Designation: A 705/A 705M – 95 (Reapproved 2009)

Standard Specification for Age-Hardening Stainless Steel Forgings[1]

This standard is issued under the fixed designation A 705/A 705M; 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[2] covers age-hardening stainless steel forgings for general use.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 Unless the order specifies an "M" designation, the material shall be furnished to inch-pound units.

NOTE 1—Bar products are covered by Specification A 564/A 564M.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

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

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

A 564/A 564M Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes

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

E 527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

2.2 *Other Documents:* [4]

SAE J 1086 Recommended Practice for Numbering Metals and Alloys (UNS)

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 Name of material (age-hardening stainless steel forgings),

3.1.3 Dimensions, including prints or sketches,

3.1.4 Type or UNS designation (Table 1),

3.1.5 Heat-treated condition (Section 5),

3.1.6 Transverse properties when required (7.4),

3.1.7 ASTM designation and date of issue, and

3.1.8 Special requirements (5.3, 5.4).

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 2—A typical ordering description is as follows: 5 age-hardening stainless steel forgings, Type 630, solution-annealed, ASTM Specification A 705 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 non-conformance with this specification.

5. Materials and Manufacture

5.1 Material for forgings shall consist of billets or bars, either forged, rolled or cast, or a section cut from an ingot. The cuts shall be made to the required length by a suitable process. This material may be specified to Specification A 564/A 564M.

5.2 The material shall be forged by hammering, pressing, rolling, extruding, or upsetting to produce a wrought structure throughout and shall be brought as nearly as possible to the finished shape and size by hot working.

5.3 When specified on the order, sample forging may be sectioned and etched to show flow lines and the condition in regard to 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.

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[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-Rolled and Wrought Stainless Steel.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-705/SA-705M in Section II of that Code.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

TABLE 1 Chemical Requirements[A]

UNS Designation[B]	Type	Composition, % Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Aluminum	Molybdenum	Titanium	Copper	Other Elements
S17400	630	0.07	1.00	0.040	0.030	1.00	15.00–17.50	3.00–5.00	...	...	...	3.00–5.00	[C]
S17700	631	0.09	1.00	0.040	0.030	1.00	16.00–18.00	6.50–7.75	0.75–1.50	...	...	...	...
S15700	632	0.09	1.00	0.040	0.030	1.00	14.00–16.00	6.50–7.75	0.75–1.50	2.00–3.00	...	...	...
S35500	634	0.10–0.15	0.50–1.25	0.040	0.030	0.50	15.00–16.00	4.00–5.00	...	2.50–3.25	...	...	[D]
S17600	635	0.08	1.00	0.040	0.030	1.00	16.00–17.50	6.00–7.50	0.40	...	0.40–1.20	...	...
S15500	XM-12	0.07	1.00	0.040	0.030	1.00	14.00–15.50	3.50–5.50	...	...	...	2.50–4.50	[C]
S13800	XM-13	0.05	0.20	0.010	0.008	0.10	12.25–13.25	7.50–8.50	0.90–1.35	2.00–2.50	...	...	[E]
S45500	XM-16	0.03	0.50	0.015	0.015	0.50	11.00–12.50	7.50–9.50	...	0.50	0.90–1.40	1.50–2.50	[F]
S45503	...	0.010	0.50	0.010	0.010	0.20	11.00–12.50	7.50–9.50	...	0.50	1.00–1.35	1.50–2.50	[F]
S45000	XM-25	0.05	1.00	0.030	0.030	1.00	14.00–16.00	5.00–7.00	...	0.50–1.00	...	1.25–1.75	[G]

[A] Limits are in percent maximum unless shown as a range or stated otherwise.
[B] New designation established in accordance with Practice E 527 and SAEJ1086, Recommended Practice for Numbering Metals and alloys (UNS).
[C] Columbium plus tantalum 0.15–0.45.
[D] Nitrogen 0.07–0.13.
[E] Nitrogen 0.01.
[F] Columbium plus tantalum 0.10–0.50.
[G] Columbium 8 times carbon minimum.

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

5.6 Material of types other than XM-9 shall be furnished in the solution-annealed condition, or in the equalized and over-tempered condition, as noted in Table 2, unless otherwise specified by the purchaser.

