INTERNATIONAL STANDARD

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Hot-rolled and cold-reduced electrolytic zinc-coated carbon steel sheet of commercial and drawing qualities

Tôles en acier au carbone laminées à chaud et à froid, revêtues par zingage électrolytique (tôles électro-zinguées) de qualité commerciale et pour emboutissage

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 5002 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 12, *Continuous mill flat rolled products*.

This third edition cancels and replaces the second edition (ISO 5002:1999), which has been technically revised.

Hot-rolled and cold-reduced electrolytic zinc-coated carbon steel sheet of commercial and drawing qualities

1 Scope

1.1 This International Standard specifies the characteristics of carbon steel sheet of commercial and drawing qualities in cut length or coil form, zinc coated by electrolytic deposition. Electrolytic zinc-coated sheet is intended for the manufacture of formed or of miscellaneous parts, and can be supplied chemically treated to render it more suitable for painting. The zinc coating is expressed in micrometres of thickness per side, for either equally coated, differentially coated or one-side-coated sheets. These sheets are generally produced with coatings which are not intended to withstand outdoor exposure without chemical treatment and painting. Electrolytic zinc-coated sheet can be produced in thicknesses of 0,36 mm and thicker (normally up to 4,0 mm) and in widths of 600 mm and over in coils or cut lengths. It is recognized that materials thinner than 0,36 mm or thicker than 4,0 mm can be suitable for electrolytic zinc coating, and, if required, be the subject of agreement between the interested parties.

1.2 The thickness of zinc-coated sheet can be specified as a combination of the base metal and metallic coating, or as the base metal alone. The purchaser indicates on the order which method of specifying thickness is required. In the event that the purchaser does not indicate any preference, the thickness as a combination of the base metal and coating will be provided. Annex A describes the requirement for specifying the thickness as base metal alone.

1.3 Electrolytic zinc-coated sheet less than 600 mm wide can be slit from wide sheet and will be considered as sheet.

1.4 Commercial quality electrolytic zinc-coated sheet (HR1 or CR1) is intended for general fabricating purposes where sheet is used in the flat state, or for bending or moderate forming.

1.5 Drawing quality electrolytic zinc-coated sheet (HR2. HR3. HR4. or CR2, CR3, CR4, CR5) is intended for drawing or severe forming. It is furnished according to all requirements of this International Standard or, by agreement when ordered, to fabricate an identified part, in which case, the mechanical properties of Table 4 (for hot-rolled steel sheet) and Table 5 (for cold-reduced steel sheet) do not apply.

Drawing qualities are identified as follows:

— HR2/CR2 — Drawing quality

— HR3/CR3 — Deep drawing quality

— HR4/CR4 — Deep drawing quality aluminum killed (see 4.8)

— CR5 — Extra deep drawing quality (stabilized interstitial free).

2 Normative references

The following standards referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 7438, *Metallic materials — Bend test*

ISO 16160, *Continuously hot-rolled steel sheet products — Dimensional and shape tolerances*

ISO 16162, *Continuously cold-rolled steel sheet products — Dimensional and shape tolerances*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
electrolytic zinc-coated steel sheet
product obtained by electrolytic deposition of a zinc coating on steel sheet on a zinc coating line to produce either electrolytic zinc-coated coils or electrolytic zinc-coated cut lengths

3.2
skin pass
light cold rolling of hot-rolled descaled sheet or of the cold-reduced and annealed steel sheet prior to zinc coating

NOTE 1 The purposes of skin passing are one or more of the following:

a) to temporarily minimize the appearance of coil breaks, stretcher strains (Lüders lines) or fluting during fabrication of finished parts;

b) to minimize the appearance of coil breaks;

c) to control shape.

NOTE 2 Some increase in hardness and some loss in ductility will result from skin passing.

