INTERNATIONAL STANDARD

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Continuous hot-dip zinc-coated twin-roll cast steel sheet of structural quality and high strength steel

Tôles coulées entre cylindres et galvanisées en continu par immersion à chaud, de qualité destinée à la construction et en acier à haute résistance

Reference number
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Foreword

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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 15211 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 12, *Continuous mill flat rolled products*.

Continuous hot-dip zinc-coated twin-roll cast steel sheet of structural quality and high strength steel

1 Scope

This International Standard specifies the characteristics of continuous hot-dip zinc-coated twin-roll cast steel sheet products of structural quality and high strength steel.

The product is intended for applications where resistance to corrosion is of prime importance.

The steel sheet is produced in a number of grades, coating mass, ordering conditions and surface treatments.

2 Normative references

The following 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 1460, *Metallic coatings — Hot dip galvanized coatings on ferrous materials — Gravimetric determination of the mass per unit area*

ISO 2178, *Non-magnetic coatings on magnetic substrates — Measurement of coating thickness — Magnetic method*

ISO 3497, *Metallic coatings — Measurement of coating thickness — X-ray spectrometric methods*

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

ISO 7438, *Metallic materials — Bend test*

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

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

ISO 16163, *Continuously hot-dipped coated 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
continuous hot-dip zinc-coated steel sheet
product obtained by hot-dip coating of cold-reduced sheet coils or hot-rolled descaled sheet coils on a continuous zinc-coating line

3.2
normal coating
layer formed as a result of unrestricted growth of zinc or zinc alloy crystals during normal solidification

NOTE Normal coating has a metallic lustre and is the type normally furnished for a wide variety of applications. It may be furnished as coating conditions S or N (see 11.4); however, it can be variable in appearance and is not suitable for decorative painting.

3.3
minimized spangle coating
finish obtained by restricting normal spangle formation during the solidification of the zinc or zinc alloy

NOTE This product may have some lack of uniformity in surface appearance within a coil or from coil to coil.

3.4
smooth finish
surface produced by skin-passing the coated material in order to achieve an improved smooth surface condition as compared with the normal as-coated product

3.5
differential coating
layer having a specified coating-mass designation on one surface and a different coating-mass designation on the other surface

3.6
skin pass
light cold rolling of the zinc-coated steel sheet

NOTE The purpose of the skin pass is to produce a higher degree of surface smoothness and, thereby, improve the surface appearance. The skin pass also temporarily minimizes the occurrence of a surface condition known as stretcher strain (Luder's Lines) or fluting during the fabrication of finished parts. The skin pass also controls and improves flatness. Some increase in hardness and loss of ductility can result from skin passing.

3.7
twin-roll cast steel sheet
steel sheet produced by casting to near final thickness directly from the liquid metal with minimal hot-rolling to achieve the final thickness

4 Thickness

4.1 Zinc-coated structural quality and high strength twin-roll cast steel sheet is produced in thicknesses of up to 2,0 mm after zinc coating, and in widths of up to 2 000 mm in coils and cut lengths.

4.2 Zinc-coated sheets less than 600 mm wide may be slit from wide sheets and may be considered sheets.

4.3 The thickness of zinc-coated twin-roll cast sheet steel may be specified as a combination of the base metal and metallic coating, or base metal alone. The purchaser shall indicate 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 requirements for specifying the thickness as base metal alone.

5 Conditions of manufacture

5.1 Chemical composition

The chemical composition (heat analysis) shall not exceed the values given in Tables 1, 2 and 3. Upon request, a report of the heat analysis shall be made to the purchaser.

A verification analysis (product analysis) may be carried out by the purchaser to verify the specified analysis of the semi-finished or finished steel. The product analysis tolerances are shown in Table 4.

The processes used in making the steel and in manufacturing the zinc-coated sheet of structural quality are left to the discretion of the manufacturer. If requested, the purchaser shall be informed of the steel-making process being used.

Table 1 — Chemical composition — Heat analysis

Mass fractions in per cent maximum

Base-metal quality	C	Mn	P	S	Si[a]
Structural — All grades	0,25	1,35	0,035	0,040	–

[a] In this table, "–" indicates that there is no requirement, but the analysis shall be reported.