5.6.1 Types 630, XM-16, and XM-25 may be furnished in the solution-annealed or age-hardened condition.

6. Chemical Composition

6.1 The steel shall conform to the chemical composition limits specified in Table 1.

6.2 Methods and practices relating to chemical analysis required by this specification shall be in accordance with Test Methods, Practices, and Terminology A 751.

TABLE 2 Solution Heat Treatment

Type	Condition	Solution Treatment	Mechanical Test Requirements in Solution Treated Condition[A] Tensile Strength, min ksi	Tensile Strength, min [MPa]	Yield Strength, min ksi	Yield Strength, min [MPa]	Elongation in 2 in. [50 mm] or 4D, min. %	Reduction of Area, minute %	Hardness[B] Rockwell C, max	Hardness[B] Brinell, max
630	A	1900 ± 25°F [1040 ± 15°C] (cool as required to below 90°F [32°C])	...	...	...	...	...	...	38	363
631	A	1900 ± 25°F [1040 ± 15°C] (water quench)	...	...	...	...	...	...	Rb89	229
632	A	1900 ± 25°F [1040 ± 15°C] (water quench)	...	...	...	...	...	...	Rb100	269[C]
634[D]	A	1900 ± 25°F [1040 ± 15°C] quench, hold not less than 3 h at minus 100°F or lower	...	...	...	...	...	...	...	363[D]
635	A	1900 ± 25°F [1040 ± 15°C] (air cool)	120	[825]	75	[515]	10	45	32	302
XM-12	A	1900 ± 25°F [1040 ± 15°C] (cool as required to below 90°F [32°C])	...	...	...	...	...	...	38	363
XM-13	A	1700 ± 25°F [925 ± 15°C] (cool as required to below 60°F [16°C])	...	...	...	...	...	...	38	363
XM-16	A	1525 ± 25°F [830 ± 15°C] (cool rapidly)	...	...	...	...	...	...	36	331
S45503	A	1525 ± 25°F [830 ± 15°C] (cool rapidly)	...	...	...	...	...	...	36	331
XM-25	A	1900 ± 25°F [1040 ± 15°C] (cool rapidly)	125[E]	[860]	95	[655]	10	40	33	311

[A] See 6.1.
[B] Either Rockwell C hardness or Brinell is permissible. On sizes of ½ in. (12.70 mm) and smaller, Rockwell C is preferred.
[C] 321 BHN for rounds cold drawn after solution treating.
[D] Equalization and over-tempering treatment 1425 ± 50°F [775 ± 30°C] for not less than 3 h, cool to room temperature, heat to 1075 ± 25°F [580 ± 15°C] for not less than 3 h.
[E] 125 – 165 ksi [860 – 1140 MPa] for sizes up to ½ in. [13 mm].

7. Mechanical Properties

7.1 The material, as represented by mechanical test specimens, shall conform to the mechanical property requirements specified in Table 2 and shall be capable of developing the properties in Table 3 when heat treated as specified in Table 3.

7.2 The yield strength shall be determined by the offset method as described in the current edition of Test Methods and Definitions A 370. The limiting permanent offset shall be 0.2 % of the gage length of the specimen.

7.3 The impact strength shall be determined at 70 to 80°F [20 to 25°C], by Charpy V-notch specimen Type A as described in Test Methods and Definitions A 370.

7.4 Material tensile tested and, when specified, impact tested in the transverse direction (perpendicular to the forging flow lines) and meeting the requirements shown in Table 3 need not be tested in the longitudinal direction.

7.5 Samples cut from forging shall conform to the mechanical properties of Table 3 when heat treated as specified in Tables 2 and 3 and tested in accordance with Test Methods and Definitions A 370.

8. Prolongations for Tests

8.1 Subject to Section 7, 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.

9. Number of Tests

9.1 For all classes of forgings weighing from 5000 to 7000 lb [2300 to 3200 kg] each, at least one tension test shall be made from each forging.

9.2 For all classes of forgings weighing more than 7000 lb [3200 kg] 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.

