INTERNATIONAL STANDARD

ISO 4977-2

First edition
1988-10-15

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ORGANISATION INTERNATIONALE DE NORMALISATION
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Double cold-reduced electrolytic tinplate —

Part 2 :
Coil for subsequent cutting into sheets

Fer blanc électrolytique laminé à froid par double réduction —

Partie 2 : Bobines destinées à être découpées en feuilles

Reference number
ISO 4977-2 : 1988 (E)

Foreword

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 4977-2 was prepared by Technical Committee ISO/TC 17, *Steel*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

ISO 4977 consists of the following parts, under the general title *Double cold-reduced electrolytic tinplate*:

— *Part 1 : Sheet*

— *Part 2 : Coil for subsequent cutting into sheets*

Annexes A, B and C form an integral part of this part of ISO 4977.

Double cold-reduced electrolytic tinplate —

Part 2 : Coil for subsequent cutting into sheets

1 Scope and field of application

This part of ISO 4977 specifies requirements for double cold-reduced electrolytic tinplate that is supplied in coils for subsequent cutting into sheet by the purchaser. It applies to tinplate strip in nominal widths of 500 mm and greater and in nominal thicknesses that are in multiples of 0,01 mm from 0,14 mm up to and including 0,29 mm. Manufacturing conditions may restrict the maximum coil widths available in certain thicknesses.

It has not been possible, in preparing this first edition of ISO 4977-2, to specify mandatory requirements for mechanical properties. Test data are still limited and there are fundamental questions concerning what are the most relevant and reliable tests for evaluating the mechanical properties of double-reduced tinplate. For guidance purposes, information is given in annex A on the levels of proof stress and hardness to be expected in practice; procedures for sampling and testing are recommended for the determination of these properties.

2 References

ISO 1024, *Metallic materials — Hardness test — Rockwell superficial test (scales* 15N, 30N, 45N, 15T, 30T *and* 45T*)*.[1)]

ISO 6892, *Metallic materials — Tensile testing.*

3 Definitions

For the purpose of this part of ISO 4977, the following definitions apply.

3.1 anvil effect : The 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.

3.2 bulk package; bulk : A multiple packaging unit comprising a pallet (see 3.10), the tinplate and packaging material.

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

3.4 consignment : A quantity of coils of the same specification made available for despatch at the same time.

3.5 double cold-reduced differentially coated electrolytic tinplate : Double cold-reduced electrolytic tinplate, one surface of which carries a heavier tin coating than the other.

3.6 double cold-reduced electrolytic tinplate : Electrolytic tinplate, the steel base of which has received a second major cold-reduction following annealing.

3.7 electrolytic tinplate : Low-carbon mild steel sheet or strip coated on both surfaces with tin that is applied in continuous electrolytic operation using anodes of at least 99,75 % tin, in a plating bath.

3.8 feather edge : Variation in thickness, characterized by a reduction in thickness close to the edges, at right angles to the rolling direction.

3.9 line inspection : The final inspection of the finished product performed by instruments and/or by visual examination at normal line speeds.

3.10 pallet : Base platform on which a tinplate coil is stacked to facilitate transportation.

1) To be published.

3.11 rolling width : The width of the strip perpendicular to the rolling direction. When the strip is sheared into sheets, the shorter edges of the sheet are not necessarily parallel to the rolling width.

3.12 standard grade tinplate : Material in sheet form which does not contain any of the following :

a) pinholes, i.e. any perforation through the whole thickness of the plate;

b) areas of thickness outside the tolerance range specified in 9.4;

c) significant surface defects which render the material unsuitable for the intended use;

d) significant damage or shape related defects which render the material unsuitable for the intended use.

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) a description of the material required, i.e. standard grade double cold-reduced electrolytic tinplate in coil;

b) reference to this part of ISO 4977;

c) the quantity, expressed on an area basis, and the dimensions of the tinplate required. The area in square metres is calculated as the product of the supplier's indicated length of the coiled strip and its ordered nominal width;

d) the designation for the required mechanical properties of the tinplate and the tin coating masses on the two surfaces (see clause 5);

NOTE — Certain classifications are suitable for shaping operations such as stamping, drawing, folding, beading and bending and assembly work such as joint forming, soldering and welding although soft soldering is impracticable and welding is only recommended if, prior to welding, removal of the coating layer is efficiently undertaken at surfaces comprising the weld area. The end use should be borne in mind when the classification is selected.

e) if the strip is to be used for scroll shearing, the maximum acceptable lateral weave (see 9.6);

f) the maximum outside diameter and mass of coils which can be handled;

g) any further special requirements.

4.2 Options

In the event that the purchaser does not indicate his wish to implement any of the options included in this part of ISO 4977 and does not specify his requirements at the time of the enquiry and order, the product shall be supplied on the following basis :

a) with a stone surface finish (see 6.2);

b) with surface passivation treatment using cathodic sodium dichromate;

c) with the location of each joint indicated by a piece of non-rigid material (see 10.3);

d) with differential tin coatings indicated on the heavier coated surface by continuous parallel lines spaced at 75 mm intervals (see clause 12);

e) with the cores of the coils vertical (see clause 15).

4.3 Additional information

In addition to the information in 4.1 and 4.2, the purchaser may wish to 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 tinplate is used.

NOTE — When ordering double cold-reduced tinplate, the purpose of manufacture for which the tinplate is intended should be stated. It should be noted that double cold-reduced tinplate is relatively less ductile than single cold-reduced tinplate and has very distinct directional properties, so for some uses, for example for built-up can bodies, the direction of rolling should be stated. When double cold-reduced tinplate is used for built-up can bodies, the rolling direction should be around the circumference of the can so as to minimize the hazard of flange cracking.

5 Designations

For the purposes of this part of ISO 4977, the following designations apply.

