Designation: A 473 – 01

Standard Specification for Stainless Steel Forgings[1]

This standard is issued under the fixed designation A 473; 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 Department of Defense.

1. Scope

1.1 This specification covers austenitic, austenitic-ferritic, ferritic, and martensitic stainless steel forgings for general use, and for low- or high-temperature service.

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

2. Referenced Documents

2.1 *ASTM Standards:*

A 314 Specification for Stainless Steel Billets and Bars for Forging[2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[3]

A 484/A 484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings[2]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[3]

E 527 Practice for Numbering Metals and Alloys (UNS)[4]

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 Dimensions, including prints or sketches,

3.1.3 Name of material (stainless steel forgings),

3.1.4 Type or UNS designation (Table 1),

3.1.5 Condition (Table 2), and

3.1.6 ASTM designation and date of issue.

3.1.7 Test for magnetic permeability if specified by customer purchase order when ordering Types 207 and 205.

3.1.8 Special requirements.

3.2 If possible the intended end use of the item should be given on the purchase order especially when the item is ordered for a specific end use or uses.

NOTE 1—A typical ordering description is as follows: 5 stainless steel forgings, Type 410, Designation A, ASTM Specification A 473 dated ———. End use: pump blocks for oil well equipment.

4. General Requirements

4.1 In addition to the requirements of this specification, all requirements of the current edition of Specification A 484/A 484M shall apply. Failure to comply with the general requirements of Specification A 484/A 484M constitutes nonconformance with this specification.

5. Manufacture

5.1 Material for forgings shall consist of ingots or blooms, billets, slabs, or bars, either forged or rolled from an ingot, and cut to the required length by a suitable process. This material, except for ingots, may be specified to Specification A 314.

5.2 The material shall be forged by hammering, pressing, rolling, extruding, or upsetting. It shall be brought as nearly as possible to the finished shape and size by hot-working; and shall be processed, if practicable, so as to cause metal-flow during the hot-working operation in the direction most favorable for resisting the stresses encountered in service as may be indicated to the manufacturer by the purchaser.

5.3 When specified on the order, a sample forging may be sectioned and etched to show flow lines and the condition as regards internal imperfections. When so specified, the question of acceptable and unacceptable metal-flow shall be subject to agreement between the manufacturer and the purchaser prior to order entry.

5.4 When specified on the order, the manufacturer shall submit for approval of the purchaser a sketch showing the shape of the rough forging before machining, or before heat treating for mechanical properties.

5.5 The grain size shall be as fine as practicable and precautions shall be taken to minimize grain growth.

6. Heat Treatment

6.1 Except for S31254, the austenitic steels shall receive a solution heat treatment, consisting of heating the material to a minimum temperature of 1900°F (1040°C), followed by cooling rapidly in air or water.

6.2 S31254 shall receive a solution heat treatment, consisting of heating the material to a minimum temperature of 2100°F (1150°C) followed by cooling rapidly in air or water.

6.3 When specified, Types 347, 348, and 321 shall receive a

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

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

[4] *Annual Book of ASTM Standards*, Vol 01.01.

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TABLE 1 Chemical Requirements[A]

