NATIONAL STANDARD OF
THE PEOPLE'S REPUBLIC OF CHINA

中华人民共和国国家标准

GB/T 16598—2013

(replacing GB/T 16598—1996)

Titanium and Titanium Alloy Discs and Rings

钛及钛合金饼和环

Issued: 2013-09-06 Implemented: 2014-05-01

Issued 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

GB/T 16598—2013 (replacing GB/T 16598—1996)

Issued: 2013-09-06 | Implemented: 2014-05-01

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 was drafted in accordance with the rules given in GB/T 1.1—2009.

This standard replaces GB/T 16598—1996 *Titanium and titanium alloy discs and rings*. Compared with GB/T 16598—1996, the main changes are as follows:

- the product size ranges were enlarged;

- in accordance with the revision of the designations and chemical compositions of commercially pure titanium in GB/T 3620.1, the designations of commercially pure titanium were correspondingly changed to TA1, TA2, TA3 and TA4;

- the titanium alloy designations TA5, TA7, TA13, TA15, TC1, TC2 and TC11 were added;

- the cross-sectional area of ring materials to which the mechanical properties apply was revised;

- a requirement for testing the β-transus temperature of titanium alloy products was added;

- the microstructure requirements for the original titanium alloy designations were revised;

- the technical requirements for the newly added designations were specified;

- the requirements for permissible deviations of product dimensions were revised;

- Annex B was added, and editorial changes were made to the format of the standard.

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

The responsible drafting organizations of this standard are: Baoji Titanium Group Co., Ltd., and Baoji Titanium Industry Co., Ltd.

The main drafters of this standard are: Wang Yongmei, Dong Jie, Ma Zhongxian, He Shulin, Li Jian and Zhang Jiangfeng.

The previous versions of the standard replaced by this standard are as follows:

- GBn 194—1983;

- GB/T 16598—1996.

1 Scope

This standard specifies the requirements, test methods, inspection rules, marking, packaging, transport, storage, certificate of quality and contents of the purchase order (or contract) for titanium and titanium alloy discs and rings.

This standard applies to titanium and titanium alloy discs and rings produced by forging and rolling.

2 Normative References

The following documents are indispensable for the application 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	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 — Creep and stress-rupture test in tension
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	Inspection methods for macrostructure and microstructure of α-β titanium alloys
GB/T 5193	Method of ultrasonic inspection for wrought titanium and titanium alloy products
GB/T 8180	Packaging, marking, transport and storage of wrought titanium and titanium alloy products
GB/T 23605	Determination method for β-transus temperature of titanium alloys

3 Requirements

3.1 Product Classification

The designations, conditions and specifications of the products shall conform to the requirements of Table 1.

Table 1

Designation	Supplied condition[a]	Product form	Specification/ mm			
			Outside diameter D	Inside diameter d	Section height H	Ring wall thickness
TA1, TA2, TA3, TA4, TA5, TA7, TA9, TA10, TA13, TA15, TC1, TC2, TC4, TC11	Hot-worked (R); annealed (M)	Disc	150~500	—	H＜D	—
			＞500~1 000	—	50~300	—
		Ring	200~500	100~400	25~300	25~150

Designation	Supplied condition[a]	Product form	Specification/ mm			
			＞500~900	300~850	110~500	25~250
			＞900~1 500	400~1 450	110~700	25~400

[a] The supplied condition of TC11 titanium alloy products is generally hot-worked (R); the annealed condition (M) is limited to products with a wall thickness or height not greater than 100 mm.

3.2 Chemical Composition

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

3.2.2 When the purchaser carries out re-verification on the products, the permissible deviations of the chemical composition shall conform to the requirements of GB/T 3620.2.

3.3 Mechanical Properties

3.3.1 The mechanical properties of the products shall be tested on specimen blanks after heat treatment (no re-heat treatment is required for the annealed condition). The recommended heat treatment schedules are given in Annex A.

3.3.2 For discs with a longitudinal section not greater than 100 cm^2 and rings with a maximum cross-sectional area not greater than 100 cm^2, the mechanical properties at room temperature shall conform to the requirements of Table 2.

Table 2 — Mechanical properties at room temperature, min.