5.1 Mechanical property classifications

The levels of mechanical properties with which double cold-reduced tinplate is supplied are designated in terms of the nominal 0,2 % proof stress, as shown in table 1.

Table 1 — Mechanical property classifications

Classification	Nominal 0,2 % proof stress N/mm^2
DR 550	550
DR 620	620
DR 660	660

5.2 Coating mass designations

The coating masses, and their combinations, with which tinplate is supplied are designated by the letters E (for equally coated) and D (for differentially coated) followed by numbers representing the nominal coating mass for each surface of the tinplate. Examples are shown in table 2.

Table 2 — Examples of tinplate designations

Tinplate	Designation
Tinplate with a nominal proof stress of 550 N/mm² and equal tin coatings of 2,8 g/m² for each surface	DR 550, E 2,8/2,8
Tinplate with a nominal proof stress of 620 N/mm² and differential tin coatings of 8,4 g/m² for one surface and 5,6 g/m² for the other	DR 620, D 8,4/5,6

6 Manufacture, finish and defects

6.1 Manufacture

The methods of manufacture of tinplate are left to the discretion of the manufacturer and are not specified in this part of ISO 4977.

The purchaser shall be informed if an alteration is made to the method of manufacture that will affect the properties of the purchased tinplate.

NOTE — It is recommended that the manufacturer supplies to the purchaser such details of the manufacturing process as may assist the purchaser in his efficient use of the tinplate.

6.2 Finish

Double cold-reduced tinplate is usually supplied with a stone surface finish characterized by a directional pattern, imparted to the strip by the use of ground work rolls in the final stages of the second reduction operation, and by a flow-brightened tin coating. It may also be available with other surface finishes.

The surface of electrolytic tinplate is normally subjected to a passivation treatment and to oiling. Passivation, produced either by a chemical treatment or by an electrochemical treatment, gives a surface with an improved resistance to oxidation and improved suitability for lacquering and printing. The usual passivation procedure is a cathodic treatment in a solution of sodium dichromate.

NOTE — Under normal conditions of transport and storage, double cold-reduced electrolytic tinplate should be suitable for surface treatments such as established lacquering and printing operations.

6.3 Defects

The producer is expected to employ his normal quality control and line inspection procedures to ensure that the tinplate manufactured is in accordance with the requirements of this part of ISO 4977. However, the production of tinplate coils in continuous strip mill operations does not afford the opportunity for removal of all tinplate that does not comply with the requirements of this part of ISO 4977.

At the time of shearing, sheets not conforming to the standard grade shall be set aside by the purchaser or his agent.

If the amount of sheets set aside exceeds 15 %, the coil shall be deemed not to comply with this part of ISO 4977.

NOTE — Items c) and d) in 3.12 cannot be verified by specific tests and should be the subject of special agreement between producer and user.

If, when processing a double cold-reduced tinplate coil, the purchaser (or his agent) encounters recurring defects which in his opinion seem excessive, it is essential — where practicable — that he stops processing the coil and advises the supplier.

The purchaser is expected to have adequate handling, roller levelling and shearing equipment and to take reasonable care during these operations.

7 General requirements

Double cold-reduced electrolytic tinplate supplied in coils shall comply with the requirements of clauses 8 to 12.

When tests are carried out to verify compliance with the requirements of clauses 8 and 9, sample sheets shall be selected from consignments in accordance with clause 13.

For the determinations of coating mass and mechanical properties, test specimens shall be taken from the sample sheets in accordance with 14.1 and shall be tested in accordance with 14.2.

NOTE — No sampling or testing requirements are specified in this part of ISO 4977 for verifying that any oil coating applied to the coils is suitable for food packaging in accordance with clause 11.

The method of dispatching tinplate coils shall be in accordance with clause 15.

8 Tin coating mass

The average coating mass, on each surface, shall be expressed in grams per square metre (g/m²). The lowest value specified in this part of ISO 4977 shall be 1 g/m² on each surface, and no upper limit is specified.

Whatever the coating mass used, the tolerance shall be as indicated in table 3, and the mass per unit area for equally and differentially coated coils respectively is determined on specimens taken from samples selected in accordance with clause 13 and tested in accordance with 14.2.

NOTE — For both equally coated and differentially coated tinplates, individual specimens of the sample may show tin coatings as low as, for example, 80 % of the minimum average coating mass, but it is emphasized that isolated specimens have no representative value in relation to the consignment under consideration.

Table 3 — Minimum average tolerances on tin coating masses

Nominal coating mass for each surface (g/m²)	Minimum average tolerance for each surface (g/m²)
> 1,0 and < 1,5	− 0,25
> 1,5 and < 2,8	− 0,30
> 2,8 and < 4,1	− 0,35
> 4,1 and < 7,6	− 0,50
> 7,6 and < 10,1	− 0,65
> 10,1	− 0,90

9 Tolerances on dimensions and shape

9.1 Introduction

Tolerances on dimensions (i.e. coil length, strip width and thickness) and shape (i.e. edge camber, lateral weave) are specified in 9.2 to 9.6, together with appropriate methods of measurement.

Other geometrical features may be present in sheets cut from double cold-reduced electrolytic tinplate supplied in coil, such as :

burr : metal displaced beyond the plane of the surface of the sheet by shearing action;

edge wave : an intermittent vertical displacement occurring at the sheet edge when the sheet is laid on a flat surface;

centre buckle (full centre) : an intermittent vertical displacement or wave in the sheet occurring other than at the edges;

longitudinal bow (line bow) : residual curvature in the sheet along the direction of rolling;

transverse bow (cross bow) : curvature of the sheet such that the distance between its edges parallel to the rolling direction is less than the sheet width.

