International Standard 4977/1

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

Double cold-reduced electrolytic tinplate — Part 1 : Sheet

Fer-blanc électrolytique laminé à froid par double réduction — Partie 1 : Feuilles

First edition — 1984-06-01

UDC 669.14-122 : 62-416 **Ref. No. ISO 4977/1-1984 (E)**

Descriptors : iron-and steel products, cold formed products, metal plates, tinplate, mechanical properties, dimensions, thickness, dimensional tolerances, tests, tin coatings, volumetric analysis, designation, marking.

Price based on 14 pages

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been authorized 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.

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.

International Standard ISO 4977/1 was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in March 1983.

It has been approved by the member bodies of the following countries :

Australia	India	Poland
Austria	Iran	South Africa, Rep. of
Belgium	Italy	Spain
Brazil	Japan	Sweden
Canada	Korea, Dem. P. Rep. of	Switzerland
China	Korea, Rep. of	Turkey
Czechoslovakia	Romania	United Kingdom
France	Netherlands	USSR
Germany, F. R.	New Zealand	
Hungary	Norway	

No member body expressed disapproval of the document.

Printed in Switzerland

Double cold-reduced electrolytic tinplate — Part 1 : Sheet

1 Scope and field of application

This part of ISO 4977 specifies the characteristics of double cold-reduced electrolytic tinplate sheet in low carbon cold-reduced mild steel. It applies to products in nominal thicknesses from 0,14 mm up to and including 0,29 mm according to mechanical properties classification.

It does not apply to double cold-reduced tinplate in coils or to single cold-reduced tinplate or to material described commercially as tinned sheets, steel sheets, blackplate or electrolytic chromium/chromium oxide coated steel (ECCS).

2 References

ISO/R 1024, *Rockwell superficial hardness test (N and T scales) for steel.*

ISO 6892, *Metallic materials — Tensile testing.*

3 Definitions

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

3.1 double cold-reduced electrolytic tinplate : Low carbon mild steel sheet coated on both surfaces with tin, applied by electro-deposition, the steel base of which has received a second major cold reduction following annealing.

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

3.3 consignment : A quantity of double cold-reduced tinplate of the same dimensions and quality made available for despatch at the same time.

4 Conditions of manufacture and utilization

4.1 The methods of manufacture of double cold-reduced tinplate are the province of the producer.

4.2 The methods of using double cold-reduced tinplate are the province of the user.

4.3 The tin used for the coating shall have a purity of not less than 99,75 %.

4.4 The chemical composition of the steel may be agreed upon between the producer and the purchaser provided that it is consistent with this part of ISO 4977 (see clause 15).

4.5 At the time that it is made available by the producer and under normal conditions of transport and storage, double cold-reduced tinplate is suitable for surface treatments such as established lacquering and printing operations. Appropriate grades are suitable for folding, bending and assembly work such as joint forming, soldering and welding, but caution is necessary when considering certain applications due to the ductility and directional properties of double cold-reduced tinplate. The purchaser's order requirements shall be consistent with the end use of the product.

4.6 Surface finishes

Double cold-reduced electrolytic tinplate is customarily supplied with a finish imparted to the strip by use of ground work rolls in the final stages of double reduction and by a flow-brightened tin coating. The product may also be available with an unmelted tin coating.

4.7 Surface treatments

4.7.1 Passivation treatment

Passivation is a chemical or electrochemical treatment applied to the surface of electrolytic tinplate to produce a surface of improved resistance to discolouration and superior lacquering and printing quality. The usual procedure is cathodic treatment in a solution of sodium dichromate [see 15d)].

4.7.2 Oiling

Normally the surface of electrolytic tinplate has applied to it a very thin coating of an oil which is suitable for food packaging [see 15a)].

NOTES

1 When ordering double cold-reduced tinplate, it is recommended that the purpose for which the double cold-reduced tinplate is intended be stated. Double cold-reduced tinplate is relatively less ductile (when compared with single-reduced products) and has very distinct directional properties.

When double cold-reduced tinplate is used for built-up can bodies, it is essential that the rolling direction should be around the circumference of the can so as to minimize the hazard of flange cracking. In such cases it is imperative that the rolling direction be clearly designated on the contract.