Designation	Tensile strength Rm/MPa	0.2% proof strength Rp0.2/MPa	Percentage elongation after fracture A/%	Percentage reduction of area Z/%
TA1	240	140	24	30
TA2	400	275	20	30
TA3	500	380	18	30
TA4	580	485	15	25
TA5	685	585	15	40
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
TC1	585	460	15	30
TC2	685	560	12	30
TC4	895	825	10	25
TC11	1 030	900	10	30

3.3.3 When required by the purchaser and stated in the purchase order (or contract), for discs with a longitudinal section not greater than 100 cm² and rings with a maximum cross-sectional area not greater than 100 cm², the mechanical properties at elevated temperature shall conform to the requirements of Table 3.

Table 3 — Mechanical properties at elevated temperature, min.

Designation	Test temperature/℃	Tensile strength Rm/MPa	Stress-rupture strength σ100h/MPa
TA7	350	490	440
TA15	500	570	470
TC1	350	345	325
TC2	350	420	390
TC4	400	620	570
TC11	500	685	640[a]

[a] When the stress-rupture strength of TC11 titanium alloy products fails to meet the requirement, inspection is permitted in accordance with the 100 h stress-rupture strength at 500 ℃, σ100h ≥ 590 MPa; if the inspection is passed, the stress-rupture strength of the lot shall be deemed conforming.

3.3.4 For discs with a longitudinal section greater than 100 cm² and rings with a maximum cross-sectional area greater than 100 cm², when required by the purchaser and stated in the purchase order (or contract), the mechanical properties of the products may be determined, and either the measured values shall be reported or the indices shall be agreed between the supplier and the purchaser.

3.4 Dimensions and Shape

3.4.1 The products shall be delivered after turning (machining of the surface). The dimensions and their permissible deviations shall conform to the requirements of Table 4.

Table 4 — Units in millimetres

Disc				**Ring**					
Diameter	Permissible deviation	Section height	Permissible deviation	Outside diameter	Permissible deviation	Inside diameter	Permissible deviation	Section height	Permissible deviation
150~300	+3 -1	＜50	+2 0	200~400	+3 -1	100~300	+1 -3	25~100	+2 0
＞ 300~600	+3 -2	50~200	+3 -1	＞ 400~600	+3 -2	＞ 300~500	+2 -3	＞ 100~200	+2 -1
＞600~1 000	+5 -3	＞ 200~500	+4 -2	＞ 600~900	+5 -3	＞ 500~800	+3 -5	＞ 200~350	+4 -1
				＞900~1 200	+6 -3	＞800~1 100	+3 -6	＞ 350~500	+4 -2
				＞1 200~1 500	+8 -4	＞1 100~1 450	+4 -8	＞ 500~700	+5 -3

3.4.2 The chamfer radius R of the products shall be 3 mm~10 mm.

3.5 β-Transus Temperature

For titanium alloy products (except TA10 and TA13), the β-transus temperature shall be provided by melting furnace heat number.

3.6 Ultrasonic Inspection

When required by the purchaser and stated in the purchase order (or contract), the products shall be subjected to ultrasonic inspection in accordance with GB/T 5193, and the inspection results shall conform to the requirements of Table 5.

Table 5

Product section height or wall thickness/mm	Acceptance level
≤150	A
＞150	B

3.7 Macrostructure

The transverse macrostructure of the products shall be free from cracks, shrinkage cavities (tails), porosity, metallic or non-metallic inclusions, segregation affecting serviceability, and any other metallurgical defects visible to the naked eye.

3.8 Microstructure

When required by the purchaser and stated in the purchase order (or contract), the microstructure of the products shall be inspected. After heat treatment, the microstructure of the products shall conform to the following requirements:

3.8.1 The microstructure of TA5, TA7 and TA13 titanium alloys shall be an equiaxed α structure or an equiaxed and elongated α structure, together with partially broken and distorted grain-boundary α and lamellar α, without a complete original β grain boundary.

3.8.2 The microstructure of the other titanium alloys shall be a structure produced by working in the two-phase region, without a complete original β grain boundary. Equiaxed α structure on a transformed β matrix, or equiaxed α and elongated α structure, together with partially broken and distorted grain-boundary α and lamellar α, are all acceptable structures.

3.9 Visual Quality

3.9.1 Minor scratches, indentations, pits and wrinkles not greater than half of the permissible deviation of the dimension are permitted on the product surface.

3.9.2 Local defects on the product surface shall be removed; the depth of cleaning shall not exceed the permissible deviation of the product dimension, and the ratio of depth to width of the cleaned area shall not be greater than 1:6.

