SPECIFICATION FOR HOT-ROLLED AND COLD-FINISHED AGE-HARDENING STAINLESS STEEL BARS AND SHAPES

SA-564/SA-564M

(Identical with ASTM Specification A 564/A 564M-02.)

1. Scope

1.1 This specification covers bars and shapes of age-hardening stainless steels. Hot-finished or cold-finished rounds, squares, hexagons, bar shapes, angles, tees, and channels are included; these shapes may be produced by hot rolling, extruding, or forging. Billets or bars for reforging may be purchased to this specification.

1.2 These steels are generally used for parts requiring corrosion resistance and high strength at room temperature, or at temperatures up to 600°F [315°C]; 700°F [370°C] for Type 632. They are suitable for machining in the solution-annealed condition after which they may be age-hardened to the mechanical properties specified in Section 7 without danger of cracking or distortion. Type XM-25 is machinable in the as-received fully heat treated condition.

1.3 Types 631 and 632 contain a large amount of ferrite in the microstructure and can have low ductility in forgings and larger diameter bars. Applications should be limited to small diameter bar.

1.4 The values stated in either inch-pound units or SI (metric) units are to be regarded separately as standards; within the text and tables, the SI units are shown in [brackets]. The values stated in each system are not exact equivalents; therefore, each system must be used independent of the other. Combining values from the two systems may result in nonconformance with the specification.

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

NOTE 1 — For forgings, see Specification A 705/A 705M.
NOTE 2 — For billets and bars for forging see Specification A 314.

2. Referenced Documents

2.1 *ASTM Standards:*

A 314 Specification for Stainless Steel Billets and Bars for Forging
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 705/A 705M Specification for Age-Hardening, Stainless Steel Forgings
A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
E 527 Practice for Numbering Metals and Alloys (UNS)

2.2 *Other Documents:*

SAE J1086 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 Type or UNS designation (Table 1),

3.1.3 Specific melt type when required,

3.1.4 Heat treated condition (5.1),

3.1.5 Transverse properties when required (7.6),

3.1.6 Finish (Specification A 484/A 484M),

3.1.7 Surface preparation of shapes (5.2.1),

3.1.8 Size, or applicable dimension including diameter, thickness, width, length, etc.,

3.1.9 Preparation for delivery (Specification A 484/A 484M),

3.1.10 Special requirements (refer to 7.4 and 8.3),

3.1.11 Marking requirements (Specification A 484/A 484M), and

3.1.12 ASTM designation and date of issue if other than that currently published.

3.2 If possible, the intended 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 3 — A typical ordering description is as follows: 5000 lb [2270 kg] Type 630, Solution-Annealed Cold Finished Centerless Ground, 1½ in. [38.0 mm] round bar, 10 to 12 ft [3.0 to 3.6 m] in length, ASTM A 564 dated _____. End use: valve shafts.

4. General Requirements

4.1 In addition to the requirements of this specification, all requirements of the current edition of Specifications 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. Materials and Manufacture

5.1 *Heat Treatment:*

5.1.1 Material of types other than XM-16, XM-25, and Type 630 shall be furnished in the solution-annealed condition, or in the equalized and oven-tempered condition, as noted in Table 2, unless otherwise specified by the purchaser.

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

5.1.2 Reforging stock shall be supplied in a condition of heat treatment to be selected by the forging manufacturer.

5.2 Shapes may be subjected to either Class A or Class C preparation as specified on the purchase order.

5.2.1 Class A consists of preparation by grinding for the removal of imperfections of a hazardous nature such as fins, tears, and jagged edges provided the underweight tolerance is not exceeded and the maximum depth of grinding at any one point does not exceed 10% of the thickness of the section.

5.2.2 Class C consists of preparation by grinding for the removal of all visible surface imperfections provided the underweight tolerance is not exceeded and the maximum depth of grinding at any one point does not exceed 10% of the thickness of the section.

6. Chemical Composition

6.1 Each alloy covered by this specification shall conform to the chemical requirements 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.

7. Mechanical Properties Requirements

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 5.1.