2 It is recommended that, if requested, the producer supply to the purchaser such details of the steel making process as may assist the purchaser in his efficient use of the material. It is further recommended that the purchaser be informed of any alterations in the method of manufacture which will significantly affect the properties of the purchased product. Similarly it is recommended that the purchaser informs the producer of modifications to the fabrication methods which will significantly affect the way in which the purchased product is used.

5 Material grading

5.1 Double cold-reduced electrolytic tinplate, standard grade

Standard grade double-cold-reduced electrolytic tinplate represents the normal production of lines employing the usual inspection and classification procedures. In normal conditions of storage and use, standard grade double cold-reduced electrolytic tinplate permits lacquering and printing over the entire surface.

NOTES

1 The surface appearance of double cold-reduced electrolytic tinplate is different from and not so consistent as that of single cold-reduced electrolytic tinplate.

2 Double cold-reduced electrolytic tinplate, second grade, is available in certain countries. It represents the best sheets rejected from the standard grade but may contain sheets exhibiting surface imperfections, tinning defects and shape and other defects to a minor extent (but not pinholes or off-thickness material). Suitability for lacquering and printing over the entire surface is not guaranteed.

6 Tin-coating masses

6.1 Expression of tin-coating masses

Tin-coating masses shall be expressed in grams per square metre (g/m^2).

6.2 Double cold-reduced electrolytic tinplate, equally coated

A number of coating masses are specified as shown in table 1.

Table 1 — Coating masses for double cold-reduced tinplate, equally coated

Designation[1)]	Nominal coating mass,[1)] g/m^2		Minimum average coating mass (see 6.4), g/m^2
	Per surface	Total both surfaces	Total both surfaces
E 2,8/2,8	2,8	5,6	4,9
E 5,6/5,6	5,6	11,2	10,5
E 8,4/8,4	8,4	16,8	15,7
E 11,2/11,2	11,2	22,4	20,2

1) The conventional designation corresponds to the nominal coating mass on each surface of the tinplate.

6.3 Double cold-reduced electrolytic tinplate, differentially coated

A number of coating masses are specified in table 2.

Table 2 — Coating masses for double cold-reduced tinplate, differentially coated

Designation[1)]	Nominal coating mass,[1)] g/m^2		Minimum average coating mass (see 6.4), g/m^2	
	Heavily coated surface	Lightly coated surface	Heavily coated surface	Lightly coated surface
D 5,6/2,8	5,6	2,8	4,75	2,25
D 8,4/2,8	8,4	2,8	7,85	2,25
D 8,4/5,6	8,4	5,6	7,85	4,75
D 11,2/2,8	11,2	2,8	10,1	2,25
D 11,2/5,6	11,2	5,6	10,1	4,75

1) The conventional designation corresponds to the nominal coating mass on each surface of the tinplate.

6.4 The average value of the coating masses of the sample selected to represent a consignment in accordance with clause 9 and tested in accordance with clause 10 shall not be lower than the appropriate minimum average coating mass specified in tables 1 or 2.

NOTES

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

2 In practice, the producer aims to apply the nominal coating mass, the minimum average coating mass values only occasionally being encountered.

6.5 Marking of differentially coated double reduced tinplate

In order to distinguish material having differential coatings, the sheet should be marked on one surface which, by agreement, can be either the lightly or the heavily coated surface. In all cases, both the surface to be marked and the surface which is to be piled uppermost should be clearly designated on the contract by the purchaser. Generally the marking system should be made on the heavier coated surface in the form of dull straight continuous parallel lines about 1 mm wide (see annex A). If the marking is on the lighter coated surface, then at least alternate lines should be interrupted, or geometrical patterns may be used.

7 Mechanical properties

7.1 No test or group of tests has been developed that adequately predicts all the factors affecting the fabricating performance of double-cold reduced electrolytic tinplate, the primary consideration being that the plate shall perform satisfactorily for the stated end use. Designations for mechanical properties arranged in generally ascending levels of strength are shown in table 3, though it is not technologically appropriate to define these to exacting limits.

7.2 The tensile test (see clause B.1 in annex B) or, when agreed between the producer and the purchaser, the springback test (see clause B.2 in annex B) or the Rockwell superficial hardness test (see clause B.3 in annex B) shall be used for evaluation of mechanical properties. The samples shall be selected in accordance with clause 8. Average values and not individual values shall be considered.

7.3 The purchaser shall select the classification he requires from table 3 and the producer shall aim to meet the values specified as appropriate.

