



Designation: A 1021 – 01

# Standard Specification for Martensitic Stainless Steel Forgings and Forging Stock for High-Temperature Service<sup>1</sup>

This standard is issued under the fixed designation A 1021; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope

1.1 This specification covers martensitic chromium stainless steel forgings, forged bar, and forging stock for high temperature service. The mechanical properties are developed by suitable heat treatment, as indicated for each alloy.

1.2 The values stated in inch-pound units are to be regarded as standard.

## 2. Referenced Documents

### 2.1 ASTM Standards:

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

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products<sup>3</sup>

A 788 Specification for Steel Forgings, General Requirements<sup>2</sup>

E 112 Test Methods for Determining Average Grain Size<sup>4</sup>

E 292 Test Methods for Conducting Time-For-Rupture Notch Tension Tests of Materials<sup>4</sup>

E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings<sup>4</sup>

E 562 Test Method for Determining Volume Fraction by Systematic Manual Point Count<sup>4</sup>

## 3. Ordering Information

3.1 In addition to the ordering information required by Specification A 788, the purchaser shall specify the grade designation, heat treatment condition, class and finish, and include a sketch or written description of the forging with the inquiry and order.

## 4. General Requirements

4.1 Materials supplied to this specification shall conform to the requirements of Specification A 788, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A 788 constitutes non-conformance with this specification.

<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 A01.06 on Steel Forgings and Billets.

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<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 03.01.

In case of conflict between the requirements of this specification and Specification A 788, this specification shall prevail.

## 5. Manufacture

5.1 *Melting Process*—All melting processes of Specification A 788 are permitted unless the purchaser invokes Supplementary Requirement S1.

5.2 *Forging Process*—Either the closed impression die or the open die, including ring rolling, forging processes may be utilized unless the purchaser specifies a process.

5.3 *Heat Treatment*—Quenched and tempered classes shall be heat-treated in accordance with Table 1.

5.3.1 *Number of Heat Treatments*—Heat treatment as defined in Table 1 shall consist of austenitizing, quenching, and tempering. Retempering is permitted but purchaser approval is required for more than one complete reheat treatment.

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

5.4.1 *Quenching after Stress Relief*—Liquid quenching of stress-relieved forgings is prohibited.

5.5 *Finish*—Forgings may be furnished in one of the following hot-finished conditions:

5.5.1 *Finish F*—As forged without descaling.

5.5.2 *Finish FD*—Forged and descaled.

5.5.3 *Finish RT*—Rough turned or rough machined to specified dimensions. Billets or blooms ordered as forging stock shall be furnished with a ground, machined, or descaled surface unless otherwise specified in the ordering document.

5.6 *Camber*—Camber shall not exceed ¼ in. (5 mm) in 5 ft (150 cm).

## 6. Chemical Composition

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

## 7. Mechanical Properties

7.1 *Tension, Impact and Hardness Tests*—All testing shall be performed after heat treatment and stress relief, as applicable. The material and test specimens shall meet the requirements of Table 3 if fully heat-treated or Table 4 if annealed. Mechanical property requirements, including hardness, do not apply to forging stock when it is to be tested after forging and heat treatment.



**TABLE 1 Heat Treatment, °F (°C)**

	Grade A	Grade B	Grade C		Grade D	Grade E	
	Class 1 & 2	Class 1	Class 1	Class 2	Class 1 & 2	Class 1	Class 2
Austenitizing	1725-1775 (940-970)	1600-1750 (870-955)	1825-1875 (995-1025)	1725-1875 (940-1025)	1875-1925 (1025-1050)	2075-2125 (1135-1165)	1725-1775 (940-970)
Quenching	Air or liquid	Air or liquid	Air or liquid	Air or liquid	Air or liquid	Air or liquid	Air or liquid
Single Tempering	1050 min (565 min)	1050 min (565 min)	1050 min (565 min)	1050 min (565 min)	1150 min (620 min)	1250 min (675 min)	1100 min (595 min)
Double Tempering	...	...	1025 min (550 min)	1025 min (550 min)	...	...	...
Stress Relieving	1025 min (550 min)	1025 min (550 min)	1000 min (540 min)	1000 min (540 min)	1100 min (595 min)	1200 min (650 min)	1050 min (565 min)