9.3 For forgings weighing less than 5000 lb [2300 kg] each, one tension test shall be made from each size classification for each heat in each heat-treating charge. Where continuous heat-treating furnaces are used, tests shall be made on 10 % of the forgings of each size classification from each heat subjected to the same heat-treatment practice.

10. Keywords

10.1 age-hardening stainless steel; precipitation hardening stainless steel; stainless steel forgings

TABLE 3 Mechanical Test Requirements After Age Hardening Heat Treatment[A]

Type	Condition	Suggested Hardening or Aging Treatment, or both[BCD]			Applicable Thickness, in. and Test Direction[E]	Tensile Strength, min		Yield Strength, min[F]		Elongation in 2 in. [50 mm] or 4D, min. %	Reduction of area, min, %	Hardness[G]		Impact Charpy-V, min	
		Temperature, °F [°C]	Time, h	Quench		ksi	[MPa]	ksi	[MPa]			Rockwell C, min	Brinell, min	ft·lbf	J
630	H900	900 [480]	1.0	air cool	Up to 3 in. incl [75 mm] (L)	190	[1310]	170	[1170]	10	40	40	388	. . .	. . .
					Over 3 in. [75 mm] to 8 in. incl [200 mm] (L)						35				
	H925	925 [495]	4.0	air cool	Up to 3 min. incl [75 mm] (L)	170	[1170]	155	[1070]	10	44	38	375	5	6.8
					Over 3 in. [75 mm] to 8 in. incl [200 mm] (L)						38				
	H1025	1025 [550]	4.0	air cool		155	[1070]	145	[1000]	12	45	35	331	15	20
	H1075	1075 [580]	4.0	air cool		145	[1000]	125	[860]	13	45	32	311	20	27
	H1100	1100 [595]	4.0	air cool	Up to 8 in. incl [200 mm] (L)	140	[965]	115	[795]	14	45	31	302	25	34
	H1150	1150 [620]	4.0	air cool		135	[930]	105	[725]	16	50	28	277	30	41
	H1150M	1400 [760] for 2 h, air cool plus 1150 [620] for 4 h, air cool.				115	[795]	75	[520]	18	55	24	255	55	75
631	RH950	1750°F [955°C] for not less than 10 min, but not more than 1 h, cool rapidly to room temperature. Cool within 24 h to minus 100 ± 10°F [75°C], hold not less than 8 h. Warm in air to room temperature. Heat to 950°F [510°C], hold 1 h, air cool.			Up to 4 in. incl. [100 mm] (L)	185	[1280]	150	[1030]	6	10	41	388	. . .	. . .
	TH1050	Alternative treatment: 1400°F [760°C] hold 90 min, cool to 55 ± 5°F [15 ± 3°C] within 1 h. Hold not less than 30 min, heat to 1050°F [565°C] hold for 90 min, air cool.			Up to 6 in. incl [150 mm] (L)	170	[1170]	140	[965]	6	25	38	352	. . .	. . .
632	RH950	Same as Type 631			Up to 4 in. incl [100 mm] (L)	200	[1380]	175	[1210]	7	25	. . .	415	. . .	. . .
	TH1050				Up to 6 in. incl [150 mm] (L)	180	[1240]	160	[1100]	8	25	. . .	375	. . .	. . .
634[H]	H1000	1750 [955] for not less than 10 min, but not more than 1 h. Water quench. Cool to not higher than minus 100°F [75°C]. Hold for not less than 3 h. Temper at 1000°F [540°C], holding for not less than 3 h.				170	[1170]	155	[1070]	12	25	37	341	. . .	. . .
635	H950	950 (510)	0.5	air cool		190	[1310]	170	[1170]	8	25	39	363	. . .	. . .
	H1000	1000 [540]	0.5	air cool		180	[1240]	160	[1100]	8	30	37	352	. . .	. . .
	H1050	1050 [565]	0.5	air cool		170	[1170]	150	[1035]	10	40	35	331	. . .	. . .
XM-12	H900	900 [480]	1.0	air cool	Up to 12 in. incl [300 mm][I] (L)	190	[1310]	170	[1170]	10	35	40	388	. . .	. . .
					Up to 12 in. incl [300 mm][I](T)					6	15				
	H925	925 [495]	4.0	air cool	Up to 12 in. incl [300 mm][I] (L)	170	[1170]	155	[1070]	10	38	38	375	5	6.8
					Up to 12 in. incl [300 mm][I](T)					7	20			. . .	. . .
	H1025	1025 [550]	4.0	air cool	Up to 12 in. incl [300 mm][I] (L)	155	[1070]	145	[1000]	12	45	35	331	15	20
					Up to 12 in. incl [300 mm][I](T)					8	27			10	14

