Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 6544

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Revised

STEEL PLATE
2.0Cr - 10Ni - 8.0Co - 1.0Mo (0.10 - 0.14C)
Premium Quality, Vacuum Melted, Solution Heat Treated

1. SCOPE:

1.1 Form: This specification covers a premium-quality, low-alloy steel in the form of rolled or forged plate.

1.2 Application: Primarily for heat treated parts requiring high strength, toughness, and weldability.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2259 - Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS 2350 - Standards and Test Methods
AMS 2370 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Wrought Products Except Forgings and Forging Stock

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products
ASTM A604 - Macroetch Testing of Consumable Electrode Vacuum Arc Remelted Steel Bars and Billets
ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
ASTM E399 - Plane-Strain Fracture Toughness of Metallic Materials

2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 Military Specifications:

MIL-I-8950 - Inspection, Ultrasonic, Wrought Metals, Process For

2.3.3 Military Standards:

MIL-STD-163 - Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

Printed in U.S.A.

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E353, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other approved analytical methods:

	min	max
Carbon	0.10	0.14
Manganese	0.05	0.25
Silicon	--	0.10
Phosphorus	--	0.010
Sulfur	--	0.006
Chromium	1.80	2.20
Nickel	9.50	10.50
Cobalt	7.50	8.50
Molybdenum	0.90	1.10
Titanium	--	0.015
Aluminum	--	0.025
Oxygen	--	0.0025 (25 ppm)
Nitrogen	--	0.0075 (75 ppm)

3.1.1 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2259. No variation is permitted for oxygen and nitrogen.

3.2 Condition: Plate shall be supplied in the following condition; hardness shall be determined in accordance with ASTM A370:

3.2.1 Rolled Plate: Hot rolled, solution heat treated, and descaled, having hardness not lower than 42 HRC or equivalent.

3.2.2 Forged Plate: Hot finished, solution heat treated, and descaled, having hardness not lower than 42 HRC or equivalent.

3.3 Heat Treatment: Plate shall be solution heat treated as in 3.3.1 or 3.3.2, as applicable, holding at heat for sufficient time to ensure complete transformation, and quenching in agitated water sufficiently cool (See 8.1) to develop the properties specified herein.

3.3.1 Plate 2.0 In. or 50 mm and Under in Nominal Thickness: Shall be solution heat treated by heating in air to 1525°F ± 25 (829.4°C ± 14) and quenching.

3.3.2 Plate Over 2.0 In. or 50 mm in Nominal Thickness: Shall be solution heat treated by heating in air to 1650°F ± 25 (898.9°C ± 14), quenching, reheating to 1525°F ± 25 (829.4°C ± 14), and quenching.

3.4 Properties: Plate shall conform to the following requirements; tensile and impact testing shall be performed in accordance with ASTM A370:

3.4.1 As Solution Heat Treated:

3.4.1.1 Macrostructure: Visual examination of transverse sections from slabs, billets, or suitable rerolled product, etched in accordance with ASTM A604 in hot hydrochloric acid (1:1) at 160° - 180°F (71.1° - 82.2°C) for sufficient time to develop a well-defined macrostructure, shall show no imperfections, such as pipe, cracks, porosity, segregation, and inclusions, detrimental to fabrication of parts. Macrostructure shall be equal to or better than the following macrographs of ASTM A604:

Class	Condition	Severity
1	Freckles	B
2	White Spots	C
3	Radial Segregation	C
4	Ring Pattern	D

3.4.2 After Aging: Plate shall meet the requirements of 3.4.2.1, 3.4.2.2, and 3.4.2.3 after being aged by heating to 950°F ± (510°C ± 5.6), holding at heat for not less than 5 hr for sections 2.0 in. or 50 mm and less in nominal thickness, and for 10 hr +0.5, -0, for thicker sections, and cooling in air.

3.4.2.1 Tensile Properties: Shall be as shown in Table I.

TABLE I

Nominal Thickness Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 2 in. or 4D %, min	Reduction of Area %, min
0.375 to 2.000, incl	190,000	180,000	14	62
Over 2.000 to 4.000, incl	190,000	175,000	15	60
Over 4.000 to 8.000, incl	190,000	170,000	15 (See 3.4.2.1.1)	50 (See 3.4.2.1.1)

TABLE I (SI)

Nominal Thickness Millimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 50.8 mm or 4D %, min	Reduction of Area %, min
9.52 to 50.80, incl	1310	1241	14	62
Over 50.80 to 101.60, incl	1310	1207	15	60
Over 101.60 to 203.20, incl	1310	1172	15 (See 3.4.2.1.1)	50 (See 3.4.2.1.1)

3.4.2.1.1 These values are tentative until more data are available; failure to meet these requirements shall not be cause for rejection.

