NATIONAL STANDARD OF
THE PEOPLE'S REPUBLIC OF CHINA

中华人民共和国国家标准

GB/T 3624—2023

(replacing GB/T 3624—2010)

Titanium and titanium alloy seamless tubes

钛及钛合金无缝管

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Foreword

This document was drafted in accordance with the rules given in GB/T 1.1—2020 "Directives for standardization — Part 1: Structure and drafting rules for standardization documents".

This document replaces GB/T 3624—2010 "Titanium and titanium alloy seamless tubes". Compared with GB/T 3624—2010, apart from structural adjustments and editorial changes, the main technical changes are as follows:

a) A chapter on "Classification and designation" was added (see Clause 4);

b) The products of the TA3 designation were deleted (see 3.1.1 and 3.3 of the 2010 edition);

c) The products of the TA0, TA1G, TA2G, TA3G and TA18 designations and their room-temperature tensile properties were added (see 4.1 and 5.3);

d) The room-temperature tensile properties of the TA1 and TA2 products were changed (see 5.3, and 3.3 of the 2010 edition);

e) The test methods were changed (see Clause 6, and Clause 4 of the 2010 edition);

f) The sampling methods were changed (see 7.4, and 5.4 of the 2010 edition).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The issuing body of this document shall not be held responsible for identifying any or all such patent rights.

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

This document is under the jurisdiction of the National Nonferrous Metals Standardization Technical Committee (SAC/TC 243).

The drafting organizations of this document are: Baoji Titanium Industry Co., Ltd., Baoji Titanium Group Co., Ltd., Nonferrous Metals Techno-Economic Research Institute Co., Ltd., Nanjing Baose Co., Ltd., and GRINM Engineering Technology Research Institute Co., Ltd.

This document was first issued in 1983, first revised in 1995, second revised in 2010, and this is the third revision.

1 Scope

This document specifies the classification and designation, technical requirements, test methods, inspection rules, marking, packaging, transport, storage, accompanying documents and contents of the purchase order for titanium and titanium alloy seamless tubes.

This document applies to titanium and titanium alloy seamless tubes (hereinafter referred to as tubes) produced by the cold-rolling (cold-drawing) method.

2 Normative References

The following documents contain provisions which, through normative reference in this document, constitute indispensable provisions of this document. For dated references, only the edition cited applies. For undated references, the latest edition (including all amendments) applies.

Standard No.	Title
GB/T 228.1—2021	Metallic materials — Tensile testing — Part 1: Method of test at room temperature
GB/T 241	Method for hydraulic test of metal tubes
GB/T 244	Metallic materials — Tubes — Bending test method
GB/T 246	Metallic materials — 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 6611	Terminology and metallographs for titanium and titanium alloys
GB/T 8180	Packaging, marking, transport and storage of wrought titanium and titanium alloy products
GB/T 23604	Sampling method for mechanical property tests of titanium and titanium alloy products
GB/T 34647	Designation codes for conditions of titanium and titanium alloy products
GB/T 38982	Methods for measuring dimensions of wrought titanium and titanium alloy products
YS/T 1262	Methods for chemical analysis of titanium sponge, titanium and titanium alloys — Determination of multi-element contents — Inductively coupled plasma atomic emission spectrometry

3 Terms and Definitions

The terms and definitions defined in GB/T 6611, GB/T 34647 and GB/T 38982 apply to this document.

4 Classification and Designation

4.1 Product Classification

The designations, conditions and specifications of the tubes shall conform to the provisions of Table 1.

Table 1 — Designations, conditions and specifications — Unit: millimetre

Designation	Condition	Outside diameter	Wall thickness	Length
TA0, TA1, TA2, TA1G, TA2G, TA3G, TA8, TA8-1, TA9, TA9-1, TA10, TA18	Annealed condition (M)	3~110	0.2~5.5	500~4 000; where the wall thickness is not greater than 2.0, 500~9 000; where the wall thickness is greater than 2.0 and not greater than 5.5, 500~6 000

Note: "○" indicates the specifications that may be produced in accordance with this document (the availability of each wall thickness for each outside diameter is marked by "○" in the matrix in the original document).

