NATIONAL STANDARD OF
THE PEOPLE'S REPUBLIC OF CHINA

中华人民共和国国家标准

GB/T 3625—2007

(replacing GB/T 3625—1995)

Titanium and titanium alloy tube for condensers and heat exchangers

换热器及冷凝器用钛及钛合金管

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Issued jointly by the General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China and the Standardization Administration of the People's Republic of China

Foreword

This standard replaces GB/T 3625—1995 "Titanium and titanium alloy tube for condensers and heat exchangers".

This standard is a revision based on GB/T 3625—1995, with reference to ASTM B338:2006 and in combination with the domestic production and use practice.

Compared with GB/T 3625—1995, the main changes of this standard are as follows:

——the designation TA0 in the original standard was deleted, the designations TA3 and TA9-1 were added, and the chemical compositions corresponding to each designation were revised to be completely consistent with those of the corresponding designations in ASTM;

——the range of wall thickness was expanded;

——the mechanical property indexes of TA3 and TA9-1 and the 0.2% proof strength (non-proportional extension) Rp0.2 of TA10 alloy tube were added, and the tensile strength index of TA10 alloy tube was raised;

——the process property indexes of TA3 and TA9-1 were added, and the hydrostatic test pressure value of TA10 tube was raised;

——the flattening test requirement is consistent with the provisions of ASTM B338:2006;

——the requirements for the purchase order (or contract) were added.

This standard was proposed by the China Nonferrous Metals Industry Association.

This standard is under the jurisdiction of the National Nonferrous Metals Standardization Technical Committee.

This standard was drafted by Baoti Group Co., Ltd. and Baoji Titanium Industry Co., Ltd.

The main drafters of this standard are: Huang Yongguang, Li Baozhen, Li Nong, Zhang Pinghui, Tong Xuewen, Yang Yulan and Wang Weiqi.

This standard is interpreted by the National Nonferrous Metals Standardization Technical Committee.

The previous editions of the standard replaced by this standard were issued as follows:

——GB/T 3625—1983; GB/T 3625—1995.

1 Scope

This standard specifies the requirements, test methods, inspection rules, marking, packaging, transport, storage and contents of the contract for titanium and titanium alloy tube.

This standard applies to titanium and titanium alloy seamless tube produced by the cold-rolled (cold-drawn) method, and titanium and titanium alloy tube produced by the welding method and the welding-rolling method.

This standard applies to titanium and titanium alloy tube used for the manufacture of heat exchangers, condensers and various pressure vessels.

2 Normative References

The following documents contain provisions which, through reference in this standard, constitute provisions of this standard. For dated references, all subsequent amendments (excluding corrigenda) or revisions do not apply to this standard; however, parties to agreements based on this standard are encouraged to study whether the latest editions of these documents can be used. For undated references, the latest edition applies to this standard.

Standard No.	Title
GB/T 228	Metallic materials — Tensile testing method at room temperature
GB/T 241	Metallic tubes — Hydraulic testing method
GB/T 242	Metallic tubes — Flaring test method
GB/T 246	Metallic tubes — Flattening test method
GB/T 3620.1	Designation and composition of titanium and titanium alloys
GB/T 3620.2	Permissible deviations in chemical composition for wrought titanium and titanium alloy products
GB/T 4698 (all parts)	Methods for chemical analysis of titanium sponge, titanium and titanium alloys
GB/T 8180	Packaging, marking, transport and storage of wrought titanium and titanium alloy products
GB/T 12969	Ultrasonic and eddy current testing method of titanium and titanium alloy tubes

3 Requirements

3.1 Product Classification

3.1.1 Designations, Conditions and Specifications of the Products

3.1.1.1

The designations, conditions and specifications of cold-rolled titanium and titanium alloy seamless tube shall conform to the provisions of Table 1.

