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Tubes of titanium and titanium alloys — Welded tubes for condensers and heat exchangers — Technical delivery conditions

Tubes en titane et alliage de titane — Tubes soudés pour condenseurs et échangeurs de chaleur — Conditions techniques de livraison

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 11, *Titanium.*

Tubes of titanium and titanium alloys — Welded tubes for condensers and heat exchangers — Technical delivery conditions

1 Scope

This International Standard specifies requirements for the manufacture of welded tubes made from titanium or titanium alloys, for use in condensers and heat exchangers.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 8492, *Metallic materials — Tube — Flattening test*

ISO 8493, *Metallic materials — Tube — Drift-expanding test*

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

ISO 25902-1, *Titanium pipes and tubes — Non-destructive testing — Part 1: Eddy-current examination*

ISO 25902-2, *Titanium pipes and tubes — Non-destructive testing — Part 2: Ultrasonic testing for the detection of longitudinal imperfections*

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

ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM E120, *Test methods for Chemical Analysis of Titanium and Titanium Alloys*

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*

3 Information to be supplied by the purchaser

3.1 General information

The purchase order shall include the following information:

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

b) grade number;

c) outside diameter and wall thickness (minimum or average);

d) length and type of length (random or fixed lengths);

e) method of manufacture and finish;

f) non-destructive tests;

g) packaging;

h) inspection;

i) certification.

3.2 Options

A number of options are specified in this International Standard and these are 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 tubes shall be supplied in accordance with the basic specification.

a) Restrictive chemistry (see 5.2).

b) Product analysis (see 5.2).

c) Special mechanical properties (see 5.3).

4 Manufacturing

The welded tube shall be made from flat-rolled strips by an automatic arc-welding, a laser welding process and other welding processes. Use of a filler material is not permitted. Butt-welds are absolutely forbidden.

After welding, the tubes shall be annealed at a temperature between 500 °C to 800 °C when agreed upon between the manufacturer and purchaser and so stated in the purchase order.

5 Requirements

5.1 General

When supplied in the delivery condition indicated in 4.1 and inspected in accordance with Clause 6, the tubes shall conform to the requirements of this International Standard.

5.2 Chemical composition

The 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 heat during melting shall be reported.

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

Table 1 — Chemical composition

Chemical composition in % by mass

Grade	Designation	Nitrogen max.	Carbon max.	Hydrogen max.	Iron max.	Oxygen max.	Aluminium	Vanadium	Ruthenium	Palladium	Molybdenum	Nickel	Chromium	Cobalt	Residuals max.		Titanium
															Each	Total	
1	CPTi240	0,03	0,08	0,015	0,20	0,18									0,1	0,4	balance
1H	CPTi270	0,03	0,08	0,015	0,20	0,18									0,1	0,4	balance
2L	CPTi340	0,03	0,08	0,015	0,25	0,20									0,1	0,4	balance
2	CPTi345	0,03	0,08	0,015	0,30	0,25									0,1	0,4	balance
3	CPTi450	0,05	0,08	0,015	0,30	0,35									0,1	0,4	balance
3H	CPTI480	0,05	0,08	0,015	0,30	0,35									0,1	0,4	balance
7L	TiCR0,18Pd340	0,03	0,08,	0,015	0,25	0,20				0,12 to 0,25					0,1	0,4	balance
7	TiCR0,18Pd345	0,03	0,08	0,015	0,30	0,25				0,12 to 0,25					0,1	0,4	balance
9	TiA3Al2,5V	0,03	0,08	0,015	0,25	0,15	2,5 to 3,5	2,0 to 3,0							0,1	0,4	balance
12	TiCR0,3Mo 0,75Ni483	0,03	0,08	0,015	0,30	0,25					0,2 to 0,4	0,6 to 0,9			0,1	0,4	balance
16L	TiCR0,06Pd345	0,03	0,08	0,015	0,30	0,25				0,04 to 0,08					0,1	0,4	balance
16	TiCR0,06Pd345	0,03	0,08	0,015	0,30	0,25				0,04 to 0,08					0,1	0,4	balance
26	TiCR0,11Ru345	0,03	0,08	0,015	0,30	0,25			0,08 to 0,14						0,1	0,4	balance
31	TiCR0,05Pd0,-5Co345	0,03	0,08	0,015	0,30	0,25				0,04 to 0,08				0,20 to 0,80	0,1	0,4	balance
33	TiCR0,015Pd0, 03Ru0.45Ni0.15Cr345	0,03	0,08	0,015	0,30	0,25			0,02 to 0.04	0,01 to 0,02		0,35 to 0,55	0.10 to 0,20		0,1	0,4	balance
37	TiCR0,1,5Al345	0,03	0,08	0,015	0,30	0,25	1,0 to 2,0								0,1	0,4	balance

5.3 Tensile properties

The room temperature tensile properties of the tubes shall conform to the requirements prescribed in Table 2.

