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(JTS/JSA)

**Titanium and titanium alloys — Welded  
tubes for heat exchangers**

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In the event of any doubts arising as to the contents,  
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## Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Titanium Society (JTS)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS H 4631:2012** is replaced with this Standard.

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The “patent rights” as mentioned here include patent right, application for a patent after opening to the public or utility model right.

# Titanium and titanium alloys — Welded tubes for heat exchangers

## Introduction

This Japanese Industrial Standard has been prepared based on ISO 18762 : 2016, Edition 1, with some modifications of the technical contents.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JB.

## 1 Scope

This Standard specifies the titanium and titanium alloy welded tubes having a circular cross-section, intended for the use in appliances where heat is exchanged between the inside and the outside of the tube wall (hereafter referred to as tubes).

**NOTE** The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 18762 : 2016 *Tubes of titanium and titanium alloys — Welded tubes for condensers and heat exchangers — Technical delivery conditions* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and JIS are IDT (identical), MOD (modified), and NEQ (not equivalent) according to ISO/IEC Guide 21-1.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS G 0415 *Steel and steel products — Inspection documents*

JIS H 0321 *General rules for inspection of non-ferrous metal materials*

JIS H 0515 *Eddy current inspection of titanium pipes and tubes*

JIS H 0516 *Ultrasonic inspection of titanium pipes and tubes*

JIS H 0517 *Differential pressure testing method of titanium welded tubes*

JIS H 1610 *Titanium and titanium alloys — Sampling methods*

JIS H 1612 *Methods for determination of nitrogen in titanium and titanium alloys*

JIS H 1614 *Methods for determination of iron in titanium and titanium alloys*

JIS H 1617 *Methods for determination of carbon in titanium and titanium alloys*

JIS H 1619 *Titanium and titanium alloys — Determination of hydrogen content*

JIS H 1620 *Methods for determination of oxygen in titanium and titanium alloys*

JIS H 1621 *Methods for determination of palladium in titanium alloys*

JIS H 1622 *Titanium alloys — Methods for determination of aluminium*

JIS H 1630 *Method for atomic emission spectrometric analysis of titanium*

JIS H 1631 *Titanium alloys — Method for X-ray fluorescence spectrometric analysis*

JIS H 1632-2 *Titanium — ICP atomic emission spectrometry — Part 2 : Determination of palladium, manganese, iron, magnesium, silicon, aluminium, vanadium, nickel, chromium, tin, copper, molybdenum, zirconium, niobium, tantalum, cobalt and yttrium*

JIS Z 2241 *Metallic materials — Tensile testing — Method of test at room temperature*

JIS Z 8401 *Guide to the rounding of numbers*

### 3 Classification and designation

The classification and designation of tubes shall be as given in Table 1.

**Table 1 Classification and designation**

| Class                                                                                                                      | Designation    | Characteristics and application examples<br>(informative)                                                                                                                                                                                                                                                    |
|----------------------------------------------------------------------------------------------------------------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Class 1                                                                                                                    | TTH 270 W      | Pure titanium for industrial use<br>Excellent in corrosion resistance, especially in sea-water resistance.<br>Applicable to chemical apparatus, petroleum refining apparatus, pulp paper making industry apparatus, power generating apparatus, sea-water de-salinization equipment or the like.             |
| Class 2                                                                                                                    | TTH 340 W      |                                                                                                                                                                                                                                                                                                              |
| Class 3                                                                                                                    | TTH 480 W      |                                                                                                                                                                                                                                                                                                              |
| Class 11                                                                                                                   | TTH 270 Pd W   | Corrosion resistant titanium alloy<br>Excellent in corrosion resistance, especially good crevice corrosion resistance.<br>Applicable to chemical apparatus, petroleum refining apparatus, pulp paper making industry apparatus, power generating apparatus, sea-water de-salinization equipment or the like. |
| Class 12                                                                                                                   | TTH 340 Pd W   |                                                                                                                                                                                                                                                                                                              |
| Class 13                                                                                                                   | TTH 480 Pd W   |                                                                                                                                                                                                                                                                                                              |
| Class 14                                                                                                                   | TTH 345 NPrC W |                                                                                                                                                                                                                                                                                                              |
| Class 15                                                                                                                   | TTH 450 NPrC W |                                                                                                                                                                                                                                                                                                              |
| Class 16                                                                                                                   | TTH 343 Ta W   |                                                                                                                                                                                                                                                                                                              |
| Class 17                                                                                                                   | TTH 240 Pd W   |                                                                                                                                                                                                                                                                                                              |
| Class 18                                                                                                                   | TTH 345 Pd W   |                                                                                                                                                                                                                                                                                                              |
| Class 19                                                                                                                   | TTH 345 PCo W  |                                                                                                                                                                                                                                                                                                              |
| Class 20                                                                                                                   | TTH 450 PCo W  |                                                                                                                                                                                                                                                                                                              |
| Class 21                                                                                                                   | TTH 275 RN W   |                                                                                                                                                                                                                                                                                                              |
| Class 22                                                                                                                   | TTH 410 RN W   |                                                                                                                                                                                                                                                                                                              |
| Class 23                                                                                                                   | TTH 483 RN W   |                                                                                                                                                                                                                                                                                                              |
| Class 50                                                                                                                   | TATH 1500 Al W | $\alpha$ alloy (Ti-1.5Al) <sup>a)</sup><br>Excellent in corrosion resistance, especially in sea-water resistance. Good hydrogen absorption resistance and thermal resistance.                                                                                                                                |
| Note <sup>a)</sup> The numeral 1.5 in front of Al indicates the nominal value of percent composition (%) of alloy element. |                |                                                                                                                                                                                                                                                                                                              |

