

Steel, Sheet, Strip, and Plate
0.75Mn - 0.78Cr - 1.8Ni - 0.35Mo - 0.20V (0.33 - 0.38C) (4335 Mod)
Vacuum Consumable Electrode Melted, Annealed

(Composition similar to UNS K33517)

RATIONALE

AMS6435F results from a Five Year Review and update of this specification that includes revision of the decarburization requirements.

1. SCOPE

1.1 Form

This specification covers a premium aircraft-quality, low-alloy steel in the form of sheet, strip, and plate.

1.2 Application

These products have been used typically for parts, that may be welded during fabrication, requiring through-hardening to high strength levels and that may be used at operational stress levels approaching the yield strength, but usage is not limited to such applications. Steel may become notch sensitive when heat treated to a tensile strength level of 240 ksi (1655 MPa) or higher.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS2252	Tolerances, Low-Alloy Steel Sheet, Strip, and Plate
AMS2259	Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS2300	Steel Cleanliness, Premium Aircraft-Quality, Magnetic Particle Inspection Procedure

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on this Technical Report, please visit
<http://www.sae.org/technical/standards/AMS6435F>**

- AMS2370 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock
- AMS2807 Identification, Carbon and Low-Alloy Steels, Corrosion and Heat-Resistant Steels and Alloys, Sheet, Strip, Plate, and Aircraft Tubing

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

- ASTM A 255 Determining Hardenability of Steel
- ASTM A 370 Mechanical Testing of Steel Products
- ASTM E 45 Determining the Inclusion Content of Steel
- ASTM E 112 Determining Average Grain Size
- ASTM E 350 Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
- ASTM E 384 Knoop and Vickers Hardness of Materials

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 350, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

TABLE 1 - COMPOSITION

Element	min	max
Carbon	0.33	0.38
Manganese	0.60	0.90
Silicon	0.40	0.60
Phosphorus	--	0.010
Sulfur	--	0.010
Chromium	0.65	0.90
Nickel	1.65	2.00
Molybdenum	0.30	0.40
Vanadium	0.17	0.23
Copper	--	0.35

3.1.1 Check Analysis

Composition variations shall meet the applicable requirements of AMS2259 except that carbon shall vary not more than 0.01 under min or over max and no variation over max will be permitted for phosphorus and sulfur.

3.2 Melting Practice

Steel shall be multiple melted using vacuum consumable electrode practice in the remelt cycle.

3.3 Condition

The product shall be supplied in the following condition; hardness shall be determined in accordance with ASTM A 370:

3.3.1 Sheet and Strip

Cold finished, bright or atmosphere annealed, and descaled if necessary, or, hot rolled, annealed, and descaled, unless otherwise ordered, having hardness not higher than 30 HRC or equivalent (See 8.2).

3.3.2 Plate

Hot rolled, annealed, and descaled having hardness not higher than 30 HRC or equivalent (See 8.2).

3.3.2.1 If allowed by purchaser, cold rolled, annealed, and descaled having hardness not higher than 30 HRC or equivalent (See 8.2).

3.3.3 When product is ordered spheroidize annealed, hardness shall be not higher than 100 HRB or equivalent (See 8.2).

3.4 Properties

The product shall conform to the following requirements; hardness and tensile testing shall be performed in accordance with ASTM A 370:

3.4.1 Micro-Inclusion Rating of Each Heat

No specimen shall exceed the limits shown in Table 2, determined in accordance with ASTM E 45, Method D.

TABLE 2 - MICRO-INCLUSION RATING LIMITS

Limits	A		B		C		D	
	Thin	Heavy	Thin	Heavy	Thin	Heavy	Thin	Heavy
Worst Field Severity	2.0	1.0	1.5	1.0	1.5	1.0	1.5	1.0
Worst Field Frequency, maximum	a	1	a	1	a	1	5	3
Total Rateable Fields Frequency, maximum	b	1	b	1	b	1	c	3

a - Combined A+B+C, not more than 3 fields

b - Combined A+B+C, not more than 5 fields

c - Any number of lower rateable D-type thin fields per specimen is permitted

3.4.1.1 Thickness of the D-type heavy shall not exceed 0.0005 inch (0.012 mm).

3.4.1.2 A rateable field is defined as one that has a type A, B, C, or D inclusion rating of at least 1.0 thin or heavy in accordance with the Jernkontoret Chart, Plate I-r, ASTM E 45 (See 8.3).

3.4.2 Average Grain Size of Plate, Sheet and Strip

Shall be ASTM No. 5 or finer, determined in accordance with ASTM E 112.

3.4.3 Hardenability of Each Heat

Shall be J1/16 inch (1.6 mm) = 58 HRC maximum and J15/16 inch (23.8 mm) = 47 HRC minimum, determined in accordance with ASTM A 255 except that the steel shall be normalized at 1700 °F ± 10 (925 °C ± 5) and the test specimen austenitized at 1625 °F ± 10 (885 °C ± 5).

