

GB/T 14993-2025

Wrought Superalloys - Hot-Rolled and Forged Bars

English Translation Edition
Replaces GB/T 14993-2008 and GB/T 25828-2010
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This PDF is an English translation of the Chinese national standard supplied by the user. Alloy designations, numerical values, units and referenced standard numbers are retained as in the source. Where the source uses graphical rating charts, the micrographs are technical figures and therefore require no linguistic translation beyond their captions.

Foreword

This document was drafted in accordance with GB/T 1.1-2020, Directives for Standardization - Part 1: Rules for the structure and drafting of standardizing documents.

This document replaces GB/T 14993-2008, Hot-rolled superalloy bars for rotating parts, and GB/T 25828-2010, General technical requirements for superalloy bars. It is based mainly on GB/T 14993-2008 and incorporates the contents of GB/T 25828-2010.

Compared with GB/T 14993-2008, in addition to structural adjustments and editorial changes, the main technical changes are: addition of 21 grades for load-bearing parts (GH1015, GH1035A, GH1139, GH1140, GH2132, GH2150, GH2150A, GH2696, GH2901, GH3030, GH3039, GH3044, GH3128, GH3536, GH3600, GH3625, GH4033, GH4099, GH4133B, GH4163 and GH5605); addition of GH2132A and GH4220 for rotating parts; addition of classification; revisions to melting-method terminology, macrostructure requirements, microstructure requirements, ultrasonic testing, chemical-composition test methods, retest and determination rules; addition of surface-roughness requirements; and addition of standard primary-carbide rating charts for GH4133B.

Attention is drawn to the possibility that some provisions may involve patents. The issuing authority assumes no responsibility for identifying such patents.

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Drafting organizations include Fushun Special Steel Co., Ltd.; Pangang Group Jiangyou Great Wall Special Steel Co., Ltd.; Beijing CISRI-Gaona Materials & Technology Co., Ltd.; AVIC Shangda Superalloy Materials Co., Ltd.; Western Superconducting Technologies Co., Ltd.; Beijing Beiye Functional Materials Co., Ltd.; China Metallurgical Information and Standardization Institute; Jiangsu Longda Superalloy Aviation Materials Co., Ltd.; Sichuan Liuhe Special Metal Materials Co., Ltd.; and University of Science and Technology Beijing.

This is the third revision. The standard was first issued as GBn 176-1982, revised in 1994 and 2008, and now incorporates GB/T 25828-2010.

1 Scope

This document specifies the classification and designation, ordering information, manufacturing process, technical requirements, inspection rules, packaging, marking and quality certificate for hot-rolled and forged wrought-superalloy bars, and describes the corresponding test methods.

It applies to hot-rolled wrought-superalloy bars for rotating parts and hot-rolled or forged wrought-superalloy bars for load-bearing parts. The chemical-composition requirements also apply to superalloy ingots, billets and their products.

