Designation: A565/A565M – 10 (Reapproved 2017)ε1

Standard Specification for Martensitic Stainless Steel Bars for High-Temperature Service[1]

This standard is issued under the fixed designation A565/A565M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

ε[1] NOTE—Revised Table 1 editorially to show commonly accepted element name Niobium (formerly Columbium) in March 2017.

1. Scope

1.1 This specification covers hot-finished and cold-finished martensitic chromium steel bars for high-temperature service. The mechanical properties are developed by suitable heat treatment, as indicated for each alloy.

1.2 Where strength at temperature is a factor, these steels are generally limited to a maximum service temperature of 1200°F [650°C]. For oxidation (scaling) resistance and at low stresses, these steels are useful to 1450°F [790°C].

1.3 This specification is expressed in both inch-pound units and SI units; however, unless the purchase order or contract specifies the applicable *M* specification designation (SI units), the inch-pound units shall apply. The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A484/A484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

A994 Guide for Editorial Procedures and Form of Product Specifications for Steel, Stainless Steel, and Related Alloys

E112 Test Methods for Determining Average Grain Size

E292 Test Methods for Conducting Time-for-Rupture Notch Tension Tests of Materials

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

E562 Test Method for Determining Volume Fraction by Systematic Manual Point Count

2.2 *SAE Document:*[3]

SAE J1086 Recommended Practice for Numbering Metals and Alloys (UNS)

3. Ordering Information

3.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Such requirements may include, but are not limited to, the following:

3.1.1 Quantity (weight or number of pieces);

3.1.2 Name of material (martensitic stainless steel);

3.1.3 Form (bar, and so forth);

3.1.4 Condition;

3.1.5 Finish;

3.1.6 Size, or applicable dimension including diameter, thickness, width, length, and so forth;

3.1.7 Grade designation (Table 1); and

3.1.8 ASTM designation number and date of issue.

4. General Requirements

4.1 Product furnished to this specification shall conform to the requirements of Specification A484/A484M, including any supplementary requirements indicated in the purchase order.

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloysand is the direct responsibility of Subcommittee A01.17 on Flat-Rolled and Wrought Stainless Steel.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

***A Summary of Changes section appears at the end of this standard**

TABLE 1 Chemical Requirements

Grade	UNS Designation[A]	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Vanadium	Tungsten	Nitrogen	Aluminum	Niobium	Copper
XM-32	S64152	0.08–0.15	0.50–0.90	0.025 max	0.025 max	0.35 max	11.00–12.50	2.00–3.00	1.50–2.00	0.25–0.40	...	0.01–0.05	...	...	...
...	S41041	0.13–0.18	0.40–0.60	0.030 max	0.030 max	0.50 max	11.50–13.00	0.50 max	0.20 max	...	...	...	0.05 max	0.15 –0.45	...
...	S41425	0.05 max	0.50–1.00	0.02 max	0.005 max	0.50 max	12.00–15.00	4.00–7.00	1.50–2.00	...	...	0.06–0.12	...	...	0.30 max
615	S41800	0.15–0.20	0.50 max	0.040 max	0.030 max	0.50 max	12.00–14.00	1.80–2.20	0.50 max	...	2.50–3.50	...	...	...	...
616	S42200	0.20–0.25	0.50–1.00	0.025 max	0.025 max	0.50 max	11.00–12.50	0.50–1.00	0.90–1.25	0.20–0.30	0.90–1.25	...	...	...	...
619	S42300	0.27–0.32	0.95–1.35	0.025 max	0.025 max	0.50 max	11.00–12.00	0.50 max	2.50–3.00	0.20–0.30	...	...	...	...	...
...	S42226	0.15–0.20	0.50–0.80	0.020	0.010	0.20–0.60	10.0–11.5	0.30–0.60	0.80–1.10	0.15–0.25	0.25	0.04–0.08	0.05	0.35 –0.55	...

[A] New designation established in accordance with Practice E527 and SAE J1086.

