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GB/T 2965—2023

(replacing GB/T 2965—2007)

Titanium and titanium alloy bars

钛及钛合金棒材

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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".

This document replaces GB/T 2965—2007 "Titanium and titanium alloy bars". Compared with GB/T 2965—2007, apart from structural adjustments and editorial changes, the main technical changes are as follows:

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

b) The specification ranges of the products were changed (see 4.1, and 3.1.1 of the 2007 edition);

c) The technical requirements for TA1, TA2, TA3 and TA5 products were changed, and TA4 was deleted (see Clause 5, and Clause 3 and Annex A of the 2007 edition);

d) The technical requirements for TA1G, TA2G, TA3G, TA4G, TA18, TB6, TC17, TC18, TC21 and TC25 products were added (see Clause 5);

e) The requirements for the dimensions and their permissible deviations were changed (see 5.2, and 3.4 of the 2007 edition);

f) The analytical methods for chemical composition were changed (see 6.1, and 4.1 of the 2007 edition);

g) The test methods for the dimensions and their permissible deviations were changed (see 6.2, and 4.8 of the 2007 edition);

h) The test methods for the room-temperature tensile properties were changed (see 6.3, and 4.2 of the 2007 edition);

i) The test methods for the elevated-temperature tensile properties were changed (see 6.4, and 4.3 of the 2007 edition);

j) The test methods for the β transus temperature were changed (see 6.6, and 4.5 of the 2007 edition);

k) The sampling requirements were changed (see Table 4, and Table 6 of the 2007 edition);

l) The judgment of inspection results was changed (see 7.5, and 5.5 of the 2007 edition);

m) Annex B "Designations, chemical compositions and room-temperature mechanical properties of commercially pure titanium in the old standard" was deleted (see Annex B of the 2007 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).

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This document was first issued in 1987, first revised in 1996, second revised in 2007, 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 bars.

This document applies to round and rectangular titanium and titanium alloy bars produced by forging and rolling.

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 228.2	Metallic materials — Tensile testing — Part 2: Method of test at elevated temperature
GB/T 2039	Metallic materials — Method of uniaxial tensile creep testing
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
GB/T 5193	Ultrasonic inspection method for wrought titanium and titanium alloy products
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 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

Standard No.	Title
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 bars shall conform to the provisions of Table 1.

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

Designation	Condition	Diameter or section thickness	Length
TA1, TA2, TA3, TA1G, TA2G, TA3G, TA4G, TA5, TA6, TA7, TA9, TA10, TA13, TA15, TA18, TA19, TB2, TB6, TC1, TC2, TC3, TC4, TC4ELI, TC6, TC9, TC10, TC11, TC12, TC17, TC18, TC21, TC25	Hot-working condition (R), cold-working condition (Y)	7~100	300~6 000
	Annealed condition (M)		300~5 000

Note: The supply conditions of TA19 and TC9 titanium alloy bars are the hot-working condition (R) and the cold-working condition (Y); the annealed condition (M) of TC6 titanium alloy bars is the ordinary annealed condition.

4.2 Product Designation

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

Example 1: A round bar manufactured with the TA2 designation, in the annealed condition, with a diameter of 100 mm and a length of 3 000 mm to 4 000 mm, is designated as:

Bar TA2 M φ100×L(or 3 000~4 000) GB/T 2965—2023

Example 2: A square bar manufactured with the TC4 designation, in the hot-working condition, with a section thickness of 90 mm and a length of 2 000 mm, is designated as:

Bar TC4 R 90×90×2 000 GB/T 2965—2023

Example 3: A round bar manufactured with the TC4 designation, in the hot-working condition, with a diameter of 80 mm and a length of 3 000 mm, is designated as:

Bar TC4 R φ80×3 000 GB/T 2965—2023

5 Technical Requirements

5.1 Chemical Composition

5.1.1

The chemical composition of the bars 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

The dimensions and their permissible deviations of the bars shall conform to the provisions of GB/T 39799.

5.3 Mechanical Properties

5.3.1

The mechanical properties of the bars shall be tested on heat-treated specimen blanks, and the recommended heat treatment procedures for the specimen blanks are given in Annex A.

5.3.2

The room-temperature tensile properties of the bars shall conform to the provisions of Table 2. When required by the purchaser and specified in the purchase order, the elevated-temperature mechanical properties of some designations of bars shall conform to the provisions of Table 3.

