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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Double cold-reduced electrolytic chromium/chromium oxide-coated steel —

Part 1 : Sheets

Fer chromé électrolytique double réduction à froid —

Partie 1 : Feuilles

Reference number
ISO 8111-1 : 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 8111-1 was prepared by Technical Committee ISO/TC 17, *Steel.*

ISO 8111 consists of the following parts, under the general title *Double cold-reduced electrolytic chromium/chromium oxide-coated steel:*

Part 1 : Sheets

Part 2 : Coil for subsequent cutting into sheets

Annexes A and B form an integral part of this part of ISO 8111.

Double cold-reduced electrolytic chromium/chromium oxide-coated steel —

Part 1 : Sheets

1 Scope

This part of ISO 8111 specifies requirements for double cold-reduced electrolytic chromium and chromium oxide-coated low carbon steel sheet. It applies to sheets in nominal thicknesses that are multiples of 0,01 mm from 0,14 mm up to and including 0,29 mm.

The term "electrolytic chromium/chromium oxide-coated steel" is usually abbreviated, for convenience, to ECCS and this abbreviation is used throughout this part of ISO 8111.

It has not been possible, in preparing this first edition of ISO 8111-1, 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 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 8111. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 8111 are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

ISO 6892 : 1984, *Steel — Tensile testing.*

ISO 8110-1 : —[1], *Single cold-reduced electrolytic chromium/chromium oxide-coated steel — Part 1 : Sheets.*

1) To be published.

3 Definitions

For the purposes of this part of ISO 8111, 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 stillage platform (see 3.8), the ECCS and packaging material.

3.3 consignment : A quantity of double cold-reduced ECCS sheets of the same specification made available for despatch at the same time.

3.4 finishes

3.4.1 stone finish : A finish on the steel base corresponding to that for single-reduced ECCS (see ISO 8110-1), characterized by a directional pattern, resulting from the use of final mill work rolls that have been ground to a lower degree of polish than those used for the smooth finish on single-reduced ECCS.

3.4.2 surface finish : The appearance of the surface of ECCS sheets, governed by the surface characteristics of the steel base which result from controlled preparation of the work rolls during the final stages of rolling.

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

3.6 rolling width : The width of the sheet perpendicular to the direction of rolling.

3.7 standard grade ECCS : 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 9.2;

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.

3.8 stillage platform : Base platform on which ECCS sheets are stacked to facilitate packing and transportation.

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. double cold-reduced electrolytic chromium/chromium oxide-coated steel sheets;

b) reference to this part of ISO 8111;

c) the quantity, expressed on an area basis, and the dimensions of the sheets required;

d) the designation for the mechanical property classification of the sheets required (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 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) 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 8111 and does not specify his requirements at the time of the enquiry and order, the product shall be supplied on the following basis :

a) the direction of the runners of the stillage platform shall be the direction of rolling (see clause 13);

b) the sheets shall be supplied with a stone surface finish (see 6.2);

c) the larger of the two dimensions of the sheet shall be the rolling width (provided this is within the capability of the mill).

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 modification to the fabrication methods that will significantly affect the way in which the purchased product is used.

NOTE — Double cold-reduced ECCS is less ductile than single cold-reduced ECCS and has very distinct directional properties.

When ordering double cold-reduced ECCS, it is recommended that the purpose for which the material is intended should be stated. When double cold-reduced ECCS is used for built-up can bodies, it is essential that the rolling direction is 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 stated in the contract.

5 Designations — mechanical property classification

For the purposes of this part of ISO 8111, the mechanical properties in which sheets complying with this part of ISO 8111 are supplied are designated in terms of a mechanical property classification based on the 0,2 % proof stress, as shown in table 1.

Table 1 — Mechanical property classification

Mechanical property classification	Nominal 0,2 % proof stress N/mm^2
DR 550	550
DR 620	620
DR 660	660

6 Manufacture, finish and defects

6.1 Manufacture

The methods of manufacture of the sheets are left to the discretion of the producer and are not specified in this part of ISO 8111.

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

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

6.2 Finish

Double cold-reduced ECCS sheets are usually provided 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. Any other surface finish shall be agreed at the time of order. Sheets complying with this part of ISO 8111 are also supplied with a coating of oil on both sides.

6.3 Defects

Sheets shall not contain any defects as defined in 3.7.

