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Titanium and titanium alloys — Plate, sheet and strip — Technical delivery conditions

Titane et alliages de titane — Tôle, bande et tôle épaisse — Conditions techniques de livraison

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 11, *Titanium*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

This document was developed in response to worldwide demand for stabilizing the quality assurance for titanium and titanium alloys by common regulations worldwide.

Determining condition concerning the technical delivery conditions for plate, sheet and strip of titanium and titanium alloys, such as chemical composition, mechanical properties and dimensional tolerance, is extremely important to promote commerce of titanium and titanium alloys products in the global market.

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning titanium alloys given in Table 1, Table 2 and Table 3.

ISO takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured ISO that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from the patent database available at www.iso.org/patents.

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Titanium and titanium alloys — Plate, sheet and strip — Technical delivery conditions

1 Scope

This document specifies requirements for the manufacture and technical delivery conditions of plate, sheet and strip made from titanium and titanium alloys.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

ISO 6892-1:2019, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 7438:2020, *Metallic materials — Bend test*

ISO 10474:2013, *Steel and steel products — Inspection documents*

ISO 11484, *Steel products — Employer's qualification system for non-destructive testing (NDT) personnel*

ISO 28401, *Light metals and their alloys — Titanium and titanium alloys — Classification and terminology*

ASTM E8/E8M, *Standard Test Methods for Tension Testing of Metallic Materials*

ASTM E29, *Practice for Using Significant Digits in test Data to Determine Conformance with Specifications*

ASTM E539, *Standard Test Method for Analysis of Titanium Alloys by Wavelength Dispersive X-Ray Fluorescence Spectrometry*

ASTM E1409, *Test method for determination of oxygen and nitrogen in titanium and titanium alloys by the inert gas fusion technique*

ASTM E1447, *Test method for determination of hydrogen in titanium and titanium alloys by the inert gas fusion thermal conductivity/ Infrared detection method*

ASTM E1941, *Standard Test method for determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis*

ASTM E2371, *Standard Test method for Analysis of Titanium and Titanium alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission Spectrometry (Performance-Based Test Methodology)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 28401 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

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3.1
plate
flat-rolled product of rectangular cross-section with uniform thickness over 5 mm, supplied in straight lengths (i.e. flat) usually with sheared, sawn or flame-cut/plasma-cut edges or water jet cutting

Note 1 to entry: The thickness does not exceed one-tenth of the width.

3.2
sheet
flat-rolled product of rectangular cross-section with uniform thickness over 0,20 mm and up to and including 5 mm inclusive, supplied in straight lengths (i.e. flat) usually with sheared or sawn edges or water jet cutting

Note 1 to entry: The thickness does not exceed one-tenth of the width.

3.3
strip
flat-rolled product of rectangular cross-section with uniform thickness over 0,20 mm, supplied in coils usually with slit edges

Note 1 to entry: The thickness does not exceed one-tenth of the width.

Note 2 to entry: In some English-speaking countries, "strip" is called "coiled sheet".

4 Information to be supplied by the purchaser

4.1 General information

The purchase order shall include the following information:

a) quantity (e.g. total mass or total length);

b) designation;

c) dimensions;

d) packaging;

e) inspection (including the type of test piece subjected to tensile testing);

f) mill product certificate;

g) certification (document issued and/or validated by an independent third party that assures that a product meets specified requirements such as a purchase order).

4.2 Options

A number of options are specified in this document and listed below. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the plate or sheet or strip shall be supplied in accordance with the basic specification.

a) restrictive chemistry (see 6.2);

b) product analysis (see 6.2);

c) special mechanical properties (see 6.3);

d) special tolerance (see 6.5);

e) method of manufacture and finish (see Clause 5 and 6.6).

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5 Manufacturing

The plate, sheet and strip shall be manufactured by hot-working or hot-rolling of ingot or intermediate product followed by appropriate cold-rolling, if necessary, and surface conditioning and heat treatment. The plate, sheet and strip shall be supplied as solid wrought product with uniform cross-section in straight shape or in coiled form.

6 Requirements

6.1 General

When supplied in the delivery condition indicated in 4.1 and inspected in accordance with Clause 7, the plate, sheet and strip shall conform to the requirements of this document.

6.2 Chemical composition

The plate, sheet and strip of titanium and titanium alloys shall conform to the chemical requirements prescribed in Table 1.

