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GB/T 42159—2022

(replacing "")

Titanium and titanium alloy bars and wires for fastener

紧固件用钛及钛合金棒材和丝材

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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".

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1 Scope

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

This document applies to titanium and titanium alloy bars and wires for fasteners (hereinafter referred to as products).

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 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 5168	Methods for macrostructure and microstructure examination of titanium and titanium alloys

Standard No.	Title
GB/T 5193—2020	Ultrasonic inspection method for wrought titanium and titanium alloy products
GB/T 6394—2017	Determination of estimating the average grain size of metal
GB/T 6400	Metallic materials — Wire and rivet shear test method
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 23601	Eddy current inspection method for titanium and titanium alloy bars and wires
GB/T 23603	Test method of surface contamination layer of titanium and titanium alloys
GB/T 23605	Method for determination of β transus temperature of titanium alloys
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
GB/T 39799	Dimensions, shapes, weights and permissible deviations of titanium and titanium alloy bars and wires
YB/T 5293	Metallic materials — Upsetting test method
YS/T 861.5	Chemical analysis method of niobium-titanium alloy — Part 5: Determination of titanium content — Ferric ammonium sulfate titration method
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, GB/T 38982 and GB/T 39799 apply to this document.

4 Classification and Designation

4.1 Product Classification

The products are classified by designation, condition and specification, and shall conform to the provisions of Table 1.

Table 1 — Designations, conditions, specifications and supply methods

Designation	Condition	Specification, mm	
		Diameter	Length
TA2G, TA3G, TA9, TA10	Annealed condition (M)	2.0~7.0	≥800
TB8	Hot-working condition (R), solution-treated condition (ST)	4.0~7.0	
TB14	Cold-working condition (Y), annealed condition (M)	2.4~7.0	

Designation	Condition	Specification, mm	
TC4	Annealed condition (M)	3.0~7.0	
TA2G, TA3G, TA9, TA10	Annealed condition (M)	>7.0~10.0	≥1 000
TB8	Hot-working condition (R), solution-treated condition (ST)	>7.0~25.0	
TB14	Cold-working condition (Y), annealed condition (M)	>7.0~10.0	
TC4	Annealed condition (M)	>7.0~20.0	

Products with a diameter not greater than 12.0 mm are supplied in coils or straight lengths; products with a diameter greater than 12.0 mm are supplied in straight lengths only.

4.2 Product Designation

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

Example 1: A bar manufactured with the TB8 designation, in the hot-working condition (R), with a diameter of 10.0 mm, is designated as:

Bar TB8 R φ10.0 GB/T ××××—××××

Example 2: A wire manufactured with the TA2G designation, in the annealed condition (M), with a diameter of 5.0 mm, is designated as:

Wire TA2G M φ5.0 GB/T ××××—××××

5 Technical Requirements

5.1 Chemical Composition

5.1.1

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

5.1.2

When the purchaser takes samples from the products for re-inspection 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 diameter of the products shall conform to the provisions of Table 2.

Table 2 — Permissible deviations of the diameter

Diameter, mm	Permissible deviation of the diameter, mm	Supply method
2.0~12.0	0 / −0.03	Coils

Diameter, mm	Permissible deviation of the diameter, mm	Supply method
2.0~25.0	0 / −0.05	Straight lengths

5.2.2

The length and its permissible deviations, the straightness and the out-of-squareness of the cut of the products shall conform to the provisions of GB/T 39799.

5.2.3

When required by the purchaser and specified in the purchase order, the products may be supplied in coils, and the coil dimensions shall be agreed between the supplier and the purchaser.

5.3 Mechanical Properties

5.3.1

The mechanical properties of the products shall be tested on heat-treated specimen blanks, and the heat treatment procedures shall preferably be carried out with reference to Annex A.

5.3.2

The room-temperature mechanical properties of the products shall conform to the provisions of Table 3.