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

Table 2 — Mechanical properties at room temperature

Grade	Designation	TS MPa		YS or 0,2 %Offset[a] MPa		Elongation 50 mm min %
		min	max	min	max	
1	CPTi240	240		138	310	24
1H	CPTi270	270	410			24
2L	CPTi340	340	510			23
2	CPTi345	345		275	450	20
3	CPTi450	450		380	550	18
3H	CPTi480	480	620			18
7L	TiCR0,18Pd340	340	510			23
7	TiCR0,18Pd345	345		275	450	20
9	TiA3Al2,5V	620		483	—	12
12	TiCR0,3Mo0,75Ni483	483		345	—	12
16L	TiCR0,06Pd345	345	515			20
16	TiCR0,06Pd345	345		275	450	20
26	TiCR0,11Ru345	345		275	450	20
31	TiCR0.05Pd0.5Co345	345	515			20
33	TiCR0,015P-d0,03Ru0,45Ni0,15Cr345	345				20
37	TiCR0,1,5Al345	345		215	450	20

[a] YS or 0,2 %Offset is specified for the tubes annealed and no specified property for as deformed tubes.

5.4 Flattening test

The test shall be carried out in accordance with ISO 8492.

The tubes shall be flattened under a load applied gradually at room temperature until the distance between the load platens reaches the value H calculated by Formula (1):

$$H = \frac{(1+e)t}{\left(e + \frac{t}{D}\right)} \tag{1}$$

where

H is the distance between platens under load, in millimetres;

t is the specified wall thickness, in millimetres;

D is the specified diameter, in millimetres;

e is a constant, the value described in Table 3.

Table 3 — constant value of "*e*"

Grade	Designation	Constant *e*
1	CPTi240	0,07
1H	CPTi270	0,07
2L	CPTi340	0,07
2	CPTi345	0,07
3	CPTi450	0,04(OD ≦ 25,4 mm) 0,06(OD > 25,4 mm)
3H	CPTi480	0,04(OD ≦ 25,4 mm) 0,06(OD > 25,4 mm)
7L	TiCR0,18Pd340	0,07
7	TiCR0,18Pd345	0,07
9	TiA3Al2,5V	To be negotiated
12	TiCR0,3Mo0,75Ni483	To be negotiated
16L	TiCR0,06Pd345	0,07
16	TiCR0,06Pd345	0,07
26	TiCR0,11Ru345	0,07
31	TiCR0.05Pd0.5Co345	0,07
33	TiCR0,015P-d0,03Ru0,45Ni0,15Cr345	0,07
37	TiCR0,1,5Al345	0,03

The weld shall be positioned on the 90° or 270° centreline during loading so as to be subjected to the maximum stress.

After testing, the test piece shall be free from cracks or breaks. Examination for cracking shall be by the unaided eye. However, slight incipient cracks at its edges shall not be regarded as justification for rejection.

However, when low D-to-t ratio tubular products are tested, because the strain imposed due to geometry is unreasonably high on the inside surface at the 6 o'clock and 12 o'clock locations, cracks at these locations shall not be cause for rejection if the D-to-t ratio is less than ten (10).

The results from all calculations are to be rounded to two decimal places.

5.5 Reverse flattening test

Tubes shall be subjected to a reverse flattening test in accordance with ASTM A370 supplementary requirement II. A section of the tube, approximately 100 mm (4 in) long, that is slit longitudinally 90° either side of the weld, shall be opened and flattened with the weld at the point of maximum bend. No cracking is permitted.

5.6 Drift-expanding (flaring) test

The test shall be carried out in accordance with ISO 8493.

The tube section, approximately 100 mm (4 in), shall be expanded with a 60° conical tool, until the percentage increase in inside diameter shown in Table 4 is reached. After testing, the test piece shall be free from cracks or breaks. Examination for cracking shall be by the unaided eye. However, slight incipient cracks at its edges shall not be regarded as justification for rejection.