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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 1111

COLD-REDUCED TINPLATE AND COLD-REDUCED BLACKPLATE

PART 1

SHEET

1st EDITION

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BRIEF HISTORY

The ISO Recommendation R 1111, *Cold-reduced tinplate and cold-reduced blackplate – Part 1 : Sheet,* was drawn up by Technical Committee ISO/TC 17, *Steel,* the Secretariat of which is held by the British Standards Institution (BSI).

Work on this question led to the adoption of a Draft ISO Recommendation.

In December 1967, this Draft ISO Recommendation (No. 1374) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia	Germany	South Africa, Rep. of
Austria	Hungary	Spain
Belgium	India	Sweden
Brazil	Israel	Switzerland
Canada	Italy	Thailand
Chile	Japan	Turkey
Colombia	Netherlands	U.A.R.
Czechoslovakia	New Zealand	United Kingdom
Denmark	Norway	U.S.A.
Finland	Poland	U.S.S.R.
France	Romania	

No Member Body opposed the approval of the Draft.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in September 1969, to accept it as an ISO RECOMMENDATION.

ISO Recommendation | R 1111 | September 1969

COLD-REDUCED TINPLATE AND COLD-REDUCED BLACKPLATE

PART 1

SHEET

SECTION I

GENERAL

1. SCOPE

1.1 This ISO Recommendation applies to cold-reduced tinplate sheet in low carbon mild steel in nominal thicknesses from 0.15 mm (0.0060 in) up to and including 0.49 mm (0.0193 in) and to cold-reduced blackplate sheet in low carbon mild steel in nominal thicknesses from 0.15 mm (0.0060 in) up to and including 0.49 mm (0.0193 in).

1.2 Thicknesses of tinplate and blackplate outside the ranges specified in clause 1.1 may be supplied by agreement between the manufacturer and the purchaser.

1.3 This ISO Recommendation does not apply to tinplate or blackplate in coils, or to double reduced tinplate or blackplate, or to material described commercially as tinned sheets or steel sheets.

2. DEFINITIONS

For the purpose of this ISO Recommendation the following definitions apply :

2.1 *Tinplate.* Low carbon mild steel sheet coated on both faces with tin, applied either by dipping in molten tin or by electro-deposition.

Tinplate produced by the hot-dipping process is called hot-dipped tinplate; that produced by electro-deposition is called electrolytic tinplate.

2.2 *Blackplate.* Low carbon mild steel sheet, not tinned, and normally not oiled or otherwise treated.

2.3 *Differentially coated tinplate.* Electrolytic tinplate, one surface of which carries a heavier tin coating than the other.

2.4 *Minimum average coating weight.* The minimum average coating weight values as shown in Tables 1, 2 and 3 represent the minimum permissible values for the arithmetic mean of a sample selected in accordance with Section II, clause 4, and determined in accordance with Section II, clause 5.

2.5 *Consignment.* A quantity of tinplate or blackplate of the same dimensions and quality made available for despatch at the same time.

3. CONDITIONS OF MANUFACTURE

3.1 The method of manufacture of tinplate and blackplate are the province of the producer.

3.2 The methods of using tinplate and blackplate are the province of the consumer.

3.3 The tin used for the coating of tinplate should have a purity of not less than 99.75 %.

3.4 For special applications, limits on the chemical composition of the steel can be agreed between the manufacturer and the purchaser provided they are consistent with this ISO Recommendation (see Section IV).

NOTES

1. When ordering tinplate and blackplate it is recommended that the purpose of manufacture for which the tinplate or blackplate is intended should be stated. When he so requires, the purchaser should indicate to the manufacturer the direction of rolling required by underlining the rolling width dimension.

2. It is recommended that the purchaser should be informed of any alterations in the method of manufacture which will significantly affect the properties of the purchased product. Similarly, the purchaser should inform the manufacturer of modifications in his fabrication methods which will significantly affect the way in which the purchased product is used.

4. USAGES

Under normal conditions of storage and transport, tinplate and blackplate are suitable for surface treatments such as lacquering and printing. Appropriate grades and tempers are also suitable for shaping operations such as stamping, drawing, folding and bending, and assembly work such as joint forming, soldering (tinplate only) and welding.

SECTION II

QUALITY REQUIREMENTS

1. GRADES

1.1 Hot-dipped tinplate

After coating, hot-dipped tinplate is inspected and graded as follows :

1.1.1 *First grade or primes.* Tinplates which at the time of despatch are free from defects readily visible to the unaided eye. In normal conditions of storage and use they are suitable for lacquering or printing over the entire surface of the sheet.

1.1.2 *Second grade or seconds.* Tinplates which at the time of despatch have visible imperfections of moderate magnitude or frequency. Lacquering or printing over the entire surface of the sheet cannot be guaranteed.

