Designation: A 646 – 95 (Reapproved 1999)

Standard Specification for Premium Quality Alloy Steel Blooms and Billets for Aircraft and Aerospace Forgings[1]

This standard is issued under the fixed designation A 646; 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 covers premium quality alloy steel semifinished rolled or forged blooms and billets for reforging into critical parts such as aircraft landing-gear forgings.

1.2 Blooms and billets, hereinafter referred to as blooms, are semifinished steel products, hot rolled or forged to approximate cross-sectional dimensions. Blooms may be square, round, hexagonal, octagonal, or rectangular in section. For the purposes of this specification, minimum bloom section size will be 16 in.^{2} (103 cm^2).

1.3 This specification covers two basic classifications of steel:

1.3.1 *Class I*—Vacuum-induction melted or consumable-electrode vacuum melted, or other suitable processes which will satisfy the quality requirements of this specification.

1.3.2 *Class II*—Air-melted vacuum degassed.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

A 255 Test Method of End-Quench Test for Hardenability of Steel[2]

A 388/A 388M Practice for Ultrasonic Examination of Heavy Steel Forgings[2]

A 604 Test Method for Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets[2]

E 30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron and Wrought Iron[3]

E 45 Test Methods for Determining the Inclusion Content of Steel[4]

E 114 Practice for Ultrasonic Pulse-Echo Straight-Beam Testing by the Contact Method[5]

E 127 Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks[5]

E 214 Practice for Immersed Ultrasonic Examination by the Reflection Method Using Pulsed Longitudinal Waves[5]

E 350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron[3]

E 381 Method for Macroetch Testing, Inspection, and Rating Steel Products, Comprising Bars, Billets, Blooms, and Forgings[4]

2.2 *AMS Standards:*[6]

AMS 2300 Premium Quality Steel Cleanliness, Magnetic Particle, and

AMS 2301 Aircraft Quality Steel Cleanliness.

2.3 *Government Standard:*[7]

MIL-STD-430A Macrograph Standards for Steel Bars, Billets, and Blooms

3. Terminology

3.1 *Definitions:*

3.1.1 *air-melted vacuum-degassed steel*—arc- or induction-furnace-melted steel that is vacuum treated immediately prior to or during the operation of pouring the ingot.

3.1.2 *consumable-electrode vacuum-remelted steel*—metal that has been remelted into a crucible in vacuum from single or multiple electrodes.

3.1.3 *electroslag-melted steel*—metal that has been remelted into a crucible from single or multiple electrodes utilizing an electrical discharge through molten slag as a source of heat.

3.1.4 *heat*—for the purpose of this specification, if consumable electrode remelting is employed, all of the remelted ingots produced one parent arc- or induction-melted heat.

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[1] This specification is under the jurisdiction of ASTM Committee A-1 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 03.05.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

[5] *Annual Book of ASTM Standards*, Vol 03.03.

[6] Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

[7] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

3.1.5 *vacuum induction melted steel*—metal that has been melted, refined, and poured from a furnace operating in vacuum.

4. Ordering Information

4.1 When this specification is to be applied to an inquiry, contract, or order, the purchaser shall so state, and shall also furnish the following information:

4.1.1 Class designation (see 1.3),

4.1.2 Quality level (Table 1), grade designation (Table 2), or detailed chemistry (Table 3) for nonstandard grades,

4.1.3 Desired billet or bloom size,

4.1.4 Weight or quantity and length,

4.1.5 Minimum forging reduction required if ordered size exceeds 225 in.^{2} (1450 cm^2) (see 5.2.2),

4.1.6 Annealing, if required (see 5.3.2),

4.1.7 Macroetch standards of acceptance (see 7.1),

4.1.8 Microcleanliness standards of acceptance (see 7.2),

4.1.9 Ultrasonic quality level required (see 7.3.7.1),

4.1.9.1 Also any further restrictions on ultrasonic, such as transducer type and size, whether contact or immersion preferred, level of reportable discontinuities and any special surface finish requirements.