Table 2 — Chemical requirements[a] — Heat analysis— High strength steel

Mass fractions in per cent maximum

Designation	C	Mn	P	S	Si[a]	V min.	Ti min.	Nb min.	N[a]
Grade[c]									
HSS 310 Class 1[b]	0,22	1,35	0,04	0,04	–	0,008	0,008	0,008	–
HSS 310 Class 2	0,15	1,35	0,04	0,04	–	0,008	0,008	0,008	–
HSS 340 Class 1[b]	0,23	1,35	0,04	0,04	–	0,008	0,008	0,008	–
HSS 340 Class 2	0,15	1,35	0,04	0,04	–	0,008	0,008	0,008	–
HSS 380 Class 1[b]	0.25	1,35	0,04	0,04	–	0,008	0,008	0,008	–
HSS 380 Class 2	0,15	1,35	0,04	0,04	–	0,008	0,008	0,00	–
HSS 410 Class 1	0,26	1,50	0,04	0,04	–	0,008	0,008	0,008	–
HSS 410 Class 2	0,15	1,50	0,04	0,04	–	0,008	0,008	0,008	–
HSS 450 Class 1	0,26	1,50	0,04	0,04	–	0,008	0,008	0,008	–[c]
HSS 450 Class 2	0,15	1,50	0,04	0,04	–	0,008	0,008	0,008	–[c]
HSS 480 Class 1	0,26	1,65	0,04	0,04	–	0,008	0,008	0,008	–[c]
HSS 480 Class 2	0,15	1,65	0,04	0,04	–	0,008	0,008	0,008	–[c]
HSS 550 Class 1	0,26	1,65	0,04	0,04	–	0,008	0,008	0,008	–[c]
HSS 550 Class2	0,15	1,65	0,04	0,04	–	0,008	0,008	0,008	–[c]

[a] In this table, "–" indicates that there is no requirement for Si and N, but the analysis shall be reported.

[b] For each reduction of 0,01 % below the specified carbon maximum, an increase of 0,06 % manganese above the specified maximum shall be permitted up to a maximum of 1,50 %.

[c] The purchaser has the option of restricting the nitrogen content. It should be noted that, depending on the microalloying scheme (for example use of vanadium) of the producer, nitrogen is permitted as a deliberate addition. Consideration should be given to the use of nitrogen-binding elements (for example vanadium and titanium).

Table 3 — Limits on additional chemical elements[a] for structural steel

Mass fractions in per cent

Element	Cu	Ni	Cr	Mo	Nb	V	Ti
	max						
Heat analysis	0,50	0,30	0,30	0,15	0,008	0,008	0,008
Product analysis	0,53	0,33	0,34	0,16	0,018	0,018	0,018

NOTE Each of the elements listed in this table shall be included in the report of the heat analysis. Where the amount of copper, nickel, chromium or molybdenum present is less than 0,02 %, the analysis shall be reported as < 0,02 %.

Table 4 — Product analysis tolerances

Mass fractions in per cent

Element	Maximum of specified element	Tolerance over the maximum specified
Carbon	≤ 0,26	0,04
Manganese	≤ 01,65	0,05
Phosphorus	≤ 0,04	0,01
Sulfur	≤ 0,04	0,01
NOTE The maximum tolerance in this table is the allowable excess over the specified requirement and not the heat.		

5.2 Mechanical properties

Structural quality and high strength grades shall satisfy the mechanical properties shown in Tables 5 and 6. On request, a report of the mechanical properties shall be made to the purchaser.

Table 5 — Mechanical properties of structural quality twin-roll cast steel sheet

Grade	R_e min.[a] MPa	R_m min. MPa	A, min.[b] $e \leq 2$ mm	
			$L_o = 50$ mm	$L_o = 80$ mm
HR275	275	380	15	14
HR340	340	340	9	8
HR380	380	380	8	7
HR410	410	410	7	6
HR480	480	480	6	5
HR550	550	550	5	4

R_e = lower yield strength

R_m = tensile strength

A = percentage elongation after fracture

L_o = gauge length on test piece

e = thickness of steel sheet, in millimetres

1 MPa = 1 N/mm^2

[a] The yield stress specified in this table shall be the lower yield stress, R_{el}. The values may also be measured by 0,5 % total elongation proof stress (proof stress under load) or by 0,2 % offset where a definite yield phenomenon is not present. Where upper yield stress, R_{eH}, is specified, the values shall be 20 N/mm^2 above the R_{el} values for each grade.