NOTE. – The term "standard grade" is applied to hot-dipped tinplate which is inspected during processing and from which material not of first or second grade is rejected. The accepted material, however, is not segregated into first and second grades.

1.2 Electrolytic tinplate, standard grade

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

NOTE. – 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 and tinning defects. Suitability for lacquering and printing over the entire surface is not guaranteed.

1.3 Blackplate

Blackplate is line inspected during processing. Material having visible imperfections of only moderate magnitude or frequency is included. Blackplate is liable to rust but, at the time it is made available by the manufacturer, the material is suitable for normal lacquering and printing over the entire surface.

NOTE. – Second grade. In certain countries, blackplate rejected during line inspection for only minor defects is available as second grade. Suitability for lacquering or printing over the entire surface is not guaranteed.

2. TIN COATING WEIGHTS

2.1 Expression of tin coating weights

The tin coating weights should be expressed in grammes per square metre.

2.2 Hot-dipped tinplate

2.2.1 Four coating weights are specified as shown in Table 1. The values stated represent the total weight (mass) of tin on both surfaces of a tinplate sheet of area 1 m^2.

TABLE 1 – **Coating weights for hot-dipped tinplate**

Code*	Nominal coating weight*	Minimum average coating weight (see clause 2.4 of Section I and clause 2.2.3 of Section II)
	g/m^2	g/m^2
H12/12	24.0	21.0
H14/14	28.0	24.6
H15/15	30.0	26.0
H17/17	33.6	28.0

* The code figures are derived from the nominal coating weight on each surface of the tinplate. In hot-dipped tinplate it is not possible, as for electrolytic tinplate, intentionally to vary the distribution between the two surfaces and the total coating is assumed to be equally divided between the two surfaces.

2.2.2 Other coating weights may be supplied by agreement between the manufacturer and the purchaser.

2.2.3 The average value of the coating weights of the sample selected to represent a consignment in accordance with clause 4 of this Section and tested in accordance with clause 5 of this Section should not be lower than the appropriate minimum average coating weight specified in Table 1.

NOTE. – On the individual specimens of the sample the check may show tin coatings as low as, for example, 60 % of the nominal coating weight, but it is emphasized that isolated specimens have no representative value in relation to the consignment under consideration.

2.3 Electrolytic tinplate, equally coated

2.3.1 Four coating weights are specified as shown in Table 2.

TABLE 2 – **Coating weights for electrolytic tinplate – equally coated**

Code*	Nominal coating weight*	Minimum average coating weight (see clause 2.4 of Section I and clause 2.3.3 of Section II)
	g/m^2	g/m^2
E2.8/2.8	5.6 (2.8/2.8)	4.9
E5.6/5.6	11.2 (5.6/5.6)	10.5
E8.4/8.4	16.8 (8.4/8.4)	15.7
E11.2/11.2	22.4 (11.2/11.2)	20.2

* The code figures are derived from the nominal coating weight on each surface of the tinplate. The nominal coating weight values refer to the total weight (mass) of coating on both surfaces; thus the nominal coating weight on each surface is half the stated value, for example, E2.8/2.8 has 2.8 g/m^2 on each surface and a total of 5.6 g/m^2 on both surfaces.

2.3.2 Other coating weights can be supplied by agreement between the manufacturer and the purchaser.

2.3.3 The average value of the coating weights of the sample selected to represent a consignment in accordance with clause 4 of this Section and tested in accordance with clause 5 of this Section should be lower than the appropriate minimum average coating weight specified in Table 2.

NOTE. – On the individual specimens of the sample the check may show tin coatings as low as, for example, 80 % of the nominal coating weight, but it is emphasized that isolated specimens have no representative value in relation to the consignment under consideration.

2.4 Electrolytic tinplate, differentially coated

2.4.1 Four coating weights are specified as shown in Table 3.

TABLE 3 – **Coating weights for electrolytic tinplate – differentially coated**

Code*	Nominal coating weight*	Minimum average coating weight (see clause 2.4 of Section I and clause 2.4.3 of Section II)
	g/m^2	g/m^2
D8.4/2.8	8.4/2.8	7.85/2.25
D11.2/2.8	11.2/2.8	10.1/2.25
D11.2/5.6	11.2/5.6	10.1/4.75
D15.1/5.6	15.1/5.6	13.4/4.75

* The code figures are derived from the nominal coating weight on each surface of the tinplate. The nominal coating weight values refer to the nominal weight (mass) of coating on each surface, for example, D8.4/2.8 has 8.4 g/m^2 on one surface and 2.8 g/m^2 on the other.