4.1.10 Hardenability standards of acceptance (see 8.1), and

4.1.11 Any supplementary requirements desired.

5. Manufacture

5.1 *Melting Practice*:

5.1.1 Class I material shall be manufactured by the vacuum-induction-melting process or by the consumably-electrode vacuum-melting process. By agreement other processes such as electroslag or electron-beam melting may be considered acceptable.

5.1.2 Class II material shall be manufactured by an electric-furnace vacuum-degassed process.

5.2 *Hot-Working Procedure*:

5.2.1 Blooms may be either hot rolled or forged.

5.2.2 Blooms having cross-sectional areas ranging from 16 to 225 in.^{2} (103 to 1450 cm^2) when made from air-melt ingots shall have at least 2 to 1 reduction of area from ingot to bloom. On blooms exceeding 225 in.^{2}, forging reduction requirements shall be by agreement. Ingot-to-final forging reduction is not included in this requirement.

5.3 *Heat Treatment*:

5.3.1 Unless otherwise specified all material purchased to this specification will be furnished in the untreated condition. In this condition some grades may not be soft enough for cold sawing.

TABLE 1 Maximum Permissible Discontinuities

NOTE 1—See 7.3.

Quality Level	Response, in. (mm)		Stringers, Length in. (mm)
	Single Discontinuities	Multiple Discontinuities	
AA	3/64 (1.2)	2/64 (0.8)	2/64 –1/2 (0.8–12.7)
A	5/64 (2.0)	3/64 (1.2)	3/64 –1 (1.2–25.4)
B	8/64 (3.2)	5/64 (2.0)	5/64 –1 (2.0–25.4)
C	12/64 (4.8)	8/64 (3.2)	8/64 –1 (3.2–25.4)

5.3.2 When specified, the material may be ordered annealed or normalized and tempered to a maximum Brinell Hardness, as specified in Table 2 or by agreement.

5.3.3 Material shall be furnished in condition to withstand, for an indefinite time, exposure to all climatic conditions without developing any external or internal cracks. The method of cooling or of treatment before shipment shall be optional with the manufacturer, but he shall be responsible (in the same manner as for discontinuities disclosed after delivery) for cracks which may develop before material is subjected to reheating. When any other specific treatment or conditioning of material is specified by the purchaser, the manufacturer shall be responsible only for carrying out those specific operations.

6. Chemical Requirements

6.1 *General Requirements*:

6.1.1 Table 2 lists 21 standard grades of alloy steel which are currently produced in premium quality; however, it is not the intent of this specification to restrict application only to the materials listed in Table 2.

6.1.2 When a standard grade is ordered, the analysis shall conform to the requirements as to chemical composition prescribed in Table 2 for the respective grades.

6.1.3 The steel when ordered to other than standard analysis shall conform to the requirements as to chemical ranges and limits prescribed in Table 3.

6.1.4 Small quantities of certain elements are present in alloy steels which are neither specified nor required. These elements are residual and may be present up to the following amounts: copper, 0.35 %; nickel, 0.25 %; chromium, 0.20 %; and molybdenum, 0.06 %.

6.2 *Heat Analysis*:

6.2.1 Each heat of steel shall be analyzed by the manufacturer to determine the percentage of elements prescribed in Table 2. This analysis shall be made on a sample taken during the pouring of the heat, except that in the event mechanical difficulties prevent obtaining samples from the ladle, that may be obtained from suitable portions of the ingots or product.

6.2.2 If consumable-electrode remelting is employed, the analysis of each resulting ingot shall conform to the requirements of Table 2. Samples for these analyses shall be removed from the top end of the ingot after adequate discard at any area midway between the center and surface of the ingot or bloom. One complete analysis from the master heat or from one remelt ingot plus carbon and manganese analysis from each remelt ingot are required.

6.3 *Product Analysis*:

6.3.1 Analysis may be made by the purchaser from material representing each heat or lot. The chemical composition thus determined shall not vary from the ranges or limits as specified in Table 2 or Table 3 by more than the amount specified in Table 4, unless otherwise agreed.