Table 2 — Room-temperature tensile properties

Designation	**Room-temperature tensile properties, not less than**		**Remark**		
	Tensile strength (Rm), MPa	Proof strength, non-proportional extension (Rp0.2), MPa	Percentage elongation after fracture (A), %	Percentage reduction of area (Z), %	
TA1	370	250	20	30	
TA2	440	320	18	30	
TA3	540	410	15	25	
TA1G	240	140	24	30	
TA2G	400	275	20	30	
TA3G	500	380	18	30	
TA4G	580	485	15	25	
TA5	685	585	13	25	

Designation	Room-temperature tensile properties, not less than				
TA6	685	585	10	27	
TA7	785	680	10	25	
TA9	370	250	20	25	
TA10	485	345	18	25	
TA13	540	400	16	35	
TA15	885	825	8	20	
TA18	620	518	12	25	
TA19	895	825	10	25	
TB2	≤980	820	18	40	Solution-treated properties
TB3	1 370	1 100	7	10	Solution and aging-treated properties
TB6	1 105	1 035	8	15	
TC1	585	460	15	30	
TC2	685	560	12	30	
TC3	800	700	10	25	
TC4	895	825	10	25	
TC4ELI	830	760	10	15	
TC6	980	840	10	25	Ordinary annealed condition
TC9	1 060	910	9	25	
TC10	1 030	900	12	25	
TC11	1 030	900	10	30	
TC12	1 150	1 000	10	25	
TC17	1 120	1 030	7	16	
TC18	1 080~1 280	1 010	9	25	
TC21	1 100	1 000	8	15	
TC25	980	—	10	20	

Note: The properties of TC6 bars are tested in the ordinary annealed condition. When required by the purchaser and specified in the purchase order, the properties in the isothermal annealed condition may be tested.

Table 3 — Elevated-temperature mechanical properties

Designation	Test temperature, ℃	Elevated-temperature mechanical properties, not less than			Remark
		Tensile strength (Rm), MPa	Creep rupture properties		
			Test stress (σ), MPa	Test duration (t), h	
TA6	350	420	390	100	
TA7	350	490	440	100	
TA15	500	570	470	50	
TA18	350	340	320	100	
	400	310	280	100	
TA19	400	620	480	35	
TC1	350	345	325	100	
TC2	350	420	390	100	
TC4	400	600	560	100	
TC6	400	685	685	50	
TC9	400	785	590	100	
TC10	400	835	785	100	
TC11	500	685	640	35	
TC12	500	700	590	100	
TC17	400	885	685	100	
TC25	500	735	637	50	

Note: Where the creep rupture properties of TC11 titanium alloy bars fail to meet the requirements, re-inspection is permitted under the conditions of 500 ℃, a test stress of 590 MPa and t≥100 h; if the re-inspection passes, the creep rupture properties of that batch of bars shall be deemed qualified.

5.4 β Transus Temperature

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

5.5 Ultrasonic Inspection

When required by the purchaser and specified in the purchase order, the bars shall be subjected to ultrasonic inspection, and the acceptance level shall be agreed between the supplier and the purchaser.

5.6 Macrostructure

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

5.7 Microstructure

When required by the purchaser and specified in the purchase order, the microstructure of the bars shall be assessed, and the assessment requirements shall be agreed between the supplier and the purchaser.

5.8 Visual Quality

5.8.1

The bars shall be supplied with turned (ground) surfaces. The surface roughness (Ra) of the bars shall be not greater than 3.2 μm.

5.8.2

Slight scratches, indentations, pitting and wrinkles, etc. with depths not greater than half of the permissible deviation of the diameter or thickness, are permitted on the surface of the bars.

5.8.3

Local defects on the surface of the bars shall be removed; the depth of removal shall not exceed the corresponding permissible deviation of the dimensions of the product, and the ratio of the depth to the width of the removed area shall be not greater than 1:6.

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. The R7 specimen shall be used.

6.4 Elevated-Temperature Tensile Properties

The elevated-temperature tensile properties of the products shall be tested in accordance with the provisions of GB/T 228.2.

6.5 Creep Rupture Properties

The creep rupture properties of the products shall be tested in accordance with the provisions of GB/T 2039.

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.

6.8 Macrostructure and Microstructure

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

6.9 Visual Quality

The visual quality of the products shall be inspected by visual inspection. The surface roughness of the bars shall be checked by the standard sample block comparison method.

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 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 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, mechanical properties, macrostructure, microstructure and ultrasonic inspection 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, macrostructure and visual quality. When specified in the purchase

order, the elevated-temperature mechanical properties, β transus temperature, ultrasonic inspection and microstructure shall also be inspected.

7.4 Sampling

The sampling of the products shall conform to the provisions of Table 4.

Table 4 — Sampling

Inspection item	Requirements of the technical requirements	Test method	Sampling provisions
Chemical composition	5.1	6.1	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
Mechanical properties	5.3	6.3, 6.4, 6.5	Where the diameter or section thickness is not greater than 38 mm, take longitudinal samples at the center or at 1/2 section thickness, 2 bars per batch, 1 specimen from each bar; where the diameter or section thickness is greater than 38 mm, take longitudinal samples at D/4 or 1/4 section thickness, 2 bars per batch, 1 specimen from each bar; other requirements shall be executed in accordance with GB/T 23604
β transus temperature	5.4	6.6	1 bar per batch, 1 specimen at D/4 or 1/4 section thickness
Macrostructure, microstructure	5.6, 5.7	6.8	1 bar per batch, 1 specimen at D/4 or 1/4 section thickness
Ultrasonic inspection	5.5	6.7	All bars
Dimensions and their permissible deviations	5.2	6.2	In accordance with GB/T 39799
Visual quality	5.8	6.9	All bars

Note: D is the diameter of the bar.