3.4.4 Decarburization of Each Lot

Decarburization shall be evaluated by one of the methods of 3.4.4.1, 3.4.4.2, or 3.4.4.3 at the discretion of the producer.

3.4.4.1 Metallographic Method

A cross section of the surface shall be visually examined metallographically at a magnification not to exceed 100X. The product shall show no layer of complete or partial decarburization exceeding the limits of Table 3.

3.4.4.2 Step Method

Specimen shall be full thickness of the product up to 0.250 inch (6.35 mm) or reduced to 0.250 inch (6.35 mm) preserving one original surface for heavier product. Recommended size is 1 inch x 4 inches (25 mm x 102 mm). Specimens shall be hardened by austenitizing and quenching. They should not be tempered, but if tempered, the tempering temperature shall be not higher than 300 °F (149 °C). During heat treatment, specimens shall be protected by suitable atmosphere or medium or by suitable plating to prevent carburization or further decarburization. The protective plating, if used, shall be removed.

For product less than 0.250 inch (6.35 mm), a portion of the specimen shall be ground to a depth of 0.050 inch (1.27 mm) or one-half thickness, whichever is less using sufficient coolant to prevent thermal or mechanical effects. The product shall not show evidence of complete decarburization (ferrite) when examined metallographically at a magnification not exceeding 100X. It shall be free of partial decarburization to the extent that the difference in hardness between the original surface and the surface (depth) generated by grinding shall not be greater than two units on the HRA scale or equivalent (See 8.2)

For product 0.250 inch (6.35 mm) and thicker, the specimens shall be ground to remove 0.010 inch (0.25 mm) of metal and a portion of the specimen shall be further ground to a depth of at least one-third the original thickness of the specimen. The difference in the hardness between the two prepared steps shall be no greater than three units on the HRA scale or equivalent (See 8.2).

3.4.4.3 Hardness Traverse Method

The total depth of decarburization determined by a traverse method using microhardness testing in accordance with ASTM E 384 at a magnification not exceeding 100X, shall be defined as the perpendicular distance from the surface to the depth under the surface below which there is not further increase in hardness. The sample shall be hardened as listed in 3.4.4.2. Acceptance shall be as listed in Table 3.

TABLE 3A - MAXIMUM DECARBURIZATION LIMITS, INCH/POUND UNITS

Nominal Thickness Inches	Total Depth of Decarburization Inch
Up to 0.500, incl	0.015
Over 0.500 to 1.000, incl	0.025
Over 1.000	0.035

TABLE 3B - MAXIMUM DECARBURIZATION LIMITS, SI UNITS

Nominal Thickness Millimeters	Total Depth of Decarburization Millimeter
Up to 12.50, incl	0.38
Over 12.50 to 25.00, incl	0.62
Over 25.00	0.88

3.4.4.4 When determining the depth of decarburization, it is permissible to disregard local areas provided the decarburization of such areas does not exceed the above limits by more than 0.005 inch (0.13 mm) and the width is 0.065 inch (1.65 mm) or less.

3.4.4.5 In the case of dispute, the microhardness traverse method shall govern.

3.4.5 Response to Heat Treatment

Specimens shall meet the requirements shown in Table 4 after being hardened by heating to 1625 °F ± 25 (885 °C ± 15), holding at heat for 60 minutes ± 5, and quenching in oil, and tempered by heating to a temperature between 400 and 500 °F (205 and 260 °C), holding at heat for not less than 2 hours, and cooling in air.

TABLE 4A - MINIMUM TENSILE PROPERTIES, INCH/POUND UNITS

Property	Value
Tensile Strength	240 ksi
Yield Strength at 0.2% Offset	210 ksi
Elongation in 2 inches or 4D, min	
Nominal Thickness, Inches	
Up to 0.070, incl	5%
Over 0.070 to 0.249, incl	6%
Over 0.249	8%

TABLE 4B - MINIMUM TENSILE PROPERTIES, SI UNITS

Property	Value
Tensile Strength	1655 MPa
Yield Strength at 0.2% Offset	1450 MPa
Elongation in 50.8 mm or 4D, min	
Nominal Thickness, Millimeters	
Up to 1.75, incl	5%
Over 1.75 to 6.25, incl	6%
Over 6.25	8%

3.5 Quality

The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

3.5.1 Steel shall be premium aircraft-quality conforming to AMS2300 except that a maximum average frequency (F) rating of 0.10 and a maximum average severity (S) rating of 0.20 shall apply.

3.6 Tolerances

Shall be in accordance with AMS2252.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of the product shall supply all samples for vendor's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Composition (3.1), condition (3.3), micro-inclusion rating (3.4.1), average grain size (3.4.2), hardenability (3.4.3), decarburization (3.4.4), and tolerances (3.6) are acceptance tests and shall be performed on each heat or lot as applicable.