2.4.2 Other coating weights can be supplied by agreement between the manufacturer and the purchaser.

2.4.3 The average value of the coating weights of the sample selected to represent a consignment in accordance with clause 4 of this Section and tested in accordance with clause 5 of this Section should not be lower than the appropriate minimum average coating weight specified in Table 3.

NOTE. – On the individual specimens of the sample the check may show tin coating weights as low as, for example, 80 % of the nominal coating weight, but it is emphasized that isolated specimens have no representative value in relation to the consignment under consideration.

2.5 Marking of differentially coated tinplate

2.5.1 In order to distinguish material having differential coatings, the sheet should be marked on one face. Usually it is marked on the face carrying the heavier coating, but by arrangement the marking can be on the lighter coated face. In all cases the code number is written with the marked face first and the face which is to be piled uppermost should be indicated by underlining the code number of the corresponding coating weight.

The marking should be in the form of dull straight parallel lines about 1 mm (0.04 in) wide. If the marking is on the more heavily coated face all the lines should be continuous; if on the lighter coated face at least the alternate lines should be broken.

2.5.2 If it is desired to indicate the coating weight combination by surface marking, the system detailed in Appendix Y is recommended.

3. TEMPER CLASSIFICATIONS

3.1 The term "temper", when applied to tinplate and blackplate, summarizes a combination of inter-related mechanical properties and no single mechanical test can measure all the various factors which contribute to the fabrication characteristics of the material. However, the Rockwell 30T hardness test (HR 30T) is the best single test available and serves as a guide to the properties of the material. This test forms the basis for a system of temper classification as shown in Tables 4 and 5, which give the hardness values at which the manufacturer should aim.

3.2 The Rockwell hardness values shown in Tables 4 and 5 are for tests performed with a diamond anvil on tinplate after de-tinning. For a given temper classification, the corresponding HR 30T values for blackplate may be as much as 4 units lower, depending on the age of the material and the conditions of storage.

3.3 The hardness of tinplate and blackplate should be determined on samples selected in accordance with clause 4 of this Section and tested in accordance with clause 6 of this Section. When evaluating the hardness of tinplate and blackplate, average values and not individual values should be considered.

3.4 The Rockwell hardness test is sensitive to the "anvil" effect and hence is affected by the thickness of the test specimen. The values in Tables 4 and 5 are typical for nominal thicknesses in the range of 0.26 to 0.30 mm (0.0099 to 0.0118 in). Material of the same metallurgical quality in 0.22 mm (0.0088 in) thickness, for instance, would be one HR 30T unit higher and material of 0.43 mm (0.0171 in) thickness, one unit lower. Thinner material, for example 0.17 mm (0.0066 in), may be 2 units higher.

3.5 The purchaser should specify the temper required by reference to the appropriate temper classification as set out in Table 4 or 5.

TABLE 4 – **Rockwell HR 30T hardness values normally associated with the temper classifications of batch annealed tinplate**

Temper classification	Rockwell HR 30T hardness aim	
	Mean	Maximum deviation of sample average
T 50	← 52 max. →	
T 52	52	± 4
T 57	57	+ 4 – 3
T 61	61	± 4
T 65	65	+ 3 – 4
T 70	70	+ 3 – 4

TABLE 5 – **Rockwell HR 30T hardness values normally associated with the temper classifications of continuously annealed tinplate**

Temper classification	Rockwell HR 30T hardness aim	
	Mean	Maximum deviation of sample average
CA 61	61	± 4
CA 65	65	+ 5 – 4
CA 70	70	+ 3 – 4

3.6 Other tempers of batch annealed or continuously annealed tinplate may be supplied by agreement between the manufacturer and the purchaser.

3.7 The mechanical properties of continuously annealed tinplate and blackplate and batch annealed material of the same HR 30T hardness are not identical.

4. SELECTION OF SAMPLE SHEETS

If tests are made to ascertain compliance with the requirements of this ISO Recommendation, the following procedure should be adopted.

4.1 Number of bulk packages

For sampling purposes each bulk package should be considered as containing approximately 1000 sheets.

For consignments comprising less than four bulk packages, each bulk package should be sampled individually. For consignments comprising any number of sheets from 4000 up to and including 20 000, i.e. four to twenty bulk packages, four bulk packages should be selected at random.

For consignments of more than 20 000 sheets, bulk package samples should be taken at random at the rate of four for every 20 000 sheets or part thereof.

4.2 Number of sheets

4.2.1 *Verification of grades.* From each of the bulk packages selected in accordance with clause 4.1, fifty sheets should be taken at random and inspected.

4.2.2 *Verification of properties*

(*a*) HOT-DIPPED TINPLATE. From each of the bulk packages selected in accordance with clause 4.1, two sheets should be taken for checking the tin coating. One of these should also be used to check the hardness.