Table 1 — Cold-rolled titanium and titanium alloy seamless tube

Designation	Condition	Outer diameter/ mm	Wall thickness/ mm											
			0.5	0.6	0.8	1.0	1.25	1.5	2.0	2.5	3.0	3.5	4.0	4.5
TA1, TA2, TA3, TA9, TA9-1, TA10	Annealed (M)	>10~15	○	○	○	○	○	○	○	○	—	—	—	—
		>15~20	—	○	○	○	○	○	○	○	—	—	—	—
		>20~30	—	○	○	○	○	○	○	○	○	—	—	—
		>30~40	—	—	○	○	○	○	○	○	○	○	—	—
		>40~50	—	—	—	○	○	○	○	○	○	○	○	—

Designation	Condition	Outer diameter/ mm	Wall thickness/ mm											
		>50~60	—	—	—	—	○	○	○	○	○	○	○	○
		>60~80	—	—	—	—	—	○	○	○	○	○	○	○

NOTE: "○" indicates the specification that can be produced according to this standard.

3.1.1.2

The designations, conditions and specifications of welded tube shall conform to the provisions of Table 2.

Table 2 — Welded tube

Designation	Condition	Outer diameter/ mm	Wall thickness/ mm							
			0.5	0.6	0.8	1.0	1.25	1.5	2.0	2.5
TA1, TA2, TA3, TA9, TA9-1, TA10	Annealed (M)	16	○	○	○	○	—	—	—	—
		19	○	○	○	○	○	○	—	—
		25, 27	○	○	○	○	○	○	—	—
		31, 32, 33	—	—	○	○	○	○	○	—
		38	—	—	—	—	○	○	○	○
		50	—	—	—	—	—	○	○	○
		63	—	—	—	—	—	○	○	○

NOTE: "○" indicates the specification that can be produced according to this standard.

3.1.1.3

The designations, conditions and specifications of titanium and titanium alloy tube produced by the welding-rolling method shall conform to the provisions of Table 3.

Table 3 — Welded-rolled tube

Designation	Condition	Outer diameter/ mm	Wall thickness/ mm						
			0.5	0.6	0.8	1.0	1.25	1.5	2.0
TA1, TA2, TA3, TA9-1, TA9, TA10	Annealed (M)	6~10	○	○	○	○	○	—	—
		＞10~15	○	○	○	○	○	○	○
		＞15~30	○	○	○	○	○	○	○

NOTE: "○" indicates the specification that can be produced according to this standard.

3.1.2 Marking Examples

The product marking shall be expressed in the order of product name, designation, production method, condition, specification and standard number. The marking examples are as follows:

Example 1:

For a TA2 cold-rolled seamless tube produced according to this standard, in the annealed condition, with an outer diameter of 36 mm, a wall thickness of 4 mm and a length of 3 000 mm, the marking is:

Tube TA2 S M Φ36×4×3 000 GB/T 3625—2007.

Example 2:

For a TA1 welded tube produced according to this standard, in the annealed condition, with an outer diameter of 25 mm, a wall thickness of 0.6 mm and a length of 4 000 mm, the marking is:

Tube TA1 W M Φ25×0.6×4 000 GB/T 3625—2007.

Example 3:

For a TA1 welded-rolled tube produced according to this standard, in the annealed condition, with an outer diameter of 19 mm, a wall thickness of 0.5 mm and a length of 4 000 mm, the marking is:

Tube TA1 WR M Φ19×0.5×4 000 GB/T 3625—2007.

3.2 Dimensions and Permissible Deviations of Dimensions

3.2.1

The permissible deviations of the outer diameter and wall thickness of the tube shall conform to the provisions of Table 4. The permissible deviation of the wall thickness of the tube does not apply to the weld area of welded tube.

Table 4 — Permissible deviations of outer diameter and wall thickness — Units in millimetres

Outer diameter	Permissible deviation of outer diameter	Permissible deviation of wall thickness
6~25	±0.10	±10%
＞25~38	±0.13	
＞38~50	±0.15	
＞50~60	±0.18	
＞60~80	±0.25	

3.2.2

The lengths of the tube shall conform to the provisions of Table 5 and Table 6.

Table 5 — Lengths of seamless tube and welded-rolled tube — Units in millimetres

Type		Length
Seamless tube	Outer diameter ≤15	500~4 000

Type		Length
	Wall thickness ≤2.0	500~9 000
	Wall thickness ＞2.0~4.5	500~6 000
Welded-rolled tube	Wall thickness 0.5~0.8	500~8 000
	Wall thickness ＞0.8~2.0	500~5 000

NOTE: When the length exceeds the lengths specified in the table, supply by negotiation is permissible.