3.3
stabilized interstitial free steel
extra low carbon steel in which all interstitial elements are combined with titanium and/or equivalent elements

3.4
grade substitution
intersitial free steel (IF steel) may be applied on orders specifying CR2 Drawing, CR3 Deep drawing, or CR4 Deep drawing special killed, provided that the customer is informed of the substitution and related shipping documents reflecting the actual material shipped.

4 Conditions of manufacture

4.1 Steelmaking

The processes used in making the steel and in manufacturing electrolytic zinc-coated cold-reduced sheet and hot-rolled sheet are left to the discretion of the manufacturer. When requested, the purchaser shall be informed of the steelmaking process being used.

4.2 Chemical composition

The chemical composition (heat analysis) shall not exceed the values given in Tables 1, 2 and 3.

Table 1 — Chemical composition (heat analysis) for hot-rolled electrolytic zinc-coated carbon steel sheet

Mass fractions in percent

Quality		C	Mn	P	S
Designation	Name	max.	max.	max.	max.
HR1	Commercial	0,12	0,60	0,045	0,035
HR2	Drawing	0,10	0,45	0,035	0,035
HR3	Deep drawing	0,08	0,40	0,030	0,030
HR4	Deep drawing aluminum killed	0,08	0,35	0,025	0,030

Table 2 — Chemical composition (heat analysis) for cold-rolled electrolytic zinc-coated carbon steel sheet

Mass fractions in percent

Quality		Carbon	Manganese	Phosphorus	Sulfur	Titanium[a]
Designation	Name	max.	max.	max.	max.	max.
CR1	Commercial	0,15	0,60	0,050	0,035	
CR2	Drawing[c]	0,10	0,50	0,040	0,035	
CR3	Deep drawing[c]	0,08	0,45	0,030	0,03	
CR4	Deep drawing aluminum killed [c] (non-ageing)	0,06	0,45	0,030	0,03	
CR5	Extra deep drawing[b] (stabilized interstitial free)	0,02	0,25	0,020	0,02	0,15

[a] Titanium may be replaced totally or partially by niobium or vanadium. Carbon and nitrogen shall be completely stabilized.

[b] By agreement, the manganese, phosphorus and sulfur maximums may be adjusted.

[c] If interstitial free (IF Steel) is to be applied to CR2, CR3 and CR4 orders, the values of 0,15 % maximum Ti and 0,10 % maximum Nb and V are acceptable to ensure that the carbon and nitrogen are fully stabilized.

4.3 Chemical analysis

4.3.1 Heat analysis

An analysis of each heat of steel shall be made by the manufacturer in order to determine compliance with the requirements given in Tables 1, 2, and 3. On request, at the time of ordering, this analysis shall be reported to the purchaser or his representative. Each of the elements listed in Tables 1 and 2 shall be included in the report of the heat analysis. If one or more of the elements in Table 3 is/are specified, the analysis shall be reported.

4.3.2 Product analysis

A product analysis may be made by the purchaser to verify the specified analysis of the semi-finished or finished steel, and shall take into consideration any normal heterogeneity. Non-killed steels (such as rimmed or capped) are not technologically suitable for product analysis.

For killed steels, the sampling method and deviation limits shall be agreed upon between the manufacturer and purchaser at the time of ordering. The product analysis tolerances shall be in accordance with Table 4.

Table 3 — Limits on additional chemical elements

Mass fractions in percent

Elements	Heat analysis max.	Product analysis max.
Cu [a]	0,20	0,23
Ni [a]	0,20	0,23
Cr [a, b]	0,15	0,19
Mo [a, b]	0,06	0,07
Nb [c, d]	0,008	0,018
V [c, d]	0,008	0,018
Ti [c, d]	0,008	0,018

[a] The sum of copper, nickel, chromium, and molybdenum shall not exceed 0,50 % on heat analysis. When one or more of these elements are specified, the sum does not apply; in which case, only the individual limits on the remaining elements will apply.

[b] The sum of chromium and molybdenum shall not exceed 0,16 % on heat analysis. When one or more of these elements are specified, the sum does not apply; in which case, only the individual limits on the remaining elements will apply.