(*b*) ELECTROLYTIC TINPLATE. From each of the bulk packages selected in accordance with clause 4.1, one sheet should be taken for checking the tin coating and hardness.

(*c*) BLACKPLATE. From each of the bulk packages selected in accordance with clause 4.1, one sheet should be taken for checking the hardness.

4.3 Location of test specimens

The test specimens should be taken from the positions indicated in Figure 1.

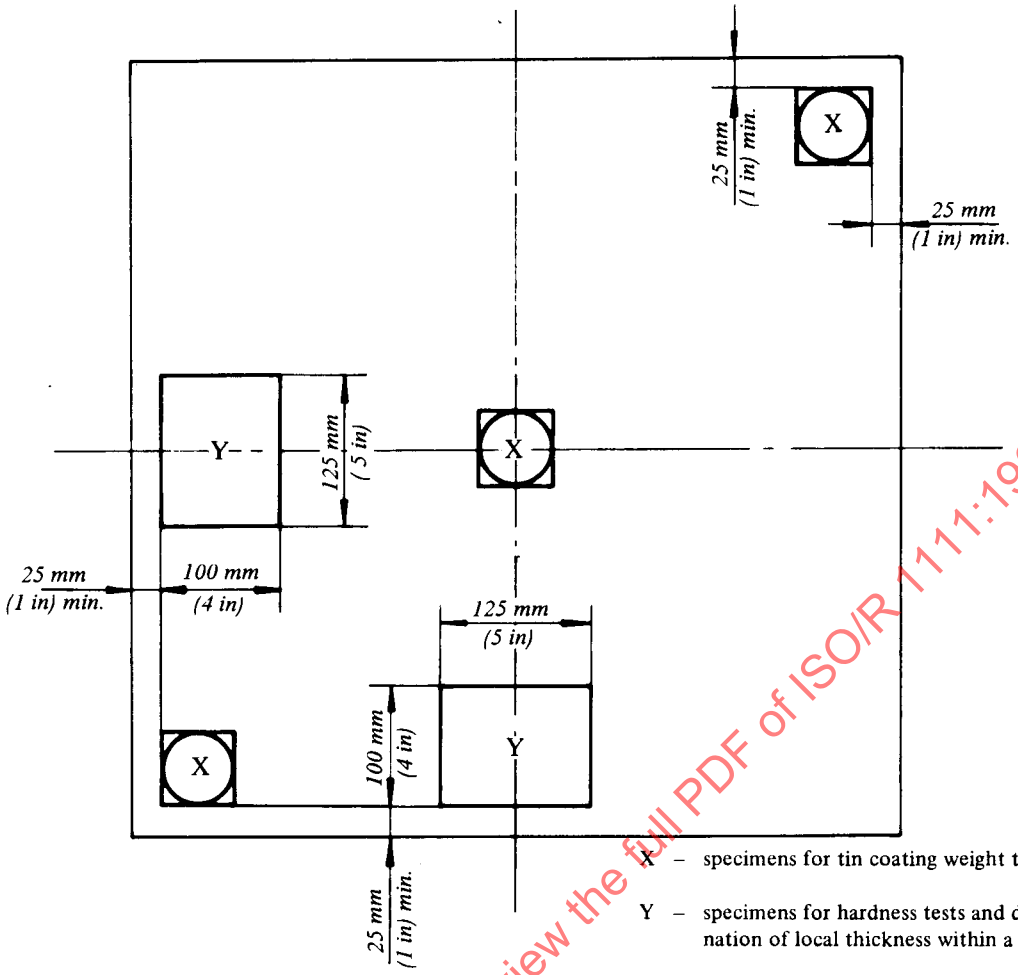


FIG. 1. – **Position of test specimens**

5. DETERMINATION OF TIN COATING WEIGHT

5.1 Specimens

For tin coating weight determination, from each sheet selected in accordance with clause 4 of this Section, three specimens each of an area not less than 25 cm^2 (4 in^2), and preferably in the form of disks, should be accurately punched, one from the centre of the sheet and the other two from diagonally opposed corners (positions X on Figure 1). The edge specimens should clear the edges of the sheet by a minimum of 25 mm (1 in).

5.2 Method of determination

The tin coating weight may be determined by any of the recognized and accepted analytical methods. The value should be expressed in grammes of tin per square metre to the nearest 0.1 g/m^2.

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

6. DETERMINATION OF HARDNESS

6.1 Specimens

For hardness determinations, from each sheet selected in accordance with clause 4 of this Section, two rectangular specimens 100 mm × 125 mm (4 in × 5 in) should be cut from the middle of adjacent sides (positions Y on Figure 1).

