AEROSPACE
MATERIAL SPECIFICATIONS
SOCIETY OF AUTOMOTIVE ENGINEERS, Inc. 485 Lexington Ave., New York 17, N.Y.

# AMS 6416

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Revised

## STEEL
## 1.6Si - 0.8Cr - 1.8Ni - 0.4Mo - 0.07V (0.41 - 0.46C)

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

2. FORM: Bars, forgings, forging stock, and mechanical tubing.

3. APPLICATION: Primarily for heat treated parts, such as pressure vessels, requiring through hardening to high strength levels. May be welded without undue difficulty.

4. COMPOSITION:

| | |
|---|---|
| Carbon | 0.41 - 0.46 |
| Manganese | 0.60 - 0.90 |
| Silicon | 1.45 - 1.80 |
| Phosphorus | 0.015 max |
| Sulfur | 0.015 max |
| Chromium | 0.70 - 0.95 |
| Nickel | 1.65 - 2.00 |
| Molybdenum | 0.30 - 0.50 |
| Vanadium | 0.05 - 0.10 |

4.1 Check Analysis: Composition variations shall meet the requirements of the latest issue of AMS 2259, paragraph titled "Low Alloy Steels", except that check analysis limit for carbon shall be 0.01 under min or over maximum.

4.2 If size is over 100 sq in. in cross sectional area, the chemical composition and check analysis limits thereon shall be negotiated between purchaser and vendor.

5. CONDITION:

5.1 Bars: Unless otherwise ordered, in a machinable condition and hot finished with hardness not higher than Brinell 241 or equivalent, except that bars ordered cold finished may have hardness as high as Brinell 262 or equivalent.

5.2 Mechanical Tubing: In a machinable condition.

5.3 Forgings: Normalized and tempered, having hardness not higher than Brinell 248 or equivalent, unless otherwise specified.

5.4 Forging Stock: As ordered by the forging manufacturer.






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6. TECHNICAL REQUIREMENTS:

6.1 Tensile Properties: Specimens normalized by heating to 1700 F ± 10, holding at heat for 1 hr, and cooling in air, austenitized by heating to 1600 F ± 10, holding at heat for 1 hr, and quenching in oil from 1600 F ± 10, and then tempered by heating to 600 F ± 10, holding at heat for 2 - 3 hr, and cooling in air shall conform to the following requirements:

| | |
|---|---|
| Tensile Strength, psi | 280,000 min |
| Yield Strength at 0.2% offset or at 0.0204 in. in 2 in. Extension Under Load (E = 28,000,000), psi | 230,000 min |
| Elongation, % in 4D | 7 min |
| Reduction of Area, % | |
| Parallel to grain flow | 20 min |
| Transverse to grain flow (mid-radius) | 8 min |

6.2 Grain Size: Predominantly 5 or finer with occasional grains as large as 3 permissible, ASTM E112-58T, Appendix III, Section A1, Treatment (1) (McQuaid-Ehn test).

6.3 Decarburization:

6.3.1 Bars or tubing ordered ground, turned, or polished shall be free from decarburization on such ground, turned, or polished surfaces. Inside decarburization of such tubing shall not exceed the maximum depth specified in 6.3.4.

6.3.2 Allowable decarburization of bars, billets, or tubing ordered for redrawing or forging, or to specified microstructural requirements, shall be as agreed upon by purchaser and vendor.

6.3.3 Decarburization of bars to which 6.3.1 or 6.3.2 is not applicable shall be not greater than the following:

| Nominal Diameter or Distance Between Parallel Sides Inches | Depth of Decarburization Inch |
|---|---|
| 0.375 and under | 0.015 |
| Over 0.375 to 0.500, incl | 0.018 |
| Over 0.500 to 0.625, incl | 0.020 |
| Over 0.625 to 1.000, incl | 0.023 |
| Over 1.000 to 1.500, incl | 0.026 |
| Over 1.500 to 2.000, incl | 0.032 |
| Over 2.000 to 2.500, incl | 0.037 |
| Over 2.500 to 3.000, incl | 0.043 |
| Over 3.000 to 4.000, incl | 0.049 |
| Over 4.000 | as negotiated |

6.3.4 Decarburization of all tubing to which 6.3.1 or 6.3.2 is not applicable shall be not greater than the following:

| Nominal Wall Thickness Inches | Depth of Decarburization, Inch | |
|---|---|---|
| | ID | OD |
| 0.109 and under | 0.008 | 0.015 |
| Over 0.109 to 0.203, incl | 0.010 | 0.020 |
| Over 0.203 to 0.400, incl | 0.012 | 0.025 |
| Over 0.400 to 0.600, incl | 0.015 | 0.030 |
| Over 0.600 to 1.000, incl | 0.017 | 0.035 |
| Over 1.000 | 0.020 | 0.040 |

6.3.5 Unless otherwise agreed upon by purchaser and vendor, decarburization shall be measured by the microscopic method or by Rockwell Superficial 30N scale hardness method, or equivalent hardness testing method, on hardened specimens. Depth of decarburization, when measured by a hardness method, is defined as the depth below which there is no further increase in hardness; such measurements shall be far enough away from any nearby intersecting surface to be uninfluenced by any decarburization or lack of decarburization thereon.

6.3.5.1 When determining the depth of decarburization, it is permissible to disregard local areas provided the decarburization of such areas does not exceed the limits above by more than 0.005 in. and the width is 0.065 in. or less.

6.4 Inclusion Rating:

6.4.1 Material shall be subject to step-down bar method of magnetic particle inspection in accordance with the latest issue of AMS 2301, unless such inspection be waived.

6.4.2 Unless otherwise specified, the inclusion rating determined in accordance with ASTM E45-51, method A using not less than 9 specimens per heat or lot selected parallel to the direction of rolling and representing the worst area of inclusions in the inspection samples shall be as specified below. The method of selection of specimens shall be such that suitable rating of the heat or lot of steel being qualified is assured. Two-thirds of all specimens as well as the average of all specimens shall not exceed the following limits:

| | Inclusion Rating | | | |
|---|---|---|---|---|
| Type | A | B | C | D |
| Thin | 2.0 | 2.0 | 2.0 | 2.0 |
| Heavy | 1.5 | 1.5 | 1.5 | 1.5 |

6.5 Macroetch Test: Full cross-sectional specimens representing the top and bottom of each ingot shall be obtained from the finished billet or a suitable rerolled product and shall be macroetched in hot hydrochloric acid (1:1) at 160 - 180 F for 1 hour. When compared with the macrographs in MIL-STD-430, the quality and cleanliness of the steel as indicated by the macroetched specimens shall be equal to or better than macrographs A-2, B-2, and C-3 with D type unacceptable.

6.5.1 If size ordered is over 100 sq in. in cross-sectional area, the macroetch test requirement shall be negotiated between purchaser and vendor.