NATIONAL STANDARD OF
THE PEOPLE'S REPUBLIC OF CHINA

中华人民共和国国家标准

GB/T 6614—2014

(replacing GB/T 6614—1994)

Titanium and titanium alloy castings

钛及钛合金铸件

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Foreword

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

This standard replaces GB/T 6614—1994 "Titanium and titanium alloy castings". Compared with GB/T 6614—1994, the main technical contents are revised as follows:

—GB/T 8170 "Rules of rounding off for numerical values and expression and judgment of limiting values" and GB/T 20967 "Non-destructive testing — Visual testing — General principles" were added as normative references;

—The purchase order description was added;

—The types of the master alloy ingot melting methods were added;

—The product classification was deleted; 3.1 of the 1994 edition was revised as 4.2 of this standard, and the supply conditions of the products were revised;

—Four new designations of titanium alloy castings, ZTA9, ZTA10, ZTA15 and ZTA17, were added;

—The units and symbols of the mechanical properties were revised;

—The arrangement positions of the designations and codes in Table 1 were adjusted;

—The table titles of each table were added;

—A supplementary explanation of the geometric dimensions for the case where the purchaser provides the mould, die or gauge was added;

—A requirement of the visual inspection for the surface quality was added;

—"X-ray" was revised as "ray";

—An explanation of the internal quality inspection methods and quality judgment criteria for thick and large castings was added;

—A requirement for the qualification of the welding personnel for weld repair was added;

—A requirement of the re-inspection of the repaired defects after the non-destructive testing was added;

—The cooling methods of the heat treatment in Table 2 were revised;

—An explanation that the hot isostatic pressing treatment may replace the stress-relief annealing treatment was added;

—The time limit for the inspection feedback in the inspection and acceptance was revised;

—A requirement for the handling of the nonconforming items of the chemical composition and mechanical properties in the inspection and acceptance was added;

—The batching was revised;

—A requirement for the handling of the defects of the specimens in the mechanical property sampling was added;

—The rounding off of numerical values was added.

This standard was proposed by and is under the jurisdiction of the National Foundry Standardization Technical Committee (SAC/TC 54).

The responsible drafting organizations of this standard are: Shenyang Foundry Research Institute, and No. 725 Research Institute of China Shipbuilding Industry Corporation.

The participating drafting organizations of this standard are: Beijing Institute of Aeronautical Materials of Aviation Industry Corporation of China, Baoji Titanium Industry Co., Ltd., Guizhou Anji Aviation Precision Casting Co., Ltd., Wuchang Shipbuilding Industry Group Co., Ltd., and Beijing Xinghang Mechanical and Electrical Equipment Co., Ltd.

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The previous editions of the standard replaced by this standard are:

—GB/T 6614—1986 and GB/T 6614—1994.

1 Scope

This standard specifies the purchase order description, technical requirements, test methods and inspection rules, as well as the marking, packaging, transport and storage requirements, etc. for titanium and titanium alloy castings.

This standard applies to titanium and titanium alloy castings produced by the machined graphite mould, rammed mould, metal mould and investment casting processes.

2 Normative References

The following documents contain provisions which, through normative reference in this standard, constitute indispensable provisions of this standard. 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 231.1	Metallic materials — Brinell hardness test — Part 1: Test method
GB/T 3623	Titanium and titanium alloy wires
GB/T 4698 (all parts)	Methods for chemical analysis of titanium sponge, titanium and titanium alloys
GB/T 5677	Radiographic testing of steel castings
GB/T 6414	Castings — Dimensional tolerances and machining allowances
GB/T 8170	Rules of rounding off for numerical values and expression and judgment of limiting values
GB/T 8180	Packaging, marking, transport and storage of wrought titanium and titanium alloy products
GB/T 9443	Penetrant testing of steel castings
GB/T 15073	Casting titanium and titanium alloys

Standard No.	Title
GB/T 20967	Non-destructive testing — Visual testing — General principles

3 Purchase Order Description

The contract or purchase order for ordering the castings shall state the following contents:

a) name and number of this standard;

b) product name, designation or code, supply condition, quantity of the castings and drawing number;

c) technical requirements and acceptance criteria;

d) other matters to be explained.