6.3.2 Samples for product analyses shall be taken from a location midway between center and surface of the bloom.

6.4 *Method of Analysis*—Test Methods E 30 and E 350 shall be used for referee purposes.

TABLE 2 Chemical and Hardness Requirements

AISI or Proprietary Name Grade	Grade No.	Composition, %										Maximum Annealed Brinell Hardness
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Vanadium	Others	
3310	1	0.08–0.13	0.45–0.60	0.025 max	0.025 max	0.20–0.35	3.25–3.75	1.40–1.75	. . .	. . .	. . .	262
9310	2	0.08–0.13	0.45–0.65	0.025 max	0.025 max	0.20–0.35	3.00–3.50	1.00–1.40	0.08–0.15	. . .	. . .	262
4620	3	0.17–0.22	0.45–0.65	0.025 max	0.025 max	0.20–0.35	1.65–2.00	. . .	0.20–0.30	. . .	. . .	229
8620	4	0.18–0.23	0.70–0.90	0.025 max	0.025 max	0.20–0.35	0.40–0.70	0.40–0.60	0.15–0.25	. . .	. . .	229
4330 Mod.	5	0.28–0.33	0.75–1.00	0.025 max	0.025 max	0.20–0.35	1.65–2.00	0.70–0.95	0.35–0.50	0.05–0.10	. . .	285
4335 Mod.	6	0.33–0.38	0.60–0.90	0.025 max	0.025 max	0.40–0.60	1.65–2.00	0.65–0.90	0.30–0.40	0.17–0.23	. . .	285
4340	7	0.38–0.43	0.65–0.85	0.025 max	0.025 max	0.20–0.35	1.65–2.00	0.70–0.90	0.20–0.30	. . .	. . .	285
300 M	8	0.38–0.43	0.65–0.90	0.012 max	0.012 max	1.45–1.80	1.65–2.00	0.70–0.95	0.35–0.45	0.05–0.10	. . .	285
D6AC	9	0.45–0.50	0.60–0.90	0.010 max	0.010 max	0.15–0.30	0.40–0.70	0.90–1.20	0.90–1.10	0.08–0.15	. . .	285
H-11	10	0.38–0.43	0.20–0.40	0.015 max	0.015 max	0.80–1.00	. . .	4.75–5.25	1.20–1.40	0.40–0.60	. . .	235
4130	11	0.28–0.33	0.40–0.60	0.025 max	0.025 max	0.20–0.35	. . .	0.80–1.10	0.15–0.25	. . .	. . .	229
4140	12	0.38–0.43	0.75–1.00	0.025 max	0.025 max	0.20–0.35	. . .	0.80–1.10	0.15–0.25	. . .	. . .	235
98BV40	13	0.40–0.46	0.75–1.00	0.025 max	0.025 max	0.50–0.80	0.60–0.90	0.80–1.05	0.45–0.60	0.01–0.06	0.0005 min, Boron	285
6150	14	0.48–0.53	0.70–0.90	0.025 max	0.025 max	0.20–0.35	. . .	0.80–1.10	. . .	0.15 min	. . .	235
52100	15	0.98–1.10	0.25–0.45	0.025 max	0.010 max	0.20–0.35	. . .	1.30–1.60	. . .	. . .	. . .	302
HP 9-4-20	16	0.17–0.23	0.20–0.40	0.010 max	0.010 max	0.10 max	8.5–9.5	0.65–0.85	0.90–1.10	0.06–0.12	Co 4.25–4.75	341
HP 9-4-30	17	0.29–0.34	0.10–0.35	0.010 max	0.010 max	0.10 max	7.0–8.0	0.90–1.10	0.90–1.10	0.06–0.12	Co 4.25–4.75	341
Marage 200	18	0.03 max	0.10 max	0.010 max	0.010 max	0.10 max	17.0–19.0	. . .	3.0–3.50	. . .	Co 8.0–9.0; Ti 0.10–0.25; Al 0.05–0.105; B, Zr, Ca added	321
Marage 250	19	0.03 max	0.10 max	0.010 max	0.010 max	0.10 max	17.0–19.0	. . .	4.6–5.2	. . .	Co 7.0–8.5; Ti 0.30–0.50; Al 0.05–0.15; B, Zr, Ca added	321
Marage 300	20	0.03 max	0.10 max	0.010 max	0.010 max	0.10 max	18.0–19.0	. . .	4.7–5.2	. . .	Co 8.5–9.5; Ti 0.50–0.80; Al 0.05–0.15; B, Zr, Ca added	321
Nit. 135	21	0.38–0.43	0.50–0.70	0.025 max	0.025 max	0.20–0.40	. . .	1.40–1.80	0.30–0.40	. . .	Al 0.95–1.30	285