Although it is not possible at present to specify methods of measuring or to specify limits for these geometrical features, certain of which are subject to the equipment employed by the purchaser, the producer should endeavour to keep the occurrence and magnitude of burr, edge wave, centre buckle and transverse bow to a minimum. He should also endeavour to minimize the variation of the longitudinal bow.

9.2 Coil length

The difference between the actual length and the producer's indicated length, measured on any single coil, shall not exceed ± 3 %.

The accumulated difference between the actual lengths and the producer's indicated lengths, measured on at least 100 coils, shall not exceed ± 0,1 %.

NOTE — The purchaser normally verifies the length of a coil by multiplying the average length of the sheets sheared from the coil by the number of sheets obtained and adding the accumulated lengths of any other portions of the coil as received. The average length of the sheets sheared from the coil is normally determined by measuring the lengths of at least ten sheets, taken at random, to an accuracy of 0,2 mm. Coil lengths may be measured by other methods, provided that the method adopted is acceptable to both the producer and the purchaser.

9.3 Width

9.3.1 Width measurement

The width of each sample sheet shall be measured to the nearest 0,5 mm. The width shall be measured across the centre of the sheet, at right angles to the rolling direction, with the sheet lying on a flat surface.

9.3.2 Width tolerance

The width, measured by the method given in 9.3.1 on each sample sheet selected in accordance with clause 13, shall be not less than the ordered width and shall not exceed the ordered width by more than 3 mm.

9.4 Thickness

9.4.1 Thickness determinations

9.4.1.1 General

Thickness shall be determined either by the weighing method described in 9.4.1.2, or by direct measurement using the micrometer method described in 9.4.1.3.

In cases of dispute and for all retests, the weighing method shall be the referee method.

However the transverse thickness profile shall be measured using the micrometer method (see 9.4.1.3).

9.4.1.2 Weighing method

9.4.1.2.1 Determine the thickness of each sample sheet as follows :

a) Weigh the sheet to obtain the mass to the nearest 2 g.

b) Measure the length and width of the sheet to the nearest 0,5 mm and calculate the area.

c) Calculate the thickness of the sheet, to the nearest 0,001 mm, using the following formula :

$$\text{thickness (mm)} = \frac{\text{mass (g)}}{\text{area (mm}^2) \times 0{,}007\,85\ (\text{g/mm}^3)}$$

9.4.1.2.2 To determine the average thickness for a consignment, calculate the arithmetic mean of the calculated thicknesses of all the sample sheets representing the consignment.

9.4.1.2.3 To determine the variation of thickness within each sample sheet, take two specimens Y (see figure 1) from the sheet. Weigh each specimen to the nearest 0,01 g, measure the length and width of each specimen to the nearest 0,1 mm, and calculate the thickness of each specimen to the nearest 0,001 mm using the formula given in 9.4.1.2.1 c).

9.4.1.3 Micrometer method

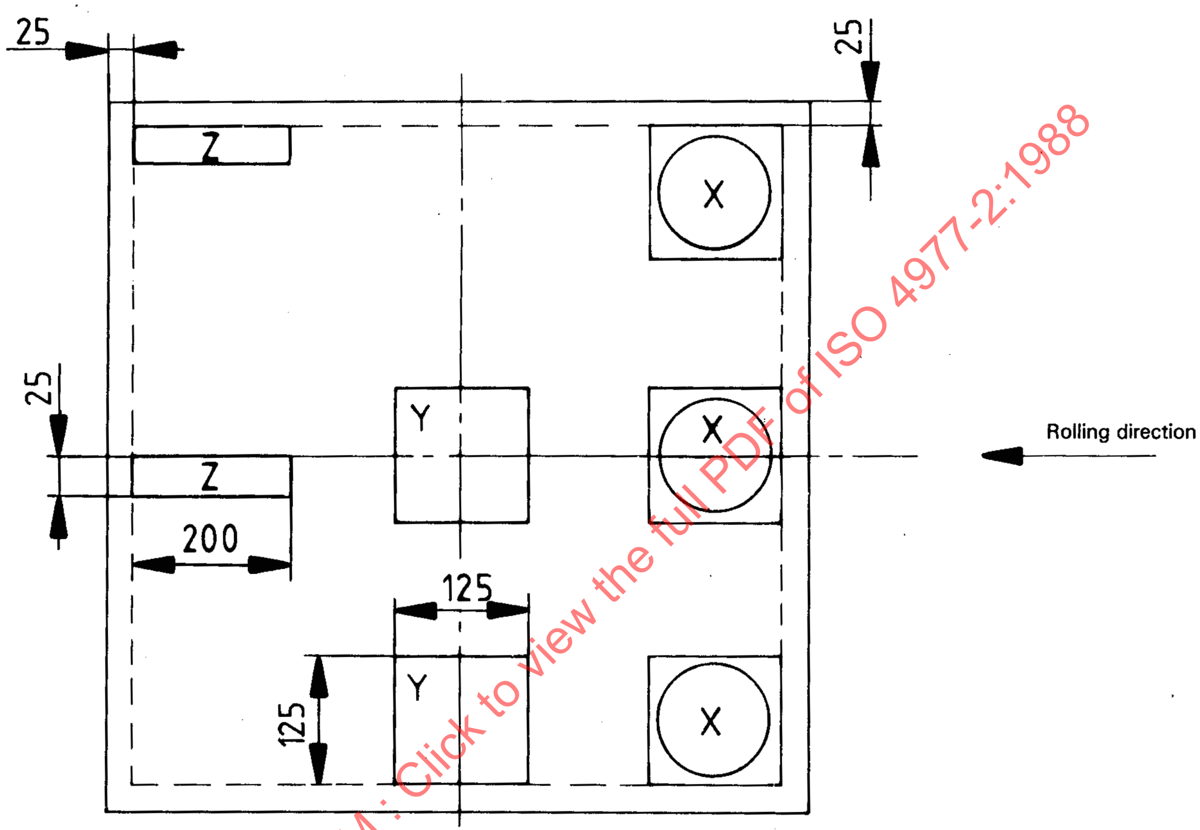
9.4.1.3.1 Determine the thickness of each sample sheet by direct measurement using a hand-operated, spring-loaded micrometer which permits readings to 0,001 mm. Measure the thickness to an accuracy of 0,001 mm, at least 10 mm from the trimmed edge of the sheet.

