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Titanium and titanium alloys — Bar, rod and billet — Technical delivery conditions

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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.

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 bar, rod and billet 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 and Table 2.

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.

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

Titanium and titanium alloys — Bar, rod and billet — Technical delivery conditions

1 Scope

This document specifies requirements for the manufacture and technical delivery conditions of bar, rod and billet 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 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/

3.1
bar
rod
solid wrought product of uniform cross-section equal to or under 10 000 mm^2 along its whole length, supplied in straight lengths

Note 1 to entry: The cross-section is in the shape of rounds, squares, rectangles or regular polygons like hexagons and octagons.

Note 2 to entry: Products with a square, rectangular or polygonal cross-section may have corners rounded along their whole length.

3.2
billet
solid wrought product of uniform cross-section above 10 000 mm^2 along its whole length, supplied in straight lengths

Note 1 to entry: The cross-section is in the shape of rounds, squares, rectangles or regular polygons like hexagons and octagons.

Note 2 to entry: Products with a square, rectangular or polygonal cross-section may have corners rounded along their whole length.

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

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. In the event that the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the bar, rod or billet 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 6.4)

e) method of manufacture and finish (see Clause 5 and 6.5)

5 Manufacturing

The bar, rod and billet shall be manufactured by hot-working such as hot-rolling, hot-forging, hot-extrusion of ingot or intermediate product followed by appropriate cold-working, if necessary, as well as surface conditioning and heat treatment. The bar, rod and billet shall be supplied as solid wrought product in straight shapes with uniform cross-section along their whole length.

6 Requirements

6.1 General

When supplied in the delivery condition indicated in 4.1 and inspected in accordance with Clause 7, the bar, rod and billet shall conform to the requirements of this document.

6.2 Chemical composition

The bar, rod and billet 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 the 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 manufacturer and the purchaser, 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. 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.

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-0,5Ni-0,05Ru	0,08	0,10	0,03	0,015	0,20				0,04-0,06	0,4-0,6					0,1	0,4

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-4V ELI	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
Ti-6Al-1Fe	0,10	0,30	0,05	0,015	0,4-1,5	5,5-6,5									0,1	0,4

6.3 Tensile properties

The room temperature tensile properties of the bar, rod and billet in longitudinal direction of the final rolling product 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 tensile testing is a rectangular or circular cross-section test piece with a gauge length of 50 mm or $4D(d_0)/W(b_0)$ or $5D(d_0)/W(b_0)$. 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 C or Annex D, shall be used as the referee test piece.

Table 2 — Tensile properties at room temperature

Designation	Applicable dimensions [a] mm	Tensile strength (R_m) MPa		0,2 % proof strength ($R_{p0,2}$) [b] MPa		Elongation in $4D(d_0)/W(b_0)$, $5D(d_0)/W(b_0)$ or 50 mm [d] min %	Reduction of area [c] min %
		min	max [b, c]	min	max [c]		
Ti1	8 to 300 included	240		138	310	24	(30)
Ti1H		270	410	165		27	
Ti2L		340	510	215		23	
Ti2		345		275	450	20	(30)
Ti3		450		380	550	18	(30)
Ti3H		480	620	345		18	
Ti4		550	(750)	483	(655)	15	(25)
Ti1-0,18Pd		240		138	310	24	(30)
Ti1H-0,18Pd		270	410	165		27	
Ti2L-0,18Pd		340	510	215		23	
Ti2-0,18Pd		345		275	450	20	(25)
Ti3H-0,18Pd		480	620	345		18	
Ti1-0,06Pd		240		138	310	24	(30)
Ti1H-0,06Pd		240	380	170		24	
Ti2L-0,06Pd		345	515	275		20	
Ti2-0,06Pd		345		275	450	20	(25)
Ti2-0,75Ni-0,3Mo		483		345	-	18	(25)
Ti-0,5Ni-0,2Fe-0,1O-0,05Ru		275	(450)	170		24	(30)
Ti-0,5Ni-0,3Fe-0,15O-0,05Ru		410	(530)	275		20	(30)
Ti-0,5Ni-0,3Fe-0,25O-0,05Ru		483	(630)	380		18	(25)

[a] Applicable dimensions are nominal diameter, width or width across flats of products. For bars (or rods) excluding Ti4, Ti-6Al-4V and Ti-6Al-4V ELI with a round cross section less than 8 mm in diameter, only tensile strength specified in this table is applied. The elongation value for such products may be established by agreement between the manufacturer and the purchaser because of the use of a test piece with a gauge length different from 50 mm.

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

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

[d] Elongation value, when using a test piece with a gauge length different from 50 mm or other than 4D, 5D, shall be established by agreement between the manufacturer and the purchaser.