7. Quality Evaluation Tests

7.1 *Macroetch*—Macroetch inspection shall be required for all material furnished to this specification. Samples representing the top and bottom of each ingot shall be examined. Macroetching shall be performed in accordance with Method E 381 and Test Method A 604, as applicable. Standards of acceptance shall be by agreement.

7.2 *Microcleanliness*—All material furnished to this specification shall be inspected for microcleanliness. At least one sample shall be removed from a location midway between the center and outside surface representing the top and bottom of the first and last ingots of each heat. The specimens shall be prepared and rated by the procedure described in Method A of Test Methods E 45. The polished face shall be longitudinal to the direction of maximum working. All specimens shall be prepared and rated in accordance with Test Methods E 45, using Method D (Modified JK Chart) for Class I steel and Method A (JK Chart) for Class II steel. Standards of acceptance shall be by agreement.

7.3 *Nondestructive Testing, Ultrasonic Inspection*:

7.3.1 *General*:

7.3.1.1 All material ordered to this specification shall be ultrasonic inspected unless otherwise specified. Inspection may be performed by either the immersion or the contact method providing that the manufacturer can ensure adequate resolution of the applicable reference standards with the chosen method.

7.3.1.2 The usage of reference blocks containing flat-bottomed holes for calibration is the preferred method for evaluation of discontinuity size up to billet cross-sectional dimensions of approximately 12 in. (305 mm). With larger sizes, it is recognized that reference block fabrication becomes difficult and in general a back reflection method of calibration can be used as an alternative as referenced in 7.3.8.3.

7.3.2 *Apparatus*—An ultrasonic, pulsed, reflection type of instrument shall be used for this inspection. The system shall have a minimum capability for testing at frequencies of 1 to 5 MHz, and shall provide linear presentation, within ±5 % up to at least 75 % of full screen height.

7.3.2.1 *Voltage Regulation*—The response of equipment to line voltage variations shall be such that no change occurs in signal amplitude for normal line voltage variations.

7.3.3 *Immersion Inspection Procedure*— This method is recommended for material where the cross-sectional dimension to be inspected is less than approximately 8 in. (203 mm). Material inspected by the immersion method shall be performed in accordance with the procedure outlined in Practice E 214.