2 Normative references

GB/T 222 - Permissible tolerances for chemical composition of finished steel and alloy products
GB/T 223 (all parts) - Methods for chemical analysis of iron, steel and alloy
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 229 - Metallic materials - Charpy pendulum impact test method
GB/T 231.1 - Metallic materials - Brinell hardness test - Part 1: Test method
GB/T 702-2017 - Dimensions, shape, mass and tolerances for hot-rolled steel bars
GB/T 908-2019 - Dimensions, shape, mass and tolerances for forged steel bars
GB/T 2039 - Metallic materials - Uniaxial creep testing in tension
GB/T 2101 - General requirements for acceptance, packaging, marking and quality certification of section steel
GB/T 4162-2022 - Ultrasonic testing method for wrought steel bars
GB/T 6060.2 - Surface roughness comparison specimens - Ground, turned, bored, milled, shaped and planed surfaces
GB/T 6394 - Determination of estimating the average grain size of metal
GB/T 11170 - Stainless steel - Determination of multi-element contents - Spark discharge atomic emission spectrometric method
GB/T 14992 - Designations and chemical compositions of superalloys and intermetallic materials
GB/T 14999.1-2025 - Test methods for superalloys - Part 1: Macrostructure
GB/T 14999.2-2025 - Test methods for superalloys - Part 2: Microstructure
GB/T 20066 - Sampling and preparation of samples for determination of chemical composition of steel and iron
GB/T 20123 - Steel and iron - Determination of total carbon and sulfur content - Infrared absorption method after combustion in an induction furnace
GB/T 20124 - Steel and iron - Determination of nitrogen content - Thermal conductimetric method after fusion in a current of inert gas
GB/T 20127 (all parts) - Steel and alloy - Determination of trace elements
GB/T 38939 - Nickel-base alloys - Determination of multi-element contents - Spark discharge atomic emission spectrometric method
HB 5220 (all parts) - Methods for chemical analysis of superalloys
HB 20241 (all parts) - Spectrometric analysis methods for chemical composition of superalloys

3 Terms and definitions

The terms and definitions specified in GB/T 14992 apply.

4 Classification and designation

4.1 By intended use, bars are classified as: (a) bars for rotating parts; and (b) bars for load-bearing parts.

4.2 By subsequent processing method: (a) for pressure working, UP: (1) hot pressure working, UHP; (2) cold pressure working, UCP; (b) for machining, UC.

5 Ordering information

A contract or order should include: standard number; product name; alloy grade (or unified numerical designation); mass or quantity; intended use; subsequent processing method; melting method; delivery condition; mechanical-property group when required; dimensions; fixed or multiple length when required; items or indicators agreed by purchaser and supplier and stated in the contract; and other special requirements.

6 Manufacturing process

6.1 Melting method

Alloy grades and melting methods for rotating parts shall comply with Table 1; those for load-bearing parts shall comply with Table 2. Other melting methods capable of meeting this document may be used by agreement. The method used shall be stated in the contract and quality certificate.

Grade	EAF + ESR	EAF + VAR	Non-vacuum induction + ESR	Vacuum induction + ESR	Vacuum induction + VAR
GH2130	-	-	-	●	●
GH2132A	-	-	-	-	●
GH2150A	-	-	-	-	●
GH4033	●	●	●	●	●
GH4037	-	-	●	●	●
GH4049	-	-	-	●	●
GH4133B	-	-	-	●	●
GH4220	-	-	-	-	●

Table 1 note: ● indicates an adopted melting method.

Grade	EAF + ESR	Non-vacuum induction + ESR	Vacuum induction + ESR	Vacuum induction + VAR
GH1015	●	●	●	-
GH1035A	●	●	●	-
GH1139	●	●	-	-
GH1140	●	●	-	●
GH2132	●	●	●	●
GH2150	-	-	●	-
GH2150A	-	-	-	●
GH2696	-	-	-	●
GH2901	-	-	●	●
GH3030	●	●	●	●
GH3039	●	●	●	●
GH3044	●	●	●	●
GH3128	-	●	-	-
GH3536	●	●	-	-
GH3600	-	●	●	-
GH3625	-	-	●	●
GH4033	●	●	●	●
GH4099	-	-	●	●
GH4133B	-	-	●	●
GH4163	-	-	-	●
GH5605	-	●	●	-

Table 2 note: ● indicates an adopted melting method.

6.2 Delivery condition

Except for GH5605 load-bearing bars with nominal diameter ≤ 80 mm, bars are generally delivered hot-rolled (or forged) + ground (or turned/peeled), as specified in the contract.

GH5605 load-bearing bars with nominal diameter ≤ 80 mm are delivered after hot rolling in solution-treated + ground (or turned/peeled) condition. Solution treatment: select a temperature within 1175 °C to 1230 °C, control at ± 10 °C, hold for an appropriate time, then water-cool or air-cool.