[b] Use either $L_o = 50$ mm or $L_o = 80$ mm to measure elongation. For material up to and including 0,6 mm in thickness, the elongation values in this table shall be reduced by 2.

Table 6 — Mechanical properties for hot-rolled twin-roll cast high strength steel sheet

Grade	R_e min.[a] MPa	R_m min. MPa	A min.[b] $e \leq 2$	
			$L_o = 50$ mm	$L_o = 80$ mm
HSS 310 Class 1	310	410	18	17
HSS 310 Class 2	310	380	18	17
HSS 340 Class 1	340	450	15	14
HSS 340 Class 2	340	410	15	14
HSS 380 Class 1	380	480	13	12
HSS 380 Class 2	380	450	13	12
HSS 410 Class 1	410	520	11	10
HSS 410 Class 2	410	480	11	10
HSS 450 Class 1	450	550	10	9
HSS 450 Class 2	450	520	10	9
HSS 480 Class 1	480	585	8	7
HSS 480 Class 2	480	550	8	7
HSS 550 Class 1	550	620	7	6
HSS 550 Class 2	550	565	7	6

R_e = yield strength

R_m = tensile strength

A = percentage elongation after fracture

L_o = gauge length on test piece

e = thickness of steel sheet, in millimetres

1 MPa = 1 N/mm^2

[a] The yield strength may be measured either by 0,5 % elongation proof stress, $R_{t0,5}$ (proof stress under load) or by 0,2 % offset, $R_{p0,2}$, where a definite yield strength phenomenon is not present.

[b] For thicknesses up to 2 mm, use either $L_o = 50$ mm or L_o 80 mm. In cases of dispute, however, only the results obtained on a 50 mm test piece shall be valid.

6 Coating

6.1 Coating mass

The coating mass shall conform to the limits for the coating designations shown in Table 7. The coating mass is the total amount of zinc on both surfaces of the sheet, expressed in grams per square metre (g/m^2) of sheet. The coating mass of differentially coated material shall be agreed upon between the interested parties. If a maximum coating mass is required, the manufacturer shall be notified at the time of ordering.

Table 7 — Mass of coating — Total both sides[a]

Coating Designation	Minimum check limit	
	Triple spot test g/m^2 (of sheet)	Single spot test g/m^2 (of sheet)
Z001	no minimum[a]	no minimum[a]
Z100	100	85
Z180	180	150
Z200	200	170
Z275	275	235
Z350	350	300
Z450	450	385
Z600	600	510
Z700	700	585

NOTE 1 Because of the many variables and changing conditions that are characteristic of continuous zinc coating, the coating mass is not always evenly divided between the two surfaces of a zinc-coated sheet; neither is the coating evenly distributed from edge to edge. However, it can normally be expected that not less than 40 % of the single spot check limit will be found on either surface.

NOTE 2 The coating thickness can be estimated from the coating mass using the following relationship:

100 g/m^2 total both sides = 0,014 mm total both sides.

[a] No minimum means that there are no established minimum check limits.

6.2 Coating adherence

The zinc-coated sheet shall be capable of being bent in any direction, in accordance with the mandrel diameter requirements for the coating designations included in Tables 8 and 9. Flaking of the coating within 7 mm from the edge of the test piece shall not be cause for rejection.

Table 8 — Coating bend test requirements structural quality

Grade	180° Bend-mandrel diameter		
	$e \leq 2$ mm		
	Coating designation		
	Up to Z350	Z450 Z600	Z700
HR 275	1a	2a	3a
HR 340	1a	2a	3a
HR 380	2a	2a	3a

e = thickness of sheet, in millimetres

a = thickness of bend test piece, in millimetres

Table 9 — Coating bend test requirements high strength steel

Grade	180° **Bend-mandrel diameter**		
	$e \leq 2$ mm		
	Coating designation		
	Up to Z350	**Z450 Z600**	**Z700**
275	1,5a	2a	3a
340	1,5a	2a	3a
380	2a	3a	3a
e = thickness of sheet, in millimetres a = thickness of bend test piece, in millimetres			

6.3 Weldability

This product is normally suitable for welding, if appropriate welding conditions are selected, with special attention to the heavier coatings. As carbon content increases above 0,15 %, spot welding becomes increasingly difficult. Because the heat of welding can have a significant effect on lowering the strength of grade 550, this grade is not recommended for welding.