Table 3 — Room-temperature mechanical properties

Designation	Diameter, mm	Specimen condition	Room-temperature mechanical properties, ≥				
			Tensile strength (Rm), MPa	Proof strength, non-proportional extension (Rp0.2), MPa	Percentage elongation after fracture (A), %	Percentage reduction of area (Z), %	Shearing strength (τ), MPa
TA2G	2.0~10.0	Annealed (M)	400	275	20	45	250
TA3G	2.0~10.0	Annealed (M)	500	380	18	40	350
TA9	2.0~10.0	Annealed (M)	345	275	20	30	250
TA10	2.0~10.0	Annealed (M)	485	345	18	25	300
TB8	4.0~25.0	Solution-treated (ST)	800	760	13	50	570
TB14	2.4~10.0	Solution and aging-treated (STA)a	1 200	1 050	8	20	720

Designation	Diameter, mm	Specimen condition	Room-temperature mechanical properties, ≥				
TC4	3.0~20.0	Annealed (M)	450	410	20	60	360
	3.0~12.7	Solution and aging-treated (STA)a	930	860	10	25	600
	>12.7~20.0		1 140	1 070	10	20	665

The proof strength, non-proportional extension, the percentage elongation after fracture and the percentage reduction of area only apply to products with a diameter greater than 3.0 mm; for products with a diameter not greater than 3.0 mm, where the proof strength, non-proportional extension, the percentage elongation after fracture and the percentage reduction of area do not meet the requirements, the measured values may be reported.

a STA is the solution and aging-treated condition, which only applies to the room-temperature mechanical property test of solution and aging-treated specimens.

5.4 Cold Upsetting Properties

The cold upsetting properties of the TA2G, TA3G, TB8 and TB14 products shall conform to the provisions of Table 4. Where required by the purchaser and specified in the purchase order, the cold upsetting properties of the other designations of products shall be agreed between the supplier and the purchaser.

Table 4 — Cold upsetting properties

Designation	Specimen condition	Diameter, mm	Ratio of the height after upsetting to the height before upsetting	Acceptance requirement
TA2G, TA3G	Annealed (M)	4.0~10.0	1:3	No cracks on the circumferential surface of the specimen
TB8	Solution-treated (ST)	4.0~10.0	1:3	No cracks on the circumferential surface of the specimen
TB14	Annealed (M)	2.4~10.0	1:4	No cracks on the circumferential surface of the specimen

5.5 β Transus Temperature

When required by the purchaser and specified in the purchase order, the products shall be supplied with the measured values of the β transus temperature per melting furnace number.

5.6 Non-Destructive Inspection

5.6.1 Ultrasonic Inspection

Products supplied in straight lengths with a diameter not less than 6.0 mm shall be subjected to the ultrasonic inspection in accordance with GB/T 5193—2020, and the longitudinal wave inspection results shall conform to the provisions of Table 5, and the transverse wave inspection results shall conform to the provisions of Table 6.

Table 5 — Longitudinal wave ultrasonic inspection

Designation	Acceptance level
TA2G, TA3G, TA9, TA10, TC4	GB/T 5193—2020, Grade AA
TB8, TB14	GB/T 5193—2020, Grade A

Table 6 — Transverse wave ultrasonic inspection

Designation	Notch-type defect dimensions	Acceptance requirement
TA2G, TA3G, TA9, TA10, TC4	Depth 0.2 mm, width 0.1 mm, length 10 mm	The amplitude of the response signal shall be not greater than the amplitude of the longitudinal notch-type defect signal
TB8, TB14	Where required by the purchaser and specified in the purchase order, agreed between the supplier and the purchaser	

5.6.2 Eddy Current Inspection

When required by the purchaser and specified in the purchase order, products supplied in coils with a diameter not greater than 12.0 mm and products supplied in straight lengths with a diameter less than 6.0 mm shall be subjected to the eddy current inspection in accordance with GB/T 23601, and the inspection results shall conform to the provisions of Table 7.

Table 7 — Eddy current inspection

Designation	Notch-type defect dimensions	Acceptance requirement
TA2G, TA3G, TA9, TA10, TC4, TB8, TB14	Depth 0.2 mm, width 0.2 mm, length 8 mm	The amplitude of the response signal shall be not greater than the amplitude of the longitudinal notch-type defect signal

5.7 Macrostructure

The macrostructure of the products shall be free from cracks, folds, gas holes, shrinkage tails, metallic or non-metallic inclusions and other metallurgical defects visible to the naked eye.

5.8 Microstructure

5.8.1

For the annealed TA2G, TA3G, TA9 and TA10 products, the microstructure shall be an equiaxed α structure, a elongated α structure, or a mixed structure of equiaxed α and elongated α phases.

5.8.2

For the annealed TC4 products, the microstructure shall be the structure produced by processing in the two-phase region, without complete original β grain boundaries. The microstructure consists of equiaxed α structure on the transformed β matrix, or equiaxed α and elongated α structures, as well as partially broken and distorted grain boundary α and lamellar α structures; the content of the primary α shall be not less than 15 %.