7.2 Samples cut from bars for forging stock shall conform to the mechanical properties of Table 2 and Table 3 when heat treated as specified in Table 2 and Table 3.

7.3 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.

7.4 The impact requirement shall apply only when specified in the purchase order. When specified, the material, as represented by impact test specimens, shall be capable of developing the impact property requirements specified in Table 3 when heat treated in accordance with 5.1.

7.5 Longitudinal impact requirements are not applicable to bars less than ⅝ in. (16.9 mm) diameter or size or flats less than ⅝ in. (16.9 mm) thick.

7.6 Tensile and impact requirements in the transverse (through thickness) direction are not applicable to bars less than 3 in. [75 mm] diameter in size or flats less than 3 in. [75 mm] thick.

7.7 Material tensile tested and, when specified, impact tested in the transverse (through thickness) direction and meeting the requirements shown in Table 3 need not be tested in the longitudinal direction.

8. Number of Tests

8.1 At least one room temperature tension test and one or more hardness tests shall be made on each lot.

8.2 One or more hardness tests and at least one tension test shall be made from each lot on test samples heat treated as required in 5.1. Unless otherwise specified in the purchase order, the condition of hardening heat treatment shall be at the option of the producer. The tests shall meet the requirements of Table 3.

8.3 When specified in the purchase order, the impact test shall consist of testing three Charpy V-notch Type A

specimens in accordance with Methods and Definitions A 370. The specimens shall be heat treated in accordance with 5.1. Unless otherwise specified in the purchase order, the condition of hardening heat treatment shall be at the option of the producer and testing shall be done at 70 to 80°F [20 to 25°C]. The tests shall meet the requirements of Table 3. When tested at temperatures other than 70 to 80°F, [20 to 25°C] the impact test requirements will be as agreed upon by purchaser and producer.

9. Keywords

9.1 age-hardening stainless steel; precipitation hardening stainless steel; stainless steel bars; stainless steel shapes

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]
S46500	. . .	0.02	0.25	0.015	0.010	0.25	11.00–12.50	10.75–11.25	. . .	0.75–1.25	1.50–1.80	. . .	[E]

[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 SAE J1086.
[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.

TABLE 2
SOLUTION TREATMENT

UNS Designation	Type	Condition	Solution Treatment	Mechanical Test Requirements in Solution Treated Condition[A]							
				Tensile Strength, min		Yield Strength, min[B]		Elongation in 2 in. [50 mm] or 4D, min, %	Reduction of Area, min, %	Hardness[C]	
				ksi	[MPa]	ksi	[MPa]			Rockwell C, max	Brinell, max
S17400	630	A	1900 ± 25°F [1040 ± 15°C] (cool as required to below 90°F (32°C))	...	...	...	...	...	...	38	363
S17700	631	A	1900 ± 25°F [1040 ± 15°C] (water quench)	...	...	...	...	...	...	HRB98	229
S15700	632	A	1900 ± 25°F [1040 ± 15°C] (water quench)	...	...	...	...	...	...	HRB100	269[D]
S35500	634[E]	A	1900 ± 25°F [1040 ± 15°C] quench, hold not less than 3 h at minus 100°F or lower	...	...	...	...	...	...	...	363[E]
S17600	635	A	1900 ± 25°F [1040 ± 15°C] (air cool)	120	[825]	75	[515]	10	45	32	302
S15500	XM-12	A	1900 ± 25°F [1040 ± 15°C] (cool as required to below 90°F (32°C))	...	...	...	...	...	...	38	363
S13800	XM-13	A	1700 ± 25°F [925 ± 15°C] Cool as required to below 60°F [16°C]	...	...	...	...	...	...	38	363
S45500	XM-16	A	1525 ± 25°F [830 ± 15°C] (cool rapidly)	...	...	...	...	...	...	36	331
S45000	XM-25	A	1900 ± 25°F [1040 ± 15°C] (cool rapidly)	125[F]	[860]	95	[655]	10	40	32	321
S45503	...	A	1525 ± 25°F [830 ± 15°C] (cool rapidly)	...	...	...	...	...	...	36	331
S46500	...	A	1800 ± 25°F [980 ± 15°C] (oil or water quench), hold for min. 8 h at minus 100°F (73°C), air warm	...	...	...	...	...	...	36	331