TABLE 3 Chemical Ranges and Limits for Alloy Steels Other Than Standard

Element	When Maximum of Specified Range is, percent:	Range, percent
Carbon	To 0.25, incl	0.05[A] 0.08[B]
	Over 0.25 to 0.40, incl	0.06[A] 0.09[B]
	Over 0.40 to 0.55, incl	0.07[A] 0.09[B]
	Over 0.55 to 0.70, incl	0.09[A] 0.11[B]
	Over 0.70 to 0.95, incl	0.11[A] 0.14[B]
	Over 0.95 to 1.35, incl	0.14[A] 0.17[B]
Manganese	To 0.45, incl	0.15
	Over 0.45 to 0.80, incl	0.20
	Over 0.80 to 1.15, incl	0.25
	Over 1.15 to 1.65, incl	0.30
	Over 1.65 to 2.10, incl	0.35
Phosphorus		0.025 max
Sulfur		0.025 max
Silicon	To 0.15, incl	0.08
	Over 0.15 to 0.20, incl	0.10
	Over 0.20 to 0.35, incl	0.15
	Over 0.35 to 0.60, incl	0.20
	Over 0.60 to 1.00, incl	0.30
	Over 1.00 to 2.20, incl	0.35
Nickel	To 0.50, incl	0.20
	Over 0.50 to 1.50, incl	0.30
	Over 1.50 to 2.00, incl	0.35
	Over 2.00 to 3.00, incl	0.40
	Over 3.00 to 5.30, incl	0.50
	Over 5.30 to 10.00, incl	1.00
	Over 1.75 to 3.99, incl	
Chromium	To 0.40, incl	0.15
	Over 0.40 to 0.80, incl	0.20
	Over 0.80 to 1.05, incl	0.25
	Over 1.05 to 1.25, incl	0.30
	Over 1.25 to 1.75, incl	0.40
	Over 1.75 to 3.99, incl	0.50
Molybdenum	To 0.10, incl	0.05
	Over 0.10 to 0.20, incl	0.07
	Over 0.20 to 0.50, incl	0.10
	Over 0.50 to 0.80, incl	0.15
	Over 0.80 to 1.15, incl	0.20
Tungsten	To 0.50, incl	0.20
	Over 0.50 to 1.00, incl	0.30
	Over 1.00 to 2.00, incl	0.50
	Over 2.00 to 4.00, incl	0.60
Vanadium	To 0.25, incl	0.05
	Over 0.25 to 0.50, incl	0.10

[A] These ranges for carbon apply to steel not exceeding 200 in.^{2}(1290 cm^2) in cross-sectional area.

[B] These ranges for carbon apply to steel exceeding 200 in.^{2} in cross-sectional area.

7.3.4 *Contact Inspection Procedure*—Material inspected by the contact method shall be performed in accordance with the procedure outlined in Practice E 114 or A 388/A 388M.

7.3.5 *Scanning*—Blooms shall be inspected using the straight-beam (longitudinal-wave) technique. Blooms having parallel surfaces shall be inspected from two adjacent sides, excluding ends. Cylindrical blooms shall be inspected a minimum of 180° around the circumference, with the beam directed along the radius, noting that an axial scan from the end faces is not normally applicable.

7.3.6 *Recalibration*—Calibration standards shall be spot checked against the primary calibration to ensure that the ultrasonic system calibration is not drifting. A calibration check at the finish of a group of blooms of a size and a minimum of one check each shift is recommended.

7.3.7 *Quality Levels and Reference Standards*:

7.3.7.1 The reference blocks shall be fabricated in accordance with the procedures of Practice E 127, with the exception of surface finish. Transducer contact surfaces of the product and the reference block should be comparable roughness. Flatbottom hole sizes shall be in accord with the applicable quality level specified in Table 1.

7.3.7.2 A comparison of the back reflections between equivalent thicknesses of the reference block material and the actual material to be tested, without change in instrument setting shall not show a variation in excess of 25 %. Reference blocks which do not meet the comparison requirement shall not be used for the specific part to be inspected.

7.3.8 *Evaluation of Discontinuities*:

7.3.8.1 When inspecting material to the flat-surface standards, estimate the size of a discontinuity by comparing its response to that of a flat-surface standard of the same depth, except as follows:

Depth of Discontinuity, in. (mm)	Allowable Difference, ± in. (mm)
Less than 1 (25.4)	⅛ (3.2)
1 to 3 (76.2)	¼ (6.4)
Greater than 3	½ (12.7)
Greater than 6 (152.4)	1 (25.4)

7.3.8.2 As an alternative, a distance-amplitude correction (DAC) curve or circuitry may be used.

7.3.8.3 Material having a cross-sectional dimension exceeding 12 in. (305 mm) may be inspected by the following procedure, using the back-reflection method, instead of preparing large reference blocks by agreement between manufacturer and purchaser. A straight-beam longitudinal-wave search unit shall be placed on the material under test in a discontinuity-free area having a satisfactory surface condition to produce the desired result. The type, size and frequency of the transducer shall be mutually agreed upon as required by the specific situation. The instrument sensitivity shall be adjusted so that the height of the first back reflection occupies at least 75 %, but less than 100 %, of the full screen amplitude. The reporting levels and acceptability limits in terms of discontinuity size shall be mutually agreed upon prior to order placement.

