



Designation: A705/A705M – 22

Standard Specification for Age-Hardening Stainless Steel Forgings¹

This standard is issued under the fixed designation A705/A705M; 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 specification² 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 are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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 [A564/A564M](#).

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*³

[A370 Test Methods and Definitions for Mechanical Testing of Steel Products](#)

[A484/A484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings](#)

[A564/A564M Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes](#)

[A751 Test Methods and Practices for Chemical Analysis of Steel Products](#)

[A788/A788M Specification for Steel Forgings, General Requirements](#)

[E527 Practice for Numbering Metals and Alloys in the Unified Numbering System \(UNS\)](#)

2.2 *Other Document:*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](#) and [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: five age-hardening stainless steel forgings, Type 630, solution-annealed, Specification A705 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 [A484/A484M](#) shall apply. Forgings shall comply with the Terminology and Forging sections of Specification [A788/A788M](#), which further clarify the forging definitions in the Terminology section of Specification [A484/A484M](#). Failure to comply with the general requirements of Specification [A484/A484M](#), constitutes nonconformance 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

⁴ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

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

TABLE 1 Chemical Requirements^A

Composition, %													
UNS Designation ^B	Type	C	Mn	P	S	Si	Cr	Ni	Al	Mo	Ti	Cu	Other Elements ^C
S17400	630	0.07	1.00	0.040	0.030	1.00	15.00–17.50	3.00–5.00	...	...	...	3.00–5.00	^D
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	...	...	^E
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	^D
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	...	...	^F
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	^G
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	^G
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	^H
S10120		0.02	0.25	0.015	0.010	0.25	11.00–12.50	9.00–10.50	0.80–1.10	1.75–2.25	0.20–0.50	...	^F
S11100		0.02	0.25	0.015	0.010	0.25	11.00–12.50	10.25–11.25	1.35–1.75	1.75–2.25	0.20–0.50	...	^F

^A Limits are in percent maximum unless shown as a range or stated otherwise.

^B Designation established in accordance with Practice E527 and SAEJ1086, Recommended Practice for Numbering Metals and Alloys (UNS).

^C Columbium (Cb) and niobium (Nb) are considered interchangeable names for element 41 in the periodic table and both names are acceptable for use.

^D Niobium 0.15–0.45.

^E Nitrogen 0.07–0.13.

^F Nitrogen 0.01.

^G Niobium 0.10–0.50.

^H Niobium 8x carbon minimum.

cuts shall be made to the required length by a suitable process. This material may be specified to Specification A564/A564M.

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.

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 A751.

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 A370. 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 A370.

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 A370.

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.

TABLE 2 Solution Heat Treatment

Type	Condition	Solution Treatment	Mechanical Test Requirements in Solution Treated Condition ^A				Hardness ^B	
			Tensile Strength, min ksi [MPa]	Yield Strength, min ksi [MPa]	Elongation in 2 in. [50 mm] or 4D, min. %	Reduction of Area, minute %	Rockwell C, max	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 -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 [860] ^E	95 [655]	10	40	33	311
S10120	A	1545 ± 25 °F [840 ± 14 °C] (cool rapidly below 90 °F [32 °C])	...	...	...	...	36	331
S11100	A	1545 ± 25 °F [840 ± 14 °C] (oil or water quench), hold for min. 8 h at minus 100 °F [-73 °C], ^F air warm	...	...	...	...	36	331

^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 to 165 ksi [860 to 1140 MPa] for sizes up to ½ in. [13 mm].

^F Required hold time at minus 100 °F [-73 °C] is not mandatory if product is under 2 in. [51 mm] thickness.

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 ^{B,C,D}		Tensile Strength, min		Yield Strength, min ^F		Elongation in 2 in. or 4D, min. %		Hardness ^G		Impact Charpy-V, min		
		Temperature, °F [°C]	Time, h	Quench	ksi [MPa]	ksi [MPa]	min. %	min. %	Rockwell C, min	Brinell, min				
630	H900	900 [480]	1.0	air cool	Up to 3 in. [75 mm], incl (L)	190	[1310]	170	[1170]	10	40	40	388	...
					Over 3 to 8 in. [75 to 200 mm], incl (L)	...	...	...	35	...	...	...
H925	H925	925 [495]	4.0	air cool	Up to 3 in. [75 mm], incl (L)	170	[1170]	155	[1070]	10	44	38	375	5
					Over 3 to 8 in. [75 to 200 mm], incl (L)	...	...	...	38	...	...	...
H1025	H1025	1025 [550]	4.0	air cool	Up to 8 in. [200 mm], incl (L)	155	[1070]	145	[1000]	12	45	35	331	15
					Over 8 to 12 in. [200 mm], incl (L)	...	...	...	...	...	...	...
631	RH950	1750 [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.	4.0	air cool	Up to 4 in. [100 mm], incl (L)	185	[1280]	150	[1030]	6	10	41	388	...
					Over 4 to 6 in. [100 mm], incl (L)	...	...	...	...	...	...	...
					Over 6 to 8 in. [150 mm], incl (L)	
					Over 8 to 10 in. [200 mm], incl (L)	
					Over 10 to 12 in. [250 mm], incl (L)	
632	RH950	Same as Type 631	4.0	air cool	Up to 4 in. [100 mm], incl (L)	200	[1380]	175	[1210]	7	25	...	415	...
					Over 4 to 6 in. [100 mm], incl (L)	...	...	...	...	...	...	...
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.	4.0	air cool	Up to 6 in. [150 mm], incl (L)	170	[1170]	155	[1070]	12	25	37	341	...
					Over 6 to 8 in. [150 mm], incl (L)	...	...	...	...	...	...	...
635	H950	950 [510]	0.5	air cool	Up to 6 in. [150 mm], incl (L)	190	[1310]	170	[1170]	8	25	39	363	...
					Over 6 to 8 in. [150 mm], incl (L)	...	...	...	...	...	...	...
					Over 8 to 10 in. [200 mm], incl (L)	
XM-12	H900	900 [480]	1.0	air cool	Up to 12 in. [300 mm], incl (L)	190	[1310]	170	[1170]	10	35	40	388	...
					Over 12 to 14 in. [300 mm], incl (L)	...	...	...	...	...	...	...
					Over 14 to 16 in. [350 mm], incl (L)	
XM-12 (continued)	H1025	1025 [550]	4.0	air cool	Up to 12 in. [300 mm], incl (L)	170	[1170]	155	[1070]	10	38	38	375	5
					Over 12 to 14 in. [300 mm], incl (L)	...	...	...	...	...	...	...