[A] See 7.1.
[B] See 7.3.
[C] Either Rockwell C hardness or Brinell is permissible. On sizes ½ in. (12.70 mm) and smaller, Rockwell C is preferred.
[D] 321 BH for rounds cold drawn after solution treating.
[E] 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.
[F] Maximum 165 ksi [1140 MPa] tensile strength only for sizes up to ½ in. (13 mm).

TABLE 3
MECHANICAL TEST REQUIREMENTS AFTER AGE HARDENING HEAT TREATMENT[A]

Type	Condition	Suggested Hardening or Aging Treatment, or both[B,C,D] Temperature, °F [°C]	Time, h	Quench[H]	Applicable Thickness, in. and Test Direction[E]	Tensile Strength, min ksi	Tensile Strength, min [MPa]	Yield Strength, min[F] ksi	Yield Strength, min [MPa]	Elongation in 2 in. [50 mm] or 4D, min, %	Reduction of area, min, %	Hardness[G] Rockwell C, min	Hardness[G] Brinell, min	Impact Charpy-V, min ft-lbf	Impact Charpy-V, min 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] (T)						35				
	H925	925 [495]	4.0	air cool	Up to 3 in. 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] (T)						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
	H1150D	1150 [620] for 4 h, air cool plus 1150 [620] for 4 h, air cool				125	[860]	105	[725]	16	50	24 33 max	255 311 max	30	41
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				Up to 4 in. incl [100 mm] (L)	200	[1380]	175	[1210]	7	25	...	415	...	...
	TH1050	Same as Type 631			Up to 6 in. incl [150 mm] (L)	180	[1240]	160	[1100]	8	25	...	375	...	...
634[I]	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] (L)	190	[1310]	170	[1170]	10	35	40	388	...	...
					Up to 12 in. incl [300 mm] (T)					6	15				
	H925	925 [495]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	170	[1170]	155	[1070]	10	38	38	375	5	6.8
					Up to 12 in. incl [300 mm] (T)					7	20			...	...

TABLE 3
MECHANICAL TEST REQUIREMENTS AFTER AGE HARDENING HEAT TREATMENT[A] (CONT'D)

Type	Condition	Suggested Hardening or Aging Treatment, or both[B,C,D] Temperature, °F [°C]	Time, h	Quench[H]	Applicable Thickness, in. and Test Direction[E]	Tensile Strength, min ksi	[MPa]	Yield Strength, min[F] ksi	[MPa]	Elongation in 2 in. [50 mm] or 4D, min, %	Reduction of area, min, %	Hardness[G] Rockwell C, min	Brinell, min	Impact Charpy-V, min ft-lbf	J
XM-12	H1025	1025 [550]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	155	[1070]	145	[1000]	12	45	35	331	15	20
					Up to 12 in. incl [300 mm] (T)					8	27			10	14
	H1075	1075 [580]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	145	[1000]	125	[860]	13	45	32	311	20	27
					Up to 12 in. incl [300 mm] (T)					9	28			15	20
	H1100	1100 [595]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	140	[965]	115	[795]	14	45	31	302	25	34
					Up to 12 in. incl [300 mm] (T)					10	29			15	20
	H1150	1150 [620]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	135	[930]	105	[725]	16	50	28	277	30	41
					Up to 12 in. incl [300 mm] (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] (L)	115	[795]	75	[515]	18	55	24	255	55	75
					Up to 12 in. incl [300 mm] (T)					14	35			35	47
XM-13	H950	950 [510]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	220	[1520]	205	[1415]	10	45	45	430	...	...
					Up to 12 in. incl [300 mm] (T)						35				
	H1000	1000 [540]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	205	[1415]	190	[1310]	10	50	43	400	...	...
					Up to 12 in. incl [300 mm] (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	[1035]	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				