6.4 Painting

Hot-dip zinc-coated twin-roll cast steel sheet is a suitable base for paint, but the first treatment may be different from those used on mild steel. Pre-treatment primers, chemical conversion coatings (chromate, phosphate or oxide type) and some paints specially formulated for direct application to zinc surfaces are all appropriate first treatments for hot-dip zinc-coated sheet. In drawing up a painting schedule, consideration shall be given to whether the hot-dip zinc-coated sheet shall be ordered passivated or not passivated.

7 Surface treatment

7.1 Mill passivation

A chemical treatment is normally applied to zinc coatings to minimize the hazard of wet storage stain (white rust) during shipment and storage. However, the inhibiting characteristics of the treatment are limited, and if a shipment is received wet, the material shall be used immediately or dried. This treatment is not usually applied to zinc-iron alloyed coatings because it interferes with the adhesion of most paints.

7.2 Mill phosphating

Zinc-coated twin-roll cast steel sheet may be processed chemically at the manufacturer's works to prepare all types of coatings for painting without further treatment, except normal cleaning.

7.3 Oiling

The zinc-coated twin-roll cast steel sheet, as produced, may be oiled to prevent marring and scratching of the soft surface during handling or shipping and to minimize wet storage stain. Where the zinc-coated sheet has received a passivating treatment, oiling further minimizes the hazard of wet storage stain.

8 Dimensional and shape tolerances

8.1 Dimensional and shape tolerances applicable to zinc-coated twin-roll cast steel sheet shall be as given in ISO 16163. The tolerances for thickness apply to products whose thickness is a combination of base-metal and coating thickness.

8.2 Where the base-metal thickness is specified, the thickness tolerances of Tables 6, 7 and 8 of ISO 16163:2010 shall apply to the average product thickness, as calculated in accordance with Annex A. The tolerances for thickness of the base metal shall be as given in ISO 16160 for hot-rolled steel and ISO 16162 for cold-rolled steel.

9 Sampling

9.1 Chemical composition

Each heat shall be tested by the manufacturer to determine compliance with the requirements of Tables 1, 2 and 3.

9.2 Tensile test

One representative transverse sample shall be taken from each lot to verify conformance with the requirements of Tables 5 and 6. Transverse test pieces shall be taken mid-way between the centre and the edge of the sheet as-rolled. A lot consists of 50 t, or less, of sheet of the same grade rolled to the same thickness and coating condition.

9.3 Coating tests

9.3.1 Coating mass

9.3.1.1 The producer/manufacturer shall develop a testing plan with a frequency sufficient to adequately characterize the lot of material and ensure conformance with specification requirements.

9.3.1.2 The purchaser may conduct verification tests by securing a sample piece of approximately 300 mm in length by the as-coated width and cutting three test specimens, one from the mid-width position and one from each side not closer than 25 mm from the side edge. The minimum area of the three specimens shall be 1 200 mm^2.

9.3.2 Triple-spot test

The triple-spot test result shall be the average coating mass found on the three specimens taken according to 9.3.1.

9.3.3 Single-spot test

The single-spot test result shall be the minimum coating mass found on any one of the three specimens used for the triple-spot test. Material, which has been slit from wide coil, shall be subjected to a single-spot test only.

9.3.4 Coating adherence

One representative sample for the coating bend test shall be taken from each lot of sheet for shipment. The specimens for the coated bend test shall be taken not closer than 25 mm from the side edge. The minimum width of the test specimen shall be 50 mm.

9.4 Retest

If a test does not satisfy the specified results, two more test pieces shall be taken at random from the same lot. Both retests shall conform to the requirements of this International Standard.

