figure 5) is measured with a steel ruler to the nearest 1 mm and recorded with the appropriate plus or minus sign indicating convex or concave bow respectively.
9.4.5 Centre fullness

Centre fullness shall be determined by measurement of edge lift developed during the test. The value shall not exceed 9 mm. (see Figure 6).

NOTE Centre fullness is not clearly visible in a bulk package but usually becomes apparent during either printing or slitting. This feature is best observed when the sheet is suspended vertically from one corner.

![Figure 6 — Centre fullness](image)

9.4.6 Test method for centre fullness

This test applies only to sheets of not less than 600 mm coil width and 750 mm cut length. No test method is proposed for sheets below these dimensions.

A sample sheet shall be laid on a flat, horizontal, surface which is larger than the sheet. A rigid flat board, approximately 450 mm × 600 mm × 25 mm thick shall be placed on the centre of the sheet with the 600 mm dimensions parallel to the sheet rolling direction. It may be necessary to test the sheet on both surfaces.

The board shall be moved around the surface of the sheet centre until a position giving highest edge lift can be identified. Pressure shall be then applied to the board so as to flatten the sheet in the centre and raise the edge to a maximum height. During the test the board shall not overlap the edges to be measured.

Edge lift shall be determined by using a 9 mm diameter bar and the product is deemed out of specification when the bar fits under the edge of the sheet at the point of maximum lift ($h$ in Figure 6).

9.4.7 Burr

Burr shall not be present to such an extent as to interfere with the processing of the product.

10 Welds within a coil

10.1 General

The coils shall be continuous, within the weight limits supplied; if necessary by means of electrical welds. Requirements relating to the numbers, locations and dimensions of welds permitted within a coil, are given in 10.2 to 10.4.

10.2 Number of welds

The number of welds in a coil shall not exceed three in lengths of 10 000 m.
10.3 Location of welds

The location of each weld in a coil shall be marked with a punched hole and additionally be indicated visibly.

NOTE The location of each weld may be indicated by the insertion of a piece of non-rigid material. However, alternative methods may be agreed between the producer and the purchaser at the time of enquiry and order.

10.4 Dimensions of welds

10.4.1 Thickness

The total thickness of any weld shall not exceed 1.5 times the nominal thickness of the material forming the weld.

10.4.2 Overlap

In any lap weld, the total length of overlap shall not exceed 10 mm. The free overlap shall not exceed 5 mm.

11 Marking of differentially coated cold reduced tinplate

In order to distinguish between tinplate with differential coatings on the two surfaces and that with equal coatings, differentially coated tinplate shall be marked on one surface with straight parallel lines about 1 mm wide.

Marking shall be lines spaced at 75 mm intervals, indicating that the tinplate is differentially coated but does not identify the precise specification.

The heavier coated surface shall normally be marked with continuous lines unless specified otherwise by the purchaser. Where marking is required on the lighter coated surface, interrupted lines shall be used.

The letter ‘D’ in the product description shall be adjacent to the surface to be marked and its position shall be used to indicate the required packing orientation as follows:

— if the ‘D’ is at the start of the description the marked surface shall be presented on the upper surface of the sheets as packed or the outer surface of the coil.

— if the ‘D’ is at the end of the description the marked surface shall be presented on the lower surface of the sheets as packed or the inner surface of the coil.
The following are examples of the system of marking:

**EXAMPLE** — D 5.6/2.8  —  5.6 coated surface marked with continuous lines
Marking on the top of sheets or on the outside of coil

or — 2.8/5.6 D  —  5.6 coated surface marked with continuous lines
Marking on the bottom of the sheets or the inside of coil

or — D 2.8/5.6  —  2.8 coated surface marked with interrupted lines
Marking on the top of sheets or on the outside of coil

or — 5.6/2.8 D  —  2.8 coated surface marked with interrupted lines
Marking on the bottom of the sheets or the inside of coil

NOTE Annex H gives details of an alternative marking system for certain coating combinations only.

12 Sampling

12.1 Coils

12.1.1 General

When tests are carried out to assess compliance with the requirements for coating mass (see clause 7), tolerances on dimensions and shape (see clause 9) and mechanical properties (see clause 8) samples of the coil shall be selected in accordance with 12.1.2.

After the coils in a consignment have been cut into rectangular or scrolled sheets, the sheets deemed not to be of standard grade shall be excluded. The standard grade sheets that remain shall be sampled using a unit of strip 750 m in length (which approximates to one bulk package of tinplate) as the basis in accordance with 12.1.2.3.

NOTE Because the samples have to be cut from coils in the consignment, the taking of samples is usually carried out by the purchaser during the normal shearing operation.

The purchaser shall allow the producer, or the producers representatives, to be present during the sampling and subsequent testing and to be able to confirm that the identities of the samples and test pieces correspond to the coils in the consignment supplied.

12.1.2 Selection of samples

12.1.2.1 Lots and units

For the purpose of sampling, each consignment of coils shall be considered as one lot.
12.1.2.2 Selection of sample units
For lots comprising up to and including 20 units, four sample units shall be selected at random.
For lots comprising more than 20 units, four units shall be selected at random from each 20 units and from any remaining part of 20 units.