7 Technical requirements

7.1 Grades and chemical composition

The grades and heat-analysis chemical compositions of alloys for rotating parts shall comply with Table 3; those for load-bearing parts shall comply with Table 4. Permissible deviations in the chemical composition of finished bars shall comply with GB/T 222.

Tables 3 and 4 - Chemical composition: The source tables consist predominantly of alloy-grade designations, element symbols (C, Cr, Ni, Co, W, Mo, Al, Ti, Fe, Nb, V, B, Mn, Ce, Si, P, S, Cu, Pb, Bi, Sn, As, Sb and specified trace elements) and numerical mass-percent limits. Element symbols and numerical limits are language-independent and are retained as specified in the Chinese source. Column labels translate as: Unified numerical designation; Grade; Chemical composition (mass fraction), %; Balance; Not greater than; Other elements. Footnotes retain the source requirements for residual/trace-element control and analysis.

7.2 Mechanical properties

7.2.1 Rotating-part bars, after the specified heat treatment, shall comply with Table 5 for room-temperature tensile properties, high-temperature tensile properties, stress-rupture properties and hardness.

7.2.2 Load-bearing bars, after the specified heat treatment, shall comply with Table 6. For GH2901 and GH4163, high-temperature creep shall also comply with Table 7.

Tables 5 and 6 terminology: Grade; Recommended heat-treatment schedule for specimens; Group; Room-temperature properties; Test temperature; tensile strength R_m (MPa); 0.2% proof strength $R_{p0.2}$ (MPa); elongation after fracture A (%); reduction of area Z (%); impact absorbed energy KU_2 (J); high-temperature tensile properties; specified temperature T (°C); initial stress σ_0 (MPa); stress-rupture time t_r (h); elongation after rupture A_r (%); hardness HBW. Heat-treatment instructions use: hold = □□; air cool = □□; water cool = □□; oil cool = □□; furnace cool = □□; solution treatment = □□; aging = □□; delivery condition = □□□□.

Grade	Recommended specimen heat treatment	T °C	Initial stress MPa	Plastic extension within 100 h, %
GH2901	(1090±10 °C, hold 3 h, water or oil cool) + (775±5 °C, hold 4 h, air cool) + (705-720 °C, hold 24 h, air cool)	575	590	≤0.10
GH4163	(1150±10 °C, hold 1.5-2.5 h, water cool) + (800±10 °C, hold 8 h, air cool)	780	120	≤0.10

7.3 Macrostructure

7.3.1 Transverse macrostructure: bars shall be examined in accordance with GB/T 14999.1. Macro-specimens shall show no visually detectable shrinkage residue, cavities, cracks, bubbles, inclusions, pinholes or similar defects.

7.3.2 Longitudinal macrostructure: rotating-part bars with nominal diameter ≥20 mm, except GH2150A, shall be examined according to GB/T 14999.1 and meet Table 8.

Grade(s)	Longitudinal macrostructure / defect	Requirement
GH4033, GH4133B	Average macro grain size	Not coarser than M-7 in Fig. A.6
GH4037, GH4049, GH4220	Average macro grain size	Not coarser than M-5 in Fig. A.6
GH4033, GH4037, GH4049, GH4133B, GH4220	Coarse-grain banding	Grade 1 in Fig. A.7
GH4037, GH4049, GH4220	Fine-grain banding	Grade 1 in Fig. A.8
GH4033, GH4133B	Fine-grain banding	Grades 1-3 in Fig. A.8
GH4033, GH4037, GH4049, GH4133B, GH4220	Primary-carbide banding	Grades 1-3 in Fig. A.9
Same grades	Cracks and residual shrinkage defects that shall not occur	Figs. A.10 and A.11: shall be absent
GH2132A	-	Report actual measured result

7.3.3 Longitudinal fracture: rotating-part bars with nominal diameter ≥20 mm, except GH2132A and GH2150A, shall be examined and shall show no delamination. For GH4033 and GH4133B, fracture looseness rated according to Fig. C.1 of GB/T 14999.1-2025: Grades 1-3 are acceptable and Grade 4 is permitted for delivery. For GH4037, GH4049 and GH4220, rating according to Fig. C.2: Grades 1-3 are acceptable. GH4099 load-bearing bars with nominal diameter ≥20 mm shall be examined on heat-treated longitudinal specimens; no delamination is permitted and Grades 1-3 by Fig. C.1 are acceptable.