Type	Condition	Suggested Hardening or Aging Treatment, or both[BCD]			Applicable Thickness, in. and Test Direction[E]	Tensile Strength, min		Yield Strength, min[F]		Elongation in 2 in. [50 mm] or 4D, min. %	Reduction of area, min, %	Hardness[G]		Impact Charpy-V, min	
		Temperature, °F [°C]	Time, h	Quench		ksi	[MPa]	ksi	[MPa]			Rockwell C, min	Brinell, min	ft·lbf	J
	H1075	1075 [580]	4.0	air cool	Up to 12 in. incl [300 mm][I] (L)	145	[1000]	125	[860]	13	45	32	311	20	27
					Up to 12 in. incl [300 mm][I](T)					9	28			15	20
	H1100	1100 [595]	4.0	air cool	Up to 12 in. incl [300 mm][I] (L)	140	[965]	115	[795]	14	45	31	302	25	34
					Up to 12 in. incl [300 mm][I](T)					10	29			15	20
	H1150	1150 [620]	4.0	air cool	Up to 12 in. incl [300 mm][I] (L)	135	[930]	105	[725]	16	50	28	277	30	41
					Up to 12 in. incl [300 mm][I](T)					11	30			20	27
	H1150M	1400 [760] for 2 h, air cool plus 1150 [620] for 4 h, air cool			Up to 12 in. incl [300 mm][I] (L)	115	[795]	75	[515]	18	55	24	255	55	75
					Up to 12 in. incl [300 mm][I](T)					14	35			35	47
XM-13	H950	950 [510]	4.0	air cool	Up to 12 in. incl [300 mm][I](L)	220	[1520]	205	[1420]	10	45	45	430	. . .	. . .
					Up to 12 in. incl [300 mm][I](T)						35				
	H1000	1000 [540]	4.0	air cool	Up to 12 in. incl [300 mm][I] (L)	205	[1420]	190	[1310]	10	50	43	400	. . .	. . .
					Up to 12 in. incl [300 mm][I] (T)					10	40				
	H1025	1025 [550]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	185	[1280]	175	[1210]	11	50	41	380	. . .	. . .
					Up to 12 in. incl [300 mm] (T)						45				
	H1050	1050 [565]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	175	[1210]	165	[1140]	12	50	40	372	. . .	. . .
					Up to 12 in. incl [300 mm] (T)						45				
	H1100	1100 [595]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	150	[1030]	135	[930]	14	50	34	313	. . .	. . .
					Up to 12 in. incl [300 mm] (T)						50				
	H1150	1150 [620]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	135	[930]	90	[620]	14	50	30	283	. . .	. . .
					Up to 12 in. incl [300 mm] (T)						50				
	H1150M	1400 [760] for 2 h, air cool plus 1150 [620] for 4 h, air cool			Up to 12 in. incl [300 mm] (L)	125	[860]	85	[585]	16	55	26	259	. . .	. . .
					Up to 12 in. incl [300 mm] (T)						55				
XM-16[I]	H900	900 [480]	4.0	air cool		235	[1620]	220	[1520]	8	30	47	444	. . .	. . .
	H950	950 [510]	4.0	air cool	Up to 6 in. incl [150 mm] (L)	220	[1520]	205	[1410]	10	40	44	415	. . .	. . .
	H1000	1000 [540]	4.0	air cool		205	[1410]	185	[1280]	10	40	40	363	. . .	. . .
S45503[J]	H900	900 [480]	4.0	air cool	Up to 6 in. incl [150 mm] (L)	235	[1620]	220	[1520]	8	30	47	444	. . .	. . .
					Up to 6 in. incl [150 mm][K] (T)					4	15				