## 4 Quality

### 4.1 Appearance

The appearance of tubes shall be free from defects detrimental to use. The judgement criteria and the treatment on defects detrimental to use shall be as agreed between the purchaser and the manufacturer.

### 4.2 Chemical composition

The tubes shall be tested in accordance with **6.1**, and the chemical composition shall be as given in Table 2.

**Table 2 Chemical composition**

Unit: %

| Class    | N         | C         | H          | Fe        | O         | Al         | Ru           | Pd           | Ta           | Co           | Cr           | Ni           | Others <sup>a)</sup> |          | Ti <sup>b)</sup> |
|----------|-----------|-----------|------------|-----------|-----------|------------|--------------|--------------|--------------|--------------|--------------|--------------|----------------------|----------|------------------|
|          |           |           |            |           |           |            |              |              |              |              |              |              | Each                 | Total    |                  |
| Class 1  | 0.03 max. | 0.08 max. | 0.013 max. | 0.20 max. | 0.15 max. | —          | —            | —            | —            | —            | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 2  | 0.03 max. | 0.08 max. | 0.013 max. | 0.25 max. | 0.20 max. | —          | —            | —            | —            | —            | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 3  | 0.05 max. | 0.08 max. | 0.013 max. | 0.30 max. | 0.30 max. | —          | —            | —            | —            | —            | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 11 | 0.03 max. | 0.08 max. | 0.013 max. | 0.20 max. | 0.15 max. | —          | —            | 0.12 to 0.25 | —            | —            | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 12 | 0.03 max. | 0.08 max. | 0.013 max. | 0.25 max. | 0.20 max. | —          | —            | 0.12 to 0.25 | —            | —            | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 13 | 0.05 max. | 0.08 max. | 0.013 max. | 0.30 max. | 0.30 max. | —          | —            | 0.12 to 0.25 | —            | —            | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 14 | 0.03 max. | 0.08 max. | 0.015 max. | 0.30 max. | 0.25 max. | —          | 0.02 to 0.04 | 0.01 to 0.02 | —            | —            | 0.10 to 0.20 | 0.35 to 0.55 | 0.1 max.             | 0.4 max. | Balance          |
| Class 15 | 0.05 max. | 0.08 max. | 0.015 max. | 0.30 max. | 0.35 max. | —          | 0.02 to 0.04 | 0.01 to 0.02 | —            | —            | 0.10 to 0.20 | 0.35 to 0.55 | 0.1 max.             | 0.4 max. | Balance          |
| Class 16 | 0.03 max. | 0.08 max. | 0.010 max. | 0.15 max. | 0.15 max. | —          | —            | —            | 4.00 to 6.00 | —            | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 17 | 0.03 max. | 0.08 max. | 0.015 max. | 0.20 max. | 0.18 max. | —          | —            | 0.04 to 0.08 | —            | —            | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 18 | 0.03 max. | 0.08 max. | 0.015 max. | 0.30 max. | 0.25 max. | —          | —            | 0.04 to 0.08 | —            | —            | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 19 | 0.03 max. | 0.08 max. | 0.015 max. | 0.30 max. | 0.25 max. | —          | —            | 0.04 to 0.08 | —            | 0.20 to 0.80 | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 20 | 0.05 max. | 0.08 max. | 0.015 max. | 0.30 max. | 0.35 max. | —          | —            | 0.04 to 0.08 | —            | 0.20 to 0.80 | —            | —            | 0.1 max.             | 0.4 max. | Balance          |
| Class 21 | 0.03 max. | 0.08 max. | 0.015 max. | 0.20 max. | 0.10 max. | —          | 0.04 to 0.06 | —            | —            | —            | —            | 0.40 to 0.60 | 0.1 max.             | 0.4 max. | Balance          |
| Class 22 | 0.03 max. | 0.08 max. | 0.015 max. | 0.30 max. | 0.15 max. | —          | 0.04 to 0.06 | —            | —            | —            | —            | 0.40 to 0.60 | 0.1 max.             | 0.4 max. | Balance          |
| Class 23 | 0.05 max. | 0.08 max. | 0.015 max. | 0.30 max. | 0.25 max. | —          | 0.04 to 0.06 | —            | —            | —            | —            | 0.40 to 0.60 | 0.1 max.             | 0.4 max. | Balance          |
| Class 50 | 0.03 max. | 0.08 max. | 0.015 max. | 0.30 max. | 0.25 max. | 1.0 to 2.0 | —            | —            | —            | —            | —            | —            | 0.1 max.             | 0.4 max. | Balance          |

In this table, “—” means that the content of the relevant element in each class is not specified. In the case where any element not specified in this table is intentionally added, the content shall be reported.