7 General requirements

The sheets shall comply with the requirements of clauses 8 to 10.

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 11.

For the determinations of dimensions and shape, the sample sheets shall be tested in accordance with the methods described in clause 9.

For the determination of coating mass, test specimens shall be taken from the sample sheets and shall be tested in accordance with clause 12.

NOTE — No sampling or testing requirements are specified in this part of ISO 8111 for verifying that any oil coating applied to the sheets is suitable for food packaging in accordance with clause 10.

The method of packaging the sheets shall be in accordance with clause 13.

8 Chromium/chromium oxide coating mass

The average values of the coating mass of the sample selected in accordance with clause 11 shall not be less than the following (see note 1) :

— chromium as metal : 30 mg/m^2 on each surface;

— chromium in the oxide : 5 mg/m^2 on each surface.

Metallic chromium is expressed as milligrams of chromium metal per square metre (mg/m^2) on each surface of the sheet.

Chromium oxides are expressed as the amount of chromium in the oxide, in milligrams per square metre (mg/m^2), on each surface of the sheet.

NOTES

1 The total chromium is made up of chromium metal and chromium oxides. The amounts of each are determined separately.

2 It is not possible to specify maximum limits for the average values for chromium metal and chromium in the oxides as the requirements for these values are closely related both to the producer's process and the user's end use.

3 The values specified, in principle, permit the material to be classified as ECCS. However, conformance with the specified coating mass minima does not guarantee acceptable performance under all conditions of use. It is therefore essential for the supplier and the user to agree upon the suitability of the particular supplier's product for the intended end use.

9 Tolerances on dimensions and shape

9.1 Introduction

Tolerances on dimensions (i.e. thickness and linear dimensions) and shape (i.e. out-of-squareness and edge camber) are specified in 9.2 to 9.5, together with appropriate methods of measurement.

Other geometrical features may be present in cold-reduced chromium/chromium oxide-coated steel sheet, 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 in 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, longitudinal bow and transverse bow to a minimum.

9.2 Thickness

9.2.1 *Thickness measurements*

9.2.1.1 General

Thickness shall be measured either by the weighing method described in 9.2.1.2, or by direct measurement using the micrometer method described in 9.2.1.3.

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

9.2.1.2 Weighing method

9.2.1.2.1 Determine the thickness of each sample sheet as follows :

a) Weigh the sheet to obtain the mass to be 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 :

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

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

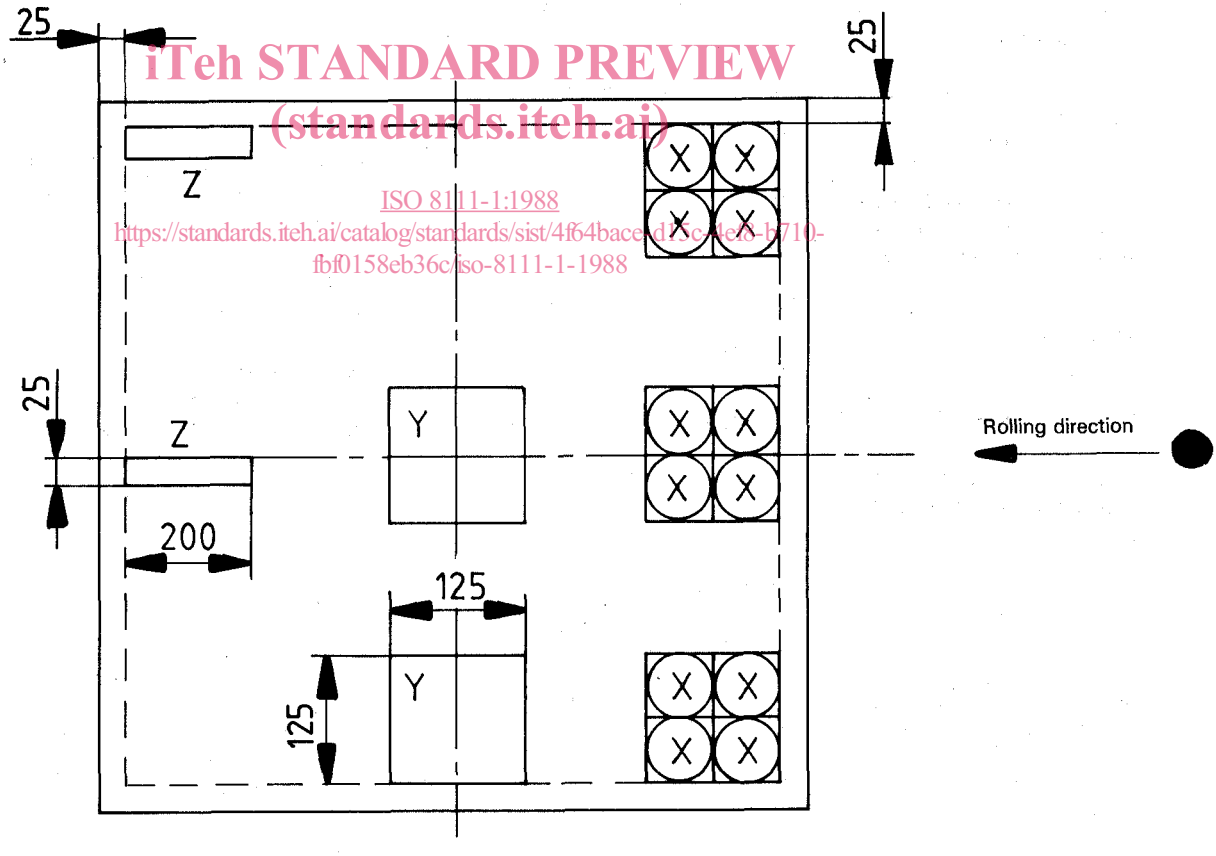
9.2.1.2.3 To determine the variation of thickness within each sample sheet, take two specimens Y (see figure 1) from the sheet. Weigh each specimen to the nearest 0,01 g, measure the length and width of each specimen to the nearest 0,1 mm, and calculate the thickness of each specimen to the nearest 0,001 mm using the formula given in 9.2.1.2.1 c).