6.2 Hardness test

6.2.1 Three measurements are made on each of the specimens (i.e. six measurements per bulk package selected). The HR 30T test is carried out by the method described in ISO Recommendation R 1024, *Rockwell superficial hardness test (N and T scales) for steel* (see also Appendix W), using the conditions detailed in clause 4.4 (*a*) of that ISO Recommendation and using a diamond anvil. The test is made on the test pieces after chemically or electro-chemically de-tinning. The average value is the arithmetic mean of all the values so obtained.

6.2.2 On light gauge plate (e.g. 0.22 mm (0.0088 in) and thinner) the hardness measurements may be made using the HR 15T test in which case the values obtained should be converted using the table given in Appendix W.

7. RETESTS

7.1 Tin coating weight

If any determination fails to meet the specified requirements, two further samples from other bulk packages should be selected as specified in clause 4 of this Section and specimens taken as described in clause 5.1. If both retests are satisfactory, the consignment is deemed to meet the requirements of this ISO Recommendation, but if either of the additional tests fails, the consignment does not meet the requirements of this ISO Recommendation.

The retest determination should be made using the iodine titration reference method specified in Appendix V.

7.2 Hardness tests

In the event of any average hardness test value, determined by the procedure in clause 6 of this Section, failing to meet the appropriate values specified in Tables 4 or 5, a retest should be taken on two further samples selected from other bulk packages according to the procedure outlined in clause 4. If both retests are satisfactory, the consignment is deemed to meet the requirements of this ISO Recommendation, but if the result of either of the retests fails, the consignment does not comply with this ISO Recommendation.

8. PACKAGING AND IDENTIFICATION

8.1 Packaging

Cold-reduced tinplate and blackplate is customarily packed on a wooden stillage platform forming a bulk package weighing between approximately 1000 and 2000 kg (1 and 2 long tons).

The number of sheets in each bulk package should be a multiple of 100.

8.2 Identification

An ISO Recommendation on identification is in course of preparation.

SECTION III

DIMENSIONAL REQUIREMENTS

1. SELECTION OF SAMPLE SHEETS

If tests are made to ascertain compliance with the requirements of this ISO Recommendation, the following procedure should be adopted.

1.1 Sample bulk packages for verification of dimensional requirements are selected in the same way as those for verification of grades and properties, i.e. by the procedure given in Section II, clause 4. In most cases the same bulk packages would be used.

1.2 From each of these selected bulk packages, five sheets should be taken at random.

2. THICKNESS

2.1 Metric thicknesses

Tinplate and blackplate ordered in metric thicknesses are normally available in any nominal thickness which is a multiple of 0.01 mm from 0.15 mm up to and including 0.49 mm.

2.2 Inch thicknesses

Tinplate and blackplate ordered in inch thicknesses are normally available in the nominal inch thicknesses listed in Table 6.

(Appendix X gives the relationship between designations in inches and designations in traditional nomenclature.)

TABLE 6 – Nominal inch thicknesses

0.0060
0.0066
0.0071
0.0077
0.0082
0.0088
0.0093
0.0099
0.0104
0.0110
0.0118
0.0149
0.0171
0.0193

NOTE. – Other thicknesses in inch dimensions may be supplied by agreement between the manufacturer and the purchaser.

2.3 The manufacturer should aim to produce the thickness ordered.

2.4 Determination of thickness

2.4.1 Except when determining the variation within a sheet (see clause 2.4.2, below), thickness is determined by weighing a whole sheet, measuring the area and applying one of the formulae given in clause 2.4.3, below. The mass of the sheet should be determined to a precision of 2 g or 0.005 lb and the dimensions of the sheet should be measured to a precision of 0.5 mm or 0.02 in. The thickness should be stated to the nearest 0.001 mm or 0.0001 in.

2.4.2 For determining the variation of thickness within an individual specimen sheet, the thickness of each of the specimens "Y" (see Fig. 1) should be determined by weighing the specimen, measuring the area and applying one of the formulae given in clause 2.4.3 below.

The mass of the specimens should be determined to a precision of 0.01 g or better and the dimensions of the specimens should be measured to a precision of 0.1 mm or 0.005 in. The thickness should be stated to the nearest 0.001 mm or 0.0001 in.

2.4.3 Thickness should be calculated by applying one of the following formulae :

$$\text{thickness (mm)} = \frac{\text{mass (g)}}{\text{actual area (cm}^2\text{)} \times 0.785}$$

$$\text{thickness (in)} = \frac{\text{mass (lb)}}{\text{actual area (in}^2\text{)} \times 0.283}$$

2.5 Thickness tolerances

2.5.1 The thickness of each sheet selected in accordance with clause 1 of this Section should be measured as described in clause 2.4. The average thickness of a consignment is represented by the arithmetic mean of all the specimen sheets tested.