3.10 Surface Condition

For products for which ultrasonic inspection is required in the contract, the surface roughness Ra shall not be greater than 3.2 μm (taking satisfaction of the inspection requirements as the criterion).

4 Test Methods

4.1 Chemical composition analysis shall be carried out in accordance with GB/T 4698.

4.2 The room-temperature tensile test shall be carried out in accordance with GB/T 228.1, using the R7 specimen.

4.3 The elevated-temperature tensile test shall be carried out in accordance with GB/T 228.2, using a specimen with a diameter of 5 mm.

4.4 The elevated-temperature stress-rupture test shall be carried out in accordance with GB/T 2039.

4.5 The β-transus temperature shall be determined by GB/T 23605 or other methods.

4.6 The ultrasonic inspection shall be carried out in accordance with GB/T 5193.

4.7 The macrostructure and microstructure inspection shall be carried out in accordance with GB/T 5168.

4.8 The dimensions and shape of the products shall be inspected with measuring tools of appropriate accuracy.

4.9 The visual quality of the products shall be inspected by visual examination.

4.10 The surface roughness of the products shall be inspected by the standard block comparison method.

5 Inspection Rules

5.1 Inspection and Acceptance

5.1.1 The products shall be inspected by the supplier to ensure that the product quality conforms to the requirements of this standard, and a certificate of quality shall be issued.

5.1.2 The purchaser shall carry out re-verification of the products received in accordance with this standard and the purchase order (or contract). If the re-verification results do not conform to the requirements of this standard and the purchase order (or contract), the purchaser shall raise the matter to the supplier in writing, and it shall be resolved through consultation between the supplier and the purchaser. Objections concerning surface quality and dimensions/shape shall be raised within one month from the date of receipt of the products; objections concerning other properties shall be raised within three months from the date of receipt of the products. If arbitration is required, the arbitration samples shall be taken 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 heat number, specification, production process, condition and production period.

5.3 Inspection Items

Each lot of products shall be inspected for chemical composition, room-temperature mechanical properties, dimensions and shape, visual quality, surface condition, β-transus temperature and macrostructure. When required by the purchase order (or contract), inspection of elevated-temperature mechanical properties, ultrasonic inspection and microstructure, etc., shall also be carried out.

5.4 Sampling

5.4.1 From each lot, one piece shall be taken at random and cut into two halves, or a sample ring shall be cut and dissected from any one piece; the supplier shall carry out tests of properties, structure, etc., on one half, and the other half shall be handed to the purchaser for re-verification.

5.4.2 When several products of similar specifications are produced simultaneously from the same ingot by similar processes, the inspection results (including mechanical properties and structure) of the product of the largest specification (cross-section) may be taken as representative of the other specifications.

5.4.3 The sampling rules for the products shall conform to the requirements of Table 6.

Table 6

Inspection item	Sampling provision	Clause for requirements	Clause for test method
Chemical composition[a]	1 sample per lot	3.2	4.1
Mechanical properties[b]	2 chordwise specimens per lot for each item	3.3	4.2, 4.3, 4.4
Dimensions and shape	Each piece	3.4	4.8
β-transus temperature[c]	Any location, 1 sample per furnace heat	3.5	4.5
Ultrasonic inspection	Each piece	3.6	4.6
Macrostructure	1 longitudinal section per lot	3.7	4.7
Microstructure	1 transverse specimen per lot	3.8	4.7
Visual quality	Each piece	3.9	4.9
Surface condition	Each piece	3.10	4.10

[a] The hydrogen content is sampled on the finished product; for the other chemical composition elements, the supplier reports the analysis results of the original ingot, while the purchaser re-verifies by sampling on the products.

[b] When the dimensions are too small to take chordwise specimens, longitudinal specimens may be taken.

[c] The supplier may report the analysis results of the ingot; the purchaser shall sample and inspect on the products.

5.5 Judgement of Inspection Results

5.5.1 When the chemical composition inspection result of the products is non-conforming, the whole lot shall be judged non-conforming.

5.5.2 When the dimensions and shape, ultrasonic inspection, visual quality or surface condition of the products are non-conforming, the individual piece shall be judged non-conforming; however, the supplier is permitted to remove the non-conforming pieces and re-form lots for delivery.