Table 2 *(continued)*

Designation	Applicable dimensions [a] mm	Tensile strength (R_m) MPa		0,2 % proof strength ($R_{p0,2}$) [b] MPa		Elongation in $4D(d_0)/W(b_0)$, $5D(d_0)/W(b_0)$ or 50 mm [d] min %	Reduction of area [c] min %
		min	max [b, c]	min	max [c]		
Ti2-0,5Co-0,06Pd		345	(515)	275	(450)	20	(30)
Ti3-0,5Co-0,06Pd		450	(590)	380	(550)	18	(30)
Ti2-0,45Ni-0,15Cr-0,03Ru-0,015Pd		345		275	450	20	(30)
Ti3-0,45Ni-0,15Cr-0,03Ru-0,015Pd		450		380	550	18	(30)
Ti-5Al-2,5Sn		828		793		10	25
Ti-1,5Al		345		215	(450)	20	(30)
Ti-3Al-2,5V	8 to 100 included	620		483	-	15	30
Ti-6Al-4V		895		825		10	25
Ti-6Al-4V ELI		825		755		10	25
Ti-22V-4Al	8 to 25 excluded	640	900	850		10	55
	25 to 100 included	640	900	800		7	45
Ti-6Al-1Fe	8 to 100 included	895		825		10	25

[a] Applicable dimensions are nominal diameter, width or width across flats of products. For bars (or rods) excluding Ti4, Ti-6Al-4V and Ti-6Al-4V ELI with a round cross section less than 8 mm in diameter, only tensile strength specified in this table is applied. The elongation value for such products may be established by agreement between the manufacturer and the purchaser because of the use of a test piece with a gauge length different from 50 mm.

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

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

[d] Elongation value when using a test piece with a gauge length different from 50 mm or other than 4D, 5D, 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.

The tensile properties apply to longitudinal sections up to 100 mm in diameter, thickness or width across flats. The direction of tensile testing for products over 100 mm in diameter, thickness or width across flats may be established by agreement between the manufacturer and the purchaser.

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

6.4 Dimensional tolerance

6.4.1 General

This document specifies dimensional tolerance for diameter of rounds, width across flats of squares, hexagons and octagons, and width and thickness for rectangles. The dimensional tolerance for such shapes as ovals, equilateral triangles and regular polygons other than squares, hexagons and octagons may be established by agreement between the manufacturer and the purchaser.

6.4.2 Tolerance of diameter and width across flats

The tolerance of diameter and width across flats for rounds and squares whose diameter or width across flats covered by this document shall conform to Table 3.

The tolerance of width across flats for hexagons and octagons whose width across flats covered by this document shall conform to Table 4.

Table 3 — Permissible variation in diameter and width across flats for rounds and squares

Nominal diameter or width across flats mm	Permissible variation in diameter and width across flats	
	Hot-worked	Cold-worked, machined
8 to 25 excluded	±0,20 mm	±0,20 mm
25 to 50 excluded	±0,40 mm	±0,25 mm
50 to 100 excluded	+1,60, −0 mm	±0,40 mm
100 to 160 excluded	+3,9, −0 mm	±1,0 mm
160 to 300 included [a]	+3, −0 %	+1,5, −0 %
[a] Permissible variation is defined as a percentage of the nominal diameter or nominal width across flats.		

Table 4 — Permissible variation in width across flats for hexagons and octagons

Nominal width across flats mm	Permissible variation in width across flats	
	Hot-worked	Cold-worked, machined
8 to 25 excluded	±0,25 mm	+0, −0,10 mm
25 to 50 excluded	±0,80 mm	+0, −0,16 mm
50 to 100 excluded	±1,60 mm	+0, −0,25 mm

When requested by the purchaser, the tolerance in diameter and width across flats 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 3 and 4.

The tolerance of diameter and width across flats for bar, rod and billet with under 8 mm in diameter and width across flats may be established by agreement between the manufacturer and the purchaser.

The tolerance of diameter and width across flats for machined or turned products except for centreless ground, polished, precision ground and precision-polished products, permissible variation specified for cold-worked conditions in Tables 3 and 4 is applied. The tolerance of diameter and width across flat for centreless ground, polished, precision ground and precision-polished products may be established by agreement between the manufacturer and the purchaser.

6.4.3 Tolerance of diameter for rounds with under 8 mm in diameter

The tolerance of diameter for bar and rod with the shape of cross section in rounds under 8 mm in diameter covered by this document shall conform to Table 5.