4 Technical Requirements

4.1 Materials

4.1.1

The master alloy ingots used for melting and pouring shall be melted by such methods as vacuum consumable, induction electroslag, plasma arc induction skull and electron beam melting.

4.1.2

When titanium sponge is used as the raw material, the master alloy ingot shall be melted at least twice.

4.1.3

Recycled material of the same designation after treatment is permitted to be used as the raw material.

4.2 Supply Conditions

4.2.1

The castings may be supplied in the following conditions: as-cast condition (C), annealed condition (M), hot isostatic pressing condition (HIP), or hot isostatic pressing (HIP) plus annealed condition (M), etc.

4.2.2

Where the purchaser has special requirements for the supply conditions of the castings, they shall be agreed between the supplier and the purchaser, and specified in the contract or technical agreement.

4.3 Chemical Composition

The chemical composition of the castings shall conform to the provisions of GB/T 15073.

4.4 Mechanical Properties

4.4.1

The room-temperature mechanical properties of the separately cast specimens of the castings shall conform to the provisions of Table 1.

4.4.2

Sampling from the casting body is permitted, and the sampling positions and the room-temperature mechanical property indices shall be agreed between the supplier and the purchaser.

4.4.3

Where the purchaser has special requirements, the mechanical property indices shall be agreed between the supplier and the purchaser, and specified in the contract or technical agreement.

Table 1 — Room-temperature mechanical properties of separately cast specimens

Code	Designation	Tensile strength Rm, MPa, not less than	Proof strength, non-proportional extension Rp0.2, MPa, not less than	Percentage elongation after fracture A, %, not less than	Hardness HBW, not greater than
ZTA1	ZTi1	345	275	20	210
ZTA2	ZTi2	440	370	13	235
ZTA3	ZTi3	540	470	12	245
ZTA5	ZTiAl4	590	490	10	270
ZTA7	ZTiAlSn2.5	795	725	8	335
ZTA9	ZTiPd0.2	450	380	12	235
ZTA10	ZTiMo0.3Ni0.8	483	345	8	235
ZTA15	ZTiAl6Zr2Mo1V1	885	785	5	—
ZTA17	ZTiAl4V2	740	660	5	—
ZTB32	ZTiMo32	795	—	2	260
ZTC4	ZTiAl6V4	835 (895)	765 (825)	5 (6)	365
ZTC21	ZTiAl6Sn4.5Nb2Mo1.5	980	850	5	350

Note: The property indices in brackets are those measured when the oxygen content is controlled at a higher level.

4.5 Geometric Shape, Dimensions and Tolerances

4.5.1

The geometric shape and dimensions of the castings shall conform to the provisions of the casting drawings or the ordering agreement. Where the mould, die or wax pattern is provided by the purchaser, the dimensions of the castings shall be agreed between the supplier and the purchaser.

4.5.2

The dimensional tolerances of the castings shall conform to the provisions of GB/T 6414. Where not specified in the drawings or the contract, the dimensional tolerances shall not be lower than the requirements of CT9 (the rammed mould castings shall not be lower than CT11). Where there are special requirements, they shall be agreed between the supplier and the purchaser, and specified in the contract or technical agreement.

4.6 Surface Quality

4.6.1

The castings shall be trimmed of flash and burrs, with smooth surfaces and free from sand adhesion.

4.6.2

Grinding or other methods are permitted to remove the burrs and such defects as slight surface flow marks and cold shuts of the castings. After grinding, no oxidation blueing is permitted, and a smooth transition with the base metal shall be ensured. After grinding, the castings shall conform to the dimensional requirements of the casting drawings. The areas not permitted to be ground shall be specified in the drawings, contract or technical agreement.

4.6.3

The castings shall be free from cracks and penetrating defects; the requirements for the sealing faces of the castings shall be specified in the drawings, contract or technical agreement.

4.6.4

Other surface defects shall satisfy the visual acceptance criteria listed in the contract or technical agreement.

4.6.5

Where the purchaser has special requirements for the surface quality of the castings, they shall be agreed between the supplier and the purchaser.

4.6.6

When required by the purchaser and specified in the contract or technical agreement, the surfaces of the castings may be subjected to the non-destructive inspection in accordance with GB/T 9443, or as agreed between the supplier and the purchaser.