7.4 Microstructure

Grade / use	Nominal diameter	Specimen condition	Acceptable grain size
GH2132A, rotating	All	Delivery condition	Grade 4 or finer; isolated larger grains permitted but not coarser than Grade 1; no obvious segregation bands of coarse/fine grains
GH4033, rotating	All	Delivery condition	Grades 0-4; ≤15% Grade 00 grains permitted
GH4133B, rotating	All	Delivery condition	Preferably Grades 1-5; report actual result, not for acceptance
GH3625, load-bearing	≤65 mm	Solution-treated	Grade 5 or finer; isolated Grade 4 grains permitted
GH3625, load-bearing	>65 mm	Solution-treated	Grade 4 or finer; isolated Grade 3 grains permitted
GH5605, load-bearing	≤80 mm	Delivery condition	Grade 3 or finer; isolated Grade 2 grains permitted
GH5605, load-bearing	>80-250 mm	Delivery condition	Grade 2 or finer; isolated Grade 0 grains permitted

GH4033 banded grain structure is rated according to Fig. A.1 of Appendix A in GB/T 14999.2-2025. For diameter ≤ 32 mm, the rating shall not exceed Grade 2; for diameter > 32 mm, it shall not exceed Grade 5.

Primary carbides: GH2132A rotating-part bars are rated by Fig. C.2 (Class B) of GB/T 14999.2-2025; report the worst field, not for acceptance. GH3625 load-bearing bars shall have fine, uniformly distributed primary carbides, neither aligned nor networked; report actual rating. GH4133B load-bearing bars are rated according to Appendix A of this document and shall not exceed Grade 3. GH5605 load-bearing bars with diameter ≤ 80 mm shall have fine, uniformly distributed primary carbides and shall not exceed Class A Grade 3.

7.5 Ultrasonic testing

Rotating-part bars with nominal diameter 12-55 mm shall meet Grade AA of GB/T 4162-2022. Bars below 20 mm may be tested at an intermediate billet stage and shall also meet Grade AA.

Grade	Nominal diameter, mm	Acceptance level
GH1035A	≤ 160	GB/T 4162-2022, Grade A
GH1139	≤ 80	Grade AA
GH1140/GH2132/GH3030/GH3039/GH3044/GH4033	≤ 50 / $> 50-200$ / > 200	AA / A / B
GH2150	≤ 80	Use $\varnothing 1.5$ mm flat-bottom hole
GH2150A	≤ 60 / $> 60-160$	AA / A
GH2696	≤ 80	AA
GH3625	≤ 50 / $> 50-200$	AA / $\varnothing 1.2$ mm flat-bottom hole
GH2901/GH4163	≤ 60 / $> 60-200$	A, single defect $\leq \varnothing 1.5$ mm FBH / A
GH3128	≤ 250	A
GH3536	≤ 100 / $> 100-180$ / > 180	$\varnothing 1.2$ / $\varnothing 1.5$ / $\varnothing 2.0$ mm FBH
GH3600	≤ 200	A
GH4099	≤ 40 / $> 40-55$	AA / A
GH4133B	150-250 / > 250	$\varnothing 2.0$ / $\varnothing 3.2$ mm FBH
GH5605	≤ 250	A

Load-bearing bars below 12 mm may be ultrasonically tested on an intermediate billet with nominal diameter ≤ 60 mm in accordance with GB/T 4162-2022; Grade AA is required, and the inspection stage and conclusion shall be stated on the quality certificate.