4.2 Product Designation

The product designation is expressed in the order of product name, designation, condition, specification and number of this document.

Example: A tube manufactured with the TA2G designation, in the annealed condition, with an outside diameter of 30 mm, a wall thickness of 1.5 mm and a length of 3 500 mm, is designated as:

Tube TA2G M Φ30×1.5×3500 GB/T 3624—2023

5 Technical Requirements

5.1 Chemical Composition

5.1.1

The chemical composition of the tubes shall conform to the provisions of GB/T 3620.1.

5.1.2

When the purchaser takes samples from the products for re-verification of the chemical composition, the permissible deviations in chemical composition shall conform to the provisions of GB/T 3620.2.

5.2 Dimensions and Their Permissible Deviations

5.2.1

The permissible deviations of the outside diameters of the tubes shall conform to the provisions of Table 2.

Table 2 — Permissible deviations of the outside diameter — Unit: millimetre

Outside diameter	3~10	>10~30	>30~50	>50~80	>80~100	>100~110
Permissible deviation of the outside diameter	±0.15	±0.30	±0.50	±0.65	±0.75	±0.85

5.2.2

The permissible deviations of the wall thickness of the tubes shall not exceed ±12.5 % of the nominal wall thickness.

5.2.3

The permissible deviations of the length of the tubes shall conform to the provisions of Table 3.

Table 3 — Permissible deviations of the length — Unit: millimetre

Length	<6 000	≥6 000
Permissible deviation of the length	+6 / 0	+10 / 0

5.2.4

The cut-to-length or multiple-length tubes shall be within the range of the random length. For multiple lengths, the cutting allowance of the tubes shall be taken into account, and the cutting allowance of each cut is 5 mm.

5.2.5

Both ends of the tubes shall be cut flat and free from burrs, and the out-of-squareness of the cut shall conform to the provisions of Table 4.

Table 4 — Out-of-squareness of the cut — Unit: millimetre

Outside diameter	3~30	>30~60	>60~110
Out-of-squareness of the cut	≤2	≤3	≤4

5.2.6

The straightness per metre of the tubes shall conform to the provisions of Table 5.

Table 5 — Straightness — Unit: millimetre

Outside diameter	3~30	>30~110
Straightness	≤3	≤4

5.2.7

The ovality and the unevenness of the wall thickness of the tubes shall not exceed the permissible deviations of the outside diameter and the wall thickness.

5.3 Room-Temperature Tensile Properties

The room-temperature tensile properties of the tubes shall conform to the provisions of Table 6.

Table 6 — Room-temperature tensile properties

Designation	Condition	Tensile strength Rm, MPa	Proof strength, non-proportional extension Rp0.2, MPa	Percentage elongation after fracture A50mm, %
TA0	Annealed condition (M)	280~420	≥170	≥24
TA1	Annealed condition (M)	370~530	≥250	≥20
TA2	Annealed condition (M)	440~620	≥320	≥18
TA1G	Annealed condition (M)	≥240	140~310	≥24
TA2G	Annealed condition (M)	≥400	275~450	≥20
TA3G	Annealed condition (M)	≥500	380~550	≥18

Designation	Condition	Tensile strength Rm, MPa	Proof strength, non-proportional extension Rp0.2, MPa	Percentage elongation after fracture A50mm, %
TA8	Annealed condition (M)	≥400	275~450	≥20
TA8-1	Annealed condition (M)	≥240	140~310	≥24
TA9	Annealed condition (M)	≥400	275~450	≥20
TA9-1	Annealed condition (M)	≥240	140~310	≥24
TA10	Annealed condition (M)	≥460	≥300	≥18
TA18	Annealed condition (M)	≥620	≥483	≥15

5.4 Technological Properties

5.4.1 Flattening Test

When required by the purchaser and specified in the purchase order, the tubes may be subjected to the flattening test. When flattened to the specified distance H, no cracks shall appear on the surface of the tubes. The distance between the platens (H) is calculated by formula (1):

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

Where:

H — distance between the platens, in millimetre (mm);

e — constant; when the diameter of the tube is not greater than 25.4 mm, e = 0.04; when the diameter of the tube is greater than 25.4 mm, e = 0.06;

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

D — nominal outside diameter of the tube, in millimetre (mm).