Failure to comply with the general requirements of Specification A484/A484M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A484/A484M, this specification shall prevail.

5. Manufacture

5.1 *Heat Treatment:*

5.1.1 The product forms covered in this specification may be furnished in one of the following conditions:

5.1.1.1 *Condition A*—Annealed,

5.1.1.2 *Condition T*—Heat treated (for machining),

5.1.1.3 *Condition HT*—Heat treated (for high-temperature service), or

5.1.1.4 *Condition H*—Heat treated.

5.2 *Condition and Finish:*

5.2.1 Bars may be furnished in one of the following hot-finished conditions:

5.2.1.1 Hot rolled, or

5.2.1.2 Rough turned (rounds only).

5.2.2 Bars may be furnished in one of the following cold-finished conditions:

5.2.2.1 Cold drawn,

5.2.2.2 Centerless ground (rounds only), or

5.2.2.3 Polished (rounds only).

6. Chemical Requirements

6.1 Each alloy covered by this specification shall conform to the chemical composition specified in Table 1.

6.2 Methods and practices relating to chemical analysis required by this specification shall be in accordance with Test Methods, Practices, and Terminology A751.

7. Metallurgical Requirements

7.1 The microstructure shall not contain more than 5 % delta-ferrite after full heat treatment as described in Table 2. Visual examination for the volume fraction of delta ferrite of various representative areas of examination is acceptable. When the visual estimation method indicates the delta ferrite content is greater than the allowed limit, the manufacturer may employ Test Method E562 for determining the acceptability of the lot.

8. Mechanical Properties Requirements

8.1 The material shall conform to the mechanical properties listed in Table 3 for the ordered condition.

TABLE 2 Heat Treatment

NOTE 1— If straightened, a stress-relieving treatment is necessary. Stress-relieving temperature should be 50°F [28°C] below the final tempering temperature.

NOTE 2—Air or oil quenching depends on section size; heavier sections, approximately 3 in. [76.2 mm] or greater, should be oil quenched. Suitable synthetic quenchants may be substituted for oil.

Grade	UNS Designation[A]	Condition	Heat Treatment
615	S41800	HT	1800 to 1850°F [980 to 1010°C], quench in air or oil and double temper at 1150°F [620°C] min for 2 h min for each tempering treatment.
...	S41425	HT	1700 to 1800°F [925 to 980°C], quench in air and temper at 1100°F [595°C] min for 1 h, min, per inch thickness.
616	S42200	HT	1875 to 1925°F [1020 to 1050°C], quench in air or oil and temper at 1150°F [620°C] min for 2 h min.
		H	1875 to 1925°F [1020 to 1050°C], quench in air or oil and temper at 1250°F [675°C] min for 2 h min.
619	S42300	HT	1875 to 1925°F [1020 to 1050°C], quench in air or oil and temper at 1150°F [620°C] min for 2 h min.
XM-32	K64152	HT	1825 to 1875°F [995 to 1020°C], quench in air or oil and temper at 1050°F [565°C] min for 2 h min.
...	S41041	HT	2075 to 2125°F [1135 to 1165°C] for 2 h min, quench in air or oil and temper at 1250°F [675°C] min for 2 h min.
...	S42226	HT	2000 to 2500°F [1095 to 1150°C], quench in rapid air, oil, or polymer and temper at 1185°F [640°C] min.

[A] New designation established in accordance with Practice E527 and SAE J1086.

TABLE 3 Mechanical Property Requirements[A]