3.4.2.1.2 Tensile properties for plate less than 0.375 in. (9.52 mm) or over 8.000 in. (203.20 mm) in nominal thickness shall be as agreed upon by purchaser and vendor.

3.4.2.2 Impact Strength: Shall be as shown in Table II.

TABLE II

Nominal Thickness Inches	Charpy V-Notch at 0°F ft-lb
0.500 to 2.000, incl	60
Over 2.000 to 4.000, incl	45
Over 4.000 to 8.000, incl	40 (See 3.4.2.1.1)

TABLE II (SI)

Nominal Thickness Millimetres	Charpy V-Notch at -18°C N·m
12.70 to 50.80, incl	81
Over 50.80 to 101.60, incl	61
Over 101.60 to 203.20, incl	54 (See 3.4.2.1.1)

3.4.2.2.1 Impact strength for plate less than 0.500 in. (12.70 mm) or over 8.00 in. (203.20 mm) in nominal thickness shall be as agreed upon by purchaser and vendor.

3.4.2.3 Fracture Toughness: Shall be not lower than 175,000 psi$\sqrt{\text{in.}}$ (192 MPa$\sqrt{\text{m}}$), determined in accordance with ASTM E399 using the compact tension specimen. Fracture toughness requirements do not apply to product under 0.500 in. (12.70 mm) in nominal thickness.

3.5 Quality:

3.5.1 Steel shall be multiple melted using vacuum induction melting plus vacuum consumable electrode remelting, unless otherwise permitted.

3.5.2 Plate shall be uniform in quality and condition and free from foreign materials and from internal and external imperfections detrimental to fabrication of parts.

3.5.3 All plate 0.50 in. or 13 mm and over in nominal thickness shall be inspected ultrasonically in accordance with MIL-I-8950 and shall meet Class AA quality requirements as defined therein. Hot-finished surfaces shall be suitably prepared prior to ultrasonic inspection.

3.6 Tolerances: Unless otherwise specified, tolerances shall conform to the requirements of Tables III through VII; for sizes not covered therein tolerances shall be as agreed upon by purchaser and vendor.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the plate shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that the plate conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to composition (3.1), hardness (3.2.1 or 3.2.2), macrostructure (3.4.1.1), tensile property (3.4.2.1), impact strength (3.4.2.2), ultrasonic (3.5.3), and tolerance (3.6) requirements are classified as acceptance tests.

4.2.2 Periodic Tests: Tests to determine conformance to fracture toughness (3.4.2.3) requirements are classified as periodic tests.

4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests.

4.2.3.1 For direct U.S. Military procurement, test material and supporting test data shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be in accordance with the following:

4.3.1 Acceptance Tests: AMS 2370, except that samples for composition shall be taken from a vacuum induction melted ingot. Each plate 0.500 in. or 13 mm and over in nominal thickness shall be subjected to ultrasonic inspection.

4.3.2 Periodic Tests and Preproduction Tests: As agreed upon by purchaser and vendor.

4.4 Reports:

4.4.1 The vendor of the plate shall furnish with each shipment three copies of a report of the results of tests on each heat in the shipment for chemical composition and macrostructure; on each size from each heat in the shipment for hardness, tensile, and impact properties and on each inspected piece in the shipment for internal soundness. This report shall include the purchase order number, heat number, material specification number, size, and quantity from each heat.

4.4.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number, contractor or other direct supplier of plate, part number, and quantity. When plate for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of plate to determine conformance to the requirements of this specification, and shall include in the report a statement that the plate conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.5 Resampling and Retesting: Shall be in accordance with AMS 2370.

5. PREPARATION FOR DELIVERY:

5.1 Identification: Plate shall be identified as in 5.1.1 unless marking as in 5.1.2 is specified. The characters shall be of such size as to be clearly legible, shall be applied using a suitable marking fluid, and shall be capable of being removed in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the plate and shall be sufficiently stable to withstand normal handling. The markings shall be applied parallel to the longitudinal material direction or parallel to the final rolling direction.

5.1.1 Each plate shall be marked at intervals not greater than 3 ft (900 mm) with AMS 6544, heat number, and manufacturer's identification.

5.1.2 Each plate shall be marked in lengthwise rows of characters recurring at intervals not greater than 3 ft or 900 mm, the rows being spaced not more than 12 in. or 300 mm apart and alternately staggered, with AMS 6544, heat number, and manufacturer's identification.

