



Designation: A 1028 – 03

## Standard Specification for Stainless Steel Bars for Compressor and Turbine Airfoils<sup>1</sup>

This standard is issued under the fixed designation A 1028; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This specification covers stainless steel bars for compressor and turbine bucket, blade, and airfoil applications.

1.2 The values stated in inch-pound units are to be considered the standard.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

A 275/A 275M Test Method for Magnetic Particle Examination of Steel Forgings<sup>2</sup>

A 484/A 484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings<sup>3</sup>

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment<sup>2</sup>

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys<sup>4</sup>

E 112 Test Methods for Determining Average Grain Size<sup>5</sup>

E 292 Test Methods for Conducting Time-for-Rupture Notch Tension Tests of Materials<sup>5</sup>

E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings<sup>5</sup>

E 562 Test Method for Determining Volume Fraction by Systematic Manual Point Count<sup>5</sup>

### 3. Terminology

3.1 Refer to Terminology A 941 for definitions of terms used in this standard.

### 4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for product under this specification. Such requirements to be considered may include but are not limited to the following:

4.1.1 Quantity (weight or number of pieces).

4.1.2 Grade and Class (Table 3).

4.1.3 Applicable dimensions including size, thickness, width, and length.

4.1.4 Whether bars are to be rolled as bars or cut from plate.

4.1.5 Supplementary Requirements.

### 5. General Requirements

5.1 Product furnished to this specification shall conform to the requirements of Specification A 484/A 484M including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A 484/A 484M constitutes nonconformance with this specification.

5.2 In case of conflict between the requirements of this specification and Specification A 484/A 484M, this specification shall prevail.

### 6. Manufacture

6.1 *Melting Process*—The steel shall be made using the Basic Electric Furnace Process with Argon-Oxygen-Decarburization (AOD) refining or by Vacuum Ladle Degasing. Use of Electro-Slag Remelting is permitted unless otherwise specified by the purchaser (see Supplemental Requirement S1).

6.2 *Heat Treatment*—Heat treating of all bars is required in accordance with Table 1 to develop the required mechanical properties.

6.2.1 *Number of Heat Treatments*—Two complete heat treatments, consisting of an austenitize, quench and temper, are permitted. Purchaser approval is required prior to any additional heat treatments.

6.2.2 *Temperature Variation*—Heat treating temperatures shall be controlled in the range of  $\pm 25^\circ\text{F}$ .

6.3 *Stress Relief*—When heat treatment for mechanical properties is followed by straightening, a stress relieving heat treatment is required in accordance with Table 1.

6.3.1 *Quenching after Stress Relief*—Water or oil quenching of stress-relieved bars is prohibited.

<sup>1</sup> 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-Rolled and Wrought Stainless Steel.

Current edition approved April 10, 2003. Published May 2003.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 01.05.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 01.03.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 01.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 03.01.

**TABLE 1 Heat Treatment, °F**

	Grade A	Grade B	Grade C		Grade D	Grade E		Grade F
	Classes 1 and 2	Class 1	Class 1	Class 2	Classes 1 and 2	Class 1	Class 2	Class 1
Austenitizing	1725-1775	1600-1750	1825 to 1875	1725 to 1875	1875 to 1925	2075 to 2125	1725 to 1775	1875 to 1925
Quenching	Air or liquid	Air or liquid	Air or liquid	Air or liquid	Air or liquid	Air or liquid	Air or liquid	Air or liquid
First temper	1100 min	1100 min	1050 min	1000 min	1150 min	1250 min	1100 min	...
Second temper	...	...	1025 min	1000 min	...	...	...	...
Aging	...	...	...	...	...	...	...	1135 to 1165
Stress Relieving	1065 min	1065 min	1000 min	1000 min	1100 min	1200 min	1050 min	1100 min