Grade	UNS Designation[B]	Condition	Tensile Strength min, ksi [MPa]	Yield Strength, min, 0.2 % Offset, ksi [MPa]	Elongation in 2 in. [50 mm] or 4D, min, %	Reduction of Area, min, %	Impact at Room Temperature, Charpy V-notch, min, ft·lbf [J]	Brinell Hardness[C]
615	S41800	A	...	...	...	...	...	311 max
		HT	140 [965]	110 [760]	15	45	...	302 to 352
...	S41425	HT	120 [825]	95 [655]	15	45	50 [70]	321 max
616	S42200	A	...	...	...	...	...	248 max
		T	...	...	...	...	...	285 max
		HT	140 [965]	110 [760]	13	30	8 [11]	302 to 352
		H	120 [825]	85 [585]	17	35	...	241 to 285
619	S42300	A	...	...	...	...	...	248 max
		T	...	...	...	...	...	285 max
		HT	140 [965]	110 [760]	8	20	8 [11]	302 to 352
XM-32	K64152	A	...	...	...	...	...	311 max
		HT	145 [1000]	115 [795]	15	30	30 [40]	302 to 352
...	S41041	HT	115 [795]	75 [515]	15	50	20 [27]	277 max
...	S42226	A	...	...	...	...	...	302 max
	S42226	HT	140 [965]	100 [690]	15	45	8 [11]	321 max

[A] The properties and associated heat treatments are those most commonly specified. For sections greater than 30 in.^{2} [193 cm^2] in cross-sectional area, it is suggested that an agreement be reached between purchaser and materials vendor.
[B] New designation established in accordance with Practice E527 and SAE J1086.
[C] Hardness taken at the surface for control purposes only. For acceptance purposes, tensile properties govern.

8.2 Material furnished in Condition A or T shall be capable of developing the room-temperature properties specified for Condition HT when subjected to heat treatment as specified in Table 2.

8.3 The yield strength shall be determined by the offset method as described in the current edition of Test Methods and Definitions A370.

8.4 The impact strength shall be determined at 70 to 80°F [21 to 27°C], by Charpy V-notch specimen Type A as described in Test Methods and Definitions A370.

8.5 Stress rupture testing of UNS S42226 shall be conducted as specified in Table 4 using a combination test bar in accordance with Test Methods E292. Rupture must occur in the smooth section of each test specimen. The test may be discontinued after the time specified, provided the certification so notes. Stress rupture testing is not required on bars less than ½ in. in diameter or thickness.

TABLE 4 Rupture Testing

	UNS S42226
Temperature °F [°C]	1200 [650]
Stress ksi [MPa], min.	33 [230]
Time to rupture, h, min	25

9. Keywords

9.1 martensitic stainless steel; stainless steel bars; stainless steel billets; stainless steel forgings; temperature service applications—high

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, and order. Details of these supplementary requirements shall be agreed upon by the manufacturer and purchaser.

S1. Non-Destructive Examination—UNS S42200

S1.1 *Method*—Each bar shall be subjected to NDE. The method used shall be: Eddy Current (ET), Magnetic Particle (MPI wet or dry), Liquid Penetrant (LPI), or Ultrasonic (UT), at the option of the vendor unless otherwise indicated in the purchase order.

S1.2 *Acceptance Criteria*—For LPI or MPI, linear indications (those indications longer than 1/16 in. [1.5 mm] with a length greater than three times their width) are unacceptable. For UT or ET, reject levels for linear indications shall be based on the alarm response from a 0.012-in. [0.3-mm] maximum deep surface notch in a calibration bar.

S2. Microstructure—UNS S42200 and UNS S42226 Condition H or HT

S2.1 Metallographic inspection shall be performed at 100× magnification to determine the metallurgical structure, grain size, and delta ferrite content.

S2.2 The microstructure shall be tempered martensite with no more than 1 % delta ferrite.

S2.3 The average grain size shall be 4 or finer. The maximum size of individual grains, distributed at random, shall be a 2. When the average grain size is 5 or finer, only the average size needs be reported. Grain size determination shall be performed in accordance with Test Methods E112.

S3. Stress Rupture Testing—UNS S42200 Condition HT

S3.1 Stress rupture testing shall be conducted at 1200°F [650°C] and 26 000 psi [180 MPa] using a combination test bar in accordance with Test Methods E292. Rupture shall occur in the smooth section of each test specimen. The test may be discontinued after 25 h provided the certification so notes. Stress rupture testing is not required on bars less than ½ in. in diameter or thickness.