



Designation: A 982 – 02

Standard Specification for Steel Forgings, Stainless, for Compressor and Turbine Airfoils¹

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1. Scope*

1.1 This specification covers stainless steel forgings 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 Test Method for Magnetic Particle Examination of Steel Forgings²

A 788 Specification for Steel Forgings, General Requirements²

E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings³

E 562 Practice for Determining Volume Fraction by Systematic Manual Point Count³

3. Ordering Information

3.1 In addition to the ordering information required by Specification A 788, the purchaser shall 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 which outlines additional ordering information, manufacturing requirements, testing and retesting methods and procedures, marking, certification, product analysis variations and additional supplementary requirements.

4.2 If the requirements of this specification are in conflict with the requirements of Specification A 788, the requirements of this specification shall prevail.

5. Manufacture

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

5.2 *Forging Process*—Either the closed impression die or the open die forging processes may be utilized unless the purchaser specifies one or the other.

5.2.1 *Forging Temperature*—The maximum part temperature during forging shall be 2150°F.

5.3 *Heat Treatment*—Heat treating all forgings is required in accordance with Table 1 to develop the required mechanical properties.

5.3.1 *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.

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

5.4 *Stress Relief*—When heat treatment for mechanical properties is followed by straightening, a stress relieving heat treatment is required at a temperature meeting the requirements of Table 1.

5.4.1 *Quenching after Stress Relief*—Water or oil quenching of stress relieved forgings is prohibited.

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 test specimens shall meet the requirements of Table 3.

7.1.1 *Number of Tests*—A minimum of two forgings from each lot shall be randomly selected for longitudinal tensile, impact, and hardness testing. Hardness values of the tension test specimen shall be reported with the tensile data.

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 A01.06 on Steel Forgings and Billets.

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² *Annual Book of ASTM Standards*, Vol 01.05.

³ *Annual Book of ASTM Standards*, Vol 03.01.

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



TABLE 1 Heat Treatment, °F

	Grade A	Grade B	Grade C		Grade D	Grade E		Grade F
	Classes 1 & 2	Class 1	Class 1	Class 2	Classes 1 & 2	Class 1	Class 2	Class 1
Austenitizing	1725-1775	1600-1750	1825-1875	1725-1875	1875-1925	2075-2125	1725-1775	1875-1925
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
Single tempering	1050 min	1050 min	1050 min	1050 min	1150 min	1250 min	1100 min	...
Double tempering	...	...	1025 min	1025 min	...	...	...	...
Aging	...	...	...	...	...	...	...	1135-1165
Stress Relieving	1025 min	1025 min	1000 min	1000 min	1100 min	1200 min	1050 min	1100 min

TABLE 2 Chemical Requirements

Composition %						
UNS Designation	Grade A	Grade B	Grade C	Grade D	Grade E	Grade F
	S41000	S41005	S41428	S42225	S41041	S17400
Carbon	0.15 max	0.10-0.15	0.10-0.17	0.20-0.25	0.13-0.18	0.07 max
Manganese	1.0 max	0.25-0.80	0.65-1.05	0.5-1.0	0.4-0.6	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	0.10-0.35	0.20-0.50	0.5 max	1.0 max
Nickel	0.75 max	0.75 max	2.25-3.25	0.5-1.0	0.5 max	3.0-5.0
Chromium	11.5-13.0	11.5-13.0	11.25-12.75	11.0-12.5	11.5-13.0	15.0-17.5
Molybdenum	0.5 max	0.5 max	1.5-2.0	0.9-1.25	0.20 max	...
Vanadium	...	Report only	0.25-0.40	0.20-0.30	...	...
Tungsten	...	0.10 max	0.10 max	0.9-1.25	...	...
Nitrogen	...	0.08 max	0.020-0.045	Report only	...	...
Aluminum	...	0.025 max	0.025 max	0.025 max	0.05 max	...
Columbium	...	0.20 max	...	0.05 max	0.15-0.45	0.15-0.45
Cobalt	...	...	...	0.20 max	...	...
Titanium	...	0.05 max	0.05 max	0.025 max	...	...
Copper	...	0.15 max	0.15 max	0.15 max	...	3.0-5.0
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	13	20	25	41
Hardness, Brinell, max	255	269	269	352	375	331	331	277	262	341

7.1.1.1 *Lot Size*—A lot shall consist of all forgings 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.

7.1.1.2 *Continuous Heat Treating Furnaces*—Test forgings shall be taken from each of the first and last push or tray to exit the furnace. Additional forgings shall be taken so that the maximum time between samples is 4 h.

7.1.1.3 *Test Locations*—One tension test specimen and one set of three impact test specimens shall be machined from the center portion of the air foil vane section.

7.1.2 *Forging Hardness Testing:*

7.1.2.1 *Batch Type Furnaces*—A minimum of 10 % of the forgings in each lot shall be hardness tested.

7.1.2.2 *Continuous Type Furnaces*—Samples for hardness testing shall be taken from every other tray or push.

8. Nondestructive Examination

8.1 *General Requirements*—All forgings shall be free of cracks, seams, laps, shrinkage, and similar discontinuities.

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

9. Certification and Reports

9.1 All tests required by this specification shall be made by the manufacturer and reported on a certificate of test to the purchaser. Each test certificate shall include the following items:

- 9.1.1 Purchase order number.
- 9.1.2 Forging identification number.
- 9.1.3 Specification number and year/date of issue, grade, and class.
- 9.1.4 Heat number.
- 9.1.5 Lot number and size.
- 9.1.6 Mechanical properties including tension, impact, and hardness.
- 9.1.7 Hardness data tabulation for each forging tested.
- 9.1.8 Heat treating and stress relieving temperature and times.