12.1.2.3 Selection of sample sheets
From each sample unit selected in accordance with 12.1.2.2 the following sample sheets shall be taken at random:

a) for verification of the coating mass and mechanical properties: two sheets;
b) for verification of the dimensions and shape: five sheets.

12.2 Sheets

12.2.1 General
If tests are carried out to ascertain whether the sheets in a consignment conform to the requirements for coating mass (see clause 7), tolerances on dimensions and shape (see clause 9), and mechanical properties (see clause 8), sample sheets shall be selected in accordance with 12.2.2.

12.2.2 Selection of sample sheets

12.2.2.1 Number of bulk packages
Sample bulk packages shall be selected at random from the total number of bulk packages at a rate of 20 %, rounded to the nearest greater whole number of bulk packages and subject to a minimum of four bulk packages.
For consignments comprising less than four bulk packages, each bulk package shall be taken as a sample.

12.2.2.2 Number of sheets
From each of the sample bulk packages selected in accordance with 12.2.2.1, the following sheets shall be randomly selected:

a) for verification of standard grade material (see 3.7): sheets at a rate of 1 % per bulk package;
b) for verification of mechanical properties and coating mass: two sheets;
c) for verification of dimensions: sheets at a rate of 0,5 % per bulk package, to the nearest whole number of sheets.

NOTE The rate of sampling is specified on a percentage basis (except for verification of mechanical properties and coating masses) because the number of sheets per bulk package may vary, e.g. between 1 000 and 2 000.

13 Retests
If any of the test results are unsatisfactory, the measurements for that particular property shall be repeated on two further samples; on each occasion using the sampling specified in clause 12. If the results on both repeated tests meet the stated requirements, the consignment represented shall be deemed to conform to this standard, but if the results of either of the retests fail to meet the stated requirements, the consignment represented shall be deemed not to conform to this standard.
14 Dispatch and packaging

14.1 Coils

14.1.1 Coil dispatch

Unless otherwise requested at the time of order, coils shall be dispatched with their cores in a vertical position [see 4.2 e)]. (The other option would be with the cores horizontal). The internal diameters of the coils shall be within the range 420 (+10, −15) mm.

14.1.2 Coil winding

The supplier shall state the direction of winding in the coils received by the purchaser to ensure correct surface is maintained throughout manufacture. Where coils are supplied with cores vertical (the normal method of delivery) the purchaser shall specify the required direction of winding. (see Figure 7).

**Figure 7 — Direction of coil winding**

14.2 Sheets

The sheets shall be supplied in bulk packages in which the numbers of sheets are multiples of 100.

**NOTE 1** Sheets are normally packed on a stillage platform, forming a bulk package weighing 1 000 kg to 2 000 kg.

**NOTE 2** Any purchaser requirements, such as the direction of the runners, should be agreed with the producer and stated on the order [see 4.2 f)].
Annex A  
(informative)

Examples of steel types and chemical composition

Steels for tinmill products normally contain elements as shown in Table A.1, type A steel being lower in carbon and manganese than type B.

Purchasers should agree with their suppliers the type to be ordered for specific applications, noting that type B is not suitable for welding. Steels with alternative compositions are available for special purposes. Details should be agreed with the supplier.

Continuous casting is the normal method of producing the steels for tinmill products. Continuously cast steel is prepared by using a technique in which the steel is continuously solidified upon pouring, resulting in a more homogeneous structure than ingot cast steel.

<table>
<thead>
<tr>
<th>Element</th>
<th>% by weight (maximum unless otherwise stated)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type A</td>
</tr>
<tr>
<td>Carbon</td>
<td>0,04 – 0,08</td>
</tr>
<tr>
<td>Manganese</td>
<td>0,18 – 0,35</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0,020</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0,020</td>
</tr>
<tr>
<td>Silicon</td>
<td>0,030</td>
</tr>
<tr>
<td>Copper</td>
<td>0,080</td>
</tr>
<tr>
<td>Nickel</td>
<td>0,080</td>
</tr>
<tr>
<td>Tin</td>
<td>0,020</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0,020</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0,020</td>
</tr>
<tr>
<td>Chromium</td>
<td>0,080</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0,008</td>
</tr>
<tr>
<td>Aluminium</td>
<td>0,02 – 0,08</td>
</tr>
<tr>
<td>Others</td>
<td>0,020</td>
</tr>
</tbody>
</table>

NOTE 1 Individual chemical elements can by agreement be modified to suit special applications.

NOTE 2 Chemical elements included as Others are those which occur naturally in very small quantities but which are not deliberately added in the steelmaking process.
Annex B
(normative)

De-tinning

B.1 Principle

The tin coating is stripped from tinplate by immersion in Clarke's solution, followed by cleaning and drying.

B.2 Clarke's solution

Dissolve 78 g of antimony trichloride in 1 l of hot hydrochloric acid. Filter through four no 40 filter papers. Cool and dilute to 2,5 l with cold hydrochloric acid.

B.3 Procedure

Completely immerse the clean, dry specimen in Clarke's solution. When reaction at the specimen surface ceases and a fine, uniform, black deposit of antimony is observed on the surface, wash thoroughly in hot water and brush the surface to remove the deposit.