TABLE 3
MECHANICAL TEST REQUIREMENTS AFTER AGE HARDENING HEAT TREATMENT[A] (CONT'D)

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[H]		ksi	[MPa]	ksi	[MPa]			Rockwell C, min	Brinell, min	ft-lbf	J
XM-16	H900	900 [480]	4.0	air cool	Up to 6 in. incl [150 mm] (L)	235	[1620]	220	[1515]	8	30	47	444	...	...
	H950	950 [510]	4.0	air cool		220	[1515]	205	[1415]	10	40	44	415	...	...
	H1000	1000 [540]	4.0	air cool		205	[1415]	185	[1275]	10	40	40	363	...	...
S45503	H900	900 [480]	4.0	air cool	Up to 6 in. incl [150 mm] (L) / Up to 6 in. incl [150 mm] (T)	235	[1620]	220	[1520]	8 / 4	30 / 15	47	444	...	...
	H950	950 [510]	4.0	air cool	Up to 6 in. incl [150 mm] (L) / Up to 6 in. incl [150 mm] (T)	220	[1515]	205	[1410]	10 / 5	40 / 20	44	415	...	...
	H1000	1000 [540]	4.0	air cool	Up to 6 in. incl [150 mm] (L) / Up to 6 in. incl [150 mm] (T)	205	[1410]	185	[1275]	10 / 6	40 / 25	40	363	...	...
XM-25	H900	900 [480]	4.0	air cool	Up to 12 in. incl [300 mm] (L) / Up to 12 in. incl [300 mm] (T)	180	[1240]	170	[1170]	10 / 6	40 / 20	39	363	...	...
	H950	950 [510]	4.0	air cool	Up to 12 in. incl [300 mm] (L) / Up to 12 in. incl [300 mm] (T)	170	[1170]	160	[1100]	10 / 7	40 / 22	37	341	...	...
	H1000	1000 [540]	4.0	air cool	Up to 12 in. incl [300 mm] (L) / Up to 12 in. incl [300 mm] (T)	160	[1100]	150	[1035]	12 / 8	45 / 27	36	331	...	...
	H1025	1025 [550]	4.0	air cool	Up to 8 in. incl [200 mm] (L)	150	[1035]	140	[965]	12	45	34	321	...	...
	H1050	1050 [565]	4.0	air cool	Up to 12 in. incl [300 mm] (L) / Up to 12 in. incl [300 mm] (T)	145	[1000]	135	[930]	12 / 9	45 / 30	34	321	...	...
	H1100	1100 [595]	4.0	air cool	Up to 12 in. incl [300 mm] (L) / Up to 12 in. incl [300 mm] (T)	130	[895]	105	[725]	16 / 11	50 / 30	30	285	...	...

TABLE 3
MECHANICAL TEST REQUIREMENTS AFTER AGE HARDENING HEAT TREATMENT[A] (CONT'D)

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[H]		ksi	[MPa]	ksi	[MPa]			Rockwell C, min	Brinell, min	ft-lbf	J
S46500	H1150	1150 [620]	4.0	air cool	Up to 12 in. incl [300 mm] (L)	125	[860]	75	[515]	10	55	26	262	...	...
					Up to 12 in. incl [300 mm] (T)					12	35				
	H950	950 [510]	4.0	air or oil	Up to 12 in. incl [300 mm] (L)	240	[1655]	220	[1515]	10	45	47	444	...	...
					Up to 12 in. incl. [300 mm] (T)					8	35				
	H1000	1000 [540]	4.0	air or oil	Up to 12 in. incl [300 mm] (L)	220	[1515]	200	[1380]	10	50	45	430	...	...
					Up to 12 in. incl. [300 mm] (T)					10	40				

[A] See 7.1.

[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 7.3.

[G] Either Rockwell C hardness or Brinell is permissible. On sizes ½ in. (12.70 mm) and smaller, Rockwell C is preferred.

[H] When air cooling is specified, gases other than air may be used.

[I] Refer to Table 2 for details on equalize and over temper heat treatment.