For tubes with D/t<10 subjected to the flattening test, cracks generated at the positions corresponding to "6 o'clock" and "12 o'clock" on the inner surface of the tubes shall not be taken as the basis for rejection.

5.4.2 Hydraulic (Pneumatic) Pressure Test

5.4.2.1

When required by the purchaser and specified in the purchase order, the tubes shall be subjected to the hydraulic or pneumatic pressure test, and the test method selected by the purchaser shall be specified in the purchase order. Where not specified in the purchase order, the supplier may not carry out the test, but shall ensure that the tubes conform to the requirements of 5.4.2.2 (hydraulic pressure test) or 5.4.2.3 (pneumatic pressure test).

5.4.2.2

For the hydraulic pressure test, the test pressure selected by the purchaser shall be specified in the purchase order. Where not specified in the purchase order, the test pressure is calculated by formula (2):

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

Where:

P — test pressure, in megapascal (MPa);

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

E — constant, 1.0;

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

D — nominal outside diameter of the tube, in millimetre (mm).

When the nominal outside diameter of the tube is not greater than 76 mm, the maximum pressure of the hydraulic pressure test shall be not greater than 17.2 MPa; when the nominal outside diameter of the tube is greater than 76 mm, the maximum pressure of the hydraulic pressure test shall be not greater than 19.3 MPa. During the test, the pressure shall be maintained for 5 s, and the tube shall not undergo distortion or leakage.

5.4.2.3

For the pneumatic pressure 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 leak.

5.4.3 Bending Test

When required by the purchaser and specified in the purchase order, tubes with an outside diameter not greater than 60 mm may be subjected to the bending test. The diameter of the bending mandrel is 12 times the outside diameter of the tube, and no cracks shall appear after bending through 90°.

Note: The bending test of TA3G tubes shall be agreed between the supplier and the purchaser, and specified in the purchase order.

5.5 Visual Quality

5.5.1

The inner and outer surfaces of the tubes shall be clean and free from cracks, folds, peeling, pinholes and other defects visible to the naked eye.

5.5.2

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

5.5.3

Scratches, dents, protrusions and straightening marks that do not exceed the permissible deviations of the outside diameter and the wall thickness are permitted on the surface of the tubes, and different colours after pickling of the tubes are permitted.

6 Test Methods

6.1 Chemical Composition

The chemical composition analysis of the products shall be carried out in accordance with the provisions of GB/T 4698 (all parts) or YS/T 1262; the arbitration analysis shall be carried out in accordance with the provisions of GB/T 4698 (all parts).

6.2 Dimensions and Their Permissible Deviations

The dimensions and their permissible deviations of the products shall be measured in accordance with the provisions of GB/T 38982.

6.3 Room-Temperature Tensile Properties

The room-temperature tensile properties of the products shall be tested in accordance with the provisions of GB/T 228.1—2021. For products with an outside diameter not greater than 35 mm, the S8 specimen is recommended; for products with an outside diameter greater than 35 mm, the S4 specimen is recommended.

6.4 Technological Properties

6.4.1

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

6.4.2

The hydraulic pressure test of the products shall be carried out in accordance with the provisions of GB/T 241.

6.4.3

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

6.4.4

The bending test of the products shall be carried out in accordance with the provisions of GB/T 244.

6.5 Visual Quality

The visual quality of the products shall be inspected by visual inspection.

7 Inspection Rules

7.1 Inspection and Acceptance

7.1.1

The products shall be inspected by the supplier or a third party to ensure that the product quality conforms to the provisions of this document or the requirements of the purchase order.