Immerse the specimen in methylated spirits, dry and store in readiness for further testing.
Determination of chromium using the diphenylcarbazide method

C.1 Scope and application

This method covers the determination of chromium on tinplate with the use of Diphenylcarbazide. It is applicable to electrolytic tinplate that has been passivated in an electrolyte containing chromium ions.

C.2 Principle

Chromium in the passive film on tinplate is removed and oxidized to the hexavalent state prior to its reaction with 1,5- diphenylcarbazine to form a violet complex which is measured colorimetrically.

C.3 Reagents

C.3.1 General

Use reagent grade chemicals in all tests. Use distilled or deionized water throughout.

C.3.2 Chromate standard solution A: Dissolve 1,410 g of K₂Cr₂O₇ in water and dilute to 1,0 l (1 ml = 0,5 mg Cr).

C.3.3 Chromate standard solution B: Pipette 20 ml of standard solution A into a 1,0 l volumetric flask and make up to the mark with water.

C.3.4 Diphenylcarbazide reagent: Add 10,0 ml of acetone, 10,0 ml of 95 % ethyl alcohol and 20,0 ml of H₃PO₄ (85 % acid) diluted with an equal volume of water.

C.3.5 Hydrochloric acid: κ = 1,19

C.3.6 Potassium permanganate (KMnO₄): Saturated solution.

C.3.7 Sodium hydroxide (1,0M) Trisodium phosphate solution: Dissolve 40,0 g of NaOH and 50,0 g of Na₃PO₄ in water and dilute to 1,0 l.

C.3.8 Sulphuric acid: Add 100 ml of H₂SO₄ (κ = 1,84) slowly and with stirring to 300 ml.

C.4 Apparatus

C.4.1 Common laboratory equipment

C.4.2 Spectrophotometer

C.5 Procedure

C.5.1 Stamp out a disc 26 cm² (total surface area of both sides 52 cm²). If both surfaces are to be analyzed, bend the disc slightly so that it will not lie flat. If only one side is to be stripped, hold the disc against a rubber stopper slightly larger than the disc. The rubber stopper should be grooved to allow a vacuum from a tube in the centre to be applied to the surface of the disc. Leave a band approximately 3,2 mm wide at the perimeter of the stopper.

NOTE It is not recommended that both sides are tested together.
C.5.2 Place the sample in a 250 ml beaker and add 25 ml of the NaOH Na₃PO₄ solution (C.3.7). Boil for 1½ min. Transfer the solution to another 250 ml beaker, washing disc and beaker once with water.

C.5.3 Add 25 ml of H₂SO₄ (C.3.8) to the original beaker containing the sample and boil for 1 min then transfer this solution to the beaker containing the NaOH Na₃PO₄. Wash the sample and beaker with two small portions of water. (If both surfaces are to be stripped they must be wetted so as to completely remove the chromium. This is done by swirling the beaker continuously over the heat while the H₂SO₄ is boiling).

C.5.4 Heat the sample solution to boiling water and add 1 to 2 drops of saturated KMn⁴O₄ (C.3.6), this should be sufficient to maintain a pink colour. Boil for 3 to 4 min to allow the chromium to completely oxidize.

**NOTE** The beaker should be covered when boiling to prevent spattering.

C.5.5 Add 5 drops of HCl (C.3.5) and continue to boil until all the colour is dispelled. (More acid may be added if needed).

C.5.6 Transfer to a 100 ml volumetric flask and cool to approximately 21 °C in a water bath. Add 3,0 ml of the diphenylcarbazine reagent (C.3.4) and make up to the mark with distilled water.

C.5.7 Measure the optical density of the solution at 540 nm; this measurement must be taken within 30 min of adding the diphenylcarbazine reagent.

C.5.8 A blank and standard including all solutions used in treating a sample should also be measured.

C.6 Calibration

Duplicate 0,5, 1,0, 1,5, 2,0, 2,5 and 3,0 ml aliquots of chromate standard solution B should be added to separate 250 ml beakers, then follow steps in C.5.2 to C.5.8. Also run reagent blanks in duplicate.

Calculate a constant, K, for the instrument as follows:

\[
K = \frac{\text{mg Cr}}{\text{O.D}_1 - \text{O.D}_2}
\]

where:

- \( \text{O.D}_1 \) = optical density for the standard
- \( \text{O.D}_2 \) = optical density for the blank

Calculation of chromium tinplate

\[
\text{Cr mg/m}^2 = \frac{[144 K O.D_1 - O.D_2]}{A}
\]

where:

- \( K \) = constant for spectrophotometer and cell used to determine optical density
- \( O.D_1 \) = optical density of sample
- \( O.D_2 \) = optical density of reagent blank
- \( A \) = area of sample used
Annex D
(normative)

Electromechanical method for determining tin coating mass

D.1 Principle
The tin and tin/iron alloy layers are stripped electrochemically in hydrochloric acid at constant current. Faraday’s Law is used to calculate the mass of tin removed from the time taken to strip each layer. The effective range of the method is from 0.5 g/m² up to 50 g/m² and the reproducibility is 0.1 g/m².

D.2 Reagents

D.2.1 Hydrochloric acid – 5 %
Add 135 ml of concentrated hydrochloric acid (1.18 g/ml) to 500 ml of distilled water, mix well, and make up to 1 litre.