10 Test methods

10.1 Tensile test

The tests shall be conducted in accordance with the methods specified in ISO 6892-1. The base-metal thickness shall be used to calculate the cross-sectional area needed for the tensile test; however, for orders specifying thickness “as base metal only”, there are two permissible methods for determining the base-metal thickness:

a) option A — determination of the actual base-metal thickness by direct measurement of the substrate of a specimen whose coating has been removed;

b) option B — calculation of the base-metal thickness by subtraction of the average coating thickness for the appropriate coating designation included in Annex A from the actual coated thickness of the test specimen.

10.2 Coating properties

10.2.1 Coating mass

The manufacturer shall conduct tests using methods deemed necessary to ensure that the material complies with the requirements shown in Table 5. Commonly used methods include those specified in ISO 2178, ISO 3497 and ISO 1460. The coating mass may be determined by converting coating thickness measurements carried out with magnetic gauges (as specified in ISO 2178) or by X-ray spectrometry (as specified in ISO 3497) using the relationship shown in Note 2 of Table 7.

10.2.2 Coating adherence

Bend tests shall be conducted in accordance with the methods specified in ISO 7438.

11 Designation system

11.1 General

The designation system includes the coating type, coating mass, coating condition, surface treatment and steel grade.

11.2 Coating type

The letter Z indicates a zinc coating.

11.3 Coating mass

The coating mass designations for zinc coating are: 001, 90, 120, 180, 275, 305, 350, 450, 500, 550, 600 and 700. For differentially coated requirements, the coating mass designations should be shown as top surface before bottom surface, for example 120/90.

NOTE For differential coatings, the standard is top surface before bottom surface.

EXAMPLE An example of a differential coating designation is: Z275M120P340.

11.4 Coating conditions

The conditions of the coating are the following:

— N: normal coating (as produced);

— S: normal coating (skin passed);

— M: minimized spangle (as produced);

— E: minimized spangle (skin passed).

The “M” and “E” coating conditions are normally furnished in designations of Z180, Z275 and Z350, and in thicknesses of 0,40 mm to 3 mm, inclusive.

11.5 Surface treatment

The types of surface treatment are the following:

— C: mill passivation;

— P: mill phosphating;

— O: oiling;

— CO: mill passivation and oiling.

11.6 Structural grades

Structural quality steels are available in grades 275, 340, 380, 410, 480 and 550.

11.7 Example of designation

The designation shall include the following components:

— zinc coating;

— coating mass;

— minimized spangle;

— mill passivation;

— steel grade.

EXAMPLE A hot-dip steel coated steel sheet of zinc coating Z, coating mass 275, minimized spangle M, mill passivation C and steel grade 275 shall be designated as follows:

Z275MC275

11.8 Resubmission

11.8.1 The manufacturer may resubmit for acceptance the products which have been rejected during earlier inspection because of unsatisfactory properties, after he/she has subjected them to a suitable treatment (for example selection and heat treatment) which, on request, shall be indicated to the purchaser. In this case, the tests should be carried out as if they apply to a new lot.

11.8.2 The manufacturer has the right to subject the rejected products to a new examination for compliance with the requirements for another quality or grade; however, the quality surface of coils shall be approved by the manufacturer.

12 Workmanship

The zinc-coated steel sheet in cut lengths shall be free from amounts of laminations, surface flaws and other imperfections, which are detrimental to subsequent appropriate processing. Processing for shipment in coils does not afford the manufacturer the opportunity to observe readily or remove defective portions as can be carried out for cut-length products; however, the surface quality of coils shall be approved by the manufacturer.

13 Inspection and acceptance

13.1 While not usually required for products covered by this International Standard, the purchaser may specify that inspection and tests for acceptance be observed prior to shipment from the manufacturer's works. In these cases, the manufacturer shall afford the purchaser's inspector all reasonable facilities to determine that the steel is being furnished in accordance with this International Standard.

13.2 Steel that is reported to be defective after arrival at the user's works shall be set aside, properly and correctly identified, and adequately protected.

14 Marking

Unless otherwise stated, the following minimum requirements for identifying the steel shall be legibly stencilled on the top of each lift or shown on a tag attached to each coil or shipping unit:

a) the manufacturer's name or identifying brand;

b) a reference to this International Standard, i.e. ISO 15211:2012;

c) the grade designation;

d) the coating designation;

e) the order number;

f) the product dimensions;

g) the lot number;

h) the bundle/coil number;

i) the mass.