Note: The hydrogen content is analyzed on samples taken from the finished products; for the other elements, the supplier reports the results of the ingot, and the re-verification by the purchaser is carried out on the finished products. The supplier may report the test results of the ingot, and the purchaser takes samples on the finished products for inspection.

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, ultrasonic inspection or visual quality fail, that piece of product shall be judged as nonconforming; however, the supplier may re-inspect the product after removing the nonconforming part, and the qualified products shall be re-batched for delivery.

7.5.3

When the inspection results of the mechanical properties fail, 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 bars one by one, and the qualified products shall be re-batched for delivery; or re-heat treatment may be carried out and then new specimens shall be taken for re-inspection.

7.5.4

When the inspection results of the macrostructure or microstructure fail, that batch 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), and the marking shall contain at least the following contents:

a) name of the supplier;

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 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.

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

Titanium and titanium alloy bars or specimen blanks may be heat-treated in accordance with Table A.1.

Table A.1 — Heat treatment procedures for titanium and titanium alloys

Designation	Heat treatment procedure
TA1	600 ℃~700 ℃, holding for 1 h~3 h, air cooling
TA2	600 ℃~700 ℃, holding for 1 h~3 h, air cooling

Designation	Heat treatment procedure
TA3	600 ℃~700 ℃, holding for 1 h~3 h, air cooling
TA1G	600 ℃~700 ℃, holding for 1 h~3 h, air cooling
TA2G	600 ℃~700 ℃, holding for 1 h~3 h, air cooling
TA3G	600 ℃~700 ℃, holding for 1 h~3 h, air cooling
TA4G	600 ℃~700 ℃, holding for 1 h~3 h, air cooling
TA5	700 ℃~850 ℃, holding for 1 h~3 h, air cooling
TA6	750 ℃~850 ℃, holding for 1 h~3 h, air cooling
TA7	750 ℃~850 ℃, holding for 1 h~3 h, air cooling
TA9	600 ℃~700 ℃, holding for 1 h~3 h, air cooling
TA10	600 ℃~700 ℃, holding for 1 h~3 h, air cooling
TA13	750 ℃~820 ℃, holding for 0.5 h~4 h, air cooling
TA15	750 ℃~850 ℃, holding for 1 h~4 h, air cooling
TA18	600 ℃~815 ℃, holding for 1 h~3 h, air cooling
TA19	955 ℃~985 ℃, holding for 1 h~2 h, air cooling; 575 ℃~605 ℃, holding for 8 h, air cooling
TB2	Solution treatment: 750 ℃~850 ℃, holding for 10 min~30 min, air cooling or water cooling; aging: 450 ℃~550 ℃, holding for 8 h~24 h, air cooling
TB6	705 ℃~775 ℃, holding for 1 h~2 h, water cooling; 480 ℃~620 ℃, holding for 8 h~10 h, air cooling; the solution treatment temperature is permitted to be adjusted within the range of 30 ℃~60 ℃ below the β transus temperature
TC1	700 ℃~850 ℃, holding for 1 h~3 h, air cooling
TC2	700 ℃~850 ℃, holding for 1 h~3 h, air cooling
TC3	700 ℃~800 ℃, holding for 1 h~3 h, air cooling
TC4	700 ℃~800 ℃, holding for 1 h~3 h, air cooling
TC4ELI	700 ℃~800 ℃, holding for 1 h~3 h, air cooling
TC6	Ordinary annealing: 800 ℃~850 ℃, holding for 1 h~2 h, air cooling; isothermal annealing: 860 ℃~880 ℃, holding for 1 h~3 h, furnace cooling to 650 ℃, holding for 2 h, air cooling
TC9	950 ℃~1 000 ℃, holding for 1 h~3 h, air cooling; 520 ℃~540 ℃, holding for 6 h, air cooling
TC10	700 ℃~800 ℃, holding for 1 h~3 h, air cooling
TC11	940 ℃~960 ℃, holding for 1 h~3 h, air cooling; 520 ℃~540 ℃, holding for 6 h, air cooling; the first annealing temperature is permitted to be adjusted within the range of 30 ℃~50 ℃ below the β transus temperature
TC12	700 ℃~850 ℃, holding for 1 h~3 h, air cooling
TC17	830 ℃~850 ℃, holding for 1 h~4 h, air cooling; 780 ℃~820 ℃, holding for 1 h~4 h, water cooling; 590 ℃~650 ℃, holding for 8 h, air cooling
TC18	

Designation	Heat treatment procedure
	820 ℃~850 ℃, holding for 1 h~3 h, furnace cooling to 740 ℃~760 ℃, holding for 1 h~3 h, air cooling; 500 ℃~650 ℃, holding for 2 h~6 h, air cooling
TC21	890 ℃~930 ℃, holding for 1 h~2 h, air cooling; 500 ℃~650 ℃, holding for 4 h~8 h, air cooling; the first annealing temperature is permitted to be adjusted within the range of 40 ℃~80 ℃ below the β transus temperature
TC25	950 ℃~970 ℃, holding for 1 h~4 h, air cooling; 530 ℃~570 ℃, holding for 6 h, air cooling; the first annealing temperature is permitted to be adjusted within the range of 30 ℃~50 ℃ below the β transus temperature