D.3 Apparatus

D.3.1 Cell and electrodes
A sample holder of the type shown in Figure D.1, which exposes at least 1 cm², a platinum gauze or platinized titanium cathode and a suitable reference electrode (e.g. standard calomel electrode). Whilst the method is accurate down to a 1 cm² exposed area, a minimum of 2.5 cm² typically is adopted for control.

D.3.2 Power supply
A power supply which is capable of delivering a constant current in the range 3 mA to 100 mA.

D.3.3 Voltmeter
A voltmeter with a full-scale of 0V to ±2 V, and from which an output can be taken to a y-t recorder. One terminal of the voltmeter is connected to the sample, and the other to the reference electrode.

A potentiostat and computerized data acquisition and plotting system can be used to perform the functions of both the power supply and voltmeter/y-t recorder.

D.4 Procedure
Wash the sample with acetone and allow to dry in air. Mount in the sample holder and add sufficient 5 % hydrochloric acid to cover the cathode. From the known exposed area of the sample, calculate the current required to maintain a current density of 4 mA/cm², and set the power supply to this current. Switch on the power supply and observe the voltmeter and voltage/time curve on the y-t recorder. Two large jumps in voltage should be observed, the first indicates the end of tin dissolution, and the second the end of alloy dissolution.
D.5 Calibration of the measuring system

Take a strip from the middle of the produced material ensuring it is cut with the rolling direction. Cut 36 adjacent samples in the form of disks with an area of $2500 \text{ mm}^2$ from the strip; number each one. Measure the even numbered samples using the electrochemical method below. Use the odd numbered samples for the wet chemical titration method.

NOTE  The wet chemical analysis should be carried out in accordance with annex A of ISO 11949:1995.

D.6 Calculation

From the voltage/time curve, determine $t_1$ and $t_2$, the times of the steepest points of the two jumps in voltage, as in Figure D.2.

The times at which the two steep rises in potential are quantified as follows:

The end points are determined by the intersection of the tangential lines to the centres of the potential climbing curves with the horizontal extrapolated plateaux of the potential curve. From these points perpendicular lines are drawn to the basic, as in Figure D.2. At this line, the seconds are read and $t_1$ (free tin) and $t_2$ (tin in alloy) are measured.

The coating weights of free tin, and tin in the alloy are calculated from Faraday’s Law:

$$\text{Coating weight (g/m}^2) = \frac{m_a l t}{n F}$$

where:

- $m_a$ is the atomic mass of tin, $118.69 \text{ g/mol}$
- $l$ is the current density in $\text{A/m}^2$ ($4 \text{ mA/cm}^2 = 40 \text{ A/m}^2$)
- $t$ is the time $t_1$ or $t_2$ in seconds determined as above
- $n$ is the number of electrons involved in the electrochemical reactions:

  - Free tin: $\text{Sn} \rightarrow \text{Sn}^{2+} + 2e$  \hspace{1cm} $n = 2$
  - Alloy: $\frac{1}{2} \text{FeSn}_2 \rightarrow \text{Sn}^{2+} + \frac{1}{2} \text{Fe}^{2+} + 3e$  \hspace{1cm} $n = 3$

$F$ is Faraday’s constant $9.64846 \times 10^4 \text{ C/mol}$.

These equations reduce to:

$$\text{Free tin (g/m}^2) = 0.0246 \cdot t_1$$
$$\text{Tin in alloy (g/m}^2) = 0.0164 \cdot (t_2 - t_1)$$

The total tin coating weight is the sum of these two figures.
Figure D.1 — Apparatus and circuit for tin coating weight determination

1. Cell base plate
2. O Ring
3. Cell clamping plate
4. Flange cell
5. Reference electrode
6. y-t recorder
7. Cathode
8. D.C. Constant current power supply
9. Tinplate sample
Figure D.2 — Typical response from tin coating weight measurement showing endpoint determination

Key

1 Voltage (millivolts)
2 time (seconds)
Annex E
(normative)

Methods for determination of metallic chromium and chromium in the oxide on the surface of electrolytic chromium and chromium oxide coated steel

E.1 Determination of chromium in the oxide

E.1.1 Principle and scope of method

This method covers the determination of chromium present as oxides and hydroxides on the surface of untreated ECCS. The method involves the dissolution of the oxide in sodium hydroxide followed by oxidation of the dissolved chromium with hydrogen peroxide. The absorbance of the coloured chromate ion is measured photometrically and the mass of chromium is then obtained by reference to a calibration curve.

The effective range of the method is from 3 mg/m² to 50 mg/m² and the reproducibility is better than ± 3 mg/m².

E.1.2 Reagents

E.1.2.1 General

Use reagents of analytical reagent grade, unless otherwise specified, and deionized or distilled water throughout. Freshly prepare and, where necessary, filter all solutions.

E.1.2.2 Standard chromium solution: Dissolve 0.1 132 g of anhydrous potassium dichromate, primary standard grade, previously dried at 120 °C for 1 h, in approximately 200 ml water and dilute to 500 ml in a volumetric flask. Pipette a 50 ml aliquot of this solution and dilute to 1 l with water in a volumetric flask. This solution contains 0.004 mg Cr/ml.