7.3.9 *Acceptance Criteria (Table 1)*:

7.3.9.1 Any single discontinuity response that exceeds that of the single discontinuity standard for the applicable quality level shall be unacceptable.

7.3.9.2 Any multiple discontinuity, that is, any two that have an indicated distance between centers of less than 1 in. (25.4 mm) and whose responses equal or exceed that of the "multiple discontinuity" standard for the applicable quality level, shall be unacceptable.

7.3.9.3 Any stringer discontinuity whose response *and* length exceeds that of the standard for the applicable quality level shall be unacceptable.

TABLE 4 Permissible Variations in Produce Analysis

NOTE 1— Product cross-sectional area is defined as either:
(*a*) maximum cross-sectional area of rough machined forging (excluding boring),
(*b*) maximum cross-sectional area of the unmachined forging, or
(*c*) maximum cross-sectional area of the billet, bloom, or slab.
Area taken at right angles to the axis of the original ingot or billet.

Element	Unit or Maximum Specified Range, %	Permissible Variation Over the Specified Maximum Limit or Under the Specified Minimum Limit, %					
		Up to and including 100 in.^{2} (645 cm^2)	Over 100 to 200 in.^{2} (645 to 1290 cm^2), incl	Over 200 to 400 in.^{2} (1290 to 2580 cm^2), incl	Over 400 to 800 in.^{2} (2580 to 5160 cm^2), incl	Over 800 to 1600 in.^{2} (5160 to 10 320 cm^2), incl	Over 1600 in.^{2} (10 320 cm^2)
Carbon	up to and including 0.05	0.005	0.005	0.005	0.01	0.01	0.01
	0.06 to 0.10, incl	0.01	0.01	0.01	0.01	0.01	0.01
	0.11 to 0.25, incl	0.02	0.03	0.03	0.04	0.05	0.05
	0.26 to 0.55, incl	0.03	0.04	0.04	0.05	0.06	0.06
	0.56 and over	0.04	0.05	0.05	0.06	0.07	0.07
Manganese	up to and including 0.90	0.03	0.04	0.05	0.06	0.07	0.08
	0.91 and over	0.06	0.06	0.07	0.08	0.08	0.09
Phosphorus	...	0.008	0.008	0.010	0.010	0.015	0.015
Sulfur	...	0.005	0.005	0.005	0.005	0.006	0.006
Silicon	up to and including 0.35	0.02	0.03	0.04	0.04	0.05	0.06
	0.36 and over	0.05	0.06	0.06	0.07	0.07	0.08
Nickel	up to and including 1.00	0.03	0.03	0.03	0.03	0.03	0.03
	1.01 to 2.00, incl	0.05	0.05	0.05	0.05	0.05	0.05
	2.01 to 5.30, incl	0.07	0.07	0.07	0.07	0.07	0.07
	5.31 to 10.00, incl	0.10	0.10	0.10	0.10	0.10	0.10
	10.01 and over	0.15	0.15	0.15	0.15	0.15	0.15
Chromium	up to and including 0.90	0.03	0.04	0.04	0.05	0.05	0.06
	0.91 to 2.10, incl	0.05	0.06	0.06	0.07	0.07	0.08
	2.11 and over	0.10	0.10	0.12	0.14	0.15	0.16
Molybdenum	up to and including 0.20	0.01	0.02	0.02	0.02	0.03	0.03
	0.21 to 0.40, incl	0.02	0.03	0.03	0.03	0.04	0.04
	0.41 to 1.15, incl	0.03	0.04	0.05	0.06	0.07	0.08
	1.16 and over	0.05	0.06	0.08	0.10	0.12	0.12
Vanadium	up to and including 0.10	0.01	0.01	0.01	0.01	0.01	0.01
	0.11 to 0.25, incl	0.02	0.02	0.02	0.02	0.02	0.02
	0.26 to 0.50, incl	0.03	0.03	0.03	0.03	0.03	0.03
	0.51 and over	0.04	0.04	0.04	0.04	0.04	0.04
Titanium	...	0.05	0.05	0.05	0.05	0.05	0.05
Cobalt	0.26 to 5.00, incl	0.07	0.07	0.07	0.08	0.08	0.09
	5.01 and over	0.14	0.14	0.14	0.16	0.16	0.18
Aluminum	up to and including 0.05	0.01	0.01	0.02	0.02	0.03	0.03
	0.06 and over	0.02	0.02	0.02	0.03	0.03	0.03
Zirconium	...	0.01	0.01	0.01	0.01	0.01	0.01