NOTE — It is recommended that the micrometer should have a ball-ended shank anvil of approximately 3 mm diameter, a curved surface base anvil of approximately 25 mm radius and a face diameter of approximately 13 mm.

9.4.1.3.2 To determine the average thickness for a consignment, calculate the arithmetic mean of the measured thicknesses of all the sheets representing the consignment.

9.4.1.3.3 To determine the variation of thickness within each sample sheet, use the micrometer to measure the thicknesses at two locations on each of the specimens Y (see figure 1). State the average thickness for each specimen to the nearest 0,001 mm.

Dimensions in millimetres



X : specimens for tin coating mass tests

Y : specimens for determination of local thickness variation within a sheet (see also A.2.2.3.1 in annex A regarding the recommended specimens for determination of hardness).

Z : specimens for tensile or springback tests if mechanical properties are to be determined in accordance with annex A.

Figure 1 — Locations of test specimens

9.4.2 Thickness tolerances

9.4.2.1 Individual sheets

When shearing a coil, sheets shall be rejected if deviating from the nominal thickness by more than

a) ± 8,5 %, if the weighing method is used, or

b) the tolerances given in table 4, if the micrometer method is used.

Table 4 — Thickness tolerances for individual sheets

Ordered nominal thickness mm	Tolerance ± mm
0,14	0,015
0,15	0,015
0,16	0,015
0,17	0,015
0,18	0,020
0,19	0,020
0,20	0,020
0,21	0,020
0,22	0,020
0,23	0,025
0,24	0,025
0,25	0,025
0,26	0,025
0,27	0,025
0,28	0,030
0,29	0,030

9.4.2.2 Average thickness for a consignment

The average thickness for a consignment, determined in accordance with 9.4.1.2.2 or 9.4.1.3.2 on the sample sheets selected in accordance with clause 13, shall not deviate from the ordered nominal thickness by more than

a) ± 2,5 % for consignments (see 13.2.1) comprising more than 15 000 m, i.e. 20 units, or

b) ± 4 % for consignments comprising 15 000 m, i.e. 20 units, or less.

9.4.2.3 Thickness variation across the width

The thickness of either of the two individual specimens determined in accordance with 9.4.1.2.3 or 9.4.1.3.3 shall not deviate by more than 4 % from the average thickness of the whole sheet.

9.4.2.4 Transverse thickness profile (feather edge)

The minimum thickness, when measured at 6 mm from the mill-trimmed edge, using the micrometer method, shall not be more than 15 % below the ordered nominal thickness and/or shall not vary by more than 9 % when compared to the centre thickness of the sheet being measured.

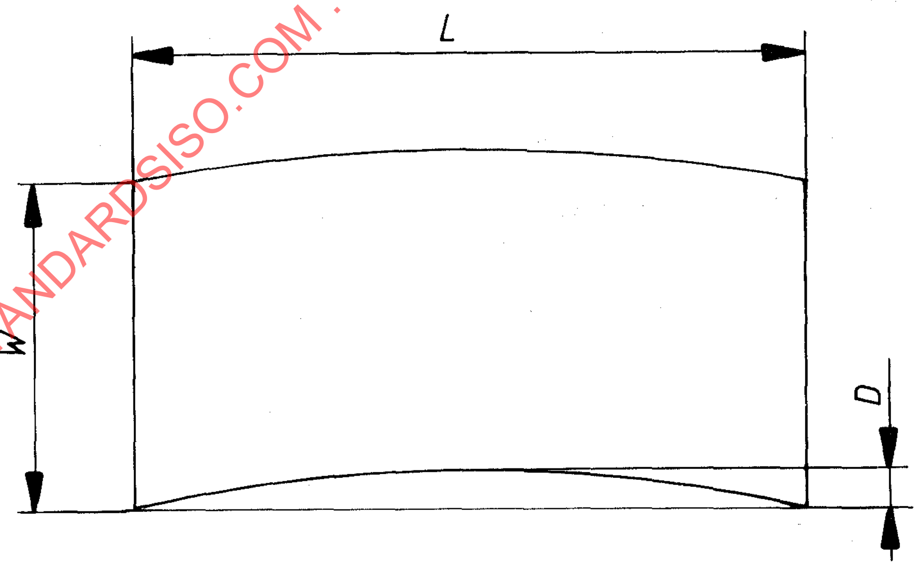
9.5 Edge camber

Edge camber is the maximum deviation (in the plane of the sheet) of an edge from a straight line forming a chord to the edge (see figure 2).

The edge camber expressed as a percentage of the chord length is calculated as follows :

$$\text{edge camber (\%)} = \frac{\text{deviation } (D)}{\text{length of chord}} \times 100$$

The edge camber, measured over a distance (chord length) of 6 m, shall not exceed 0,1 % (i.e. 6 mm).



W : rolling width

L : length of chord

D : deviation from straight line

Figure 2 — Edge camber

9.6 Lateral weave (short-pitch camber)

Lateral weave is the deviation of a mill-trimmed edge from a straight line lying in the same plane as the edge and forming a chord to it over a relatively short distance.

With the exception of strip required for scroll shearing, the lateral weave, measured over a chord length of 1 m, shall not exceed 1,0 mm when measured prior to shearing.

NOTE — If the strip is required for scroll shearing, the acceptable lateral weave should be agreed between the producer and the purchaser at the time of enquiry and order.