Table 6 — Lengths of welded tube — Units in millimetres

Type	Length
Wall thickness 0.5~1.25	500~15 000
Wall thickness ＞1.25~2.0	500~6 000
Wall thickness ＞2.0~2.5	500~4 000

NOTE: When the length exceeds the lengths specified in the table, supply by negotiation is permissible.

3.2.3

The exact length or multiple length of the tube shall be within its random length range. When the exact length is less than 6 000 mm, the permissible deviation is +60/0 mm; when the exact length is not less than 6 000 mm, the permissible deviation is +10/0 mm. The cutting allowance of the tube shall also be taken into account for the multiple length, with each cutting allowance being 5 mm.

3.2.4

Both ends of the tube shall be cut flat and square, and shall be free from burrs; the skew of cutting shall conform to the provisions of Table 7.

Table 7 — Skew of cutting — Units in millimetres

Outer diameter	Skew of cutting, not greater than
＞6~30	2
＞30~60	3
＞60~80	4

3.2.5

The straightness of the tube shall conform to the provisions of Table 8.

Table 8 — Straightness

Outer diameter/mm	Straightness/(mm/m), not greater than
≤30	2
＞30~80	3

3.2.6

The out-of-roundness and non-uniformity of wall thickness of the tube shall not exceed the permissible deviations of the outer diameter and wall thickness.

3.3 Chemical Composition

The chemical composition of the products shall conform to the provisions of GB/T 3620.1. When the purchaser re-verifies, the permissible deviations of the chemical composition shall conform to the provisions of GB/T 3620.2.

3.4 Mechanical Properties

3.4.1

The room-temperature mechanical properties of the tube in the supply condition shall conform to the provisions of Table 9. The 0.2% proof strength (non-proportional extension) Rp0.2 shall be tested only when required by the purchaser and stated in the contract.

Table 9 — Room-temperature mechanical properties

Alloy designation	Condition	Room-temperature mechanical properties		
		Tensile strength Rm/MPa	0.2% proof strength (non-proportional extension) Rp0.2/MPa	Percentage elongation after fracture A50mm/%
TA1	Annealed (M)	≥240	140~310	≥24
TA2		≥400	275~450	≥20
TA3		≥500	380~550	≥18
TA9		≥400	275~450	≥20
TA9-1		≥240	140~310	≥24
TA10		≥460	≥300	≥18

3.5 Process Properties

3.5.1 Flattening Test

3.5.1.1

The tube shall be subjected to the flattening test. When flattened to the specified distance H, no cracks shall appear on the surface of the tube. The distance H between the flattening plates is calculated by formula (1):

$$H = (1+e)t / (e + t/D) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:

H——distance between the flattening plates, in millimetres (mm);

t——nominal wall thickness of the tube, in millimetres (mm);

D——nominal outer diameter of the tube, in millimetres (mm);

e——constant, of which the value is 0.07 for TA1, TA2, TA9 and TA9-1; for TA3, when the diameter of the tube is not greater than 25.4 mm, e is 0.04, and when the diameter of the tube is greater than 25.4 mm, e is 0.06; for TA10, e is 0.04.

3.5.1.2

When the flattening test is carried out on tube with D/t<10, extremely high stresses are produced at the positions corresponding to "6 o'clock" and "12 o'clock" on the inner surface of the tube for geometrical reasons; therefore, cracks produced at these positions shall not be used as the basis for rejection.

3.5.1.3

The flattening direction and the weld position of welded tube are shown in Figure 1.

(Figure 1 — Flattening direction and weld position of welded tube)

3.5.1.4 Flatten-Out Test

Welded tube and welded-rolled tube shall be subjected to the flatten-out test. After flattening out, no cracks shall appear at the weld of the test piece.

3.5.2 Flaring Test

The tube shall be subjected to the flaring test. The flaring shall be carried out with a tool with a taper of the punch of 60°. When the expansion of the inner diameter of the test piece after flaring conforms to the provisions of Table 10, no cracks shall appear on the test piece.