UNS Designation[B]	Type Number	Carbon, %	Manganese, %	Phosphorus, %	Sulfur, %	Silicon, %	Chromium, %	Nickel, %	Molybdenum, %	Nitrogen, %	Other Elements, %
					Austenitic Grades						
S20100	201	0.15	5.5–7.5	0.060	0.030	1.00	16.0–18.0	3.5–5.5	...	0.25	
S20200	202	0.15	7.5–10.0	0.060	0.030	1.00	17.0–19.0	4.0–6.0	...	0.25	
S20500	205	0.12–0.25	14.0–15.5	0.060	0.030	1.00	16.5–18.0	1.00–1.75	...	0.32–0.40	
S21900	XM-10	0.08	8.0–10.0	0.060	0.030	1.00	19.0–21.5	5.5–7.5	...	0.15–0.40	
S21904	XM-11	0.04	8.0–10.0	0.060	0.030	1.00	19.0–21.5	5.5–7.5	...	0.15–0.40	
S28200	...	0.15	17.0–19.0	0.045	0.030	1.00	17.0–19.0	...	0.75–1.25	0.40–0.60	Cu 0.75–1.25
S30200	302	0.15	2.00	0.045	0.030	1.00	17.0–19.0	8.0–10.0	...	0.10	
S30215	302B	0.15	2.00	0.045	0.030	2.00–3.00	17.0–19.0	8.0–10.0	...	...	
S30300	303	0.15	2.00	0.20	0.15 min	1.00	17.0–19.0	8.0–10.0	0.60[C]	...	
S30323	303 Se	0.15	2.00	0.20	0.06	1.00	17.0–19.0	8.0–10.0	...	...	Se 0.15 min
S30400	304	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–10.5	...	0.10	
S30403	304L	0.030	2.00	0.045	0.030	1.00	18.0–20.0	8.0–12.0	...	0.10	
S30500	305	0.12	2.00	0.045	0.030	1.00	17.0–19.0	10.5–13.0	...	...	
S30800	308	0.08	2.00	0.045	0.030	1.00	19.0–21.0	10.0–12.0	...	...	
S30815	...	0.10	0.80	0.040	0.030	1.40–2.00	20.0–22.0	10.0–12.0	...	0.14–0.20	Ce 0.03–0.08
S30900	309	0.20	2.00	0.045	0.030	1.00	22.0–24.0	12.0–15.0	...	...	
S30908	309S	0.08	2.00	0.045	0.030	1.00	22.0–24.0	12.0–15.0	...	...	
S31000	310	0.25	2.00	0.045	0.030	1.50	24.0–26.0	19.0–22.0	...	...	
S31008	310S	0.08	2.00	0.045	0.030	1.50	24.0–26.0	19.0–22.0	...	...	
S31254	...	0.020	1.00	0.030	0.010	0.80	19.5–20.5	17.5–18.5	6.0–6.5	0.18–0.22	Cu 0.50–1.00
S31400	314	0.25	2.00	0.045	0.030	1.50–3.00	23.0–26.0	19.0–22.0	...	...	
S31600	316	0.08	2.00	0.045	0.030	1.00	16.0–18.0	10.0–14.0	2.00–3.00	0.10	
S31603	316L	0.030	2.00	0.045	0.030	1.00	16.0–18.0	10.0–14.0	2.00–3.00	0.10	
S31700	317	0.08	2.00	0.045	0.030	1.00	18.0–20.0	11.0–15.0	3.0–4.0	0.10	
S32100	321	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	...	Ti 5×C min
S34700	347	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	Cb+Ta 10×C, min
S34800	348	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	Cb+Ta 10×C, min Ta 0.10 Co 0.20
					Austenitic-Ferritic Grades						
S32550[D]	...	0.04	1.50	0.040	0.030	1.00	24.0-27.0	4.5-6.5	2.9-3.9	0.10-0.25	Cu 1.50–2.50
S32760[D]	...	0.030	1.00	0.030	0.010	1.00	24.0–26.0	6.0–8.0	3.0–4.0	0.20–0.30	Cu 0.50–1.00 W 0.50–1.00
S32950	...	0.03	2.00	0.035	0.010	0.60	26.0–29.0	3.5–5.2	1.00–2.50	0.15–0.35	
					Ferritic Grades						
S40500	405	0.08	1.00	0.040	0.030	1.00	11.5–14.5	0.60	...	...	A1 0.10–0.30
S42900	429	0.12	1.00	0.040	0.030	1.00	14.0–16.0	0.75	...	...	
S43000	430	0.12	1.00	0.040	0.030	1.00	16.0–18.0	0.75	...	...	
S43020	430F	0.12	1.25	0.06	0.15 min	1.00	16.0–18.0	0.75	0.60[C]	...	
S43023	430F Se	0.12	1.25	0.06	0.06	1.00	16.0–18.0	0.75	...	...	Se 0.15 min
S44600	446	0.20	1.50	0.040	0.030	1.00	23.0–27.0	0.75	...	0.25	
					Martensitic Grades						
S40300	403	0.15	1.00	0.040	0.030	0.50	11.5–13.0	...	...	...	...
S41000	410	0.15	1.00	0.040	0.030	1.00	11.5–13.5	0.75	...	...	...
S41008	410S	0.08	1.00	0.040	0.030	1.00	11.5–13.5	0.75	...	...	...
S41400	414	0.15	1.00	0.040	0.030	1.00	11.5–13.5	1.25–2.50	...	...	...
S41425	...	0.05	0.50–1.00	0.020	0.005	0.50	12.0–15.0	4.0–7.0	1.50–2.00	0.06–0.12	Cu 0.30
S41500	[E]	0.05	0.5–1.0	0.030	0.030	0.60	11.5–14.0	3.5–5.5	0.40–0.80	...	
S41600	416	0.15	1.25	0.06	0.15 min	1.00	12.0–14.0	...	0.60[C]	...	
S41623	416 Se	0.15	1.25	0.06	0.06	1.00	12.0–14.0	...	...	...	Se 0.15 min
S42000	420	Over 0.15	1.00	0.040	0.030	1.00	12.0–14.0	...	...	...	...
S43100	431	0.20	1.00	0.040	0.030	1.00	15.0–17.0	1.25–2.50	...	...	...
S44002	440A	0.60–0.75	1.00	0.040	0.030	1.00	16.0–18.0	...	0.75	...	
S44003	440B	0.75–0.95	1.00	0.040	0.030	1.00	16.0–18.0	...	0.75	...	
S44004	440C	0.95–1.20	1.00	0.040	0.030	1.00	16.0–18.0	...	0.75	...	