Type	Condition	Suggested Hardening or Aging Treatment, or both[B,C,D]			Applicable Thickness, in. and Test Direction[E]	Tensile Strength, min		Yield Strength, min[F]		Elongation in 2 in. [50 mm] or 4D, min. %	Reduction of area, min, %	Hardness[G]		Impact Charpy-V, min	
		Temperature, °F [°C]	Time, h	Quench		ksi	[MPa]	ksi	[MPa]			Rockwell C, min	Brinell, min	ft·lbf	J
	H950	950 [510]	4.0	air cool	Up to 6 in. incl [150 mm] (L)	220	[1520]	205	[1410]	10	40	44	415	. . .	. . .
					Up to 6 in. incl [150 mm][K](T)					5	20				
	H1000	1000 [540]	4.0	air cool	Up to 6 in. incl [150 mm] (L)	205	[1410]	185	[1280]	10	40	40	363	. . .	. . .
					Up to 6 in. incl [150 mm] (T)					6	25				
XM-25[J]	H900	900 [480]	4.0	air cool	Up to 8 in. incl [200 mm]	180	[1240]	170	[1170]	10	40	39	363	. . .	. . .
					Up to 12 in. incl 300 mm[K](L)					10	40				
					Up to 12 in. incl [300 mm][K](T)					6	20				
	H950	950 [510]	4.0	air cool	Up to 8 in. incl [200 mm]	170	[1170]	160	[1100]	10	40	37	341	. . .	. . .
					Up to 12 in incl [300 mm][K](L)					10	40				
					Up to 12 in. incl [300 mm][K](T)					7	22				
XM-25[J]	H1000	1000 [540]	4.0	air cool	Up to 8 in. incl [200 mm]	160	[1100]	150	[1030]	12	45	36	331	. . .	. . .
					Up to 12 in. incl [300 mm][K] (L)					12	45				
					Up to 12 in. incl [300 mm][K] (T)					6	27				
	H1025	1025 [550]	4.0	air cool	Up to 8 in. incl [200 mm]	150	[1030]	140	[965]	12	45	34	321	. . .	. . .
	H1050	1050 [565]	4.0	air cool	Up to 8 in. incl [200 mm]	145	[1000]	135	[930]	12	45	34	321	. . .	. . .
					Up to 12 in. incl [300 mm][K] (L)					12	45				
					Up to 12 in. incl [300 mm][K] (T)					9	30				
	H1100	1100 [595]	4.0	air cool	Up to 8 in. incl [200 mm]	130	[895]	105	[725]	16	50	30	285	. . .	. . .
					Up to 12 in. incl [300 mm][K] (L)					16	50				
					Up to 12 in. incl [300 mm][K] (T)					11	30				
	H1150	1150 [620]	4.0	air cool	Up to 8 in. incl [200 mm]	125	[860]	75	[515]	15	50	26	262	. . .	. . .
					Up to 12 in. incl [300 mm][K] (L)					18	55				
					Up to 12 in. incl [300 mm][K] (T)					12	35				

[A] See 6.1.
[B] Time refers to minimum time material is at temperature and may be extended to obtain required ductility properties.
[C] Unless otherwise noted, temperatures shown are suggested temperatures and may be varied to obtain required tensile properties.
[D] Intermediate temperatures must meet the ductility requirements of the next highest suggested hardening or aging temperature, or both.
Example: Type 630 at 1050°F [565°C] must have 13 % elongation and 45 % reduction, same as for age hardening at 1075°F [580°C].
[E] (L) - Longitudinal axis of specimen parallel to direction of grain flow during rolling or forging. (T) - Transverse axis of specimen perpendicular to direction of grain flow during rolling or forging.
[F] See 6.2.
[G] Either Rockwell C hardness or Brinell is permissible. On sizes ½ in. (12.70 mm) and smaller, Rockwell C is preferred.

[H] Refer to Table 2 for details on equalize and over temper heat treatment.
[I] Applies to consumable electrode vacuum remelted.
[J] Only tensile strength applicable to sizes up to ½ in. (13 mm).
[K] Consumable electrode remelted only.