2.5.2 The value of the arithmetic mean should not deviate from the nominal thickness

- by more than ± 2.5 % for a consignment of more than 20 000 sheets,
- by more than ± 4 % for a consignment of 1500 up to and including 20 000 sheets,
- by more than $^{+6}_{-4}$ % for a consignment of 100 up to but not including 1500 sheets.

2.5.3 *Tolerances on nominal thickness of individual sheets.* No sheet among those selected in accordance with clause 1 and measured as described in clause 2.4 should deviate from the nominal thickness by more than ± 8.5 %.

2.5.4 *Tolerances on local thickness within a sheet.* The thickness of either of the two individual specimens determined in accordance with clause 2.4.2 should not deviate from the actual average thickness of the whole sheet determined in accordance with clause 2.4.1 by more than 4 %.

3. LINEAR DIMENSIONS OF SHEETS

3.1 Determination of linear dimensions

The measurements should be made on the sample selected in accordance with clause 1 of this Section with the sheets being laid on a flat surface. The measurement of length and width to the nearest 0.5 mm (0.02 in) should be made across the centre of the sheet.

3.2 Size of sheet

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

3.3 Tolerances on linear dimensions

Each sheet in the sample should be of not less than the ordered dimensions. Normally no sheet should exceed either dimension by more than 3 mm (1/8 in) and in no circumstances should a sheet exceed the ordered dimension by more than 5 mm (3/16 in).

4. OUT-OF-SQUARE 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 opposide edge.

For each sheet in the sample the out-of-squareness should not normally exceed 0.15 % but in no circumstances should it exceed 0.25 %.

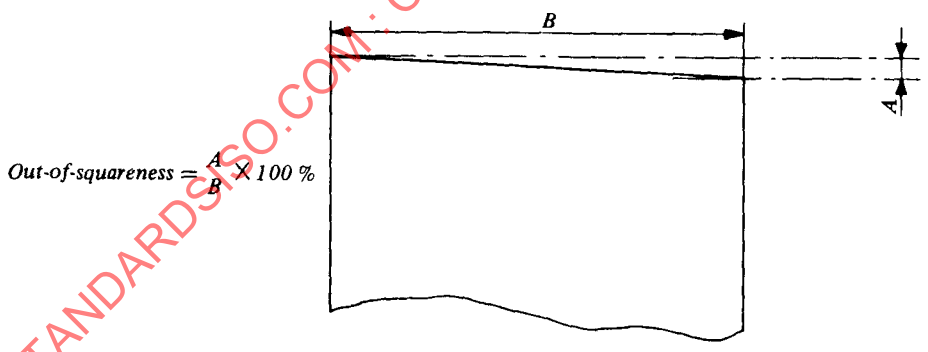


FIG. 2 – **Measurement of out-of-squareness**

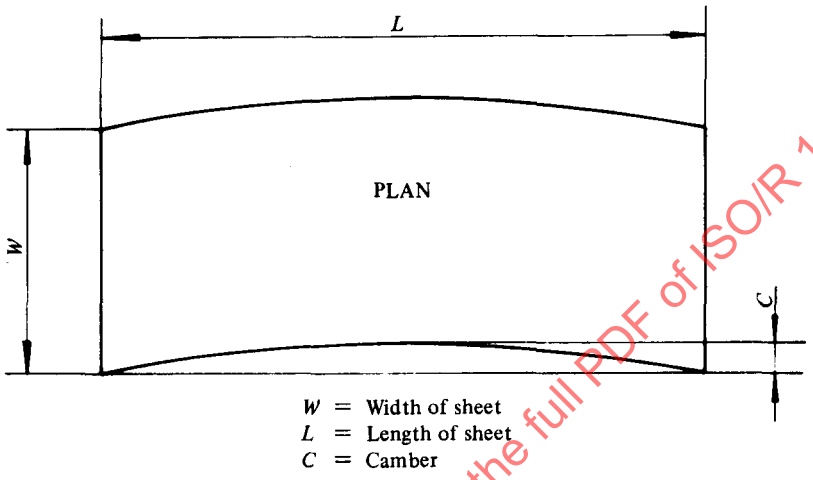
5. CAMBER TOLERANCE

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

Camber is expressed as

$$\frac{\text{deviation}}{\text{length of chord}} \times 100\,\%$$

For each sheet in the sample the camber should not exceed 0.15 %.



W = Width of sheet
L = Length of sheet
C = Camber

FIG. 3 – **Camber of sheet**

6. RETESTS

If the result of any dimensional check is unsatisfactory, a further check should be made on two further samples selected from other bulk packages. If both retests are satisfactory, the consignment should be deemed to meet the requirements of this ISO Recommendation but if either of the additional checks fails to meet the relevant requirements, the consignment represented should be deemed not to comply with this ISO Recommendation.