The elements listed in Table 1 are either intentional alloy additions or elements that are inherent to the manufacture of titanium sponge, ingot or mill product.

The content of any element intentionally added to the formulation of heat shall be reported.

Other elements are those not specified in the relevant designated material such as Cr and Mo of Ti1-0,18Pd and those not originally specified in the Table 1 such as Co and Hf. Generally, other elements include aluminium, vanadium, tin, molybdenum, chromium, manganese, zirconium, nickel, copper, silicon, cobalt, tungsten, hafnium and yttrium except for alloying elements contained in the designation. The element which is taken as the other element shall be subjected to the agreement between the purchaser and the manufacturer, and shall be noted in the purchase order.

Other elements should not be reported unless the content is greater than 0,1 % for each, or 0,4 % for total. The content of yttrium should not be reported unless the content is greater than 0,005 % for each.

When agreed upon between the manufacturer and the purchaser and specified in the purchase order, other specific residual elements not listed in Table 1 may be added and their content shall be reported.

The chemical analysis shall be conducted by the standard techniques normally used by the manufacturer and the purchaser. In case of disagreement, the test methods defined in ASTM E2371 or ASTM E539 shall be used as the referee method except for carbon, oxygen, and hydrogen, which are not covered in these standards. The test methods defined in ISO 22960, ISO 22961 or ISO 22962 may be used as the referee method for iron instead of ASTM E2371 or ASTM E539. The test method defined in ASTM E1409 shall be used as a referee method for oxygen and nitrogen, and ISO 22963 may be used as a referee method for oxygen. The test method defined in ASTM E1447 shall be used as a referee method for hydrogen and the test method defined in ASTM E1941 shall be used as a referee method for carbon.

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Table 1 — Chemical composition

Chemical composition in % mass fraction

Designation	C max	O max	N max	H max	Fe max	Al	V	Pd	Ru	Ni	Mo	Cr	Co	Sn	Other elements max	
															single	total
Ti1	0,08	0,18	0,03	0,015	0,20										0,1	0,4
Ti1H	0,08	0,18	0,03	0,015	0,20										0,1	0,4
Ti2L	0,08	0,20	0,03	0,015	0,25										0,1	0,4
Ti2	0,08	0,25	0,03	0,015	0,30										0,1	0,4
Ti3	0,08	0,35	0,05	0,015	0,30										0,1	0,4
Ti3H	0,08	0,35	0,05	0,015	0,30										0,1	0,4
Ti4	0,08	0,40	0,05	0,015	0,50										0,1	0,4
Ti1-0,18Pd	0,08	0,18	0,03	0,015	0,20			0,12-0,25							0,1	0,4
Ti1H-0,18Pd	0,08	0,18	0,03	0,013	0,20			0,12-0,25							0,1	0,4
Ti2L-0,18Pd	0,08	0,20	0,03	0,015	0,25			0,12-0,25							0,1	0,4
Ti2-0,18Pd	0,08	0,25	0,03	0,015	0,30			0,12-0,25							0,1	0,4
Ti3H-0,018Pd	0,08	0,35	0,05	0,015	0,30			0,12-0,25							0,1	0,4
Ti1-0,06Pd	0,08	0,18	0,03	0,015	0,20			0,04-0,08							0,1	0,4
Ti1H-0,06Pd	0,08	0,18	0,03	0,013	0,20			0,04-0,08							0,1	0,4
Ti2L-0,06Pd	0,08	0,20	0,03	0,015	0,25			0,04-0,08							0,1	0,4
Ti2-0,06Pd	0,08	0,25	0,03	0,015	0,30			0,04-0,08							0,1	0,4
Ti2-0,75Ni-0,3Mo	0,08	0,25	0,03	0,015	0,30					0,6-0,9	0,2-0,4				0,1	0,4
Ti1L-0,5N-0,05Ru	0,08	0,10	0,03	0,015	0,20				0,04-0,06	0,4-0,6					0,1	0,4