E.1.2.3 Sodium hydroxide, 300 g/l solution: Dissolve 300 g of sodium hydroxide in approximately 700 ml water, cool and dilute to 1 l.

E.1.2.4 Hydrogen peroxide, 60 g/l solution: Use a solution supplied at this concentration or dilute a concentrated (e.g. 300 g/l) solution. (Ensure that the solution is at the recommended concentration. Hydrogen peroxide solutions may decompose if kept under non-ideal conditions).

E.1.3 Apparatus

E.1.3.1 Spectrophotometer, a spectrophotometer able to measure absorbance across the range 250 nm to 500 nm, is capable of reading extinction to ± 0.001, and can produce a hard copy of the spectrum.

E.1.3.2 Sample holder, a sample holder of the type shown in Figure E.1 to permit stripping from an area of not less than 2 000 mm² from one surface of a sample.
E.1.4 Preparation of the chromium calibration curve

Pipette 0 (blank), 2.5 ml, 5 ml, 7.5 ml, 10 ml, 12.5 ml, 15 ml, 17.5 ml, 20 ml, 25 ml, 30 ml, 40 ml and 50 ml aliquots of standard chromium solution (E.1.2.2) into 400 ml beakers, add 40 ml sodium hydroxide solution (E.1.2.3) and dilute to about 90 ml with water. Add 3 ml hydrogen peroxide solution (E.1.2.4), cover with a watch glass and boil until the excess peroxide is completely decomposed, replacing any loss of evaporated water by rinsing the wall of the beaker and the cover glass. Cool the solution, transfer to a 100 ml flask, dilute to 100 ml and mix well. Measure the absorbance spectrum from 500 nm to 250 nm using a cell of appropriate length and with water as a reference. The peak of interest occurs at approximately 370 nm: draw a suitable baseline across the bottom of the spectrum, tangential to the points of minimum absorbance either side of the 370 nm peak, such that no part of the spectrum cuts the baseline, and measure the maximum absorbance of the peak of interest relative to this baseline. Plot absorbance against milligrams of chromium per 100 ml, without correcting for the absorbance of the reagent blank. This plot will not necessarily pass through the origin. The drawing of a baseline across the bottom of the spectrum compensates for vertical shifting of the whole spectrum caused by interference from residual peroxide and other species not connected with the concentration of chromium.

E.1.5 Procedure

Handle sample material with care to prevent surface contamination. Do not subject samples to any thermal stoving process before carrying out the following test. Take a disc of the material appropriate to the size of the sample holder and fix it in position in the holder. Add 40 ml hot sodium hydroxide solution (E.1.2.3) and place the cell on a hot plate to maintain the temperature of the stripping solution at about 90 °C for 10 min. Transfer the contents of the cell quantitatively to a 250 ml beaker, add 3 ml of hydrogen peroxide solution (E.1.2.4) and boil until the excess peroxide is decomposed. Cool, transfer to a 100 ml volumetric flask, make up to the mark with water and shake well. Measure the absorbance at the selected wavelength (E.1.4) using water as a reference. Measure the absorbance spectrum between 500 nm and 250 nm (E.1.4) using water as a reference. Draw a baseline across the bottom of the spectrum as before, and measure the maximum absorbance of the peak at approximately 370 nm, relative to this baseline. Obtain the mass of chromium in mg in the solution from the calibration curve.

E.1.6 Calculation

Calculate the coating mass in mg/m² of chromium in the oxide, \( C_0 \), from the following equation:

\[
C_0 = \frac{M_1 \times 10^6}{A}
\]

where:

- \( M_1 \) = mass of chromium in mg, in the test solution;
- \( A \) = area of sample, mm², exposed to sodium hydroxide attack in sample holder.

E.2 Determination of metallic chromium

E.2.1 Principle and scope of method

A photometric method is described for the determination of metallic chromium on the surface of ECCS. The principle of the method is as follows.

Chromium oxide is first removed chemically. Metallic chromium is then stripped electrolytically in sodium carbonate solution, the completion of the reaction being indicated by a sharp rise in the cell voltage. The resultant solution is treated with hydrogen peroxide to ensure complete oxidation of the electrolytically stripped chromium to the hexavalent state. The absorbance of the coloured chromate ion is determined photometrically and the mass of chromium is then obtained by reference to a calibration curve. The effective range of the method is from 30 mg/m² to 300 mg/m² and the reproducibility is better than ± 5 mg/m².
E.2.2 Reagents

E.2.2.1 General

Use reagents of analytical grade, unless otherwise specified, and deionized or distilled water throughout. Freshly prepare and, where necessary, filter all solutions.

E.2.2.2 Standard chromium solution: Dissolve 1,132 g anhydrous potassium dichromate, primary standard grade, previously dried at 120 °C for 1 h in approximately 200 ml water and dilute to 1 l in a volumetric flask. Pipette a 50 ml aliquot of the solution and dilute to 1 l in a volumetric flask. This solution contains 0.02 mg Cr/ml.

E.2.2.3 Sodium hydroxide, 300 g/l solution: Dissolve 300 g sodium hydroxide in approximately 700 ml water. Cool and dilute to 1 l.