**TABLE 2 Chemical Requirements**

UNS Designation	Composition %					
	Grade A	Grade B	Grade C	Grade D	Grade E	Grade F
	S41000	S41005	S41428	S42225	S41041	S17400
Carbon	0.15 max	0.10 to 0.15	0.10 to 0.17	0.20 to 0.25	0.13 to 0.18	0.07 max
Manganese	1.0 max	0.25 to 0.80	0.65 to 1.05	0.5 to 1.0	0.4 to 0.6	1.0 max
Phosphorus, max	0.018	0.018	0.020	0.020	0.030	0.040
Sulfur, max	0.015	0.015	0.015	0.010	0.030	0.030
Silicon	0.5 max	0.5 max	0.10 to 0.35	0.20 to 0.50	0.5 max	1.0 max
Nickel	0.75 max	0.75 max	2.25 to 3.25	0.5 to 1.0	0.5 max	3.0 to 5.0
Chromium	11.5 to 13.0	11.5 to 13.0	11.25 to 12.75	11.0 to 12.5	11.5 to 13.0	15.0 to 17.5
Molybdenum	0.5 max	0.5 max	1.5 to 2.0	0.9 to 1.25	0.20 max	...
Vanadium	...	Report only	0.25 to 0.40	0.20 to 0.30	...	...
Tungsten	...	0.10 max	0.10 max	0.9 to 1.25	...	...
Nitrogen	...	0.08 max	0.020 to 0.045	Report only	...	...
Aluminum	...	0.025 max	0.025 max	0.025 max	0.05 max	...
Columbium	...	0.20 max	...	0.05 max	0.15 to 0.45	0.15 to 0.45
Cobalt	...	...	...	0.20 max	...	...
Titanium	...	0.05 max	0.05 max	0.025 max	...	...
Copper	...	0.50 max	0.50 max	0.15 max	...	3.0 to 5.0
Tin	...	0.05 max	0.05 max	0.02 max	...	...

**TABLE 3 Tensile, Impact, and Hardness Requirements**

	Grade A		Grade B		Grade C		Grade D		Grade E		Grade F
	Class 1	Class 2	Class 1	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2	Class 1	
Tensile strength, min, ksi	100	110	110	145	160	140	140	115	110	135	
Yield strength, min, ksi, 0.2 % offset	70	80	90	115	120	90	100	75	80	105	
Elongation in 2 in., min, %	20	18	18	15	16	13	13	15	18	16	
Reduction of area, min, %	60	50	50	30	50	30	35	50	55	50	
Impact strength, min, av., Cv, Rt, ft-lb	30	25	30	30	40	8	10	20	25	41	
Hardness, Brinell, max	255	269	269	352	375	331	331	277	262	341	

## 7. Chemical Composition

7.1 The steel shall conform to the requirements for chemical composition prescribed in Table 2.

## 8. Mechanical Properties

8.1 *Lot Size*—A lot shall consist of all bars of the same size from one electric furnace heat of steel and heat treated, either in the same charge in either a batch furnace or a continuous type furnace.

8.2 *Hardness Tests*—All testing shall be performed after heat treatment and stress relief, as applicable. The test specimens shall meet the requirements of Table 3.

8.2.1 *Number of Tests*—A minimum of four bars or 10 % of the lot, whichever is less, shall be tested on each end.

8.3 *Tensile and Impact Tests*—One room temperature tensile test and two room temperature Charpy V-Notch Impact tests shall be taken from the softest and hardest Bar in each lot of material. Impact tests are only required on bars or shapes 1/2 in. or larger in minor dimension.

8.3.1 *Test Specimen Location*—The axis of the specimen shall be located at the center of the bars up to and including 1 1/2 in. width. For bars over 1 1/2 in. width, the axes of the specimen shall be located midway between the center and the edge (corner) of the bar.

## 9. Workmanship and Nondestructive Examination

9.1 *General Requirements*—All bars shall be free of cracks, fissures, seams, laps, bursts, shrinkage, and similar discontinuities.

9.2 *Nondestructive Tests*—Nondestructive testing and corresponding acceptance criteria shall be as specified by the purchaser.

## 10. Dimensions, Tolerances, and Finish

10.1 Hot-rolled or cold-finished bar, or both, shall be furnished to the tolerances (permissible variations) in Specification A 484/A 484M, with the following additional requirements: