Designation: A 831/A831M – 95 (Reapproved 2000)

Standard Specification for Austenitic and Martensitic Stainless Steel Bars, Billets, and Forgings for Liquid Metal Cooled Reactor Core Components[1]

This standard is issued under the fixed designation A 831/A831M; 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.

1. Scope

1.1 This specification covers hot- and cold-finished austenitic and martensitic stainless steel bars, billets, and forgings intended for use in manufacturing core components used at high temperatures in liquid metal cooled nuclear reactors.

1.2 The bars, billets, and forgings are intended for machining, welding, hot- and cold-forming operations.

1.3 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 are not 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.

1.4 This specification and the applicable material specifications are expressed in both inch-pound and SI units. However, unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished in inch-pound units.

2. Referenced Documents

2.1 *ASTM Standards:*

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[2]

A 388/A388M Practice for Ultrasonic Examination of Heavy Steel Forgings[3]

A 484/A484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings[3]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[2]

E 3 Methods of Preparation of Metallographic Specimens[4]

E 45 Practice for Determining the Inclusion Content of Steel[4]

E 112 Test Methods for Determining Average Grain Size[4]

E 407 Test Methods for Microetching Metals and Alloys[4]

2.2 *ANSI Standard:*

B 46.1 Surface Texture[5]

2.3 *ASNDT Standard:*

SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualifications and Certification[6]

2.4 *ASME Standard:*

NQA-1 Quality Assurance Program Requirements for Nuclear Facilities[7]

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 Condition (cold-worked, annealed, or tempered).

3.1.3 Finish.

3.1.4 Applicable dimensions, including size, thickness, width, and length (if forgings, include prints or sketches).

3.1.5 Form (bars, billets, etc.).

3.1.6 Grade designation.

3.1.7 ASTM designation and year of issue.

3.1.8 Marking requirements.

3.1.9 Other applicable documents (2.4).

3.1.10 Melting process (4.1).

3.1.11 Approval of procedures for conversion of ingots (4.2).

3.1.12 Cold working requirements for austenitic grades (4.4.3).

3.1.13 Identification requirements (4.6).

3.1.14 Chemistry requirements (5.1).

3.1.15 Product analysis tolerances (5.3).

3.1.16 Grain size limits for bar, billets, and forgings requiring rework (6.1).

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

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[2] *Annual Book of ASTM Standards,* Vol 01.03.

[3] *Annual Book of ASTM Standards,* Vol 01.05.

[4] *Annual Book of ASTM Standards,* Vol 03.01.

[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[6] Available from American Society for Nondestructive Testing, P.O. Box 5642, 3200 Riverside Dr., Columbus, OH 43228.

[7] Available from American Society of Mechanical Engineers, 345 E. 47th St., New York, NY 10017.

3.1.17 Alternate inclusion limits (6.2).
3.1.18 Surface roughness limits (4.3.2).
3.1.19 Surface marring limits (4.3.3).
3.1.20 Ultrasonic test requirements (8.1).
3.1.21 Sampling levels (10.1).
3.1.22 Packaging requirements (12.1).

NOTE 1—A typical ordering description is as follows: 5000-lb [2000-kg] stainless steel, annealed and centerless ground, round bar 1½ in. [38 mm] in diameter, 10 to 12 ft. [3 to 4 m] Type 316, ASTM Specification A 831 – xx.

4. Manufacture

4.1 *Melting*—Unless an alternative melting process has been specified in Section 9, the process for austenitic grades shall consist of a vacuum induction melt followed by a consumable electrode vacuum-arc remelt. Additions of rare earths during melting are prohibited unless approved by the purchaser. The melting process for other grades shall be specified in the order.

4.2 *Ingot Processing*—A procedure for conversion of ingots shall be approved by the purchaser prior to use if specified in the order. The parameters for the conversion of austenitic grades shall be selected to minimize the formation of complex carbides and carbonitrides.

4.3 *Surface Requirements*:

4.3.1 *Surface Condition*—The finished bar shall be free of all scale, splits, laps, cracks, seams, and visible oxide.

4.3.2 *Surface Roughness*—The surface finish of finished bar shall meet the minimum requirements listed in Table 1. The surface finish of bar that will be machined subsequently shall be as specified in the order and shall be compatible with nondestructive examination requirements.

4.3.3 *Surface Marring*—The finished bar shall be free of scratches, dents, or mars as specified in the order.