7.1.2

The purchaser may inspect the received products in accordance with the provisions of this document. When the inspection results do not conform to the provisions of this document or the requirements of the purchase order, a written claim shall be submitted to the supplier, and the matter shall be settled through consultation between the supplier and the purchaser. Claims on the dimensions and their permissible deviations and the visual quality shall be submitted within one month from the date of receipt of the products; claims on the chemical composition, room-temperature tensile properties and technological properties shall be submitted within three months from the date of receipt of the products. Where arbitration is required, the supplier and the purchaser shall take samples jointly or as agreed.

7.2 Batching

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

7.3 Inspection Items

Each batch of products shall be inspected for the chemical composition, dimensions and their permissible deviations, room-temperature tensile properties, technological properties and visual quality. The inspection items specified in the purchase order shall also be inspected.

7.4 Sampling

The sampling of the products shall conform to the provisions of Table 7, and the other requirements shall be executed in accordance with the provisions of GB/T 23604.

Table 7 — Sampling

Inspection item	Sampling provisions
Chemical composition	The hydrogen content shall be analyzed on samples taken from the finished products; for the other elements, the supplier shall report the analysis results of the ingot, and the re-verification by the purchaser shall be carried out on the finished products
Room-temperature tensile properties	2 tubes per batch, 1 specimen from each tube
Technological properties	2 tubes per batch, 1 specimen from each tube
Dimensions and their permissible deviations	5 tubes per batch, 1 specimen from each tube
Visual quality	For products with an inside diameter not greater than 20 mm, 5 tubes per batch may be taken, and a 150 mm tube section from each tube shall be split longitudinally into two halves for the inspection of the wall thickness and the inner surface quality, and the inspection results shall replace the inspection results of that item

7.5 Judgment of Inspection Results

7.5.1

When the inspection results of the chemical composition fail, that batch of products shall be judged as nonconforming.

7.5.2

When the inspection results of the dimensions and their permissible deviations or the hydraulic (pneumatic) pressure test fail, that piece of product shall be judged as nonconforming.

7.5.3

In the room-temperature tensile properties, flattening test or bending test, when the inspection result of one specimen fails, double specimens shall be taken from that batch of products for repeated inspection. When one specimen still fails in the repeated inspection, that batch of products shall be judged as nonconforming. However, the supplier may inspect the nonconforming items tube by tube, and the qualified products shall be re-batched for delivery.

7.5.4

When the inspection results of the visual quality fail, that piece of product shall be judged as nonconforming. For products with an inside diameter not greater than 20 mm, when the inspection results of the visual quality fail, that batch of products shall be judged as nonconforming; however, the supplier may inspect the nonconforming items tube by tube, and the qualified products shall be re-batched for delivery.

8 Marking, Packaging, Transport, Storage and Accompanying Documents

8.1 Marking

8.1.1 Product Marking

Labels or tags shall be affixed to the qualified products, and shall contain at least the following contents:

a) name and trade mark of the manufacturer;

b) designation;

c) specification;

d) condition;

e) batch number;

f) number of this document.

8.1.2 Packaging Marking

The packaging marking of the products shall conform to the provisions of GB/T 8180.

8.2 Packaging, Transport and Storage

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

8.3 Accompanying Documents

Each batch of products shall be accompanied by the accompanying documents, which, in addition to the supplier information, product information, number of this document, and date of issue or date of packaging, shall preferably include:

a) a quality certificate, with the following contents:

——product name, designation, specification and condition;

——product ingot number, batch number, batch weight and quantity;

——main properties and technical parameters of the product;

——results of all analyses and inspections, and the seal of the quality inspection department;

——others.

b) a certificate of conformity, with the following contents:

——ingot number or batch number;

——date of inspection;

——signature or seal of the inspector;

——others.

c) others.

9 Contents of the Purchase Order

According to its own needs, the purchaser may list the following contents in the purchase order for the products specified in this document:

a) product name;

b) designation;

c) specification;

d) condition;

e) weight;

f) quantity;

g) number of this document;

h) others.