[c] An analysis greater than 0,008 % may be supplied after agreement between the producer and consumer.

[d] For interstitial free (IF steel), only the value of 0,15 % maximum titanium and 0,010 % maximum for niobium and vanadium are acceptable to ensure the carbon and nitrogen are fully stabilized.

Table 4 — Product analysis tolerances

Element	Maximum of specified element %	Tolerance over maximum specified %
Carbon	⩽ 0,15	0,03
Manganese	⩽ 0,60	0,03
Phosphorus	⩽ 0,05	0,01
Sulfur	⩽ 0,05	0,01
Titanium	⩽ 0,3	0,01

NOTE The maximum tolerance in this table is the allowable excess over the specified requirements and not the heat analysis.

4.4 Zinc coating

4.4.1 Coating mass

The amount of coating is expressed in micrometres of thickness per surface of sheet and shall conform to the requirements of minimum thickness given in Table 5.

4.4.2 Coating adherence

The zinc-coated sheet shall be capable of being bent in any direction, in accordance with the mandrel diameter requirements for the quality designations included in Table 6.

Table 5 — Zinc coatings for electrolytic zinc-coated hot-rolled and cold-reduced steel sheet

Coating designation[a]	**Nominal thickness per surface** µm	**Minimum thickness per surface** µm	**Nominal coating mass per surface** (for information only) g/m^2
ZE 04	0,4	0,4	3
ZE 10	1,0	0,9	7
ZE 14	1,4	1,2	10
ZE 25	2,5	2,2	18
ZE 28	2,8	2,4	20
ZE 38	3,8	3,4	27
ZE 42	4,2	3,6	30
ZE 50	5,0	4,5	36
ZE 56	5,6	4,8	40
ZE 70	7,0	6,0	50
ZE 75	7,5	6,8	54
ZE 100	10,1	9,1	75
ZE 135	13,5	12,2	96
ZE 150	15,0	13,5	107
NOTE The density of zinc used is 7 100 kg/m^3.			
[a] Equally coated material should be designated as ZE 10/10, for example. Differentially coated material should be designated as ZE 50/10, for example. Single-surface-coated material should be designated as ZE 38/0, for example.			

Table 6 — Coating bend-test requirements for electrolytic zinc-coated hot-rolled and cold-reduced steel sheet

Designation	**180° Bend-mandrel diameter**	
	$e < 3$	$e \geqslant 3{,}2$
HR1, HR2, HR3, HR4	0	1,0a
CR1, CR2, CR3, CR4, CR5	0	0
e = thickness of sheet, in millimetres a = thickness of bend test piece		

4.5 Weldability

The product is suitable for welding if appropriate conditions are selected.

4.6 Application

It is desirable that electrolytic zinc-coated steel sheet be identified for fabrication by the name of the part, or by the intended application. Steel sheet of drawing qualities HR2, HR3, HR4, and CR2, CR3, CR4 and CR5 may be produced to make an identified part within a properly established breakage allowance, which shall be previously agreed upon between the interested parties. In this case, the part name, the details of fabrication, and special requirements (i.e. exposed or unexposed, freedom from stretcher strains or fluting, coating performance requirements) shall be specified, and the mechanical properties of Table 7 or 8 do not apply.

4.7 Mechanical properties

Except when ordered according to an identified part as explained in 4.6, at the time that the steel is made available for shipment, the mechanical properties shall be as stated in Table 7 or 8 when they are determined on test pieces obtained according to the requirements of Clause 6. Prolonged storage of the sheet can cause a change in mechanical properties, leading to a decrease in drawability. To minimize this effect, quality CR4 or CR5 should be specified. The properties in Table 8 are after skin passing.