4.7 Internal Quality

When required by the purchaser and specified in the contract or technical agreement, the castings may be subjected to radiographic inspection, and the inspection methods and quality judgment criteria shall be in accordance with the requirements of GB/T 5677, or as agreed between the supplier and the purchaser. For thick and large castings for which the radiographic inspection is difficult, other inspection methods may be adopted, and the specific inspection methods and quality judgment criteria shall be agreed between the supplier and the purchaser.

4.8 Weld Repair

4.8.1

Except for the areas where weld repair is not permitted as specified in the part drawings, contract or technical agreement, all exposed blowholes, shrinkage cavities, porosity, cracks, inclusions and dimensional defects after grinding on the castings are permitted to be weld-repaired. Before weld repair, the defective areas shall be thoroughly cleaned until bright metallic surfaces are exposed.

4.8.2

Defects exposed during machining, or defects found by radiographic inspection, may be weld-repaired as required.

4.8.3

The weld repair shall be carried out under vacuum or argon protection, and the weld spots shall not show oxidation blueing.

4.8.4

The filler wire shall generally be the material of the designation corresponding to the casting or the material of the same type with a lower strength level, and its quality shall conform to the provisions of GB/T 3623. Before welding, the surfaces of the filler wire shall be cleaned; if there is oil contamination, they shall be cleaned.

4.8.5

During weld repair, the supplier shall formulate the welding procedure, which shall be completed by welders with appropriate qualifications. The supplier shall retain the relevant procedure documents and the welder qualification certification documents.

4.8.6

Where the stress generated by the weld repair may affect the normal service of the castings, the castings shall be subjected to the stress-relief annealing treatment. Unless otherwise agreed between the two parties, the decision on the stress-relief annealing treatment shall be made by the supplier, and the castings shall be cooled to room temperature by air cooling or furnace cooling according to the method of 4.9, or as agreed between the two parties.

4.8.7

For defects detected by non-destructive testing methods, after weld repair, the original defect positions shall be re-inspected correspondingly.

4.9 Heat Treatment

4.9.1

The castings (including weld-repaired pieces) may be subjected to the stress-relief annealing treatment as required.

4.9.2

When the purchaser requires the vacuum annealing treatment, it shall be specified in the contract or technical agreement.

4.9.3

The common stress-relief annealing treatment procedures for titanium and titanium alloy castings may refer to Table 2. In special cases, the heat treatment procedures shall be agreed between the supplier and the purchaser.

Table 2 — Stress-relief annealing treatment procedures

Alloy code	Temperature, ℃	Holding time, min	Cooling method
ZTA1, ZTA2, ZTA3	500~600	30~60	Furnace cooling or air cooling
ZTA5	550~600	30~90	Furnace cooling or air cooling
ZTA7	550~650	30~120	Furnace cooling or air cooling
ZTA9, ZTA10	500~600	30~120	Furnace cooling or air cooling
ZTA15	550~750	30~240	Furnace cooling or air cooling
ZTA17	550~650	30~240	Furnace cooling or air cooling
ZTC4	550~650	30~240	Furnace cooling or air cooling

4.9.4

Castings with special requirements for the internal quality may be subjected to the hot isostatic pressing treatment, and the hot isostatic pressing treatment may replace the stress-relief annealing treatment. The hot isostatic pressing procedure shall be agreed between the supplier and the purchaser.

5 Test Methods

5.1

The chemical composition analysis methods of the castings shall be executed in accordance with the provisions of GB/T 4698 (all parts). Other analysis methods may be adopted as agreed between the supplier and the purchaser.

5.2

The room-temperature tensile test of the castings shall be executed in accordance with the provisions of GB/T 228.1.

5.3

The hardness test of the castings shall be executed in accordance with the provisions of GB/T 231.1.

5.4

The surface quality inspection of the castings shall be executed by the visual method of GB/T 20967 or in accordance with the provisions of GB/T 9443.

5.5

The radiographic inspection of the castings shall be executed in accordance with the provisions of GB/T 5677.

6 Inspection Rules

6.1 Inspection and Acceptance

6.1.1

The castings shall be inspected by the quality supervision department of the supplier to ensure that the casting quality conforms to the provisions of this standard, and a quality certificate shall be filled in.