Table 3 — Mechanical properties

Classification	Proof stress (0,2 % non-proportional elongation[1]) longitudinal, N/mm²	Rockwell hardness HR 30T
DR 550 (DR 8)	550 ± 70	73 ± 3
DR 620 (DR 9)	620 ± 70	76 ± 3
DR 660 (DR 9M)	660 ± 70	77 ± 3

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

8 Dimensional requirements

8.1 Thickness

8.1.1 Nominal thickness

Double cold-reduced electrolytic tinplate ordered in metric thicknesses is normally available in any nominal thickness which is a multiple of 0,01 mm from 0,14 mm up to and including 0,29 mm.

8.1.2 The producer shall aim to produce the thickness ordered.

8.1.3 Determination of thickness

8.1.3.1 The average thickness of the consignment may be determined by weighing whole sheets, or by direct measurement using a micrometer. When the weighing technique is used, the mass of each whole sheet is determined, its area is measured, and the thickness determined by applying the formula given in 8.1.3.2.

The mass of the sheet shall be determined to a precision of 2 g and the dimensions of the sheet shall be measured to a precision of 0,5 mm. The thickness shall be stated to the nearest 0,001 mm.

If the average thickness of a consignment is to be determined by direct measurement, a hand operated spring loaded micrometer shall be used. It shall be accurate to 0,001 mm. The measurement of thickness shall be carried out at least 10 mm from the trimmed edge.

In any case of dispute, retesting of thickness by the weighing method only shall be employed.

NOTE — It is recommended that when a micrometer is used it 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.

8.1.3.2 Thickness shall be calculated by applying the formula

$$d = \frac{m}{S \times 0{,}007\,85}$$

where

d is the thickness of the sheet, in millimetres;

m is the mass of the sheet, in grams;

S is the actual area of the sheet in square millimetres.

8.1.3.3 For determining the variation of thickness within a sheet, using the specimens Y (see figure 3), either the weighing or the direct measurement technique may be employed. If the former, the thickness of each of the specimens Y shall be determined by weighing the specimen, measuring the area and applying the formula given in 8.1.3.2 above.

The mass of the specimens shall be determined to a precision of 0,01 g or better, and the dimensions of the specimen shall be measured to a precision of 0,1 mm. The thickness shall be to the nearest 0,001 mm.

If the variation in thickness is determined by direct measurement, the micrometer to be used shall be as defined in 8.1.3.1 and the specimen Y (see figure 3) shall be measured at two locations. The thickness shall be stated to the nearest 0,001 mm.

8.1.3.4 Transverse thickness profile (feather edge) — A term used to define the reduction in sheet thickness at right angles to the rolling direction, close to the edge. It is measured at a location 6 mm from the mill trimmed edge of the sheet by a hand micrometer or other suitably precise means agreeable to both manufacturer and purchaser.

8.1.4 Thickness tolerances

8.1.4.1 The thickness of each sheet selected in accordance with 9.2.3 shall be measured as described in 8.1.3. The average thickness of a consignment shall be represented by the arithmetic mean of all the specimen sheets tested.

8.1.4.2 The value of the arithmetic mean shall not deviate from the nominal thickness by more than :

a) ± 2,5 % for a consignment of more than 20 000 sheets; or

b) ± 4 % for a consignment of 20 000 sheets or less.

8.1.4.3 Tolerances on nominal thickness of individual sheets

No sheet among those selected in accordance with 9.2.3 and measured as described in 8.1.3 shall deviate from the nominal thickness by more than

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

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

Table 4 — Ordered thickness and thickness tolerances

Dimensions in millimetres

Ordered thickness	Tolerance
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

Any sheets not meeting the requirements of table 4 are subject to rejection.

8.1.4.4 Tolerances on local thickness within a sheet

The thickness of either of the two individual specimens determined in accordance with 8.1.3.3 shall not deviate from the actual average thickness of the whole sheet determined in accordance with 8.1.3.1 by more than 4 %.

8.1.4.5 Transverse thickness profile tolerance

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

8.2 Linear dimensions of sheets

8.2.1 Determination of linear dimensions

The measurements shall be made on the sample selected in accordance with 9.2.3, the sheets being laid on a flat surface. The measurement of length and width to the nearest 0,5 mm shall be made across the centre of the sheet.