Table 7 — Mechanical property requirements for hot-rolled electrolytic zinc-coated carbon steel sheet

Base-metal quality		R_m [a]	A [b] min %			
			Material thickness, mm [b]			
Designation	Name	max.	$e < 3$		$3 \leqslant e \leqslant 6$	
		MPa^2	$L_o = 80$ mm	$L_o = 50$ mm	$L_o = 5{,}65\sqrt{S_o}$	$L_o = 50$ mm
HR1	Commercial	440	23	24	28	29
HR2	Drawing	420	25	26	30	31
HR3	Deep drawing	400	28	29	33	34
HR4	Deep drawing aluminum killed	380	31	32	36	37

R_m tensile strength

A percent elongation after fracture

L_o gauge length of original test piece.

S_o original cross-sectional area of gauge length

e thickness of steel sheet in millimetres

1 MPa = 1 N/mm^2

[a] The minimum tensile strength for qualities HR2, HR3 and HR4 would normally be expected to be 270 N/mm^2. All tensile strength values are determined to the nearest 10 N/mm^2.

[b] The non-proportional test piece with a fixed gauge length (50 mm), up to 6 mm thick sheet, can be used in conjunction with a conversion table. In case of dispute, however, only the results obtained on a proportional test piece will be valid for material 3 mm and over in thickness.

Table 8 — Mechanical property requirements [a] for cold-reduced electrolytic zinc-coated carbon steel sheet

Quality		R_e [a] max.	R_m max.	A min %[b]			
Designation	Name	MPa	MPa	L_o = 80 mm	L_o = 50 mm	$\bar{r}$ [c, d, e, g]	$\bar{n}$ [c, d, f, g]
CR1	Commercial [i]	280	410	27 (⩽ 0,6 mm) 28 (> 0,6 mm)	28	—	—
CR2	Drawing	240	370	33 (⩽ 0,6 mm) 34 (> 0,6 mm)	31	—	—
CR3	Deep drawing	220	350	35 (⩽ 0,6 mm) 36 (> 0,6 mm)	35	1,3 min.	0,16 min.
CR4	Deep drawing aluminum killed (non-ageing)	210	350	37 (⩽ 0,6 mm) 38 (> 0,6 mm)	37	1,4 min.	0,19 min.
CR5	Extra deep drawing (stabilized interstitial free)	190	350	39 (⩽ 0,6 mm) 40 (> 0,6 mm)	38	1,7 min.	0,22 min.

R_e yield stress

R_m tensile strength

A percent elongation after fracture

L_o gauge length of original test piece

$\bar{r}$ plastic strain ratio

$\bar{n}$ tensile strain hardening exponent

1 MPa = 1N/mm^2

[a] The minimum tensile strength for qualities CR2,CR3 and CR4 would normally be expected to be 270 MPa. All tensile strength values are determined to the nearest 10 MPa. For designing purposes, the lower limit for R_e may be assumed to be 140 MPa for grades CR1, CR2, CR3 and CR4, and 120 MPa for grade CR5.

[b] For material up to and including 0,6 mm in thickness, the elongation values in this table shall be reduced by 1.

[c] r and n values are only applicable to thicknesses ⩾ 0,5 mm. For thicknesses > 2,0 mm, the r value is reduced by 0.2.

[d] $\bar{r}$ can also be written as r-bar and $\bar{n}$ can also be written as n-bar.

[e] r is an index of the drawability of the product.

[f] n is an index of the stretchability of the product.

[g] For grades CR3, CR4 and CR5, r-bar and n-bar values may be modified or excluded from this specification by agreement between the producer and purchaser.

[h] Mechanical properties are not generally done on commercial quality products and the values in this table are for information only.

4.8 Strain ageing

Electrolytic zinc-coated steel sheet (except CR4 and CR5) tends to strain age and this may lead to the following:

a) surface marking from stretcher strains or fluting when the steel is formed;

b) deterioration in ductility.

Cold-reduced electrolytic zinc-coated carbon steel sheet of quality CR4 supplied in the skin-passed condition may be subject to strain ageing under certain conditions.