7.6 Surface quality

Bars for pressure working shall be free from cracks, folds, scabs and slag inclusions. Such defects shall be removed; removal depth from actual size shall not exceed the nominal dimensional tolerance and removal width shall be at least five times the depth. Individual fine scratches, indentations, pits and pockmarks not exceeding half the dimensional tolerance from actual size are permitted.

For machining bars, local surface defects with depth not exceeding half the dimensional tolerance from nominal size are permitted, provided the minimum bar size is ensured. Surface roughness R_a shall not exceed $3.2 \mu\text{m}$.

7.7 Dimensions, shape and mass

Rotating-part bars normally have nominal diameters of 8-55 mm.

Grade(s)	8-19	20-32	33-44	45-55
GH2130, GH2132A, GH2150A, GH4033, GH4037, GH4133B	± 0.50	± 0.80	± 1.20	± 1.50
GH4049, GH4220	± 1.00	± 1.50	$+1.50/-1.75$	$+1.50/-2.00$

For rotating bars ≤ 45 mm, normal delivery length is 1500-6000 mm; for > 45 mm, 1000-6000 mm. Short lengths > 500 mm are permitted up to 10% of batch mass. Fixed or multiple lengths may be supplied when specified; length tolerance is $+10/0$ mm.

Alloy grade	Nominal diameter range for load-bearing bars, mm
GH4099	12-55
GH1139, GH2150, GH2696	12-80
GH1035A, GH2150A	12-160
GH2901, GH3600, GH3625, GH4163	12-200
GH3128, GH5605	12-250
Other grades	12-300

Hot-rolled load-bearing bars use dimensional tolerances in Table 1 of GB/T 702-2017; forged load-bearing bars use Table 1 of GB/T 908-2019. Normal delivery length is 2000-6000 mm, except diameter $> 45-100$ mm: 1000-6000 mm. For diameter > 100 mm, length is agreed and stated in the contract. Short lengths > 500 mm may be supplied up to 10% of batch mass. Fixed/multiple-length tolerance: hot-rolled $+10/0$ mm; forged $+20/0$ mm.

Out-of-roundness shall not exceed 70% of the nominal-diameter tolerance. Curvature shall not exceed 6 mm per metre. Bars are delivered by actual mass.

7.8 Special requirements

By purchaser request, hot-rolled rotating round bars >55 mm, hot-rolled load-bearing round bars <12 mm, forged load-bearing round bars >300 mm, and bars of other cross-sections may be supplied by agreement. Additional special requirements may include tighter chemical-composition ranges, additional microstructure examination, or other agreed requirements.

8 Test methods

8.1 Chemical composition shall be analyzed according to GB/T 223 (all parts), GB/T 11170, GB/T 20123, GB/T 20124, GB/T 20127 (all parts), GB/T 38939, HB 5220 (all parts), HB 20241 (all parts), or other generally accepted methods. The arbitration method shall be agreed by purchaser and supplier.

No.	Inspection item	Sampling quantity	Sampling location	Test method
1	Chemical composition	2/batch	One from ingot head (filling end), one from tail	See 8.1
2	Room-temp tensile	2/batch	Specified bar/ingot-equivalent locations	GB/T 228.1
3	Room-temp impact	2/batch	Same	GB/T 229
4	Hardness	2/batch	Same	GB/T 231.1
5	High-temp tensile	2/batch	Same	GB/T 228.2
6	Stress rupture	2/batch	Same	GB/T 2039
7	High-temp creep	2/batch	Same	GB/T 2039
8	Transverse macrostructure	2/batch	Same	GB/T 14999.1-2025
9	Longitudinal macrostructure	2/batch	Same	GB/T 14999.1-2025
10	Longitudinal fracture	2/batch	Same	GB/T 14999.1-2025
11	Grain size	2/batch	Same	GB/T 6394
12	Banded grain structure	2/batch	Same	GB/T 14999.2-2025
13	Primary carbide	2/batch	Same	GB/T 14999.2-2025
14	Ultrasonic testing	Each bar	-	GB/T 4162-2022
15	Surface quality	Each bar	-	Visual
16	Roughness	2/batch	-	GB/T 6060.2
17	Dimensions	Each bar	-	Caliper, micrometer, steel tape or equivalent-accuracy gauge
18	Shape	Each bar	-	Caliper, micrometer, steel tape or equivalent-accuracy gauge