8.2.2 Size of sheet

Each sheet shall be such that a rectangle of the ordered dimensions is available in it.

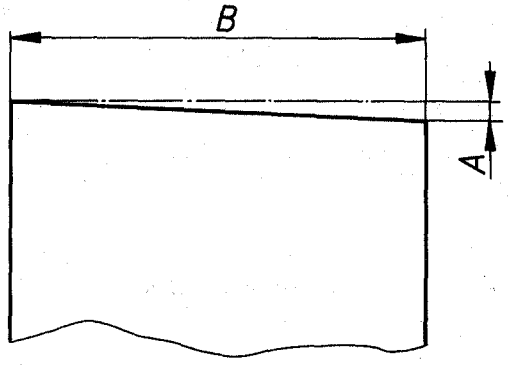
8.2.3 Tolerances on linear dimensions

Each sheet in the sample shall be of not less than the ordered dimensions. It is trimmed on both edges and the trimmed (coil width) dimension shall not exceed the ordered dimension by more than 3 mm. Normally the drum cut dimension will not exceed the ordered dimension by more than 3 mm, but in no case shall it exceed the ordered dimension by more than 5 mm.

8.3 Out-of-squareness tolerance

Out-of-squareness is the deviation of an edge from a straight line drawn at a right angle to the other edge of the sheet, touching one corner and extending to the opposite edge.

For each sheet in the sample the out-of-squareness will not normally exceed 0,15 % but in no circumstances shall it exceed 0,25 %.



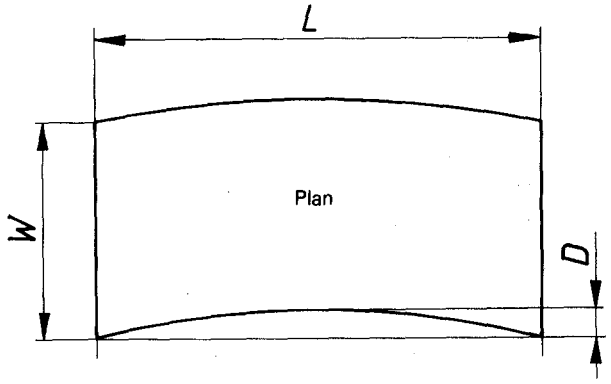
$$\text{Out-of squareness, \%} = \frac{A}{B} \times 100$$

Figure 1 — Measurement of out-of-squareness

8.4 Camber tolerance

Camber is the deviation of an edge from a straight line forming a chord to it. Camber expressed as a percentage is defined as

$$\frac{D}{L} \times 100$$



W is the rolling width

L is the length of chord

D is the deviation

Figure 2 — Camber of sheet

For each sheet in the sample the camber shall not exceed 0,15 %.

NOTE — Other geometrical features may be present in double cold-reduced tinplate sheets, 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 remaining along the direction of rolling;

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

Although it is not possible at present to define methods of measuring or to specify limits for these geometrical features, certain of which are subjective 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 variation of the longitudinal bow.

9 Sampling

If tests are made to ascertain compliance with the requirements of this part of ISO 4977, the following procedure shall be adopted.

9.1 Number of bulk packages

As the number of sheets per bulk package can vary e.g. between 1 000 and 2 000, the rate of sampling is specified on a percentage basis (other than for verification of properties).

For consignments comprising less than four bulk packages, each bulk package shall be sampled individually. For other size consignments, bulk package samples shall be selected at random, at the rate of 20 % of the total number of bulk packages, subject to a minimum of four bulk packages.

9.2 Number of sheets

9.2.1 Verification of grades

From each of the bulk packages selected in accordance with 9.1, sheets at the rate of 1 % per bulk package shall be taken at random and inspected. In cases of dispute further sheets at the rate of 5 % per bulk package shall be taken at random and inspected (see clause 12).

9.2.2 Verification of properties

From each of the bulk packages selected in accordance with 9.1, two sheets shall be taken for checking the tin coating mass and mechanical properties.

9.2.3 Verification of dimensions

From each of the bulk packages selected in accordance with 9.1, sheets at the rate of 0,5 % per bulk package shall be taken at random.

9.3 Location of test specimens

The test specimens shall be taken from the positions indicated in figure 3.