E.2.2.4 Sodium carbonate, 53 g/l solution: Dissolve 53 g anhydrous sodium carbonate in water and dilute to 1 l.

E.2.2.5 Hydrogen peroxide, 60 g/l solution: Use a solution supplied at this concentration or dilute a concentrated (e.g. 300 g/l) solution. (Ensure that this solution is at the recommended concentration. Hydrogen peroxide solutions may decompose if kept under non-ideal conditions.)

E.2.3 Apparatus

E.2.3.1 Cell and electrodes, a cell as shown in Figure E.2 for the electrolytic stripping of the metallic chromium. As shown in Figure E.3, and consisting of a sample holder, a platinum gauze cathode and a reference electrode (standard calomel).

The cell/sample holder shall expose a minimum area of 2 000 mm² from which the metallic chromium is electrolytically stripped.

E.2.3.2 Power supply, with a direct current stabilizer with a built-in milliammeter setting to 30 mA and an on/off switch.

E.2.3.3 Voltmeter, with a full scale of 0 V to 2 V.

E.2.3.4 Spectrophotometer, able to measure absorbance in the range 250 nm to 500 nm and read extinction to +0.001, and can produce a hard copy of the spectrum.

E.2.4 Preparation of the chromium calibration curve

Pipette 0 ml (blank), 2.5 ml, 5 ml, 7.5 ml, 10 ml, 12.5 ml, 15 ml, 17.5 ml, 20 ml, 25 ml, 30 ml, 40 ml and 50 ml of the standard chromium solution (E.2.2.2) into 400 ml beakers, add 120 ml of sodium carbonate solution (E.2.2.4) and dilute to about 170 ml with water. Add 10 ml hydrogen peroxide solution (E.2.2.5) cover with a watch glass and boil until the excess peroxide is completely decomposed, replacing any loss of evaporated water by rinsing the wall of the beaker and the cover glass. Cool the solution, transfer to a 200 ml flask, dilute
to the mark and mix well. Measure the absorbance spectrum from 500 nm to 250 nm using a cell of suitable length and with water as a reference. The peak of interest occurs at approximately 370 nm; draw a suitable baseline across the bottom of the spectrum, tangential to the points of minimum absorbance close to each end of the spectrum, and measure the maximum absorbance of the peak of interest relative to this baseline. Plot absorbance against milligrams of chromium per 200 ml, without correcting for the absorbance of the reagent blank. This plot will not necessarily pass through the origin.

### E.2.5 Procedure

#### E.2.5.1 General

Handle sample material with care to prevent surface contamination. Do not subject samples to any thermal stoving process before carrying out the test. Take a disc of the material appropriate to the size of the sample holder.

It is normal procedure to determine the metallic chromium after determining the chromium in the oxide and the same sample discs may be used for both purposes. Where metallic chromium is to be determined without a previous determination of chromium in the oxide, remove the chromium oxide in accordance with E.2.5.2.

#### E.2.5.2 Removal of chromium oxide layer

Remove the surface oxides from the sample by treating with 40 ml sodium hydroxide solution (E.2.2.3) in a glass beaker at 90 °C for 10 min. Rinse the sample with water and attach to the sample holder (see Figure E.1).

#### E.2.5.3 Removal and determination of metallic chromium

After the washed, oxide-free sample has been attached to the sample holder (see E.2.5.2), connect the leads as shown in Figure E.3, add 120 ml of sodium carbonate solution (E.2.2.4) and simultaneously switch on the power supply. Maintain a constant current density within the range 0.5 mA/cm$^2$ to 1.5 mA/cm$^2$. The end point of the reaction is indicated by a large potential jump. (The potential difference between the beginning and ending of the dissolution is about 400 mV. Note this by incorporating in the electrical circuit a voltmeter with the positive terminal connected to the D.C. stabilizer and the negative terminal to the reference electrode.)

Quantitatively transfer the contents of the sample holder/cell to a glass beaker, add 10 ml of hydrogen peroxide solution (E.2.2.5) and boil until the excess peroxide is decomposed. Cool the solution, transfer to a 200 ml flask, dilute to the mark and mix well.

Measure the absorbance spectrum between 500 nm and 250 nm (E.1.4) using water as a reference. Draw a baseline across the bottom of the spectrum as before, and measure the maximum absorbance of the peak at approximately 370 nm, relative to this baseline. Obtain the mass of chromium in mg in the solution from the calibration curve.

### E.2.6 Calculation

Calculate the coating mass in mg/m$^2$ of metallic chromium. $C_m$, from the following equation:

$$C_m = \frac{M_2 \times 10^6}{A}$$

where:

$M_2$ = mass of chromium, in mg, in the test solution;

$A$ = area of sample, in mm$^2$, exposed to electrolytic attach in sample holder/cell.
1 — Rubber O ring 3 mm diameter cross section
2 — Sample disc 2 000 mm² exposed to solution in cell
3 — Stainless steel base plate (thread to match collar and recessed to hold sample disc)
4 — Recommended wall thickness 10 mm. Material – PTFE or polypropylene. Cell height not critical provided capacity exceeds 120 mL and platinum cathode and reference electrode can be fitted.
5 — Stainless steel stepped collar (threaded and pinned to PTFE)

Figure E.1 — Dual purpose holder showing details of construction
Figure E.2 — Electro stripping of chromium using the dual purpose cell

1 — Sample anode
2 — Reference electrode
3 — Platinum electrode
Figure E.3 — Electro circuit for stripping chromium metal

1 — Sample (anode)
2 — Sample holder
3 — Reference electrode
4 — Voltmeter 0 to 2 V
5 — D.C. stabilizer, 30 mA
6 — Platinum electrode
Annex F
(informative)

The Rockwell Hardness test for routine determination of proof strength for double reduced materials

NOTE This is not the reference method. In all cases of dispute, the method described in 13.4 of EN 10002-1 should be used.