9.2.1.3 Micrometer method

9.2.1.3.1 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.

Dimensions in millimetres



X : specimens for 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

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

9.2.1.3.3 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.

9.2.1.3.4 To determine the transverse thickness profile, use either the micrometer or some other suitably precise means to measure the thickness at a location 6 mm in from the mill-trimmed edges of the sheet at right angles to the rolling direction.

NOTE — If means other than the micrometer are used to measure the transverse thickness profile, such means should be agreeable to both the producer and the purchaser.

9.2.2 Thickness tolerances

9.2.2.1 Individual sheets

The thickness of each of the individual sample sheets selected from a consignment in accordance with clause 11, determined in accordance with 9.2.1.2 or 9.2.1.3, shall not deviate from the ordered nominal thickness by more than

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

b) the tolerance given in table 2 if the micrometer method is employed.

Table 2 — Ordered thickness and thickness tolerances

Ordered 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

9.2.2.2 Average thickness for a consignment

The average thickness for a consignment, determined in accordance with 9.2.1.2 on the sample sheets selected in accordance with clause 11, shall not deviate from the ordered 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.

9.2.3 Permissible local thickness variations within a sheet

The thickness of either of the two individual specimens determined in accordance with 9.2.1.2.3 or 9.2.1.3.3 shall not deviate by more than 4 % from the average thickness of the whole sheet.

9.2.2.4 *Transverse thickness profile (feather edge)*

Transverse thickness profile is the reduction in sheet thickness at right angles to the rolling direction, close to the edge. The minimum thickness, when measured at 6 mm from the mill-trimmed edge in accordance with 9.2.1.3.4, shall not be more than 15 % below the ordered nominal thickness and/or shall not vary more than 9 % when compared to the centre thickness of the sheet being measured.

9.3 *Linear dimensions of sheets*

9.3.1 Size of sheet

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

9.3.2 Tolerances on linear dimensions

In addition to being not less than the ordered dimensions, each sheet shall be trimmed on both edges and the trimmed (coil width) dimension shall not exceed the ordered dimension by more than 3 mm. Normally the cut in the rolling direction 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.

9.3.3 Measurement of linear dimensions

Lay each sample sheet, selected in accordance with clause 11, on a flat surface and measure the length and width to the nearest 0,5 mm across the centre of the sheet.

9.4 Out-of-squareness

Out-of-squareness is the deviation of an edge from a straight line drawn, at a right angle to the adjacent edge of the sheet, from a corner to the opposite edge (see figure 2).

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

$$\text{out-off-squareness (\%)} = \frac{\text{deviation } (A)}{\text{sheet dimension } (B)} \times 100$$

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 %.

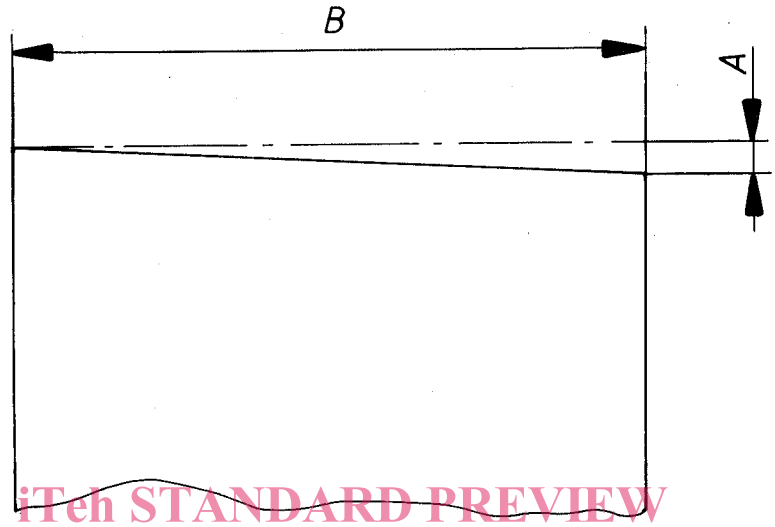
9.5 Edge camber

Edge camber is the maximum deviation (in the plane of the sheet) of an edge from a straight line forming a chord to it (see figure 3).

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

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

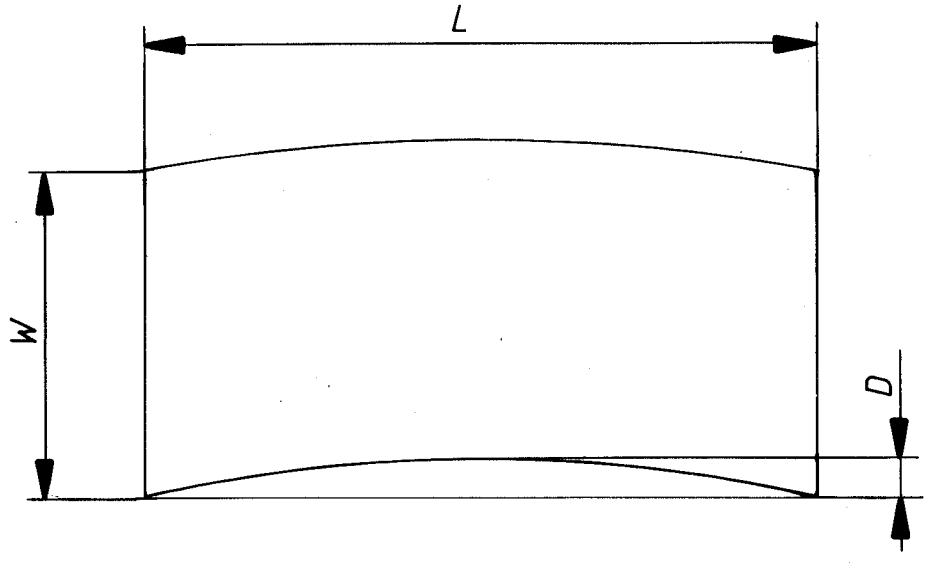
For each sample sheet, the camber shall not exceed 0,15 %.



A : deviation

B : length or width of the sheet measured at right angles to an edge

Figure 2 — Measurement of out-of-squareness



W : width of sheet

L : length of chord

D : deviation

Figure 3 — Edge camber of sheet

10 Oiling

The oil applied to the surfaces of ECCS sheets shall be one that is recognized (i.e. by the relevant national or international authority) as being suitable for food packaging.

11 Sampling

11.1 General

If tests are carried out to ascertain whether the sheets in a consignment comply with the requirements for coating mass (see clause 8) and the requirements for the tolerances on dimensions and shape (see clause 9), sample sheets shall be selected in accordance with 11.2.

11.2 Selection of sample sheets

11.2.1 Number of bulk packages

Sample bulk packages shall be selected at random from the total number of bulk packages at the rate of 20 % rounded to the nearest greater whole number of bulk packages and subject to a minimum of four bulk packages.