**TABLE 2 Chemical Requirements<sup>A</sup>**

Type—Similar to	Composition %				
	Grade A	Grade B	Grade C	Grade D	Grade E
	403/410 SS UNS S41000	403/410 SS MOD.	XM-32 Mod	422 SS	UNS S41041
Carbon	0.15	0.10-0.15	0.10-0.17	0.20-0.25	0.13-0.18
Manganese	1.00	0.25-0.80	0.65-1.05	0.50-1.00	0.40-0.60
Phosphorus	0.018	0.018	0.020	0.025	0.030
Sulfur	0.015	0.015	0.015	0.010	0.030
Silicon	1.00	0.50	0.35	0.50	0.50
Nickel	0.75	0.75	2.25-3.25	0.50-1.00	0.50
Chromium	11.5-13.5	11.5-13.0	11.25-12.75	11.0-12.5	11.5-13.0
Molybdenum	0.50	0.50	1.50-2.00	0.90-1.25	0.20
Vanadium	...	Report only	0.25-0.40	0.20-0.30	...
Tungsten	...	0.10	0.10	0.9-1.25	...
Nitrogen	...	0.08	0.020-0.045	Report only	...
Aluminum	...	0.025	0.025	0.025	0.050
Columbium	...	0.20	...	...	0.15-0.45
Cobalt	...	...	...	0.20	...
Titanium	...	0.05	0.05	0.025	...
Copper	...	0.50	0.50	0.50	...
Tin	...	0.05	0.05	0.02	...

<sup>A</sup> Maximum or range unless otherwise specified.

**TABLE 3 Mechanical Properties—Quenched & Tempered Classes**

	Grade A		Grade B	Grade C		Grade D		Grade E	
	Class 1	Class 2	Class 1	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2
Tensile strength, KSI min (MPa)	100 (690)	110 (760)	110 (760)	145 (1000)	160 (1105)	140 (965)	140 (965)	115 (795)	110 (760)
Yield Strength min, KSI (MPa), 0.2 % Offset	70 (485)	80 (550)	90 (620)	115 (795)	120 (825)	90 (620)	100 (690)	75 (515)	80 (550)
Elongation in 2 in., min %	20	18	18	15	16	13	13	15	18
Reduction of area, min, %	60	50	50	30	50	30	35	50	55
Impact Strength, min, avg., CV, RT, ft-lb (J)	30 (41)	25 (34)	30 (41)	30 (41)	40 (54)	8 (11)	13 (18)	20 (27)	25 (34)
Impact Strength, min of one specimen per Test Methods A 370, CV, RT, ft-lb (J)	20 (27)	17 (23)	20 (27)	20 (27)	27 (36)	5 (7)	9 (12)	13 (18)	17 (23)
Hardness, Brinell, max	255	269	269	352	375	331	331	277	262
Hardness, Rockwell C, max	26	28	28	38	40	36	36	29	27

**7.2 Test Specimens**—Forgings may be lot tested. Test specimens may be obtained from production forgings or from separately forged test blanks prepared from the stock used to make the finished part. Forgings that are lot tested shall be produced from the same heat of steel and heat treated at the same time. Separately forged test blanks shall receive essentially the same type of hot-working and forging reduction as the production forgings; however, a longitudinally forged bar with dimensions not less than  $T$  by  $T$  by  $3T$  may be used to represent a ring forging. The dimension  $T$  shall be representative of the heaviest effective cross section of the forging.

**TABLE 4 Mechanical Properties—Annealed Classes**

	Grade A	Grade B	Grade C	Grade D	Grade E
	Class 3	Class 2	Class 3	Class 3	Class 3
Hardness, Brinell, max	248	248	311	248	248
Hardness, Rockwell C, max	24	24	33	24	24

**7.3 Test Specimen Orientation**—Mechanical property requirements are for samples oriented in the direction of grain flow. Unless otherwise specified in the purchase order, manufacturers may orient the samples in any direction provided the mechanical property requirements are met.