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Table 1 *(continued)*

Designation	C max	O max	N max	H max	Fe max	Al	V	Pd	Ru	Ni	Mo	Cr	Co	Sn	Other elements max	
															single	total
Ti2L-0,5Ni-0,05Ru	0,08	0,15	0,03	0,015	0,30				0,04-0,06	0,4-0,6					0,1	0,4
Ti2-0,5Ni-0,05Ru	0,08	0,25	0,05	0,015	0,30				0,04-0,06	0,4-0,6					0,1	0,4
Ti2-0,5Co-0,06Pd	0,08	0,25	0,03	0,015	0,30			0,04-0,08					0,2-0,8		0,1	0,4
Ti3-0,5Co-0,06Pd	0,08	0,35	0,05	0,015	0,30			0,04-0,08					0,2-0,8		0,1	0,4
Ti2-0,45Ni-0,15Cr-0,03Ru-0,015Pd	0,08	0,25	0,03	0,015	0,30			0,01-0,02	0,02-0,04	0,35-0,55		0,1-0,2			0,1	0,4
Ti3-0,45Ni-0,15Cr-0,03Ru-0,015Pd	0,08	0,35	0,05	0,015	0,30			0,01-0,02	0,02-0,04	0,35-0,55		0,1-0,2			0,1	0,4
Ti-5Al-2,5Sn	0,08	0,20	0,03	0,015	0,50	4,0-6,0								2,0-3,0	0,1	0,4
Ti-1,5Al	0,08	0,25	0,03	0,015	0,30	1,0-2,0									0,1	0,4
Ti-3Al-2,5V	0,08	0,15	0,03	0,015	0,25	2,5-3,5	2,0-3,0								0,1	0,4
Ti-6Al-4V	0,08	0,20	0,05	0,015	0,40	5,5-6,75	3,5-4,5								0,1	0,4
Ti-6Al-4VELI	0,08	0,13	0,03	0,012 5	0,25	5,5-6,5	3,5-4,5								0,1	0,4
Ti-22V-4Al	0,10	0,25	0,05	0,015	1,00	3,50-4,50	20,0-23,0								0,1	0,4

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6.3 Tensile properties

The room temperature tensile properties of the plate, sheet and strip in both longitudinal and transverse directions of the final rolling shall conform to the requirements prescribed in Table 2.

The tensile testing shall be conducted in a method that is normally used by the manufacturer and the purchaser and specified in this document. The test piece subjected to tension testing is a rectangular or circular cross-section test piece with a gauge length of 50 mm, and the type of test piece shall be included in the purchase order. In case of disagreement, the test piece specified in ISO 6892-1, Annex B or Annex D shall be used as the referee test piece.

Table 2 — Tensile properties at room temperature

Designation	**Tensile strength** (R_m) MPa		**0,2 % Proof strength** ($R_{p0,2}$) [a] MPa		**Elongation in 50 mm** [c] min%
	min	max [b]	min	max [b]	
Ti1	240		138	310	24
Ti1H	270	410	165		27
Ti2L	340	510	215		23
Ti2	345		275	450	20
Ti3	450		380	550	18
Ti3H	480	620	345		18
Ti4	550	(750)	483	(655)	15
Ti1-0,18Pd	240		138	310	24
Ti1H-0,18Pd	270	410	165		27
Ti2L-0,18Pd	340	510	215		23
Ti2-0,18Pd	345		275	450	20
Ti3H-0,18Pd	480	620	345		18
Ti1-0,06Pd	240		138	310	24
Ti1H-0,06Pd	240	380	170		24
Ti2L-0,06Pd	345	515	275		20
Ti2-0,06Pd	345		275	450	20
Ti2-0,75Ni-0,3Mo	483		345	-	18
Ti1L-0,5Ni-0,05Ru	275	(450)	170		24
Ti2L-0,5Ni-0,05Ru	410	(530)	275		20
Ti2-0,5Ni-0,05Ru	483	(630)	380		18
Ti2-0,5Co-0,06Pd	345	(515)	275	(450)	20
Ti3-0,5Co-0,06Pd	450	(590)	380	(550)	18
Ti2-0,45Ni-0,15Cr-0,03Ru-0,015Pd	345		275	450	20
Ti3-0,45Ni-0,15Cr-0,03Ru-0,015Pd	450		380	550	18
Ti-5Al-2.5Sn	828		793		10
Ti-1,5Al	345		215	(450)	20

[a] 0,2 % proof strength is specified. When specific yielding point is exhibited, the yield strength (R_e) shall satisfy the specified strength.

[b] Specified number in parentheses shall be applied when agreed upon the manufacturer and the purchaser and specified in the purchase order.

[c] Elongation value when using a test piece with a gauge length different from 50 mm shall be established by agreement between the manufacturer and the purchaser.

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Table 2 *(continued)*

Designation	Tensile strength (R_m) MPa		0,2 % Proof strength ($R_{p0,2}$) [a] MPa		Elongation in 50 mm [c] min%
	min	max [b]	min	max [b]	
Ti-3Al-2,5V	620		483	-	15
Ti-6Al-4V	895		825		10
Ti-6Al-4VELI	825		755		10
Ti-22V-4Al	640	900	850		10

[a] 0,2 % proof strength is specified. When specific yielding point is exhibited, the yield strength (R_e) shall satisfy the specified strength.

[b] Specified number in parentheses shall be applied when agreed upon the manufacturer and the purchaser and specified in the purchase order.

[c] Elongation value when using a test piece with a gauge length different from 50 mm shall be established by agreement between the manufacturer and the purchaser.

Tensile testing shall be carried out in accordance with ISO 6892-1 or ASTM E8/E8M.

For measurement of the yield strength, the strain increase rate on the gauge length shall be 0,3 %/min to 0,7 %/min. For measurement of the tensile strength after that of yield strength, the strain increase rate estimated from the crosshead displacement rate shall be approximately 10 %/min to 40 %/min.

Mechanical properties for conditions other than those given in Table 2 may be established by agreement between the manufacturer and the purchaser.

6.4 Bend test

The room temperature bend test of sheet and strip in longitudinal direction of the final rolling shall be carried out in accordance with ISO 7438.

The sheet and strip, when subjected to the bending test under the conditions specified in Table 3, shall not generate any cracks outside the bent portion.

The conditions of the room temperature bend test for plate may be established by agreement between the manufacturer and the purchaser.

Table 3 — Bend test at room temperature

Designation	Bending angle Degree (°) [a]	Inside radius (T: thickness of the bend test specimen)	
		Under 1,8 mm in thickness	1,8 mm to 5 mm in thickness
Ti1	105	1,5T	2T
Ti1H	105	1,5T	2T
Ti2L	105	2T	2,5T
Ti2	105	2T	2,5T
Ti3	105	2T	2,5T
Ti3H	105	2T	2,5T
Ti4	105	2,5T	3T
Ti1-0,18Pd	105	1,5T	2T
Ti1H-0,18Pd	105	1,5T	2T
Ti2L-0,18Pd	105	2T	2,5T

[a] Upon request of the purchaser, bend test may be carried out at 180°.

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Table 3 *(continued)*

Designation	Bending angle Degree (°) [a]	Inside radius (T: thickness of the bend test specimen)	
		Under 1,8 mm in thickness	1,8 mm to 5 mm in thickness
Ti2-0,18Pd	105	2T	2,5T
Ti3H-0,18Pd	105	2T	2,5T
Ti1-0,06Pd	105	1,5T	2T
Ti1H-0,06Pd	105	1,5T	2T
Ti2L-0,06Pd	105	2T	2,5T
Ti2-0,06Pd	105	2T	2,5T
Ti2-0,75Ni-0,3Mo	105	2T	2,5T
Ti1L-0,5Ni-0,05Ru	105	1,5T	2T
Ti2L-0,5Ni-0,05Ru	105	2T	2,5T
Ti2-0,5Ni-0,05Ru	105	2T	2,5T
Ti2-0,5Co-0,06Pd	105	2T	2,5T
Ti3-0,5Co-0,06Pd	105	2T	2,5T
Ti2-0,45Ni-0,15Cr-0,03Ru-0,015Pd	105	2T	2,5T
Ti3-0,45Ni-0,15Cr-0,03Ru-0,015Pd	105	2T	2,5T
Ti-5Al-2.5Sn	105	4T	4,5T
Ti-1,5Al	105	2T	2,5T
Ti-3Al-2,5V	105	2,5T	3T
Ti-6Al-4V	105	4,5T	5T
Ti-6Al-4VELI	105	4,5T	5T
Ti-22V-4Al	105	5,5T	6T

[a] Upon request of the purchaser, bend test may be carried out at 180°.

6.5 Dimensional tolerance

6.5.1 Tolerance of thickness

The tolerances of thickness for plate, sheet and strip covered by this document shall conform to Table 4 and Table 5.

Table 4 — Permissible variation in thickness for plate (over 5 mm in thickness)

Nominal thickness mm	Permissible variation in thickness [a] mm			
	Nominal width mm			
	Up to 2 150	Over 2 150 to 3 050	Over 3 050 to 3 660	Over 3 660
Over 5 to 7 included	1,1	1,3	---	---
Over 7 to 10 included	1,3	1,4	---	---
Over 10 to 15 included	1,4	1,5	1,9	2,3
Over 15 to 25 included	1,5	1,7	2,2	2,5
Over 25 to 50 included	1,8	1,9	2,4	2,9

[a] Tolerance over specified thickness.

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Table 4 *(continued)*

Nominal thickness mm	Permissible variation in thickness [a] mm			
	Nominal width mm			
	Up to 2 150	Over 2 150 to 3 050	Over 3 050 to 3 660	Over 3 660
Over 50 to 75 included	3,2	3,8	4,4	5,1
Over 75 to 100 included	4,4	5,3	6,2	7,1
Over 100 to 150 included	6,4	7,6	8,9	10,2
Over 150 to 200 included	8,9	10,7	12,5	14,2
[a] Tolerance over specified thickness.				

Table 5 — Permissible variation in thickness for cold rolled sheet (under 5 mm in thickness, over 610 mm to 1 525 mm in width)

Nominal thickness t, mm	Permissible variation in thickness [a] mm
0,2 to 0,4 included	±0,05
Over 0,4 to 0,6 included	±0,08
Over 0,6 to 1,0 included	±0,10
Over 1,0 to 1,5 included	±0,13
Over 1,5 to 2,0 included	±0,18
Over 2,0 to 3,0 included	±0,23
Over 3,0 to 5 included [a]	±0,36
[a] This tolerance is also applied for hot rolled sheet.	

Table 6 — Permissible variation in thickness for strip (under 5 mm in thickness, up to 610 mm in width)

Nominal thickness mm	Permissible variation in thickness [a] mm		
	Nominal width mm		
	Under 152	Over 152 to 305	Over 305 to 610
0,2 to 0,4 included	±0,04	±0,05	±0,05
Over 0,4 to 0,6 included	±0,06	±0,06	±0,08
Over 0,6 to 1,0 included	±0,08	±0,08	±0,10
Over 1,0 to 1,5 included	±0,10	±0,12	±0,13
Over 1,5 to 2,0 included	±0,15	±0,16	±0,17
Over 2,0 to 3,0 included	±0,20	±0,21	±0,22
Over 3,0 to 4,75 included [a]	±0,30	±0,32	±0,34
[a] This tolerance is also applied for hot rolled strip.			

Table 4 shall be applied for plate with under 10 000 mm in length.

Table 5 shall be applied for sheet with under 1 525 mm in width and 4 000 mm in length.

Table 6 shall be applied for strip with under 610 mm in width.

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The tolerance of thickness of plate, sheet and strip not covered in Tables 4, 5 and 6 shall be established by agreement between the manufacturer and the purchaser.

In the case of sheet and strip, when requested by the purchaser, the tolerance on thickness may be designated as either plus or minus side only. In this case, the tolerance of the lower side or the upper side may be 0 mm within the same range of tolerance specified in Tables 5 to 6.

6.5.2 Tolerance of width

The tolerance of width for plate, sheet and strip covered by this document shall conform to Tables 7 to 9.

Table 7 — Permissible variation in width of plate

Nominal width mm	**Nominal length** mm	**Permissible variation in width** [a] mm		
		Nominal thickness mm		
		Over 5 to 10 excluded	10 to 16 excluded	16 and over
Up to 1 525	Under 3 650	10,0	11,0	13,0
Over 1 525 to 2 150 included		11,0	13,0	16,0
Over 2 150 to 2 750 included		13,0	16,0	19,0
Over 2 750		16,0	19,0	22,0
Up to 1 525	3 650 to 6 100 excluded	10.0	13,0	16,0
Over 1 525 to 2 150 included		13,0	16,0	19,0
Over 2 150 to 2 750 included		14,0	18,0	21,0
Over 2 750		16,0	19,0	22,0
Up to 1 525	6 100 to 9 150 included	10,0	13,0	16,0
Over 1 525 to 2 150 included		13,0	16,0	19,0
Over 2 150 to 2 750 included		14,0	19,0	22,0
Over 2 750		18,0	22,0	25,0
Up to 1 525	9 150 to 12 000 included	11,0	13,0	16,0
Over 1 525 to 2 150 included		13,0	16,0	19,0
Over 2 150 to 2 750 included		14,0	19,0	22,0
Over 2 750		19,0	22,0	25,0

[a] Minus tolerance should be 7 mm for all widths and lengths in all thickness.