8. Heat Treat Quality

8.1 *Hardenability*—All heats of material produced to this specification shall be tested for hardenability in accordance with Test Method A 255. The standards of acceptance shall be by agreement.

9. Permissible Variations in Weight

9.1 The permissible variation from the specified or theoretical weight of the blooms or billets shall be ±5 % for individual pieces or for lots of less than 20 tons (18100 kg). For lots of 20 tons or over, the permissible variation shall be ±2.5 % of the specified or theoretical weight of the lot.

9.2 The term "lot" is defined as all the blooms or billets of the same nominal cross-sectional dimensions and specified piece weight in a shipment.

10. Finish and Appearance

10.1 The material shall be free from rejectable discontinuities.

10.2 Conditioning, cutting, or parting of material may be done by scarfing or flame cutting when methods involved preheating and temperature control necessary to avoid any damage to flame-cut material are employed.

10.3 The surface of the bloom must be adequate for ultrasonic inspection to the applicable reference standard. In some cases, a smooth ground or milled surface may be necessary for adequate penetration and resolution.

10.4 Material may be conditioned to remove rejectable surface discontinuities, provided the depth of conditioning does not exceed 1⁄16 in. (1.6 mm) for each inch of dimension concerned, up to a maximum depth of 3⁄4 in. (19.0 mm), and provided that the width of the conditioning is at least four times its greatest depth. The maximum depth of conditioning on two parallel sides at opposite locations shall not exceed 1½ times the maximum allowed for one side.

11. Marking

11.1 Each bloom shall be legibly stamped by the manufacturer with the manufacturer's name or trademark; the manufacturer's heat number; A 646 followed by the appropriate class number, grade number, ingot number, and cut location.

12. Inspection

12.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy him that the material is being produced and furnished in accordance with this specification. Mill inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operation. All tests and inspections shall be made at the place of manufacture, unless otherwise agreed to.

13. Rejection

13.1 Any rejection based on tests made in accordance with 6.3 shall be reported to the manufacturer within 60 days from the receipt of the material by the purchaser.

13.2 Material that shows rejectable discontinuities prior to or subsequent to acceptance at the purchaser's plant shall be subject to rejection and the manufacturer shall be notified.

14. Certification and Reports

14.1 The manufacturer shall furnish the following information on the test report:

14.1.1 Chemical analysis,

14.1.2 Macroetch rating (if required, Test Method A 604 only),

14.1.3 Microcleanliness ratings,

14.1.4 Hardenability results,

14.1.5 Ultrasonic inspection report including statement: "Ultrasonically inspected in accordance with ASTM A _____, Class _____," and

14.1.6 Results of supplementary requirements when required.

15. Keywords

15.1 aerospace application; reforging stock; steel billets; steel blooms

SUPPLEMENTARY REQUIREMENTS

These requirements shall not apply unless specified in the order.

S1. Magnetic Particle Cleanliness

S1.1 When specified, each heat of billet or bloom material shall be inspected in accordance with either Aeronautical Material Specification AMS 2300 for Class I or AMS 2301 for Class II.

S2. Mechanical Property Capability

S2.1 When specified, mechanical property testing may be required to represent the capability of the material to respond to the final heat treatment to be performed on the end product. The purchaser must specify the details of the capability heat treatment along with minimum property levels to be achieved with the specimens after heat treatment.