6.1.2

The purchaser may re-verify the received castings in accordance with the provisions of this standard. Where there is a dispute over the re-verification results, it shall be fed back to the supplier within 90 days from the receipt of the castings; otherwise, the acceptance shall be deemed as agreed.

6.1.3

When the purchaser carries out the inspection of the castings at the supplier's premises, the supplier shall provide the inspector of the purchaser with all reasonable and necessary facilities required for the production of the castings in accordance with this standard. The inspection work of the purchaser shall not interfere with the work of the supplier.

6.1.4

Where the supplier and the purchaser have a dispute over the inspection results, it shall be settled through consultation or by arbitration analysis carried out by a third party, and the arbitration analysis results shall be regarded as the final results for judging whether the castings conform to this standard.

6.2 Batching

The castings shall be submitted for inspection in batches. Each batch shall consist of castings of the same designation, the same raw material batch number, the same production process and the same condition. Each batch shall not exceed 20 melting furnace heats.

6.3 Inspection Items

Each batch of castings shall be inspected for the chemical composition, mechanical properties, geometric dimensions and surface quality. When special inspection items are required, they shall be agreed between the supplier and the purchaser, and specified in the contract.

6.4 Sampling Positions and Sampling Quantities

6.4.1 Chemical Composition Sampling

For the chemical composition analysis of the castings, samples may be taken from the sprue, the body of the castings, or the mechanical property test bars poured in the same heat, in any heat of each batch, and one

specimen per batch shall be taken. The oxidation layer on the casting surface of the specimen used for the chemical composition analysis shall be removed.

6.4.2 Mechanical Property Sampling

For measuring the mechanical properties of the castings, samples may be taken from the mechanical property test bars poured in the same heat or the casting body, in any heat of each batch, and two specimens per batch shall be taken. Where the purchaser has special requirements for the sampling positions and sampling quantities, they shall be agreed between the supplier and the purchaser, and specified in the contract. Where any specimen has defects, other specimens of the same heat may be used instead.

6.4.3 Geometric Dimension Inspection Sampling

The geometric dimensions of each batch of castings may be inspected piece by piece or by sampling, and the specific inspection method shall be agreed between the supplier and the purchaser.

6.4.4 Surface Quality Inspection Sampling

The castings shall be inspected piece by piece for the surface quality.

6.4.5 Non-Destructive Inspection Sampling

Where the non-destructive inspection of the castings is required, the inspection quantity and inspection positions per batch shall be agreed between the supplier and the purchaser.

6.5 Re-inspection

6.5.1

Where the chemical analysis result fails, new specimens may be taken for re-analysis of the nonconforming elements. Where the re-analysis result still fails, sampling analysis per furnace heat is permitted; where any element fails, the castings of that heat shall be judged as nonconforming, and the qualified ones may be re-batched for acceptance.

6.5.2

In the mechanical property inspection, where the test result of one specimen fails, double the number of specimens shall be taken for re-verification. Where one specimen still fails in the re-verification result, sampling per melting furnace heat is permitted for inspection; where one specimen fails, the castings of that melting furnace heat shall be judged as nonconforming, and the qualified ones may be re-batched for acceptance.

6.6 Rounding Off of Numerical Values

The rounding off of the numerical values of the test results shall be executed in accordance with the provisions of GB/T 8170.

7 Marking, Quality Certificate, Packaging, Transport and Storage

7.1 Marking

The castings shall be marked or labelled at appropriate positions, stating:

a) material designation or code;

b) batch number or heat number;

c) condition.

7.2 Quality Certificate

Each batch of castings shall be accompanied by a quality certificate. Except for special requirements, the following contents shall generally be stated:

a) name of the supplier;

b) product name;

c) alloy designation or code;

d) supply condition;

e) batch number and/or heat number of the castings;

f) weight and quantity of the castings;

g) results of all analyses and inspections required by the contract, and the seal of the quality supervision department;

h) number of this standard;

i) date of delivery (or packaging).

7.3 Packaging, Transport and Storage

The packaging, marking, transport and storage of the castings shall be executed in accordance with the provisions of GB/T 8180.