Table 8 — Permissible variation in width of cold rolled sheet

Nominal thickness mm	**Permissible variation in width** [a] mm	
	Nominal width mm	
	610 to 1 220 included	Over 1 220
Over 0,2 to 3,0 included	+1,6 −0	+3,2 −0
Over 3,0 to 5 included [a]	+6,4 −0	+6,4 −0

[a] This tolerance is applied for hot rolled sheet.

Table 9 shall be applied for sheet with under 610 mm in width and 4 000 mm in length.

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Table 9 — Permissible variation in width of strip

Nominal thickness t, mm	Permissible variation in width mm		
	Nominal width mm		
	Under 150	Over 150 to 305	Over 305 to 610
Over 0,2 to 1,7 included	±0,15	±0,25	±0,50
Over 1,7 to 2,5 included	±0,20	±0,25	±0,50
Over 2,5 to 4,1 included	±0,25	±0,40	±0,50
Over 4,1 to 5 included	±0,40	±0,50	±0,80
Over 5 to 8 included	––	±0,80	±1,20

The tolerance of width of plate, sheet and strip not covered in Tables 7, 8 and 9 shall be established by agreement between the manufacturer and the purchaser.

If the special tolerance of width is established by agreement between the manufacturer and the purchaser and is included in the purchase order, the specified special tolerance shall supersede the tolerance of this document.

6.5.3 Tolerance of length

The tolerance of length for plate, sheet and strip covered by this document shall conform to Table 10.

Table 10 — Permissible variation in length of plate

Nominal width mm	Nominal length mm	Permissible variation in length [a] mm		
		Nominal thickness mm		
		Over 5 to 10 excluded	10 to 16 excluded	16 and over
Up to 1 525	Under 3 650	13,0	16,0	19,0
Over 1 525 to 2 150 included		16,0	17,0	22,0
Over 2 150 to 2 750 included		19,0	22,0	25,0
Over 2 750		22,0	25,0	29,0
Up to 1 525	Over 3 650 to 6 100 excluded	19,0	22,0	25,0
Over 1 525 to 2 150 included		19,0	22,0	25,0
Over 2 150 to 2 750 included		22,0	24,0	29,0
Over 2 750		25,0	29,0	32,0
Up to 1 525	Over 6 100 to 9 150 included	25,0	29,0	32,0
Over 1 525 to 2 150 included		25,0	29,0	32,0
Over 2 150 to 2 750 included		25,0	29,0	35,0
Over 2 750		29,0	32,0	35,0
Up to 1 525	Over 9 150 to 12 000 included	29,0	32,0	38,0
Over 1 525 to 2 150 included		32,0	35,0	38,0
Over 2 150 to 2 750 included		32,0	35,0	38,0
Over 2 750		35,0	38,0	41,0

[a] Minus tolerance should be 7 mm for all widths and lengths in all thickness.

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Table 11 — Permissible variation in length of cold rolled sheet

Nominal thickness mm	Permissible variation in length [a] mm	
	Nominal length mm	
	Up to 3 050 included	Over 3 050
Over 0,2 to 5 included	+7,0 −0	+13,0 −0
[a] This tolerance is applied for hot rolled sheet with over 3 mm in thickness.		

Table 12 — Permissible variation in length of strip

Nominal length mm	Permissible variation in length mm
Up to 1 525	+10,0 −0
Over 1 525 to 3 050 included	+13,0 −0
Over 3 050 to 6 100 included	+16,0 −0

Table 10 shall be applied for plate with under 4 000 mm in width and 12 000 mm in length.

Table 11 shall be applied for sheet with under 1 600 mm in width and 4 000 mm in length.

Table 12 shall be applied for strip with under 610 mm in width and 6 000 mm in length.

The tolerance of length of plate, sheet and strip not covered in Tables 10, 11 and 12 shall be established by agreement between the manufacturer and the purchaser.

If the special tolerance of length is established by agreement between the manufacturer and the purchaser and is included in the purchase order, the specified special tolerance shall supersede the tolerance of this document.

6.5.4 Tolerance of flatness

The tolerance of flatness of sheet and plate shall conform to Tables 13 and 14.