5.2 Protective Treatment: The product shall be coated with a suitable corrosion-preventive compound prior to shipment.

5.3 Packaging:

5.3.1 The product shall be prepared for shipment in accordance with commercial practice to ensure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.3.2 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-163, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.3.1 will be acceptable if it meets the requirements of Level C.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Material not conforming to this specification or to authorized modifications will be subject to rejection.

8. NOTES:

8.1 The temperature of the agitated-water quenching bath is an important factor in the development of adequate mechanical properties. Quenching water temperature of not over 70°F or 20°C at the end of the quenching operation has been found to be satisfactory.

8.2 For direct U.S. Military procurement, purchase documents should specify the following:

Title, number, and date of this specification
Form and size of plate desired
Quantity of plate desired
Applicable method of identification marking (5.1.1 or 5.1.2)
Applicable level of packaging (See 5.3.2).

TABLE III

Thickness Tolerances for Plate Up to 2.00 In., Incl, in Thickness

Nominal Thickness Inches (See Note 2)	Tolerance, Plus (See Note 1) Width Ranges, Inches								
	Up to 40, incl	Over 40 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, excl	120 to 132, excl	132 and over
0.375	0.015	0.015	0.021	0.027	0.027	0.035	0.035	0.042	-----
0.438	0.015	0.015	0.021	0.027	0.027	0.035	0.042	0.042	0.052
0.500	0.021	0.021	0.021	0.027	0.027	0.035	0.042	0.042	0.052
0.512	0.021	0.021	0.027	0.027	0.027	0.035	0.042	0.052	0.052
0.625	0.027	0.027	0.027	0.027	0.027	0.035	0.042	0.052	0.052
0.688	0.027	0.027	0.027	0.027	0.027	0.035	0.042	0.052	0.052
0.750	0.027	0.027	0.027	0.027	0.035	0.035	0.042	0.052	0.068
0.812	0.027	0.035	0.035	0.035	0.035	0.042	0.052	0.052	0.068
0.875	0.035	0.035	0.035	0.035	0.042	0.042	0.052	0.062	0.068
0.938	0.035	0.035	0.035	0.035	0.042	0.042	0.052	0.062	0.075
1.000	0.035	0.035	0.042	0.042	0.042	0.042	0.052	0.062	0.075
1.062	0.035	0.035	0.042	0.042	0.042	0.052	0.052	0.062	0.075
1.125	0.042	0.042	0.042	0.042	0.042	0.052	0.052	0.068	0.075
1.188	0.042	0.042	0.052	0.052	0.052	0.052	0.062	0.075	0.085
1.250	0.042	0.042	0.052	0.052	0.052	0.062	0.062	0.075	0.085
1.312	0.042	0.042	0.052	0.052	0.052	0.062	0.062	0.075	0.095
1.375	0.047	0.052	0.052	0.052	0.052	0.062	0.068	0.085	0.095
1.438	0.047	0.052	0.062	0.062	0.062	0.062	0.075	0.085	0.105
1.500	0.052	0.052	0.062	0.062	0.062	0.068	0.075	0.085	0.105
1.562	0.052	0.052	0.062	0.062	0.062	0.068	0.075	0.095	0.105
1.625	0.062	0.062	0.062	0.062	0.062	0.075	0.085	0.095	0.115
1.688	0.062	0.062	0.068	0.068	0.068	0.075	0.085	0.105	0.115
1.750	0.062	0.062	0.068	0.068	0.068	0.075	0.085	0.105	0.125
1.812	0.062	0.062	0.075	0.075	0.075	0.085	0.095	0.105	0.125
1.875	0.062	0.062	0.075	0.075	0.075	0.085	0.095	0.115	0.125
1.938	0.068	0.068	0.075	0.075	0.075	0.085	0.095	0.115	0.141
2.000	0.068	0.068	0.075	0.075	0.075	0.085	0.095	0.115	0.141

Note 1. Plus tolerance in inches (average) for specified nominal thickness. A tolerance 0.010 in. under specified thickness will be permitted.

Note 2. For intermediate nominal thicknesses, the tolerance of the nearer nominal thickness shall apply. In case of mid-point, the tolerance for the lower thickness or an interpolated value shall apply.