For consignments comprising less than four bulk packages, each bulk package shall be taken as a sample.

11.2.2 Number of sheets

NOTE — As the number of sheets per bulk package may vary, for example between 1 000 and 2 000, the rate of sampling is specified on a percentage basis (except for verification of coating masses).

11.2.2.1 Verification of grade (see 3.7)

From each of the bulk packages selected in accordance with 11.2.1, sheets at the rate of 1 % per bulk package shall be taken at random and inspected. In case of dispute, further sheets at the rate of 5 % per bulk package shall be taken at random and inspected.

11.2.2.2 Verification of chromium/chromium oxide masses

From each of the sample bulk packages selected in accordance with 11.2.1, two sheets shall be taken at random.

11.2.2.3 Verification of dimensions

From each of the sample bulk packages selected in accordance with 11.2.1, sheets at the rate of 0,5 % per bulk package to the nearest greater whole number of sheets shall be taken at random.

11.3 Retests

11.3.1 Chromium/chromium oxide coating masses

In the event of the average chromium/chromium oxide masses failing to meet the specified requirements, two further sets of samples, from other bulk packages, shall be selected as specified in 11.2 and specimens taken as described in 12.2.1. If both retests are satisfactory, the consignment shall be deemed to comply with the requirements of this part of ISO 8111, but if either of the additional tests is a fail the consignment shall be deemed not to meet the requirements of this part of ISO 8111.

The retest determinations shall be made using the referee methods described in annex B.

11.3.2 Dimensions

If any of the dimensions measured are unsatisfactory, further measurements shall be made on two further sets of samples selected, from other bulk packages, in accordance with 11.2. If both remeasurements are satisfactory, the consignment shall be deemed to comply with the requirements of this part of ISO 8111, but if either of the additional measurements fails to meet the relevant requirements, the consignment represented shall be deemed not to comply with this part of ISO 8111.

12 Test methods

12.1 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 11, at the locations shown in figure 1.

12.2 Determination of chromium/chromium oxide coating masses

12.2.1 Specimens

From each sheet selected in accordance with clause 11, four discs, each of area not less than 2 500 mm^2, shall be taken from each of the three sets of positions marked X in figure 1. The test area of each disc (see B.1.3.2) shall be accurately determined and not less than 2 000 mm^2. The specimens shall clear the edges and end of the sheet by 25 mm.

Two of the four discs from each position shall be used for the separate determinations of the mass of chromium in the metallic chromium layer and the mass of chromium in the chromium oxide layer on one surface of the sheet and the other two discs shall be used for the corresponding determinations on the other surface.

12.2.2 Method of determination

The masses of metallic chromium and chromium oxide shall be expressed in milligrams per square metre to the nearest 1 mg/m^2.

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

Any tests carried out using the methods in annex B shall be done on virgin ECCS, i.e. untreated material, in the as-produced state.

13 Packaging

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

NOTES

1 The sheets are customarily packed on a stillage platform forming a bulk package weighing between approximately 1 000 and 2 000 kg.

2 If the purchaser has any preference for the direction of the runners of the stillage platform, his requirements should be agreed with the producer and stated in the order [see 4.2 a)].

Annex A
(normative)

Mechanical properties

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 ECCS sheets, 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 classifications (see clauses 4 and 5), representing the 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 stresses and hardnesses corresponding to the mechanical property classification levels are shown in table A.1. In practice, it is expected that the producer will aim to achieve the nominal values given in table A.1, within the ranges also given in the table.

The values included in table A.1 are based on average values determined in accordance with the sampling and test methods recommended in clause A.2; individual hardness values are not considered to have any representative significance in relation to a consignment of ECCS.

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

A.2.1 Samples

For determination of the representative mechanical properties for a consignment of double cold-reduced ECCS sheets, use the two sheets taken in accordance with 11.2.2.2, for verification of the coating mass, from each of the bulk packages selected in accordance with 11.2.1. (However, see also the note to A.2.2.3.1.)

A.2.2 Determination of mechanical properties

A.2.2.1 General

It is unnecessary to remove the chromium/chromium oxide coating on the specimen, but remove all other coatings such as lacquers, varnishes and printing inks from the surface prior to 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 ECCS 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 A.1 — Mechanical properties

Mechanical property classification	Average proof stress (0,2 % non-proportional elongation)1), longitudinal		Average Rockwell hardness HR 30 T	
	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.