SECTION IV

SPECIAL ARRANGEMENTS

Special arrangements between the manufacturer and user may contain other provisions, provided they are not inconsistent with this ISO Recommendation.

Examples of such arrangements are as follows :

(*a*) heavy oil coatings (it should be noted that such coatings may affect lacquerability);

(*b*) chemical composition of the steel (for example, limitation of certain elements which may affect performance);

(*c*) utilization of cupping tests;

(*d*) marking of differentially coated tinplate (for example, broken lines may be used to indicate marking on the light-coated face).

APPENDIX V

VOLUMETRIC METHOD FOR DETERMINING TIN COATING WEIGHT (IODINE METHOD)

V.1 PRINCIPLE OF METHOD

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

The effective range of the method is from 2.5 g/m^2 up to 50 g/m^2 and the reproducibility is ± 0.1 g/m^2.

V.2 REAGENTS

All reagents should be of the highest purity obtainable (except the aluminium, where the 99.5 % is preferable) and distilled water should be used throughout. Solutions should be freshly prepared and where necessary filtered.

Reagents V.2.2 to V.2.7 inclusive should be prepared with freshly boiled distilled water, to ensure that the solutions are as free from dissolved oxygen as practicable.

V.2.1 *Hydrochloric acid* (750 g/l). Dilute 750 ml of hydrochloric acid (d = 1.16) to 1000 ml with water.

V.2.2 *Sodium hydrogen carbonate* saturated solution.

V.2.3 *Potassium iodide solution* (100 g/l). Dissolve 10 g of potassium iodide in water and dilute to 100 ml.

V.2.4 *Standard potassium iodate solution*, 0.1 N (solution No. 1). For use with hot-dipped tinplate. Dissolve 3.5670 g of potassium iodate (previously dried to constant mass at 180 °C) in water and dilute to 1000 ml with water. (1 ml of this solution is equivalent to 0.005 935 g of tin).

V.2.5 *Standard potassium iodate solution*, 0.05 N (solution No.2). For use with electrolytic tinplate, equally coated. Dissolve 1.7835 g of potassium iodate (previously dried to constant mass at 180 °C) in water and dilute to 1000 ml with water.

V.2.6 *Standard potassium iodate solution*, 0.025 N (solution No. 3). For use with electrolytic tinplate, differentially coated. Dissolve 0.8918 g of potassium iodate (previously dried to constant mass at 180 °C) in water and dilute to 1000 ml with water.

V.2.7 *Starch.* Make a suspension of 1 g of soluble starch in 10 ml of water and add to 100 ml of boiling water. Boil for two or three minutes and cool.

V.2.8 *Ethyl ether*, technical grade (d = 0.72).

V.2.9 *Platinum wire.* A length of approximately 750 mm of 0.6 mm diameter platinum wire is formed into a flat spiral of two turns and approximately 125 mm diameter. (See Fig. 5).

V.2.10 *Aluminium*, 99.5 % purity (tin-free), as heavy foil, coarse millings or drillings.

V.2.11 *Lacquer.* A suitable air-drying cellulose lacquer.

V.3 APPARATUS

A suitable assembly for carrying out the reduction of tin consists of a 750 ml conical flask marked at a volume of 250 ml and having a neck of about 25 mm (1 in) diameter. The flask is fitted with a rubber bung containing a bent outlet tube and a Contat-Göckel trap. (See Fig. 4.)

Grade A graduated glassware should be used throughout.