Notes <sup>a)</sup> Others are the elements shown by “—” or those not listed in this table, and applicable only when the elements to be analysed are determined upon the agreement between the purchaser and the manufacturer.

<sup>b)</sup> Other elements than those for which the component values are specified in this table are taken as balance, and the balance need not be analysed.

### 4.3 Mechanical properties

The tubes shall be tested in accordance with 6.2, and the mechanical properties (tensile strength and elongation) shall be as given in Table 3. The mechanical properties of the tubes of which the outside diameter is under 10 mm or over 63 mm shall be as agreed between the purchaser and the manufacturer. The value of elongation for the tensile test using a No.12 test piece specified in E.2.2.2.1 of JIS Z 2241 shall be as agreed between the purchaser and the manufacturer.

**Table 3 Mechanical properties of tubes**

| Class                            | Tensile strength<br>MPa | Elongation<br>% |
|----------------------------------|-------------------------|-----------------|
| Class 1                          | 270 to 410              | 24 min.         |
| Class 2                          | 340 to 510              | 23 min.         |
| Class 3                          | 480 to 620              | 18 min.         |
| Class 11                         | 270 to 410              | 23 min.         |
| Class 12                         | 340 to 510              | 20 min.         |
| Class 13                         | 480 to 620              | 18 min.         |
| Class 14                         | 345 min.                | 20 min.         |
| Class 15                         | 450 min.                | 18 min.         |
| Class 16                         | 343 to 481              | 25 min.         |
| Class 17                         | 240 to 380              | 20 min.         |
| Class 18                         | 345 to 515              | 20 min.         |
| Class 19                         | 345 to 515              | 20 min.         |
| Class 20                         | 450 to 590              | 18 min.         |
| Class 21                         | 275 to 450              | 24 min.         |
| Class 22                         | 410 to 530              | 20 min.         |
| Class 23                         | 483 to 630              | 18 min.         |
| Class 50                         | 345 min.                | 20 min.         |
| NOTE 1 MPa = 1 N/mm <sup>2</sup> |                         |                 |

### 4.4 Flaring resistance

The tubes shall be subjected to the flaring test in accordance with 6.3, and the test piece shall be free from cracks after the test.

### 4.5 Flattening resistance

The tubes shall be subjected to the flattening test in accordance with 6.4, and the test piece shall be free from cracks after the test.

### 4.6 Reverse flattening resistance

The tubes shall be subjected to the reverse flattening test in accordance with 6.5, and the weld shall be free from cracks after the test.

### 4.7 Airtightness

The airtightness of tubes shall be tested according to any of the pneumatic test specified in 6.6.2, the hydrostatic test in 6.6.3 or the differential pressure test in 6.6.4.

When subjected to the pneumatic test or the hydrostatic test, tubes shall be free from leakage. When subjected to the differential pressure test, the pressure difference observed shall be under the value of differential pressure as agreed between the purchaser and the manufacturer. If the non-destructive inspection characteristics are applied, the airtightness need not be applied as agreed between the purchaser and the manufacturer.

#### 4.8 Non-destructive inspection characteristics

The non-destructive inspection characteristics of tubes shall be tested according to either of the eddy current inspection specified in 6.7.2 or the ultrasonic inspection specified in 6.7.3, and the tubes shall be free from defects detrimental to use after the test. If the airtightness is applied, the non-destructive inspection characteristics need not be applied as agreed between the purchaser and the manufacturer.

### 5 Dimensions and tolerances

#### 5.1 Dimensions

The representative dimensions of tubes are shown in Annex JA as reference.

#### 5.2 Tolerances on outside diameter and wall thickness

The tolerances on the outside diameter and the wall thickness of tubes shall be as given in Table 4. The tolerances on the outside diameter of the tubes of which the outside diameter is under 10 mm or over 63 mm shall be as agreed between the purchaser and the manufacturer.

When requested by the purchaser, only the plus side or the minus side tolerance may be applied to the outside diameter. In this case, the tolerance value given in Table 4 shall be doubled, and 0 shall apply to the upper side or lower side tolerance.

The wall thickness shall not be measured at the weld. The tolerances on the wall thickness at the weld of tube of which the outside diameter is under 10 mm or over 63 mm shall be as agreed between the purchaser and the manufacturer.

When requested by the purchaser, only the plus side or the minus side tolerance may be applied to the wall thickness. In this case, the tolerance value given in Table 4 shall be doubled, and 0 shall apply to the upper side or lower side tolerance.