[A] Maximum, unless range or minimum is indicated.
[B] New designation established in accordance with Practice E 527 and SAE J 1086.
[C] At manufacturer's option; reported only when intentionally added.
[D] % Cr + 3.3 × % Mo + 16 × % N ≥ 40.
[E] Wrought version of CA6NM.

stabilization heat treatment in addition to the solution heat treatment specified in 6.1, which shall consist of holding the forgings at 1550 to 1750°F (845 to 955°C) for 1 h for each inch of section thickness with a minimum holding time of 2 h, followed by air-cooling or water quenching. The stabilization heat treatment is not usually specified, unless thesesteels are

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TABLE 2 Mechanical Property Requirements

Type	Condition	Yield Strength, min, ksi (MPa)[A]	Tensile Strength, min, ksi (MPa)	Elongation in 2 in. (50 mm) or 4D, min %	Reduction of Area, min, %	Brinell Hardness Number, max
		Austenitic Grades				
201, 302, 302B, 303, 303SE, 305, 308, 309, 309S, 310, 310S, 314, 317, 321, 347, 348	A	30 (205)	75 (515)	40	50	...
202	A	45 (310)	90 (620)	40	50	...
205	A	50 (345)	90 (620)	40	50	...
304 and 316, Sections 5 in. (127 mm) and Under	A	30 (205)	75 (515)	40	50	...
304 and 316, Sections Over 5 in. (127 mm)	A	30 (205)	70 (485)	40	50	...
304L and 316L	A	25 (170)	65 (450)	40	50	...
XM-10 and XM-11	A	50 (345)	90 (620)	45	60	...
S28200	A	60 (415)	110 (760)	40	55	...
S30815	A	45 (310)	87 (600)	40	50	...
S31254	A	44 (300)	95 (650)	35	50	...
		Austenitic-Ferritic Grades				
S32550	A	80 (550)	109 (750)	25.0	...	290
S32950	A	70 (480)	100 (690)	15	...	293
S32760	A	80 (550)	109 (750)	25	...	290
		Ferritic Grades				
430F, 430FSE, 446	A	40 (275)	70 (485)	20	45	223
405	A	30 (205)	60 (415)	20	45	207
429	A	35 (240)	65 (450)	23	45	207
430	A	35 (240)	70 (485)	20	45	217
		Martensitic Grades				
403, 410, 416, 416SE	A	40 (275)	70 (485)	20	45	223
410S	A	35 (240)	65 (450)	22	45	217
414	A	... ...	... ...	...	...	298
	T	90 (620)	115 (795)	15	45	321
	H	100 (690)	125 (860)	15	45	321
S41425	T	120 (825)	95 (655)	15	45	321
S41500	normalized and tempered	90 (620)	115 (795)	15	45	295
420	A	... ...	... ...	...	...	223
431	A	... ...	... ...	...	...	277[B]
	T	90 (620)	115 (795)	15	...	321
	H	135 (930)	175 (1210)	13	...	440
440A, 440B, 440C	A	... ...	... ...	...	...	269

[A] Yield strength shall be determined by the 0.2 % offset method in accordance with Test Methods and Definitions A 370. An alternative method of determining yield strength may be used based on a total extension under load of 0.5 %.

[B] Type 431 forgings of designation *A*, when specified, shall be capable of meeting the above mechanical property requirements of designation *T* after oil quenching from 1800 to 1900°F (980 to 1038°C) and tempering at not less than 1100°F (595°C), or designation *H* when oil quenched from 1850 to 1950°F (1010 to 1065°C) and tempered at not more than 700°F (370°C).

intended for severely corrosive environments in the temperature range from 800 to 1600°F (425 to 870°C). When specified, the stabilization heat treatment shall be the final heat treatment and may be performed before machining.

6.4 S32950 shall receive an annealing treatment, consisting of heating the material to a temperature of 1825°F (995°C) to 1875°F (1025°C) for an appropriate time followed by water quenching or rapid cooling by other means.

6.5 S32760 shall receive an annealing treatment consisting of heating the material to a minimum temperature of 2010°F (1100°C), followed by water quenching or rapid cooling by other means.

6.6 The ferritic grades shall be properly annealed:

6.7 Except for S41425 and S41500, the martensitic grades shall be annealed, or hardened and tempered as specified. Liquid quenching shall be permitted only by agreement with the purchaser.

6.8 For S41425, heat to 1700°F (925°C) minimum and hold for 1 h at temperature minimum. Air cool to below 90°F (32°C) and temper at 1100°F (595°C) minimum for 1 h/in. of cross-sectional thickness minimum.