10 Joints within a coil

10.1 General

The producer shall ensure continuity of the coils within the limits of the lengths ordered, if necessary by means of electrically welded joints made after cold reduction. Requirements relating to the numbers, locations and dimensions of the joints permitted within a coil are given in 10.2 to 10.4.

10.2 Number of joints

The number of joints in a coil shall not exceed three in a length of 6 000 m or pro rata.

10.3 Location of joints

The location of each joint in a coil shall be indicated clearly.

NOTE — The location of each joint may be indicated, for example, 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 joints

10.4.1 Thickness

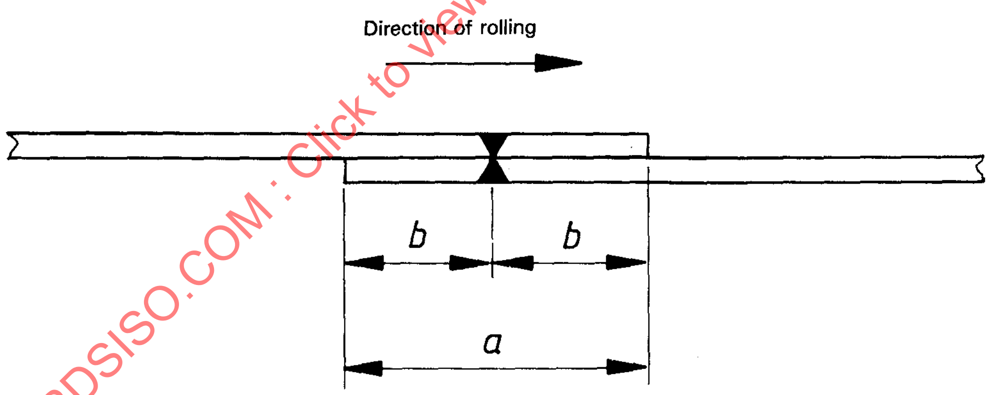
The total thickness of any joint shall not exceed three times the nominal thickness of the tinplate forming the joint.

10.4.2 Overlap

In any lap joint, the total length of overlap shall not exceed 25 mm. The free overlap shall not exceed 12 mm (see figure 3).

11 Oiling

Double cold-reduced electrolytic tinplate strip is supplied with an oil coating. The oil shall be one that is recognized (i.e. by the relevant national or international authority) as being suitable for food packaging.



a : total length of overlap

b : free overlap

Figure 3 — Joint overlap

12 Marking of differentially coated double cold-reduced tinplate strip

In order to distinguish between strip with differential tin coatings and strip with equal coatings on the two surfaces, differentially coated strip shall be marked on one surface only.

Differentially coated strip shall be marked either

a) on the heavily coated surface by matt, straight, continuous parallel lines about 1 mm wide and spaced at 75 mm intervals, or

b) on the lightly coated surface by either alternate continuous and interrupted parallel lines spaced at 75 mm intervals or geometric patterns.

If no option is indicated at the time of order, option a) will be adopted [see 4.2 d)].

Annex B gives details of an alternative marking system.

NOTE — If the purchaser has preferences for the side to be marked and the marking system to be used, these should be agreed with the producer at the time of ordering and stated on the order.

13 Sampling

13.1 General

If tests are carried out to ascertain whether the tinplate in a consignment complies with the requirements for coating mass (see clause 8), and tolerances on dimensions and shape (see clause 9), samples of the tinplate shall be selected in accordance with 13.2 and 13.3.

After the coils in a lot have been cut into rectangular or scrolled sheets, the sheets deemed not to be of standard grade tinplate shall be excluded. The standard grade sheets that remain shall be sampled on the basis of units of strip 750 m in length in accordance with 13.2.2.

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

The purchaser shall allow the producer, or his representatives, to be present during the sampling and subsequent testing, so that the producer, or his representatives, can confirm that the identities of the samples and test specimens correspond with the coils in the consignment supplied.

13.2 Selection of samples

13.2.1 Lots

For the purpose of sampling, each consignment of coils shall be considered as one lot.

13.2.2 Selection of sample units

For lots comprising up to and including 20 units, 4 sample units shall be selected at random.

For lots comprising more than 20 units, 4 units shall be selected at random from each 20 units and from any remaining part of 20 units.

13.2.3 Selection of sample sheets

From each sample unit selected in accordance with 13.2.2, the following sample sheets shall be taken at random :

a) for verification of the tin coating mass: two sheets;

b) for verification of the dimensions and shape: five sheets.

13.3 Retests

13.3.1 Tin coating masses

In the event of the average tin coating mass failing to meet the specified requirements, two further sample units, from other bulk packages, shall be selected as specified in 13.2 and specimens taken as described in 14.2.1. If both retests are satisfactory, the consignment shall be deemed to meet the requirements of this part of ISO 4977, but if either of the additional tests is failed the consignment shall be deemed not to meet the requirements of this part of ISO 4977.

13.3.2 Dimensions

If any of the dimensions measured are unsatisfactory, further measurements shall be made on two further sample units selected from other bulk packages according to the procedure outlined in 13.2. If both remeasurement results are satisfactory, the consignment shall be deemed to meet the requirements of this part of ISO 4977, but if either of the additional measurement results fails to meet the relevant requirements, the consignment represented shall be deemed not to comply with this part of ISO 4977.

14 Test methods

14.1 Locations of test specimens

Test specimens for the determinations of coating mass and local thickness variation within a sheet shall be taken from each sample sheet selected in accordance with clause 13 at the locations shown in figure 1.