5.9 Grain Size

5.9.1

For the solution-treated TB8 products with a diameter less than 10.0 mm, the grain size shall be not lower than Grade 5 in GB/T 6394—2017; with a diameter not less than 10.0 mm, the grain size shall be not lower than Grade 4 in GB/T 6394—2017.

5.9.2

For the annealed TB14 products, the grain size shall be not lower than Grade 5 in GB/T 6394—2017.

5.10 Surface Contamination

The surfaces of the products shall be free from any oxygen-enriched layer, such as an α layer or other surface contamination.

5.11 Surface Condition

5.11.1

Products supplied in straight lengths shall be supplied with machined, ground, cold-worked or pickled surfaces.

5.11.2

Products supplied in coils shall be supplied with machined, cold-worked or pickled surfaces.

5.11.3

For products supplied with machined or ground surfaces, the surface roughness (Ra) shall be not greater than 1.6 μm.

5.11.4

Where the purchaser has special requirements for the surface condition of the products, they shall be agreed between the supplier and the purchaser and specified in the purchase order.

5.12 Visual Quality

5.12.1

The surfaces of the products shall be clean, free from mill scale, cracks, peeling, scars and inclusions; individual scratches, pits and drawing marks not exceeding the permissible deviations of the diameter, as well as slight straightening marks not affecting service, are permitted.

5.12.2

Local defects on the surfaces of the products may be repaired by grinding, provided that the grinding depth does not exceed the permissible deviations of the diameter and the minimum dimensions of the products are ensured.

6 Test Methods

6.1 Chemical Composition

The chemical composition of the products shall be analyzed in accordance with the provisions of GB/T 4698 (all parts), YS/T 1262 and YS/T 861.5; the niobium content of the TB14 products shall be calculated by the difference method. For arbitration, the 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 methods specified in GB/T 228.1—2021. For products with a diameter less than 3.2 mm, full-section tensile specimens are taken, with a gauge length (L0) of 50 mm; for products with a diameter of 3.2 mm to 6.0 mm, full-section tensile specimens are taken, with a gauge length (L0) of 4 times the diameter; for products with a diameter greater than 6.0 mm and not greater than 10.0 mm, the R8 specimen is taken; for products with a diameter greater than 10.0 mm, the R7 specimen is taken.

6.4 Room-Temperature Shearing Properties

The room-temperature shearing properties of the products shall be tested in accordance with the provisions of GB/T 6400.

6.5 Cold Upsetting Properties

The cold upsetting properties of the products shall be tested in accordance with the provisions of YB/T 5293.

6.6 β Transus Temperature

The β transus temperature of the products shall be tested in accordance with the provisions of GB/T 23605.

6.7 Ultrasonic Inspection

The ultrasonic inspection of the products shall be carried out in accordance with the provisions of GB/T 5193—2020.

6.8 Eddy Current Inspection

The eddy current inspection of the products shall be carried out in accordance with the provisions of GB/T 23601.

6.9 Macrostructure

The macrostructure of the products shall be inspected in accordance with the provisions of GB/T 5168.

6.10 Microstructure

The microstructure of the products shall be inspected in accordance with the provisions of GB/T 5168.

6.11 Average Grain Size

The average grain size of the products shall be inspected in accordance with the provisions of GB/T 6394—2017.

6.12 Surface Contamination

The surface contamination of the products shall be inspected in accordance with the provisions of GB/T 23603.

6.13 Surface Condition

6.13.1

The surface condition of the products shall be inspected by visual inspection.

6.13.2

The surface roughness of the products shall preferably be measured by the standard block comparison method.

6.14 Visual Quality

The visual quality of the products shall be inspected by visual inspection or other inspection methods, and a magnifying glass of 5 to 10 times shall be used for inspection when necessary.

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 and the purchase order.

7.1.2

The purchaser may inspect the received products in accordance with the provisions of this document. Where the inspection results do not conform to the provisions of this document and 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, the surface condition and the visual quality shall be submitted within one month from the date of receipt of the products; claims on the chemical composition, mechanical properties, etc. 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 production period.

7.3 Inspection Items

Each batch of products shall be inspected for the chemical composition, dimensions and their permissible deviations, mechanical properties, cold upsetting properties, non-destructive inspection, macrostructure, microstructure, surface contamination, surface condition and visual quality. Where the purchaser has requirements for the β transus temperature and specifies them in the purchase order, the β transus temperature of the products shall also be inspected.

7.4 Sampling

The sampling of the products shall conform to the provisions of Table 8.