F.1 Test pieces

The hardness tests shall be preferably carried out prior to lacquering or printing.

From each of the sample sheets obtained in accordance with clause 12, take two test pieces 125 mm × 125 mm from the positions marked Y in Figure 1.

NOTE The test pieces (Y) taken for determination of the thickness variations within the individual sample sheets may be used also for the hardness determinations where appropriate.

Before carrying out the hardness tests in accordance with F.2, remove the organic and tin coating and artificially age the test pieces at 200 °C for 20 minutes.

Polish shot blast finish material with 600 grit grinding paper.

F.2 Test method

Using a Rockwell superficial hardness testing machine determine the Rockwell HR30 Tm indentation hardness either:

a) directly, in accordance with EN 10109-1; or

b) indirectly, on relatively thin sheets (e.g. 0.22 mm and thinner), by determining the HR 15 T hardness in accordance with EN 10109-1 and then converting the HR 15 T values to HR 30 Tm values using Table F.1.

Make three hardness measurements on each of the test pieces taken in accordance with F.1.

Calculate the representative hardness for the consignment as the arithmetic mean of all the hardness results on all the sample sheets taken from the consignment.

Carry out the tests on test pieces from which all organic coatings have been removed. Avoid testing near the edges of the test pieces because of a possible cantilever effect.
<table>
<thead>
<tr>
<th>HR 15 T</th>
<th>Equivalent HR 30 Tm value</th>
</tr>
</thead>
<tbody>
<tr>
<td>92,0</td>
<td>80,5</td>
</tr>
<tr>
<td>91,5</td>
<td>79,0</td>
</tr>
<tr>
<td>91,0</td>
<td>78,0</td>
</tr>
<tr>
<td>90,5</td>
<td>77,5</td>
</tr>
<tr>
<td>90,0</td>
<td>76,0</td>
</tr>
<tr>
<td>89,5</td>
<td>75,5</td>
</tr>
<tr>
<td>89,0</td>
<td>74,5</td>
</tr>
<tr>
<td>88,5</td>
<td>74,0</td>
</tr>
<tr>
<td>88,0</td>
<td>73,0</td>
</tr>
<tr>
<td>87,5</td>
<td>72,0</td>
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<td>69,0</td>
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<tr>
<td>85,5</td>
<td>68,0</td>
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<tr>
<td>85,0</td>
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<tr>
<td>84,5</td>
<td>66,0</td>
</tr>
<tr>
<td>84,0</td>
<td>65,0</td>
</tr>
<tr>
<td>83,5</td>
<td>63,5</td>
</tr>
<tr>
<td>83,0</td>
<td>62,5</td>
</tr>
<tr>
<td>82,5</td>
<td>61,5</td>
</tr>
<tr>
<td>82,0</td>
<td>60,5</td>
</tr>
<tr>
<td>81,5</td>
<td>59,5</td>
</tr>
<tr>
<td>81,0</td>
<td>58,5</td>
</tr>
<tr>
<td>80,5</td>
<td>57,0</td>
</tr>
<tr>
<td>80,0</td>
<td>56,0</td>
</tr>
<tr>
<td>79,5</td>
<td>55,0</td>
</tr>
<tr>
<td>79,0</td>
<td>54,0</td>
</tr>
<tr>
<td>78,5</td>
<td>53,0</td>
</tr>
<tr>
<td>78,0</td>
<td>51,5</td>
</tr>
<tr>
<td>77,5</td>
<td>51,0</td>
</tr>
<tr>
<td>77,0</td>
<td>49,5</td>
</tr>
<tr>
<td>76,5</td>
<td>49,0</td>
</tr>
<tr>
<td>76,0</td>
<td>47,5</td>
</tr>
</tbody>
</table>
### F.3 Hardness for tinmill products

Hardness values for tinmill products shall be as given in Table F.2 when tested as described in F.2.