5.5.3 When any specimen in the mechanical property inspection results is non-conforming, twice the number of specimens shall be taken for repeat testing of that item; if any one of the repeat test results is still non-conforming, the lot shall be judged non-conforming. However, the supplier is permitted to re-heat-treat and re-sample for inspection; re-heat treatment shall be limited to once.

5.5.4 When forging cracks, non-metallic inclusions or shrinkage cavities (tails) are found in the macrostructure specimens, the supplier is permitted to inspect the products piece by piece, remove the defective pieces, and re-form lots with the conforming pieces for delivery.

5.5.5 When the microstructure inspection is non-conforming, the lot shall be judged non-conforming; however, the supplier is permitted to inspect the remaining products piece by piece and re-form lots with the conforming pieces for delivery.

6 Marking, Packaging, Transport, Storage and Certificate of Quality

6.1 Product Marking

The following contents shall be marked on each piece of product that has passed inspection:

a) designation;

b) lot number or melting furnace heat number;

c) specification;

d) supplied condition.

6.2 Packaging, Marking, Transport and Storage

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

6.3 Certificate of Quality

Each lot of products shall be accompanied by a certificate of quality, stating:

a) name of the supplier;

b) name of the product;

c) designation;

d) specification;

e) supplied condition;

f) lot number or melting furnace heat number;

g) net weight and number of pieces;

h) results of all analyses and inspections and the stamp of the quality inspection department;

i) number of this standard;

j) date of dispatch (or date of packaging).

7 Contents of the Purchase Order (or Contract)

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

a) name of the product;

b) designation;

c) condition;

d) dimensions and specification;

e) number of pieces;

f) special requirements;

g) number of this standard;

h) others.

Annex A (Informative) Heat Treatment Schedules for Titanium and Titanium Alloys

A.1 Heat Treatment Schedules for Titanium and Titanium Alloys

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

Table A.1

Designation	Heating temperature, holding time and cooling method
TA1	600 ℃~700 ℃, 1 h~4 h, air cooling
TA2	600 ℃~700 ℃, 1 h~4 h, air cooling
TA3	600 ℃~700 ℃, 1 h~4 h, air cooling
TA4	600 ℃~700 ℃, 1 h~4 h, air cooling
TA5	700 ℃~850 ℃, 1 h~4 h, air cooling
TA7	750 ℃~850 ℃, 1 h~4 h, air cooling
TA9	600 ℃~700 ℃, 1 h~4 h, air cooling
TA10	600 ℃~700 ℃, 1 h~4 h, air cooling
TA13	780 ℃~800 ℃, 0.5 h~4 h, air cooling
TA15	700 ℃~850 ℃, 1 h~4 h, air cooling
TC1	700 ℃~850 ℃, 1 h~4 h, air cooling
TC2	700 ℃~850 ℃, 1 h~4 h, air cooling
TC4	700 ℃~800 ℃, 1 h~4 h, air cooling
TC11	950 ℃±10 ℃, 1 h~3 h, air cooling + 530 ℃±10 ℃, 6 h, air cooling

NOTE: The first annealing temperature of TC11 titanium alloy is permitted to be adjusted within 30 ℃~50 ℃ below the β-transus temperature.

Annex B (Informative) Designations, Chemical Compositions and Room-Temperature Mechanical Properties of Commercially Pure Titanium in the Former Standard

B.1 Designations and Chemical Compositions of Commercially Pure Titanium in the Former Standard

Table B.1 — Mass fraction/%

Designation	Main component	Impurity elements, max.						
	Ti	Fe	C	N	H	O	Each of the remainder	Sum of the remainder
TA0	Balance	0.15	0.10	0.03	0.015	0.15	0.1	0.4
TA1	Balance	0.25	0.10	0.03	0.015	0.20	0.1	0.4
TA2	Balance	0.30	0.10	0.05	0.015	0.25	0.1	0.4
TA3	Balance	0.40	0.10	0.05	0.015	0.30	0.1	0.4

B.2 Room-Temperature Mechanical Properties of Commercially Pure Titanium in the Former Standard

Table B.2 — Room-temperature mechanical properties, min.

Designation	Tensile strength Rm/MPa	Specified proportional extension strength Rp0.2/MPa	Percentage elongation after fracture A/%	Percentage reduction of area Z/%
TA0	280	170	30	35
TA1	370	250	20	35
TA2	440	320	18	35
TA3	540	410	15	30