TABLE III (SI)

Thickness Tolerances for Plate Up to 50 mm, Incl, in Nominal Thickness

Nominal Thickness Millimetres (See Note 2)	Tolerance, Plus (See Note 1) Width Ranges, Millimetres								
	Up to 1015, incl	Over 1015 to 1525, excl	1525 to 1830, excl	1830 to 2135, excl	2135 to 2440, excl	2440 to 2745, excl	2745 to 3050, excl	3050 to 3350, excl	3350 and over
9.52	0.38	0.38	0.53	0.69	0.69	0.89	0.89	1.07	----
11.13	0.38	0.38	0.53	0.69	0.69	0.89	1.07	1.07	1.32
12.70	0.53	0.53	0.53	0.69	0.69	0.89	1.07	1.07	1.32
13.00	0.53	0.53	0.69	0.69	0.69	0.89	1.07	1.32	1.32
15.88	0.69	0.69	0.69	0.69	0.69	0.89	1.07	1.32	1.32
17.48	0.69	0.69	0.69	0.69	0.69	0.89	1.07	1.32	1.32
19.05	0.69	0.69	0.69	0.69	0.89	0.89	1.07	1.32	1.73
20.62	0.69	0.89	0.89	0.89	0.89	1.07	1.32	1.32	1.73
22.22	0.89	0.89	0.89	0.89	1.07	1.07	1.32	1.57	1.73
23.83	0.89	0.89	0.89	0.89	1.07	1.07	1.32	1.57	1.90
25.40	0.89	0.89	1.07	1.07	1.07	1.07	1.32	1.57	1.90
26.97	0.89	0.89	1.07	1.07	1.07	1.32	1.32	1.57	1.90
28.58	1.07	1.07	1.07	1.07	1.07	1.32	1.32	1.73	1.90
30.18	1.07	1.07	1.32	1.32	1.32	1.32	1.57	1.90	2.16
31.75	1.07	1.07	1.32	1.32	1.32	1.57	1.57	1.90	2.16
33.32	1.07	1.07	1.32	1.32	1.32	1.57	1.57	1.90	2.41
34.92	1.19	1.32	1.32	1.32	1.32	1.57	1.73	2.16	2.41
36.53	1.19	1.32	1.57	1.57	1.57	1.57	1.90	2.16	2.67
38.10	1.32	1.32	1.57	1.57	1.57	1.73	1.90	2.16	2.67
39.67	1.32	1.32	1.57	1.57	1.57	1.73	1.90	2.41	2.67
41.28	1.57	1.57	1.57	1.57	1.57	1.90	2.16	2.41	2.92
42.88	1.57	1.57	1.73	1.73	1.73	1.90	2.16	2.67	2.92
44.45	1.57	1.57	1.73	1.73	1.73	1.90	2.16	2.67	3.18
46.02	1.57	1.57	1.90	1.90	1.90	2.16	2.41	2.67	3.18
47.62	1.57	1.57	1.90	1.90	1.90	2.16	2.41	2.92	3.18
49.23	1.73	1.73	1.90	1.90	1.90	2.16	2.41	2.92	3.58
50.00	1.73	1.73	1.90	1.90	1.90	2.16	2.41	2.92	3.58

Note 1. Plus tolerance in millimetres (average) for specified nominal thickness. A tolerance 0.25 mm under nominal thickness will be permitted.

Note 2. For intermediate nominal thicknesses the tolerance of the nearer nominal thickness shall apply. In case of mid-point, the tolerance for the lower thickness or an interpolated value shall apply.

TABLE IV

Thickness Tolerances for Plate Over 2.00 In. in Nominal Thickness

Nominal Thickness Inches	Tolerance, Plus (See Note 1) Width Ranges, Inches					
	Up to 36, excl	36 to 60, excl	60 to 84, excl	84 to 120, excl	120 to 132, excl	132 and over
Over 2.0 to 3.0, excl	0.063	0.094	0.109	0.125	0.125	0.141
3.0 to 4.0, excl	0.078	0.094	0.109	0.125	0.125	0.141
4.0 to 6.0, excl	0.094	0.125	0.141	0.141	0.156	0.172
6.0 to 8.0, incl	0.109	0.125	0.156	0.156	0.172	0.188

Note 1. Plus tolerance in inches (average) for specified nominal thickness. A tolerance of 0.010 in. under nominal thickness will be permitted.

TABLE IV (SI)

Thickness Tolerances for Plate Over 50 mm in Nominal Thickness

Nominal Thickness Millimetres	Tolerance, Plus (See Note 1) Width Ranges, Millimetres					
	Up to 915, excl	915 to 1525, excl	1525 to 2135, excl	2135 to 3050, excl	3050 to 3350, excl	3350 and over
Over 50 to 75, excl	1.60	2.40	2.75	3.20	3.20	3.60
75 to 100, excl	2.00	2.40	2.75	3.20	3.20	3.60
100 to 150, excl	2.40	3.20	3.60	3.60	3.95	4.35
150 to 200, incl	2.75	3.20	3.95	3.95	4.35	4.80

Note 1. Plus tolerance in millimetres (average) for specified nominal thickness. A tolerance of 0.25 mm under nominal thickness will be permitted.