6.9 For S41500 heat to 1750°F (955°C) minimum, air cool to 200°F (95°C) or lower prior to any optional intermediate temper and prior to the final temper. The final temper shall be between 1050°F (565°C) and 1150°F (620°C).

6.10 Types 420, 440A, 440B, and 440C should be used by the purchaser in the hardened and tempered condition. In response to heat treatment, these materials shall be capable of meeting the minimum hardness requirements as specified in Table 3.

6.11 Type S32550 shall receive an annealing treatment consisting of heating the material to a minimum temperature of 1940°F (1060°C), followed by water quenching of rapid cooling by other means.

7. Chemical Composition

7.1 The steel shall conform to the requirements for chemical composition specified in Table 1.

7.2 Methods and practices relating to chemical analysis required by this specification shall be in accordance with

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TABLE 3 Response to Heat Treatment

Type[A]	UNS	Heat Treatment[B] Temperature °F (°C)	Quenchant	Hardness HRC, min
403	S40300	1750 (955)	Air	35
410	S41000	1750 (955)	Air	35
410S	S41008	1750 (955)	Oil	25 max
414	S41400	1750 (955)	Oil	42
416	S41600	1750 (955)	Air	35
416 Se	S41623	1750 (955)	Air	35
420	S42000	1825 (955)	Air	50
431	S43100	1875 (1020)	Oil	40
440A	S44002	1875 (1020)	Air	55
440B	S44003	1875 (1020)	Oil	56
440C	S44004	1875 (1020)	Air	58

[A] Samples for testing shall be in the form of a section not exceeding ⅜ in. (9.50 min) in thickness.

[B] Temperature tolerance is ±25°F (14°C).

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8. Mechanical Properties Requirements

8.1 The material shall conform to the room temperature mechanical requirements specified in Table 2.

8.2 Instead of tension tests, hardness requirements, in accordance with Table 2, may be specified by the purchaser for the ferritic and the martensitic steels.

8.3 The martensitic grades shall be capable of meeting the hardness requirements, after heat treating, as specified in Table 3.

9. Magnetic Permeability

9.1 When required by the purchase order, the magnetic permeability of Types 201 and 205 in the annealed condition shall not exceed 1.2 as tested by a Severn-type indicator.

10. Prolongations for Tests

10.1 Subject to Sections 10 and 12, the forgings shall be produced with prolongations for testing, unless otherwise specified. The producer may elect to submit an extra forging to represent each test lot instead of prolongations, or the test specimens can be taken from the forgings themselves.

11. Number of Tests

11.1 For all classes of forgings weighing from 5000 to 7000 lb (2270 to 3180 kg) each, at least one tension test shall be made from each forging. Also, one magnetic permeability test must be made when specified on the customer order.

11.2 For all classes of forgings weighing more than 7000 lb each, one tension test shall be made from each end of each forging. In the case of ring forgings, the tension test specimen shall be removed from each of two locations on the periphery, approximately 180° apart, or insofar as practicable from opposite ends of the forging. Also, one magnetic permeability test must be made when specified on the customer order.

11.3 For forgings weighing less than 5000 lb each, one tension test shall be made from each size classification for each heat in each heat-treating charge. When the heat-treating cycles are the same and the furnaces (either batch or continuous type) are controlled within ± 25°F (±14°C) and equipped with recording pyrometers so that complete records of heat treatment are available, then only one tension test from each heat of each size classification is required. Also, one magnetic permeability test must be made when specified on the customer order.

12. Test Specimens

12.1 Tension test specimens shall be taken from the test prolongations or from the forgings as provided in Section 10.

12.2 Depending upon the method of forging, test specimens shall be procured as follows, unless otherwise specified:

12.2.1 The axis of the specimen shall be located at any point midway between the center and the surface of solid forgings; at any point midway between the inner and outer surfaces of the wall of bored forgings; and shall be parallel to the direction of greatest metal flow.

12.2.2 The axis of the specimen shall be tangential to the forging on the periphery; that is, at right angles to both the radius and the axis of the forging.

12.3 The tension test specimens shall be machined to the form and dimensions for standard round tension test specimens with 2-in. or 50-mm gage length shown in Fig. 5 of Test Methods and Definitions A 370. On small forgings where it is not practicable to use such specimens, the substitution of specimens conforming to the small-size specimens of Fig. 6 of Test Methods and Definitions A 370 is permitted.

13. Retreatment

13.1 If any specimen selected to represent any lot as described in Section 12 fails to meet any of the test requirements, the material represented by such specimens may be retreated and resubmitted for test.

14. Keywords

14.1 austenitic stainless steel; austenitic-ferritic duplex stainless steel; ferritic stainless steel; martensitic stainless steel; stainless steel forgings

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