14.2 Determination of tin coating masses

14.2.1 Specimens

For tin coating mass determination, from each sheet selected in accordance with clause 13, three specimens, each of an accurately determined area not less than 2 500 mm^2, and preferably in the form of discs, shall be carefully prepared. These specimens shall be selected at edge-centre-edge locations along a line normal to the rolling (tinning) direction (positions marked X in figure 1). The specimens shall clear the edges and end of the sheet by 25 mm.

14.2.2 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 test purposes, the coating mass may be determined by any of the recognized and accepted analytical methods but, in cases of dispute, and for all retests, the method described in annex C shall be the referee method.

Whether tin coating determinations are made on individual or grouped specimens, the tin coating mass of a consignment shall be taken as the average of all the results.

15 Methods of 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.

NOTE — ECCS strip is usually supplied in consignments of coils with outside diameters of at least 1 200 mm, but a limited number of coils with smaller outside diameters may be included in the consignment.

Annex A

Mechanical properties

(This annex forms an integral part of the standard.)

A.1 Nominal mechanical properties

No test or group of tests has been developed that adequately predicts all the factors affecting the fabricating performance of double cold-reduced tinplate sheets cut from coil, the primary consideration for these products being that the sheets perform satisfactorily for the intended end use.

In the absence of such tests, it is customary to order the sheets to mechanical property classification (see 5.1), representing the nominal 0,2 % proof stress (as determined by the tensile test or the springback test) and hardness (as determined by the Rockwell superficial hardness test). The proof stress and hardness values corresponding to the mechanical property classification levels are shown in table 5. In practice, it is expected that the producer will aim to achieve the nominal values given in table 5, within the ranges also given in the table.

The values included in table 5 are based on average values determined in accordance with the sampling and test methods recommended in A.2; individual values are not considered to have any representative significance in relation to a consignment of tinplate.

A.2 Recommended procedures for determining the nominal mechanical properties for consignments of double cold-reduced tinplate

A.2.1 Samples

For determination of the representative mechanical properties for a consignment of double cold-reduced tinplate coils, use the sheets taken in accordance with 13.2.3 a), for verification of the coating mass, from each of the sample units selected in accordance with 13.2.2. (However, see also the note to A.2.2.3.1.)

A.2.2 Determination of mechanical properties

A.2.2.1 General

All coatings (other than tin) such as lacquers, varnishes and printing inks shall be removed from the surface of the test pieces prior to testing. For tensile or springback tests it is unnecessary to remove the tin coating but it is essential that it is removed prior to hardness testing.

NOTE — Attention is drawn to the effects of heat treatment during lacquering/printing which may influence the results of mechanical property tests.

Calculate the representative value of each property (proof stress and hardness) for the consignment as the arithmetic mean of all the values determined on all the sample sheets taken from the consignment.

A.2.2.2 0,2 % proof stress ($R_{p\,0,2}$)

A.2.2.2.1 Introduction

Two methods of determining the proof stress values of double cold-reduced tinplate are available. The first, the conventional tensile test, provides the more accurate measure, but is relatively slow and requires very careful, skilled preparation of the test specimens. The second, the springback test, was developed to give a reasonably accurate value and yet be fairly rapid. Therefore the tensile test is normally used for referee and calibration purposes while, for routine purposes, the springback test is considered generally to be adequate.

A.2.2.2.2 Tensile test

A.2.2.2.2.1 *Specimens*

For the determination of proof stress by the tensile test procedure, from each sheet selected in accordance with A.2.1 cut

Table 5 — Mechanical properties

Mechanical property classification	Average proof stress (0,2 % non-proportional elongation)[1], longitudinal		Average Rockwell hardness HR 30T	
	Nominal N/mm²	Range N/mm²	Nominal	Range
DR 550 (DR 8)	550	480 to 620	73	70 to 76
DR 620 (DR 9)	620	550 to 690	76	73 to 79
DR 660 (DR 9 m)	660	590 to 730	77	74 to 80

1) The term tensile yield strength (0,2 % offset) is used in the USA and Canada.

two rectangular specimens approximately 200 mm long × 25 mm wide with the rolling direction parallel to the length of the specimen at the positions marked Z in figure 1. Ensure that the specimens clear the edges and end of the sheet by a minimum of 25 mm.

A.2.2.2.2.2 Test method

Make one test on each of the specimens selected in accordance with A.2.2.2.2.1 (i.e. two tests per sheet selected).

Determine the proof stress ($R_{p\,0,2}$) in accordance with ISO 6892 but take the following precautions if the thickness is less than 0,5 mm (ISO 6892 does not apply to thicknesses less than 0,5 mm, and thicknesses lower than this are commonly employed for double cold-reduced tinplate) :

a) Ensure that the edges of the specimen are entirely free of discernible burrs, if necessary by finishing the preparation of the edges with fine emery paper.

b) Use specimens with a gauge length (effective length with parallel edges) of 50 ± 0,5 mm and a width of 12,5 ± 1 mm.

c) Use a rate of straining of 1 mm/min.

d) Employ grips that are capable of securing the sample such that no skew occurs during straining, to ensure that the applied stress is aligned centrally along the major axis of the test specimen.

A.2.2.2.3 Springback test

A.2.2.2.3.1 Specimens

For the determination of proof stress by the springback method, from each sheet selected in accordance with A.2.1 cut two rectangular specimens 150 ± 1 mm long × approximately 25 mm wide with the rolling direction parallel to the length of the specimen at the positions marked Z in figure 1.

A.2.2.2.3.2 Test method

Make one test on each of the specimens obtained in accordance with A.2.2.2.3.1 (i.e. two tests per sheet selected). Carry out the test using the springback Temper Tester model G.67.[1)]

In making the test, strictly observe the operational instructions provided with the springback Temper Tester. The principal steps in the test are :

a) Measure the thickness of the tinplate specimen to the nearest 0,001 mm.

b) Insert the specimen into the tester and fix it firmly in the testing position by gently tightening the clamping screw using light finger pressure.

c) Bend the specimen through an angle of 180° 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 specimen.

e) Remove the specimen from the tester and, using the recorded thickness of the specimen and the springback angle, determine the appropriate springback index value from a suitable conversion formula (for example Bower) agreed between producer and purchaser.

NOTE — Calibrate each new springback Temper Tester using the standard tensile test (see A.2.2.2.2) or another, "reference" springback Temper Tester. In addition, since malfunctions arising, for example, from excessive wear or inadvertent abuse of the test equipment may not be readily apparent, it is recommended that the springback temper test readings should be regularly compared with readings obtained from the standard tensile test or a "reference" springback Temper Tester. It is also recommended that such direct cross-checks should be supplemented by the frequent use of reference tinplate samples of known proof stress.

A.2.2.3 Hardness

A.2.2.3.1 Specimens

For the determination of hardness, from each sheet selected in accordance with A.2.1 cut two rectangular specimens 25 mm × 125 mm from the middle of adjacent sides, that is at the positions marked Y in figure 1.

NOTE — The specimens (Y) taken in accordance with 9.4.1.2.3 and 9.4.1.3.3 for the determination of the thickness variations within the individual sample sheets taken in accordance with 13.2.3 b), may be used also for the hardness determinations where appropriate. For example, from a sample coil which has been cut into 200 sheets, two sheets would be required [13.2.3 a)] for coating mass determinations and one sheet [13.2.3 b)] for verification of dimensions; clearly the sheet taken in accordance with 13.2.3 b) (and therefore the specimens Y taken from it) could be one of the two sheets taken in accordance with 13.2.3 a).

Polish each surface of the specimens with 600 grade emery paper.

A.2.2.3.2 Test method

Determine the Rockwell HR 30T indentation hardness either

a) directly, in accordance with ISO 1024, or

b) indirectly, on relatively thin sheets (for example 0,22 mm and thinner), by determining the HR 15T hardness in accordance with ISO 1024 and then converting the HR 15T values to HR 30T values using table 6.

Make three hardness measurements on each of the specimens taken in accordance with A.2.2.3.1.

1) The Temper Tester model G.67 is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

To measure the indentation hardness, use a Rockwell superficial hardness testing machine, employing the 30T or 15T scale (see ISO 1024), as appropriate. Provide the machine with an anvil having a diamond centre spot. Avoid testing near the edges of the specimen because of a possible cantilever effect.

Place the specimen on the anvil and bring it into contact with the ball indenter by turning the hand wheel until the indicator on the dial shows that the minor load is applied. Then turn the adjustable rim of the dial until the pointer indicates zero and apply the major load by operating the handle. The rate of loading is controlled by a dash-pot incorporated in the machine. As soon as the loading is complete, remove the major load by pulling the handle forward and read the Rockwell hardness number directly from the appropriate scale.

Table 6 — Rockwell HR 15T values and their HR 30T equivalents

HR 15T value	Equivalent HR 30T value
93,0	82,0
92,5	81,5
92,0	80,5
91,5	79,0
91,0	78,0
90,5	77,5
90,0	76,0
89,5	75,5
89,0	74,5
88,5	74,0
88,0	73,0
87,5	72,0
87,0	71,0
86,5	70,0
86,0	69,0
85,5	68,0
85,0	67,0

Annex B

Alternative marking system

(This annex forms an integral part of the standard.)

The marking system consists of parallel straight lines about 1 mm wide, the distance between the lines indicating the coating masses.

The following spacings are used :

Code	Line spacing
D 5,6/2,8	12,5 mm
D 8,4/2,8	25 mm
D 8,4/5,6	25 mm alternating with 12,5 mm
D 11,2/2,8	37,5 mm
D 11,2/5,6	37,5 mm alternating with 12,5 mm
D 15,1/5,6	50 mm alternating with 12,5 mm

An illustration of the marking system is given in figure 4.

NOTE — Differentially coated tinplate with nominal coatings not indicated above should be marked with parallel lines employing 75 mm spacings.

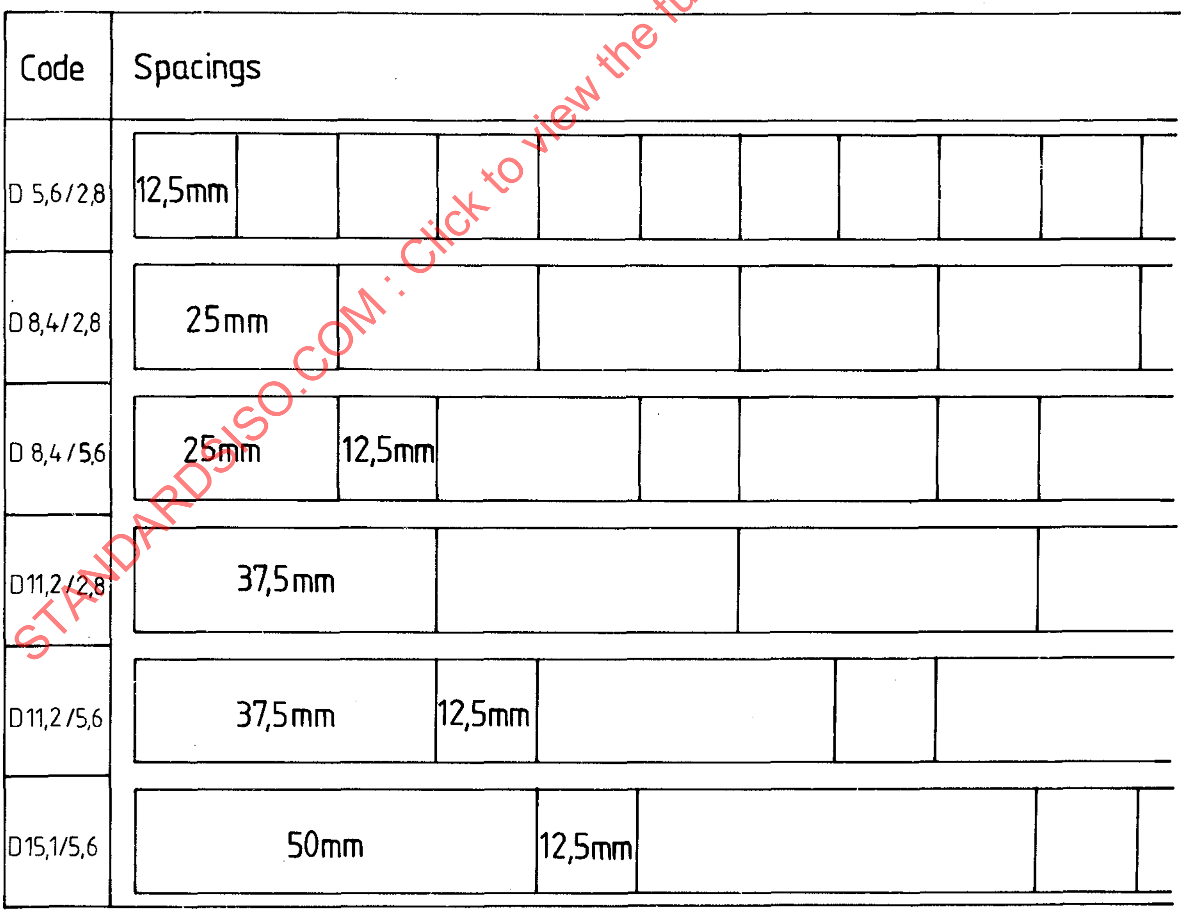


Figure 4 — Alternative marking system for electrolytic tinplate — differentially coated

Annex C

Volumetric method for determining tin coating mass (iodine method)

(This annex forms an integral part of the standard.)

C.1 Principle

The tin coating is dissolved in hydrochloric acid and the tin in an aliquot portion is reduced to the bivalent state with metallic aluminium. The tin in the reduced state is determined by titration with standard volumetric potassium iodate solution.

The effective range of the method is from 0,5 g/m^2 up to 50 g/m^2 and the reproducibility is $\pm$ 0,1 g/m^2.

C.2 Reagents and materials

C.2.1 General

During the analysis, use only reagents of recognized analytical grade and only distilled water or water of equivalent purity.

Prepare freshly and, where necessary, filter all solutions.

Prepare reagents C.2.4, C.2.5 and C.2.6 with freshly boiled distilled water to ensure that the solutions are as free from dissolved oxygen as is practicable.

C.2.2 Hydrochloric acid, 75 % (*V*/*V*).

Dilute 750 ml of hydrochloric acid (ϱ = 1,16 g/ml) to 1 000 ml with water.

C.2.3 Iron(III) chloride, 100 g/l solution.

Dissolve 100 g of hydrated iron(III) chloride in water containing 100 ml of hydrochloric acid (ϱ = 1,16 g/ml) and dilute to 1 000 ml with water.

C.2.4 Potassium iodate, standard volumetric solution, $c(KIO_3)$ = 0,05 mol/l. For use only with electrolytic tinplate coated equally on both sides.

Dissolve 1,783 5 g of potassium iodate (previously dried to constant mass at 180 °C) and 19 g of potassium iodide in water containing 0,5 g of sodium hydroxide and dilute to 1 000 ml with water.

1 ml of this solution is equivalent to 0,002 967 g of Sn.

C.2.5 Potassium iodate, standard volumetric solution, $c(KIO_3)$ = 0,025 mol/l. For use only with electrolytic tinplate coated differentially on each side.

Dissolve 0,891 8 g of potassium iodate (previously dried to constant mass at 180 °C) and 10 g of potassium iodide in water containing 0,5 g of sodium hydroxide and dilute to 1 000 ml with water.

1 ml of this solution is equivalent to 0,001 484 g of Sn.

C.2.6 Starch solution.

Make a suspension of 1 g of soluble starch in 10 ml of water and add to 100 ml of boiling water. Boil for 2 or 3 min and cool.

C.2.7 Ethyl ether, technical grade (ϱ = 0,72 g/ml).

C.2.8 Platinum wire, approximately 750 mm long and 0,6 mm in diameter, formed into a flat spiral of two turns and approximately 125 mm diameter (see figure 6).

C.2.9 Aluminium metal, 99,99 % purity (tin free), as foil, 0,25 mm thickness.

C.2.10 Carbon dioxide, oxygen-free.

C.2.11 Lacquer : a suitable air-drying cellulose lacquer.

C.3 Apparatus

A suitable assembly for carrying out the reduction of tin consists of a 500 ml wide-neck conical flask marked at a volume of 200 ml. The flask is fitted with a rubber bung containing a bent gas inlet tube, a small Liebig-type condenser and a rubber-sealed tube for burette entry at the titration stage (see figure 5).

C.4 Procedure

C.4.1 Electrolytic tinplate — equally coated

Degrease with ether (C.2.7) the disc-shaped specimens taken from sheets in accordance with 14.2.1. Place the spiral of platinum wire centrally in a shallow dish (see figure 6). Place six of the discs in a circle on the platinum wire and carefully pour 150 ml of the hydrochloric acid (C.2.1) into the dish.

As soon as the coating is completely dissolved from both faces, leaving the steel surfaces exposed (see note 1 below), transfer the acid quantitatively to a 1 000 ml one-mark volumetric flask. Wash twice with 25 ml of water, transferring the washings to the flask. Repeat the whole procedure with the remaining six discs, combining the acid and washings in the same volumetric flask, finally diluting to the mark with water.