4.4 *Heat Treatment*:

4.4.1 *Austenitic Grades*—Except for material ordered in the cold-worked condition, all austenitic grade material shall be furnished in the solution-annealed condition. Solution annealing shall consist of heating the material to a temperature of 1900°F [1038°C] minimum, for a time appropriate to ensure full carbide solution, followed by rapid cooling in air or water to prevent carbide precipitation at the grain boundaries.

4.4.2 *Martensitic Grades*—Unless otherwise specified by the purchaser, martensitic grade materials shall be supplied in the normalized and tempered condition. Tempered material shall be normalized at 1900°F [1038°C] minimum as a final heat treatment. Tempered martensitic materials shall be held at tempering temperature for at least 1 h/1in. [25 mm] of cross section as follows:

4.4.2.1 *Grade T91*—1350°F [732°C] minimum, 1485°F [807°C] maximum.

TABLE 1 Austenitic Stainless Steel Bar—Surface Finishes

Bar Diameter, in. (mm)	Surface Designation (ANSI B 46.1)
⅛ to ¼ [3.2 to 6.4] incl	32 µin. [0.8 µm] or finer
over ¼to 2 [6.4 to 50.8] incl	63 µin. [1.6 µm] or finer
over 2 to 10 [50.8 to 254.0] incl	125 µin. [3.2 µm] or finer

4.4.2.2 *S42100*—1365°F [740°C] minimum, 1470°F [799°C] maximum.

4.4.3 *Cold-Worked Austenitic Grades*—If required by the purchaser, austenitic grades shall be furnished in the cold-worked condition. Prior to any final cold working operations, solution annealing shall be performed in accordance with 4.4.1. Percentage of cold work shall be based upon reduction in area.

4.4.4 *Cleanliness During Manufacture*—All lubricants shall be removed prior to any heat treatment.

4.5 *Lotting*—Items of the same nominal dimension shall be lotted on the basis of material having the same metallurgical history, produced from the same melt heat, processed in one final tooling setup, annealed in the same annealing charge (or processed in one continuous run if annealed in a continuous furnace) and given the same cold work.

4.6 *Identification*—Material shall be identified and processed in a manner that will ensure traceability as specified in the order.

4.7 *Handling*—Special handling procedures shall be employed to maintain the identity of material from the final working operation through packaging for shipment. The handling procedure shall be submitted to the purchaser for review and approval prior to use.

5. Chemical Requirements

5.1 The material shall conform to the applicable chemistry requirements specified in Table 2 unless otherwise specified in the order.

5.2 An analysis of each heat of steel shall be made by the steel manufacturer in accordance with Test Methods, Practices, and Terminology A 751 to determine the percentages of the elements specified. If secondary melting processes are employed, the heat analysis shall be obtained from one remelted ingot or the product of one remelted ingot of each primary melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in 5.1.

TABLE 2 Chemical Requirements

	Grade (UNS Designation)			
	316 (S31600)	. . . S 38660	. . . S 42100	T91 (. . .)
Carbon	0.040 to 0.060	0.030 to 0.050	0.17 to 0.23	0.08 to 0.12
Manganese	1.00 to 2.00	1.65 to 2.35	0.40 to 0.70	0.30 to 0.60
Phosphorus, max	0.040	0.040	0.040	0.020
Sulfur, max	0.010	0.010	0.010	0.010
Silicon	0.50 to 0.75	0.50 to 1.00	0.20 to 0.30	0.20 to 0.50
Nickel	13.0 to 14.0	14.5 to 16.5	0.30 to 0.80	0.40 max
Chromium	17.0 to 18.0	12.5 to 14.5	11.0 to 12.5	8.0 to 9.5
Molybdenum	2.00 to 3.00	1.50 to 2.50	0.80 to 1.20	0.85 to 1.05
Titanium	. . .	0.10 to 0.40[A]	. . .	. . .
Columbium	0.050 max	0.050 max	0.050 max	0.06 to 0.10
Tantalum, max	0.020	0.020	. . .	. . .
Tungsten	. . .	. . .	0.40 to 0.60	. . .
Nitrogen	0.010 max	0.005 max	. . .	0.03 to 0.07
Aluminum, max	0.050	0.050	0.050	0.04
Arsenic, max	0.030	0.030	. . .	. . .
Boron, max	0.0020	0.0020	. . .	. . .
Cobalt, max	0.050	0.050	. . .	. . .
Copper, max	0.04	0.04	. . .	. . .
Vanadium	0.05 max	0.05 max	0.25 to 0.35	0.18 to 0.25

[A] Aim for 0.25.