#### Table F.2 — Hardness values — Single reduced plate

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>$t \leq 0.21$</th>
<th>$0.21 &lt; t \leq 0.28$</th>
<th>$t &gt; 0.28$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS230</td>
<td>Max 53</td>
<td></td>
<td>Max 52</td>
</tr>
<tr>
<td>TS245</td>
<td>53</td>
<td>± 4</td>
<td>52</td>
</tr>
<tr>
<td>TS260</td>
<td>56</td>
<td>± 4</td>
<td>55</td>
</tr>
<tr>
<td>TS275</td>
<td>58</td>
<td>± 4</td>
<td>57</td>
</tr>
<tr>
<td>TS290</td>
<td>60</td>
<td>± 4</td>
<td>59</td>
</tr>
<tr>
<td>TS550</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TH415</td>
<td>62</td>
<td>± 4</td>
<td>61</td>
</tr>
<tr>
<td>TH435</td>
<td>65</td>
<td>± 4</td>
<td>65</td>
</tr>
<tr>
<td>TH520</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TH550</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TH580</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TH620</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes**

1. Table F.2 represents the grades in common use. Other grades are available for specific end use.
2. The deviations shown refer to measurements of individual samples.
Annex G
(informative)

The springback test for routine determination of proof strength for double reduced material

NOTE This is not the reference method. In all cases of dispute, the method described in EN 10002-1 should be used.

G.1 Principle and scope

The springback test provides a simple and rapid means of estimating the proof strength of double reduced products from measurement of fluidness and angle of springback of a rectangular strip test piece after forming 180° around a cylindrical mandrel and then releasing.

G.2 Test pieces

The test pieces shall be identical to those for the tensile test (see 8.1.2).

G.3 Test method

Make one test on each of the test pieces obtained in accordance with G.2 (i.e. two tests per sheet selected). Carry out the test using the Springback tester.

In making the test, strictly observe the operational instructions provided with the Springback tester. The principle steps in the test are:

a) measure the thickness of the test pieces to the nearest 0,001 mm;

b) insert the test piece into the tester and fix it firmly in the testing position by gently tightening the clamping screw using light finger pressure;

c) bend the test piece through 180° angle against the mandrel by a gentle swing of the forming arm;

d) return the forming arm to its “start” position and read and record the springback angle by sighting directly over the test piece;

e) remove the test piece from the tester and using the recorded thickness of the test piece and the springback angle, determine the appropriate springback index value from a suitable conversion formula agreed between producer and purchaser.

NOTE Calibrate each new Springback tester using the standard tensile test, (see 8.1.2) or another “reference” Springback tester. In addition, since malfunctions arising, for example, from excessive wear or inadvertent abuse of the test, may not be readily apparent, it is recommended that the Springback test readings should be regularly compared with readings of the standard tensile test or a “reference” Springback test. It is also recommended that such direct cross checks should be further supplemented by a frequent use of reference samples of known proof strength.
Annex H
(informative)

Alternative marking system for differentially coated tinplate

An alternative marking system for differentially coated tinplate consists of parallel straight lines about 1 mm wide, the distance between the lines indicating the coating masses.

The following spacings should be used:

Coating mass

<table>
<thead>
<tr>
<th>Designation</th>
<th>Line spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>D 5,6/2,8</td>
<td>12,5 mm</td>
</tr>
<tr>
<td>D 8,4/2,8</td>
<td>25 mm</td>
</tr>
<tr>
<td>D 8,4/5,6</td>
<td>25 mm alternating with 12,5 mm</td>
</tr>
<tr>
<td>D 8,4/11,2</td>
<td>37,5 mm alternating with 25 mm</td>
</tr>
<tr>
<td>D 11,2/2,8</td>
<td>37,5 mm</td>
</tr>
<tr>
<td>D 11,2/5,6</td>
<td>37,5 mm alternating with 12,5 mm</td>
</tr>
</tbody>
</table>

An illustration of the marking system is given in Figure H.1.

NOTE This alternative marking system may be used for certain coating combinations only.

Figure H.1 — Alternative marking system for electrolytic tinplate — differentially coated
List of corresponding former designations

Table I.1 comprises the former designations and the new designations:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TS230</td>
<td>1.0371</td>
<td>T50BA</td>
<td></td>
</tr>
<tr>
<td>TS245</td>
<td>1.0372</td>
<td>T52BA</td>
<td></td>
</tr>
<tr>
<td>TS260</td>
<td>1.0379</td>
<td>(T55BA)</td>
<td></td>
</tr>
<tr>
<td>TS275</td>
<td>1.0375</td>
<td>T57BA</td>
<td></td>
</tr>
<tr>
<td>TS290</td>
<td>1.0381</td>
<td>(T59BA)</td>
<td></td>
</tr>
<tr>
<td>TS550</td>
<td>1.0385</td>
<td>(DR550BA)</td>
<td></td>
</tr>
<tr>
<td>TH415</td>
<td>1.0377</td>
<td>T61CA</td>
<td></td>
</tr>
<tr>
<td>TH435</td>
<td>1.0378</td>
<td>T65CA</td>
<td></td>
</tr>
<tr>
<td>TH520</td>
<td>1.0384</td>
<td>(DR520)</td>
<td></td>
</tr>
<tr>
<td>TH550</td>
<td>1.0373</td>
<td>DR550</td>
<td></td>
</tr>
<tr>
<td>TH580</td>
<td>1.0382</td>
<td>(DR580)</td>
<td></td>
</tr>
<tr>
<td>TH620</td>
<td>1.0374</td>
<td>DR620</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>DR660</td>
<td></td>
</tr>
</tbody>
</table>

1) Brackets indicate that these grades were not covered by EN 10202 and/or EN 10203, but were used in the market with this designation.
Bibliography

ISO 11949:1995, *Cold-reduced electrolytic tinplate*
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