Table 5 — Permissible variation in diameter for bar and rod with the shape of cross-section in rounds under 8 mm in diameter

Nominal diameter mm	Permissible variation in diameter
1 to 2 excluded	±0,04 mm
2 to 3 excluded	±0,06 mm
3 to 5 excluded	±0,08 mm
5 to 8 excluded	±0,10 mm

When requested by the purchaser, the tolerance in diameter 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 Table 5.

6.4.4 Tolerance of width and thickness

The tolerance of width and thickness for rectangular bar, rod and billet covered by this document shall conform to Table 6.

Table 6 — Permissible variation in thickness and width for rectangles (for over 8 mm in width and thickness)

Nominal width mm	Permissible variation in thickness and width					
	Hot-worked			Cold-worked, machined		
	Nominal thickness mm			Width mm	Width mm	Thickness mm
	8 to 12	12 to 25	25 to 50			
8 to 25 excluded	±0,20 mm	±0,25 mm	±0,80 mm	±0,40 mm	±0,06 mm	±0,05 mm
25 to 50 excluded	±0,30 mm	±0,38 mm		±0,80 mm	±0,08 mm	±0,08 mm
50 to 100 excluded	±0,38 mm	±0,51 mm		+1,6, −0,80 mm	±0,13 mm	±0,13 mm
100 to 160 excluded	±0,38 mm	±0,51 mm		+2,4, −1,6 mm	---	----
160 to 250 included	±0,53 mm	±0,80 mm		+4,0, −4,8 mm	---	---

When requested by the purchaser, the tolerance in width and 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 Table 6.

6.4.5 Tolerance of length

The tolerance of length for bar, rod and billet covered by this document shall conform to Table 7.

Table 7 — Permissible variation in length

Nominal length mm	Permissible variation in length mm
Less than or equal to 7 000	+40 −0

Length tolerance for bar, rod and billet over 7 000 mm in length may be established by agreement between the manufacturer and the purchaser.

6.4.6 Straightness

6.4.6.1 Cold-worked and machined finished

The maximum curvature (depth of arc) shall not exceed 1,6 mm in any 1 500 mm of length but shall not exceed 1,1 × length in meters.

6.4.6.2 Hot-worked finished

The maximum curvature (depth of arc) shall not exceed 3,1 mm in any 1 500 mm of length but shall not exceed 2,1 × length in meters.

6.5 Surface conditions, imperfections and defects

The finished bar, rod and billet 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 their use shall be as agreed 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 bar, rod and billet shall be smooth, and the surface treated by alkaline washing, pickling, sandblasting and ground for supply is permitted.

The surface quality for the bar, rod and billet shall be examined by visual inspection or defect inspector.

6.5.1 Non-destructive inspection

6.5.1.1 General

When requesting the confirmation of internal properties, the inspection of internal properties of the bar, rod and billet shall be carried out with an ultrasonic test equipment.

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

6.5.1.2 Indication

Indication is the response from or the evidence on the projected screen of the 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.

6.5.1.3 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.

6.5.1.4 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.

6.5.1.5 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 manufacturer and the purchaser.

7.2 Specific inspection

7.2.1 General

All tests and inspection required by this document shall be made at the place of the manufacturer prior to shipment and at the manufacturer's expense unless otherwise specified and shall be so conducted as not to interfere unnecessarily with the operation of the works. When specified in the order, the manufacturer shall notify the purchaser in time so that the purchaser has his or her inspector present to witness any part of the tests as desired.

7.2.2 Samples and test pieces for chemical composition and mechanical testing for product analysis

7.2.2.1 General

The preparation of test pieces for tensile testing requested by this document shall conform to ISO 377.

The test pieces and the tests for mechanical testing, in accordance with this document, shall conform to those described in ISO 6892-1 or ASTM E8/E8M.

All routine mechanical testing shall be made at room temperature.

7.2.2.2 Number of tests

Chemical composition of the lot with the same nominal size produced with the same ingot, processing, heat treatment and chemical treatment shall be the ingot manufacturer's analysis, except for hydrogen or the product manufacturer's analysis. At a minimum, the chemical analysis of the samples taken from the top and bottom of the ingot or taken on the product from positions representing the top and bottom of the ingot shall be reported for all elements listed for the respective designation in Table 1. The content of hydrogen shall be determined on each sample from the lot with the same nominal size produced with the same ingot, processing, heat treatment and chemical treatment. Hydrogen determination shall be one analysis per lot.

As for the sample for mechanical testing, one sample shall be selected from a lot with the same nominal size produced with the same ingot, processing, heat treatment and chemical treatment. The size of the lot may be either the manufactured lot or the purchased lot at the manufacturer's option.

NOTE A lot is defined as a set of products with the same nominal size produced with the same ingot, processing, heat treatment and chemical treatment.

One tension test, in accordance with 6.3, shall be made on each sample.