Table 10 — Flaring test

Designation	Expansion rate of the inner diameter of the tube/%, not less than
TA1, TA9-1	22
TA2, TA9	20
TA3, TA10	17

3.5.3 Hydrostatic (Pneumatic) Test

3.5.3.1

The tube shall be subjected to the hydrostatic or pneumatic test. The test method selected by the purchaser shall be stated in the contract; when not stated in the contract, the supplier may choose it at its own discretion.

3.5.3.2

In the hydrostatic test, the test pressure selected by the purchaser shall be stated in the contract. When not stated in the contract, the test pressure is calculated by formula (2):

$$P = SEt / (D/2 - 0.4t) \quad \ldots\ldots (2)$$

where:

P——test pressure, in megapascals (MPa);

S——allowable stress, taken as 50% of the minimum value of the corresponding 0.2% proof strength (non-proportional extension), in megapascals (MPa);

D——nominal outer diameter of the tube, in millimetres (mm);

t——nominal wall thickness of the tube, in millimetres (mm);

E——constant, taken as 1.0 for seamless tube, and 0.85 for welded tube and welded-rolled tube.

When the nominal outer diameter of the tube is not greater than 76 mm, the maximum pressure of the hydrostatic test shall not be greater than 17.2 MPa; when the nominal outer diameter of the tube is greater than 76 mm, the maximum pressure of the hydrostatic test shall not be greater than 19.3 MPa. During the test, the pressure shall be maintained for 5 s, and the tube shall not be distorted or leak.

3.5.3.3

In the pneumatic test, the internal pressure of the tube is 0.7 MPa. During the test, the pressure shall be maintained for 5 s, and the tube shall not be distorted or leak.

3.6 Non-Destructive Testing

The tube with an outer diameter of 10 mm~60 mm shall be subjected to ultrasonic or eddy current testing, and shall conform to the provisions of GB/T 12969. The testing method selected by the purchaser shall be stated in the contract. When not stated in the contract, the supplier shall determine one method for testing at its own discretion. When ultrasonic or eddy current testing is required for tubes of other specifications, it shall be agreed upon between the supplier and the purchaser.

3.7 Visual Quality

3.7.1

The inner and outer surfaces of the tube shall be clean and free from defects visible to the naked eye such as cracks, folding, peeling and pinholes. The weld of welded tube shall be fully filled and smoothly transitioned.

3.7.2

Local defects on the surface of the tube may be removed, provided that after removal the outer diameter and wall thickness do not exceed their permissible deviations.

3.7.3

Scratches, pits, protrusions and straightening marks not exceeding the permissible deviations of the outer diameter and wall thickness are permitted on the surface of the tube. Different colours of the tube after pickling are permitted.

4 Test Methods

4.1 Method of Arbitration Chemical Composition Analysis

The arbitration chemical composition analysis of the tube shall be carried out in accordance with GB/T 4698.

4.2 Test Methods for Mechanical Properties

4.2.1

The room-temperature tensile test method of the tube shall be carried out in accordance with GB/T 228.

4.2.2

For tube with an outer diameter of not greater than 35 mm, the S8 test piece in GB/T 228 shall be used; for tube with an outer diameter greater than 35 mm, the S4 test piece shall be used.

4.3 Test Methods for Process Properties

4.3.1

The hydrostatic test of the tube shall be carried out in accordance with GB/T 241.

4.3.2

The pneumatic test of the tube shall be carried out by the method agreed upon between the supplier and the purchaser.

4.3.3

The flaring test of the tube shall be carried out in accordance with GB/T 242.

4.3.4

The flattening test of the tube shall be carried out in accordance with GB/T 246.

4.4 Non-Destructive Testing Methods

For tubes conforming to the size range of GB/T 12969, the ultrasonic and eddy current testing shall be carried out in accordance with GB/T 12969. When the specification of the tube exceeds the applicable range of GB/T 12969, the manual ultrasonic testing method is permitted.

4.5 Dimension Measurement Method

The dimension inspection of the tube shall be carried out with measuring instruments of corresponding accuracy.

4.6 Visual Quality Inspection Method

The visual quality of the tube shall be inspected by visual examination.