Table 13 — Permissible variation in flatness of sheet

Nominal thickness mm	Permissible variation in flatness mm	
	Nominal width mm	
	Up to 915	Over 915 to 1 600
Over 0,2 to 5 excluded	13	19

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Table 14 — Permissible variation in flatness of plate

Nominal thickness mm	Permissible variation in flatness mm				
	Nominal width mm				
	Up to 1 525	Over 1 525 to 2 150	Over 2 150 to 3 100	Over 3 100 to 3 700	Over 3 700
Over 5 to 7 included	27	35	48	51	57
Over 7 to 10 included	19	29	40	48	54
Over 10 to 15 included	15	19	32	37	45
Over 15 to 25 included	15	16	24	26	29
Over 25 to 40 included	15	15	18	19	26
Over 40 to 100 included	8	12	16	19	23
Over 100 to 150 included	10	15	23	25	29

Table 13 shall be applied for sheet with under 1 600 mm in width and 4 000 mm in length.

Table 14 shall be applied for plate with under 4 000 mm in width and 12 000 mm in length.

Flatness of plate and sheet not covered in Tables 13 and 14 shall be established by agreement between the manufacturer and the purchaser.

6.5.5 Tolerance of straightness

The tolerance of straightness of sheet and strip shall conform to Table 15.

Table 15 — Camber tolerance for sheet and strip

Nominal width mm	Camber tolerance mm
Up to 40 included	12,7
Over 40 to 610 excluded	6,4
610 to 920 included	3,2
Over 920	2,4
NOTE Camber tolerances apply in any 2 400 mm of length.	

The straightness of plate shall be of such straightness that the maximum edgewise curvature shall not exceed 3 mm in any 1 500 mm of length.

Table 15 shall be applied for sheet and strip with under 1 600 mm in width and 4 000 mm in length.

6.6 Surface conditions, imperfections and defects

6.6.1 General

The finished plate, sheet and strip shall be clean and free of foreign materials, and shall be free of injurious external and internal imperfections detrimental to their use. Minor defects can be removed, provided the dimensional tolerances are not exceeded. The specific index value for defects and the treatment of defects detrimental to use shall be as agreed between the purchaser and the manufacturer.

The edges of the plate, sheet and strip shall be regular by slitting, shear-cutting, flame-cutting, plasma-cutting, laser-cutting, waterjet-cutting, saw-cutting and other appropriate cutting methods without splitting and curling.

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The mill edges may be acceptable with the agreement between the manufacturer and the purchaser.

The edges shall be cut at right angle and the slope shall not exceed the allowable tolerance of width and length specified.

The surface of the plate, sheet and strip shall be smooth without lamination, and the surface treated by alkaline washing, pickling, sandblasting and ground for supply is permitted.

The surface quality for the plate, sheet and strip shall be examined by visual inspection or defect inspector.

6.6.2 Non-destructive inspection

6.6.2.1 General

When requesting the confirmation of internal properties, the inspection of internal properties of plate, sheet and strip shall be carried out with an ultrasonic test equipment.

Any products showing an indication more than that obtained from the calibration standard shall be set aside and subject to rework, retest or rejection. A product thus set aside may be examined further for confirmation of the presence of a defect and may be resubmitted for inspection if no defect is found.

Employers shall follow the qualification system stipulated in ISO 11484 for NDT personnel under the employer's responsibility.

6.6.2.2 Indication

Indication is the response from or the evidence on the projected screen of the equipment. Any product showing an indication more than that obtained from the calibration standard shall be set aside and subject to rework, retest or rejection.

6.6.2.2.1 Flaw indication during NDT

Various types of flaw indications are observed during ultrasonic testing. Among those flaw indications, excluding signals unrelated to the internal soundness of the material such as noise, indications from the flaws existing inside the material shall be detected. It shall be determined whether those are subject to re-examination or to rejection.

6.6.2.2.2 Flaw indication judged to defect

Flaw indications that show an indication above a certain criterion is determined as a defect. The defect should be fixed based on acceptance criterion of purchaser specification. Defects may be able to be removed or repaired by agreement between the manufacturer and the purchaser.

6.6.2.3 Inspection method and acceptance criterion

The method of ultrasonic test and the criterion for acceptance may be established by agreement between the manufacturer and the purchaser.

7 Inspection

7.1 Types of inspection and inspection documents

Conformity with the requirements of the purchase order shall be checked by specific inspection in accordance with ISO 10474.

Inspection documents shall be in printed form or in electronic form as an electronic data interchange (EDI) transmission that conforms to any EDI agreement between the purchaser and the manufacturer.

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