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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](http://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](http://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](http://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](http://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 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](http://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/>

**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](#)).

## 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 Ti-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.

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   |

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   |

### 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 ( $R_m$ )<br>MPa |                  | 0,2 % Proof strength<br>( $R_{p0,2}$ ) <sup>a</sup><br>MPa |                  | Elongation in<br>50 mm <sup>c</sup><br>min% |
|----------------------------------|-----------------------------------|------------------|------------------------------------------------------------|------------------|---------------------------------------------|
|                                  | min                               | max <sup>b</sup> | min                                                        | max <sup>b</sup> |                                             |
| 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                                          |

<sup>a</sup> 0,2 % proof strength is specified. When specific yielding point is exhibited, the yield strength ( $R_e$ ) shall satisfy the specified strength.

<sup>b</sup> Specified number in parentheses shall be applied when agreed upon the manufacturer and the purchaser and specified in the purchase order.

<sup>c</sup> 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.

Table 2 (continued)

| Designation                                                                                                                                                                  | Tensile strength ( $R_m$ )<br>MPa |                  | 0,2 % Proof strength<br>( $R_{p0,2}$ ) <sup>a</sup><br>MPa |                  | Elongation in<br>50 mm <sup>c</sup><br>min% |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------------------|------------------------------------------------------------|------------------|---------------------------------------------|
|                                                                                                                                                                              | min                               | max <sup>b</sup> | min                                                        | max <sup>b</sup> |                                             |
| 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                                          |
| <sup>a</sup> 0,2 % proof strength is specified. When specific yielding point is exhibited, the yield strength ( $R_e$ ) shall satisfy the specified strength.                |                                   |                  |                                                            |                  |                                             |
| <sup>b</sup> Specified number in parentheses shall be applied when agreed upon the manufacturer and the purchaser and specified in the purchase order.                       |                                   |                  |                                                            |                  |                                             |
| <sup>c</sup> 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<br>Degree (°) <sup>a</sup> | Inside radius<br>(T: thickness of the bend test specimen) |                                |
|-----------------------------------------------------------------------------------|------------------------------------------|-----------------------------------------------------------|--------------------------------|
|                                                                                   |                                          | Under 1,8 mm in<br>thickness                              | 1,8 mm to 5 mm in<br>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                           |
| <sup>a</sup> Upon request of the purchaser, bend test may be carried out at 180°. |                                          |                                                           |                                |

**Table 3 (continued)**

| Designation                      | Bending angle<br>Degree (°) <sup>a</sup> | Inside radius<br>(T: thickness of the bend test specimen) |                                |
|----------------------------------|------------------------------------------|-----------------------------------------------------------|--------------------------------|
|                                  |                                          | Under 1,8 mm in<br>thickness                              | 1,8 mm to 5 mm in<br>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                             |

<sup>a</sup> 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<br>mm | Permissible variation in thickness <sup>a</sup><br>mm |                        |                        |            |
|-------------------------|-------------------------------------------------------|------------------------|------------------------|------------|
|                         | Nominal width<br>mm                                   |                        |                        |            |
|                         | Up to 2 150                                           | Over 2 150 to<br>3 050 | Over 3 050<br>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        |

<sup>a</sup> Tolerance over specified thickness.

**Table 4 (continued)**

| Nominal thickness<br>mm                          | Permissible variation in thickness <sup>a</sup><br>mm |                     |                     |            |
|--------------------------------------------------|-------------------------------------------------------|---------------------|---------------------|------------|
|                                                  | Nominal width<br>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       |
| <sup>a</sup> 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<br>t, mm                                        | Permissible variation in thickness <sup>a</sup><br>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 <sup>a</sup>                               | ±0,36                                                 |
| <sup>a</sup> 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<br>mm                                           | Permissible variation in thickness <sup>a</sup><br>mm |                 |                 |
|-------------------------------------------------------------------|-------------------------------------------------------|-----------------|-----------------|
|                                                                   | Nominal width<br>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 <sup>a</sup>                            | ±0,30                                                 | ±0,32           | ±0,34           |
| <sup>a</sup> 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.

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<br>mm          | Nominal length<br>mm        | Permissible variation in width <sup>a</sup><br>mm |                      |             |
|------------------------------|-----------------------------|---------------------------------------------------|----------------------|-------------|
|                              |                             | Nominal thickness<br>mm                           |                      |             |
|                              |                             | Over 5 to 10<br>excluded                          | 10 to 16<br>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<br>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<br>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<br>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        |

<sup>a</sup> 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<br>mm             | Permissible variation in width <sup>a</sup><br>mm |            |
|-------------------------------------|---------------------------------------------------|------------|
|                                     | Nominal width<br>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 <sup>a</sup> | +6,4 – 0                                          | +6,4 – 0   |

<sup>a</sup> 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.

**Table 9 — Permissible variation in width of strip**

| Nominal thickness<br>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<br>mm          | Nominal length<br>mm             | Permissible variation in length <sup>a</sup> |                      |             |
|------------------------------|----------------------------------|----------------------------------------------|----------------------|-------------|
|                              |                                  | mm                                           |                      |             |
|                              |                                  | Nominal thickness                            |                      |             |
|                              |                                  | mm                                           |                      |             |
|                              |                                  | Over 5 to 10<br>excluded                     | 10 to 16<br>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<br>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<br>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<br>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        |

<sup>a</sup> Minus tolerance should be 7 mm for all widths and lengths in all thickness.

**Table 11 — Permissible variation in length of cold rolled sheet**

| Nominal thickness<br>mm                                                                  | Permissible variation in length <sup>a</sup><br>mm |            |
|------------------------------------------------------------------------------------------|----------------------------------------------------|------------|
|                                                                                          | Nominal length<br>mm                               |            |
|                                                                                          | Up to 3 050 included                               | Over 3 050 |
| Over 0,2 to 5 included                                                                   | +7,0 –0                                            | +13,0 –0   |
| <sup>a</sup> This tolerance is applied for hot rolled sheet with over 3 mm in thickness. |                                                    |            |

**Table 12 — Permissible variation in length of strip**

| Nominal length<br>mm         | Permissible variation in length<br>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<br>mm | Permissible variation in flatness<br>mm |                   |
|-------------------------|-----------------------------------------|-------------------|
|                         | Nominal width<br>mm                     |                   |
|                         | Up to 915                               | Over 915 to 1 600 |
| Over 0,2 to 5 excluded  | 13                                      | 19                |

**Table 14 — Permissible variation in flatness of plate**

| Nominal thickness<br>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<br>mm     | Camber tolerance<br>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.

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.