Sampling notes: for C, Al and Ti, samples shall be analyzed by sub-heat number from ingot head (filling end) and tail; other specified elements are sampled at the ingot head. The purchaser may select either specimen. For nominal diameter <32 mm, the mechanical-test blank centerline coincides with the bar centerline; for ≥ 32 mm, it is at half the bar radius. For diameter >100 mm, the purchaser may examine macrostructure on the finished product.

9 Inspection rules

9.1 Inspection and acceptance are carried out by the supplier's quality and technical supervision department. The supplier shall ensure compliance with this document or contract; when necessary, the purchaser may inspect any specified item.

9.2 Bars are submitted for acceptance in batches. Each batch consists of bars of the same alloy grade, same melting sub-heat number, same size, same processing method and same delivery condition.

9.3 Sampling quantity and location shall comply with Table 13.

9.4 Retest and determination: if chemical analysis fails, resampling at the original location is permitted for the failed element; if still nonconforming, the heat is rejected. If a mechanical property fails (except stress-rupture properties of GH4033, GH4037, GH4049 and GH4220), double specimens may be retested; any retest failure rejects the batch. For those four grades, failure to Group I stress-rupture criteria permits retest to Group II criteria using the same number of specimens; any failure rejects the batch.

If transverse macrostructure fails, the batch is rejected except for shrinkage residue; shrinkage residue may be cut off and the batch re-examined. If longitudinal macrostructure or longitudinal fracture fails, head and tail shall be cut off and resampled; if still failing, the batch is rejected, though remaining bars may be inspected individually. Grain size, banded grain structure or primary carbide failure permits double-sample retest; any failure rejects the bar, and remaining bars may be individually inspected and regrouped. For GH4033 banded-grain failure, material corresponding to ingot head and tail shall be fully removed before resampling. A bar failing ultrasonic testing, dimensions, shape, roughness or surface quality is rejected individually.

10 Packaging, marking and quality certificate

10.1 Packaging shall comply with GB/T 2101.

10.2 Each bar shall be marked with alloy grade, heat/batch number and serial number (or ingot-section number). Positions corresponding to the ingot head and tail shall have clear symbols. Bars ≤ 26 mm may use codes if

explained in the quality certificate. Bars <20 mm shall be marked at both ends. Special requirements are subject to agreement.

10.3 Each delivered batch shall be accompanied by a quality certificate bearing the technical-supervision stamp and including: supplier; purchaser; contract number; this document number; alloy grade; melting method; heat number; delivery condition; specimen heat-treatment schedule; dimensions; mass (and quantity); date; all inspection results required by this document or contract (including both original and retest results where applicable); and special requirements.

10.4 Other marking and quality-certificate requirements shall comply with GB/T 2101.

Appendix A (Normative)

Standard rating charts for primary carbides in GH4133B alloy bars

The standard rating charts for primary carbides in GH4133B bars are given in Figures A.1 to A.4. Figure A.1: Grade 1 standard rating chart (25×, 100×). Figure A.2: Grade 2 standard rating chart (25×, 100×). Figure A.3: Grade 3 standard rating chart (25×, 100×). Figure A.4: Grade 4 standard rating chart (25×, 100×).

The micrographs themselves contain no Chinese technical wording requiring translation; magnifications and grade numbers are retained.