Table 8 — Sampling

Inspection item	Sampling provisions	Clause of the requirements	Clause of the test method
Chemical composition	The hydrogen content shall be analyzed on samples taken from the finished products; for the other components, the supplier may report the analysis results of the ingot, and the re-verification by the purchaser shall be carried out on the finished products	5.1	6.1
Room-temperature tensile properties	2 coils (pieces) per batch, 1 longitudinal specimen from each; where the order quantity is less than 2 coils (pieces), 1 longitudinal specimen	5.3.2	6.3
Room-temperature shearing properties	2 coils (pieces) per batch, 1 longitudinal specimen from each; where the order quantity is less than 2 coils (pieces), 1 longitudinal specimen	5.3.2	6.4
Cold upsetting properties	2 coils (pieces) per batch, 1 longitudinal specimen from each; where the order quantity is less than 2 coils (pieces), 1 longitudinal specimen	5.4	6.5
β transus temperature	1 coil (piece) per batch, 1 specimen	5.5	6.6
Non-destructive inspection	All products	5.6	6.7, 6.8
Macrostructure	2 coils (pieces) per batch, 1 transverse specimen from the end of each; where the order quantity is less than 2 coils (pieces), 1 transverse specimen from the end of each	5.7	6.9
Microstructure	2 coils (pieces) per batch, 1 transverse specimen from the end of each; where the order quantity is less than 2 coils (pieces), 1 transverse specimen from the end of each	5.8	6.10
Average grain size	2 coils (pieces) per batch, 1 transverse specimen from the end of each; where the order quantity is less than 2 coils (pieces), 1 transverse specimen from the end of each	5.9	6.11

Inspection item	Sampling provisions	Clause of the requirements	Clause of the test method
Surface contamination	2 coils (pieces) per batch, 1 specimen from each	5.10	6.12
Surface condition and visual quality	All products	5.11, 5.12	6.13, 6.14

7.5 Judgment of Inspection Results

7.5.1

Where the chemical composition inspection result fails, that batch of products shall be judged as nonconforming.

7.5.2

In the mechanical properties, cold upsetting properties and surface contamination tests, where the test result of one specimen fails, double the number of specimens shall be taken from that batch of products for the repeated test of the nonconforming item. Where 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 coil (piece) by coil (piece), and the qualified ones shall be re-batched for delivery.

7.5.3

Where the inspection results of the macrostructure, microstructure and grain size fail, that batch of products shall be judged as nonconforming.

7.5.4

Where the inspection results of the dimensions and their permissible deviations, the non-destructive inspection, the surface condition and the visual quality fail, that coil (piece) of products shall be judged as nonconforming.

8 Marking, Packaging, Transport, Storage and Accompanying Documents

8.1 Marking

8.1.1 Product Marking

The qualified products shall be marked (or labelled, tagged), and shall contain at least:

a) name 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:

——date of inspection;

——signature or seal of the inspector;

——others.

c) others.

9 Contents of the Purchase Order

The purchase order for ordering the products in accordance with this document shall include the following contents:

a) product name;

b) designation;

c) condition;

d) specification;

e) weight or quantity;

f) determination of the β transus temperature (when required by the purchaser);

g) number of this document;

h) others.

Annex A (Informative) — Heat treatment procedures for titanium and titanium alloys

Titanium and titanium alloy products or specimen blanks shall preferably be heat-treated in accordance with Table A.1.

Table A.1 — Recommended heat treatment procedures

Designation	Heating temperature, holding time and cooling method
TA2G	(600~700) ℃, holding for 0.5 h~1.5 h, air cooling or furnace cooling (furnace cooling for vacuum annealing)
TA3G	(600~700) ℃, holding for 0.5 h~1.5 h, air cooling or furnace cooling (furnace cooling for vacuum annealing)
TA9	(600~700) ℃, holding for 0.5 h~1.5 h, air cooling or furnace cooling (furnace cooling for vacuum annealing)
TA10	(600~700) ℃, holding for 0.5 h~1.5 h, air cooling or furnace cooling (furnace cooling for vacuum annealing)
TB8	Solution treatment: (750~830) ℃, holding for 0.5 h~2 h, air cooling or cooling at a higher speed; aging: (460~580) ℃, holding for 8 h~12 h, air cooling
TB14	Vacuum annealing: (790~870) ℃, holding for 1 h~2 h, furnace cooling or cooling with argon filling
TC4	Annealing: (700~850) ℃, holding for 0.5 h~2 h, air cooling or furnace cooling; solution treatment: (890~970) ℃, holding for 0.5 h~2 h, air cooling or water quenching; aging: (480~690) ℃, holding for 4 h~8 h, air cooling