15 Information to be supplied by the purchaser

To specify requirements adequately in accordance with this International Standard, enquiries and orders shall include the following information:

a) a reference to this International Standard, i.e. ISO 15211:2012;

b) the name and designation of the material, for example hot-dip zinc-coated steel sheet, Z275NC275 (see Clause 11);

c) the dimensions:

   1) for cut lengths, the thickness (combination of base metal and coating or base metal alone), width, length and bundle mass and the total quantity required;

   2) for coils, the thickness (combination of base metal and coating or base metal alone), width, minimum or range of inside diameter, outside diameter and the maximum acceptable coil mass, and the quantity required;

NOTE 1 Where the base metal alone is specified, see Annex A for details.

NOTE 2 Where the method of specifying thickness is not indicated, the combination of base metal and coating is provided.

d) the application (name of part), if available;

NOTE 3 Identification of the application provides the opportunity to assess the compatibility of the end use with the ordered grade and coating designation. Proper identification of the part can include a description of the part or a visual examination of a submitted part and/or part prints or any combination thereof.

e) indication of whether oiled or not (see 7.3);

f) indication of whether mill passivated or not (see 7.1);

g) indication of whether mill phosphated or not (see 7.2);

h) the report of the mechanical properties and/or heat analysis, if required;

i) the inspection and tests for acceptance prior to shipment from the manufacturer's works, if required (see Clause 13);

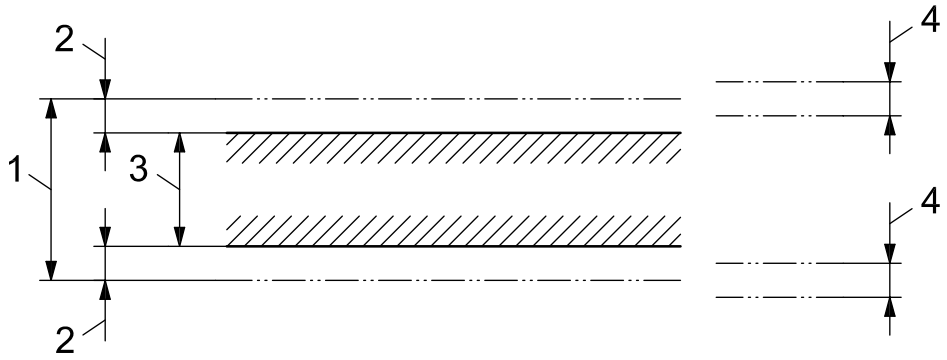
NOTE 4 The following is a typical ordering description:

International Standard ISO 15211:2012, hot-dip zinc-coated twin-roll cast structural quality steel sheet, grade 340, Z180NO340, 0,46 mm (base metal and coating) × 1 200 × 2 400 mm, 20 000 kg, to fabricate drawn shells, part 7201, mill passivation and oiled, maximum lift 4 000 kg.

Annex A
(normative)

Orders requiring base-metal thickness

A.1 Where specified by the purchaser, the ordered thickness shall be the base-metal thickness. In these cases, the average coated product thickness shall be calculated as the base-metal thickness plus the average thickness for each surface (see Table A.1) of the coating mass, as indicated in Figure A.1. Thickness tolerance tables apply to the average coated product thickness.



Key

1 average coated product thickness, $\bar{a}_p$
2 average coating thickness, $\bar{a}_c$
3 base-metal thickness, a_b
4 thickness tolerance, Δa

Figure A.1 — Calculation of the average coated product thickness

Table A.1 — Average thickness for coating mass —Total both sides

Coating designation	Average coating thickness[a] for calculation mm
Z180	0,034
Z275	0,054
Z350	0,064
Z450	0,080
Z600	0,102
[a] Coating mass data derived from actual production results.	

Bibliography

[1] ASTM A1063/A1063M, *Standard Specification for Steel Sheet, Twin-Roll Cast, Zinc-Coated (Galvanized) by the Hot-Dip Process*[1)]

1) This document is recognized by ISO/TC 17/SC 12 to cover a subject similar to that of this International Standard. The information is given for the convenience of users of this International Standard and constitutes neither an endorsement of the document by ISO/TC 17/SC 12 or ISO, nor a statement regarding its degree of equivalence with this International Standard.

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