TABLE 3 Continued

Type	Condition	Suggested Hardening or Aging Treatment, or Both ^{B,C,D}		Tensile Strength, min		Yield Strength, min ^F		Elongation in 2 in. Reduction of area, or 4D, min. %		Hardness ^G		Impact Charpy-V, min								
		Temperature, °F [°C]	Time, h	Quench	ksi [MPa]	[MPa]	ksi	[MPa]	min. %	min. %	Rockwell C, min	Brinell, min	ft.-lbf	J						
H1075	H1075	1075 [580]	4.0	air cool	Up to 12 in. [300 mm], incl' (L)	145	[1000]	125	[860]	13	45	32	311	20	27					
																Up to 12 in.	9	28	15	20
																[300 mm], incl' (T)				
H1100	H1100	1100 [595]	4.0	air cool	Up to 12 in. [300 mm], incl' (L)	140	[965]	115	[795]	14	45	31	302	25	34					
																Up to 12 in.	10	29	15	20
																[300 mm], incl' (T)				
H1150	H1150	1150 [620]	4.0	air cool	Up to 12 in. [300 mm], incl' (L)	135	[930]	105	[725]	16	50	28	277	30	41					
																Up to 12 in.	11	30	20	27
																[300 mm], incl' (T)				
H1150M	H1150M	1400 [760] for 2 h, air cool plus 1150 [620] for 4 h, air cool	4.0	air cool plus	Up to 12 in. [300 mm], incl' (L)	115	[795]	75	[515]	18	55	24	255	55	75					
																Up to 12 in.	14	35	35	47
																[300 mm], incl' (T)				
XM-13	H950	950 [510]	4.0	air cool	Up to 12 in. [300 mm], incl' (L)	220	[1520]	205	[1420]	10	45	45	430	...	...			
																Up to 12 in.	35			
																[300 mm], incl' (T)				
H1000	H1000	1000 [540]	4.0	air cool	Up to 12 in. [300 mm], incl' (L)	205	[1420]	190	[1310]	10	50	43	400	...	...			
																Up to 12 in.	10	40		
																[300 mm], incl' (T)				
H1025	H1025	1025 [550]	4.0	air cool	Up to 12 in. [300 mm], incl' (L)	185	[1280]	175	[1210]	11	50	41	380	...	...			
																Up to 12 in.	45			
																[300 mm], incl' (T)				
H1050	H1050	1050 [565]	4.0	air cool	Up to 12 in. [300 mm], incl' (L)	175	[1210]	165	[1140]	12	50	40	372	...	...			
																Up to 12 in.	45			
																[300 mm], incl' (T)				
H1100	H1100	1100 [595]	4.0	air cool	Up to 12 in. [300 mm], incl' (L)	150	[1030]	135	[930]	14	50	34	313	...	...			
																Up to 12 in.	50			
																[300 mm], incl' (T)				
H1150	H1150	1150 [620]	4.0	air cool	Up to 12 in. [300 mm], incl' (L)	135	[930]	90	[620]	14	50	30	283	...	...			
																Up to 12 in.	50			
																[300 mm], incl' (T)				
H1150M	H1150M	1400 [760] for 2 h, air cool plus 1150 [620] for 4 h, air cool	4.0	air cool plus	Up to 12 in. [300 mm], incl' (L)	125	[860]	85	[585]	16	55	26	259	...	...			
																Up to 12 in.	55			
																[300 mm], incl' (L)				
XM-16 ^I	H900	900 [480]	4.0	air cool	Up to 12 in. [300 mm], incl' (L)	235	[1620]	220	[1520]	8	30	47	444	...	...			
																Up to 12 in.	8	30	47	444
																[300 mm], incl' (T)				
H950	H950	950 [510]	4.0	air cool	Up to 6 in. [150 mm], incl' (L)	220	[1520]	205	[1410]	10	40	44	415	...	...			
																Up to 6 in.	10	40	44	415
																[150 mm], incl' (L)				
H1000	H1000	1000 [540]	4.0	air cool	Up to 6 in. [150 mm], incl' (L)	205	[1410]	185	[1280]	10	40	40	363	...	...			
																Up to 6 in.	8	30	47	444
																[150 mm], incl' (L)				
S45503 ^V	H900	900 [480]	4.0	air cool	Up to 6 in. [150 mm], incl' (L)	235	[1620]	220	[1520]	8	30	47	444	...	...			
																Up to 6 in.	4	15		
																[150 mm], incl' (T)				