10 Determination of tin-coating masses

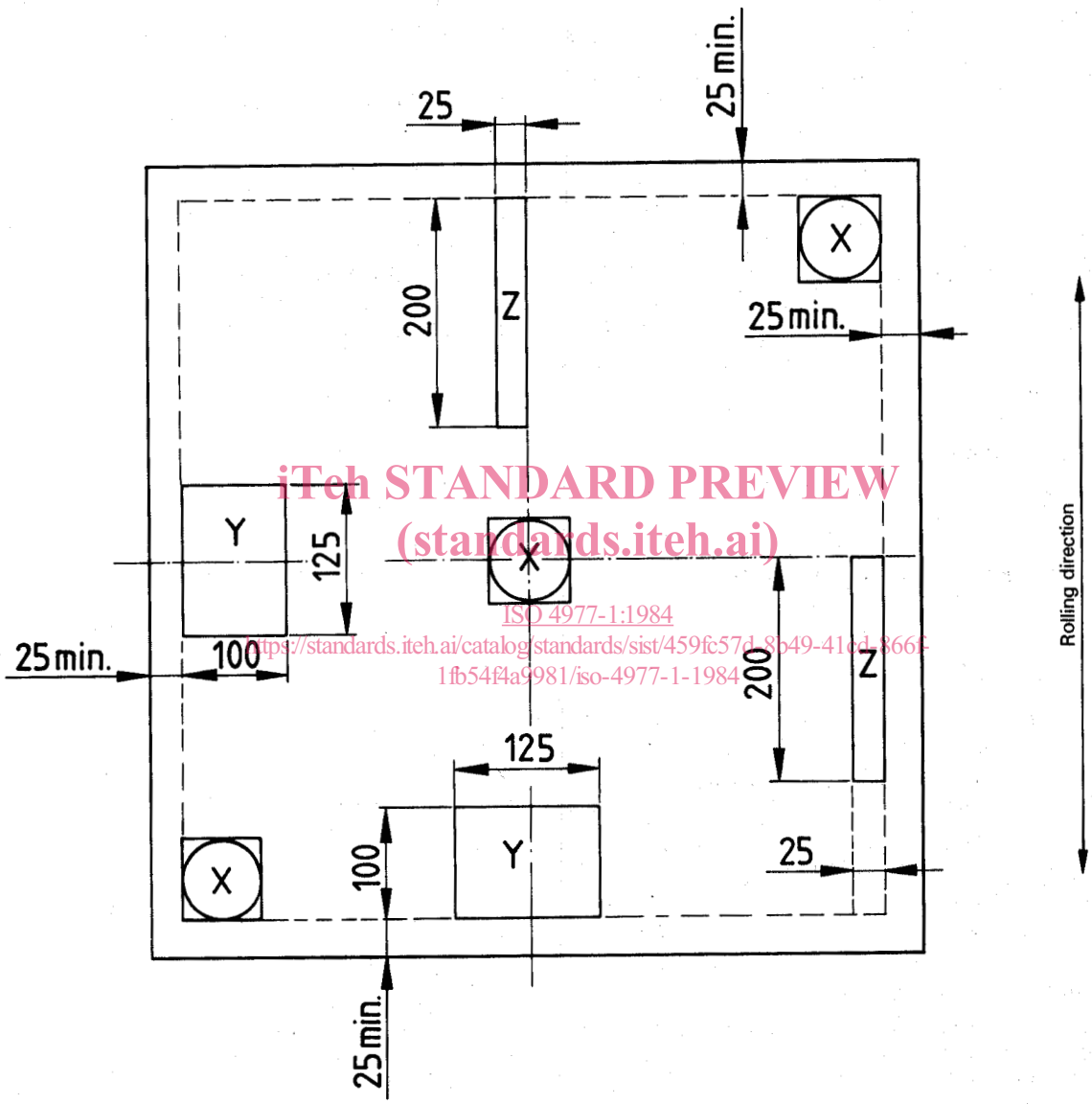
10.1 Specimens

For tin-coating mass determinations, from each sheet selected in accordance with clause 9, 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 shall be selected either one from the centre of the sheet and the other two from diagonally opposed corners (position X on figure 3) or, for routine purposes, at edge-centre-edge locations in a line at right angles to the rolling (tinning) direction. The edge specimens shall clear the edges of the sheet by 25 mm.