5 Inspection Rules

5.1 Inspection and Acceptance

5.1.1

The products shall be inspected by the quality inspection department of the supplier to ensure that the product quality conforms to the provisions of this standard or the contract, and a quality certificate shall be filled in.

5.1.2

The products received by the purchaser shall be accepted in accordance with the provisions of this standard. When the inspection results do not conform to the provisions of this standard, the matter shall be raised with the supplier within three months from the date of receipt of the products, and settled through negotiation between the supplier and the purchaser. If arbitration is required, the arbitration sampling shall be carried out jointly by the supplier and the purchaser.

5.2 Batching

The products shall be submitted for acceptance in lots. Each lot shall consist of products of the same designation, melting furnace number, specification, manufacturing method, condition and from the same heat-treatment furnace batch.

5.3 Inspection Items

Each lot of products shall be subjected to the inspection of chemical composition, dimension deviations, mechanical properties, process properties, non-destructive testing and visual quality. The inspection items stated in the contract shall also be inspected.

5.4 Sampling Positions and Sampling Quantities

The sampling of the products shall conform to the provisions of Table 11.

Table 11 — Sampling positions and sampling quantities

Inspection item	Sampling provision	Clause for requirements	Clause for test method
Chemical composition	The supplier may report the analysis results of the original ingot; the purchaser may take samples from the finished tubes for analysis	3.3	4.1
Mechanical properties	2 tubes taken at random per lot, 1 test piece from each	3.4	4.2
Flattening test	2 tubes taken at random per lot, 1 test piece from each	3.5.1	4.3.4
Flaring test	2 tubes taken at random per lot, 1 test piece from each	3.5.2	4.3.3
Hydrostatic or pneumatic test	Every tube	3.5.3	4.3.1 4.3.2
Ultrasonic or eddy current testing	According to the contract requirements, or every tube	3.6	4.4
Dimensions	Every tube	3.2	4.5
Visual quality	Every tube. For tube with an inner diameter of not greater than 20 mm, it is permissible to take 5 tubes at random from each lot, cut a 150 mm tube section from each, split it longitudinally into two halves, measure the wall thickness and inspect the inner surface, in place of inspecting every tube	3.7	4.6

NOTE: When the purchaser requires and states in the contract that the hydrogen content analysis shall be carried out on the finished product, 1 test piece shall be taken at random from the finished tubes of each lot for the analysis of the hydrogen content.

5.5 Repeat Testing and Judgement of Inspection Results

5.5.1

When the chemical composition is non-conforming, the lot shall be judged non-conforming.

5.5.2

In the inspections of the room-temperature mechanical properties, the flattening test and the flaring test, if the inspection result of one test piece is non-conforming, double the number of test pieces shall be taken from the lot for a repeat test of the non-conforming item. If one test piece in the repeat test results is still non-conforming, the lot shall be judged non-conforming; however, the supplier is permitted to inspect the non-conforming item tube by tube, and the conforming products may be re-formed into lots.

5.5.3

When the dimensions and shape, surface quality, hydrostatic test and ultrasonic testing of the tube are non-conforming, the individual tube shall be judged non-conforming.

6 Marking, Packaging, Transport and Storage

6.1 Marking

The following marks shall be made on the inspected conforming tubes and on the packing cases:

a) designation of the products;

b) product name;

c) supply condition;

d) batch number;

e) number of this standard.

6.2 Packaging, Transport and Storage

The packaging, transport and storage of the products shall conform to the relevant provisions of GB/T 8180.

6.3 Quality Certificate

Each lot of tubes shall be accompanied by a quality certificate, on which the following shall be stated:

a) name of the supplier;

b) product name;

c) designation, specification, manufacturing method and condition of the products;

d) melting furnace number, lot number, lot weight and number of pieces;

e) analysis and inspection results and the seal of the quality inspection department;

f) number of this standard;

g) date of packaging.

7 Contents of the Purchase Order (or Contract)

The purchase order (or contract) for ordering the materials listed in this standard shall include the following contents:

a) product name;

b) designation;

c) condition;

d) dimension specification;

e) quantity;

f) working pressure of the hydrostatic test;

g) ultrasonic or eddy current testing;

h) number of this standard;

i) others.