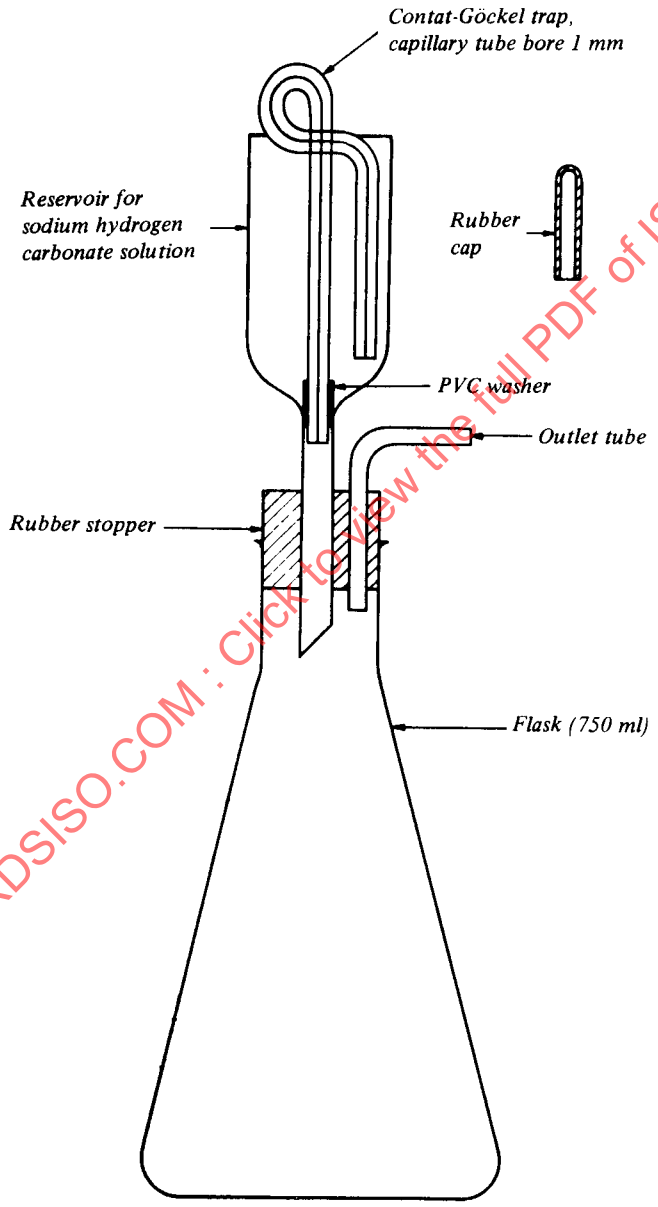


FIG. 4 – **Assembly for reduction of tin**

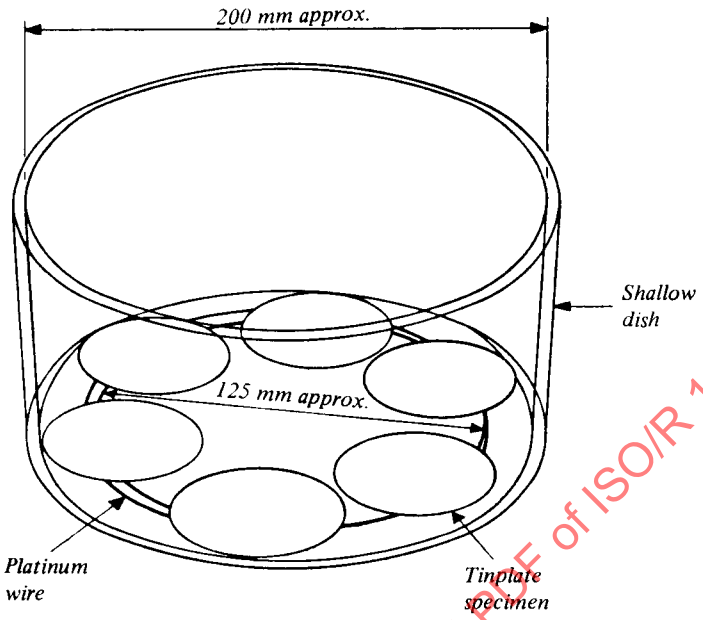


FIG. 5 – **Arrangement of specimens for dissolution of tin**

V.4 PROCEDURE

V.4.1 Hot-dipped tinplate

Degrease with ether (V.2.8) the specimens from eight sheets taken in accordance with Section II, clauses 4 and 5. Place the spiral of platinum wire centrally in a shallow dish (see Fig. 5). Place six of the disks in a circle on the platinum wire and carefully pour 150 ml of hydrochloric acid (V.2.1) into the dish. As soon as the coating is completely dissolved from both faces, leaving the steel surfaces exposed (see Note, below), transfer the acid quantitatively to a 1000 ml volumetric flask. Wash twice with 25 ml of water, transferring the washings to the flask. Repeat this whole procedure with successive lots of six disks, combining the acid and washings in the same volumetric flask, finally diluting to the mark with water.

Transfer a 100 ml aliquot of the solution to a 750 ml conical flask, add 30 ml of hydrochloric acid ($d = 1.16$), dilute to 250 ml with water, and place on the hot-plate. When nearly boiling, carefully add tin-free aluminium (V.2.10) in small amounts until 2 g have been added. Before final dissolution of the last addition of aluminium, close the flask with the Contat-Göckel trap assembly (the reservoir of the trap previously having been filled with saturated sodium hydrogen carbonate solution) and boil gently for 30 minutes. Cool slightly and close the outlet tube with a rubber cap.

Cool in running water to room temperature. Remove the Contat-Göckel trap assembly and add 5 ml of starch solution (V.2.7) and 10 ml of potassium iodide solution (V.2.3). Titrate with standard potassium iodate solution No. 1 (V.2.4) to a permanent blue colour.

NOTE. – The time required for complete dissolution depends on the coating weight. It may vary from about 3 minutes for an E2.8/2.8 coating up to about 15 minutes for an H17/17 coating.