10.2 Method of determination

The tin-coating mass may be determined by any of the recognized and accepted analytical methods (but see 12.2). The value shall be expressed in grams of tin per square metre to the nearest 0,1 g/m^2.

Dimensions in millimetres



X — specimens for tin-coating mass tests

Y — specimens for hardness tests and determination of local thickness within a sheet

Z — specimens for tensile tests or springback tests

Figure 3 — Position of test specimens

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.

11 Determination of proof stress ($R_{p\,0,2}$) and hardness

11.1 Introduction

Two methods of determining the proof stress values of double cold-reduced tinplate are available. The first, the conventional tensile test, provides a 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. For routine purposes this latter test is considered generally to be adequate.

11.2 Tensile test

For determination of proof stress by the tensile test procedure for each sheet selected in accordance with clause 9, two rectangular specimens approximately 200 mm × 25 mm wide shall be cut with the rolling direction parallel to the length of the specimen at positions marked Z in figure 3. The edge specimens shall clear the edges of the sheet by a minimum of 25 mm. A measurement shall be made on each of the specimens (i.e. 2 measurements per sheet selected). The test is carried out in accordance with the method described in ISO 6892, but paying particular attention to the precautions necessary (see clause B.1 in annex B).

11.3 Springback test

For determination of proof stress by the springback method for each sheet selected in accordance with clause 9, two rectangular specimens approximately 150 mm long × 25 mm wide shall be cut with the rolling direction parallel to the length of the specimen at positions marked Z in figure 3. A measurement is made on each of the specimens (i.e. 2 measurements per sheet selected). The test is carried out using the Springback temper tester model G-67 described in clause B.2 in annex B, special care being exercised in specimen preparation. The method consists of forming the specimen 180° around a 25 mm diameter mandrel and allowing it to spring back. The amount of the springback angle and the thickness of the specimen are then used to obtain the springback index in terms of the proof stress from a suitable conversion formula (e.g. Bower) agreed between producer and purchaser.

NOTE — In the case of both 11.2 and 11.3 it is unnecessary to de-tin the test specimen but all other coatings such as lacquers, varnishes and printing inks shall be removed from the surface prior to testing. Additionally, attention is drawn to the effects of heat-treatment during lacquering/printing which may influence results of mechanical property tests.

11.4 Hardness test

For determination of hardness, for each sheet selected in accordance with clause 9 two rectangular specimens 100 mm × 125 mm shall be cut from the middles of adjacent sides i.e. at positions marked Y in figure 3.

Three measurements are made on each of the specimens (i.e. six measurements per sheet selected). The HR 30T (or HR 15T) test is carried out as outlined in clause B.3 in annex B.

On relatively thin plate (e.g. 0,22 mm and thinner) the hardness tests shall be made using the HR 15T test, in which case the values obtained shall be converted using the table given in clause B.3 in annex B.

NOTE — In the case of each of the parameters outlined in 11.2, 11.3, and 11.4, the average value of a consignment is the arithmetic mean of all the values so obtained.

12 Retests

12.1 Material grades

In the event of the sample selected in accordance with clause 9 failing to meet the requirements of clause 5, a further set of samples selected from other bulk packages at the rate of 5 % per bulk package shall be taken at random and inspected. If the retest is satisfactory, the consignment shall be deemed to meet the requirements of this part of ISO 4977, but if the retest fails the consignment shall be deemed not to meet the requirements of this part of ISO 4977.

12.2 Tin-coating masses

In the event of the average tin-coating mass failing to meet the specified requirements, two further sets of samples from other bulk packages shall be selected as specified in clause 9 and specimens taken as described in 10.1. 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 fails the consignment shall be deemed not to meet the requirements of this part of ISO 4977.

The retest determination shall be made using the iodine titration reference method specified in annex C.

12.3 Mechanical properties

If the initial test result is deemed to be inconsistent with the appropriate value in table 3, then a suitable procedure for retesting should be agreed between the producer and purchaser. In cases of dispute, only the tensile test shall be used.

12.4 Dimensional tests

If the result of any dimensional check is unsatisfactory, a further check shall be made on two further sets of samples selected from other bulk packages according to the procedure outlined in clause 9. 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 checks fails to meet the relevant requirements, the consignment represented shall be deemed not to comply with this part of ISO 4977.

NOTE — In case of dispute involving the average thickness of a consignment and/or variation of thickness within a sheet, the weighing method only shall be used.