

# AEROSPACE MATERIAL SPECIFICATION



**MAM 2241D**

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Superseding MAM 2241C

Tolerances, Metric  
Corrosion and Heat Resistant Steel, Iron Alloy,  
Titanium, and Titanium Alloy Bars and Wire

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AMS 2241 covers the same requirements.

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## 1. SCOPE:

This specification covers established metric manufacturing tolerances applicable to corrosion and heat resistant steel, iron alloy, titanium, and titanium alloy bars and wire ordered to metric dimensions. These tolerances apply to all conditions, unless otherwise noted. The term "excl" is used to apply only to the higher figure of the specified range.

1.1 AMS 2241 is the inch/pound version of this MAM.

## 2. DIAMETER, THICKNESS, AND WIDTH:

## 2.1 Cold Finished Bars:

2.1.1 Rounds, Squares, Hexagons, and Octagons (See 2.1.3): See Table 1.

TABLE 1 - Diameter or Thickness Tolerances

| Specified Diameter<br>or Thickness<br>Millimeters | Tolerance, Millimeter                     |                                                                   |
|---------------------------------------------------|-------------------------------------------|-------------------------------------------------------------------|
|                                                   | Plus and Minus<br>(See 2.1.1.1)<br>Rounds | Minus Only<br>(See 2.1.1.2)<br>Squares, Hexagons,<br>and Octagons |
| Over 12.50 to 25.00, excl                         | 0.05                                      | 0.10                                                              |
| 25.00                                             | 0.062                                     | 0.10                                                              |
| Over 25.00 to 37.50, excl                         | 0.026                                     | 0.15                                                              |
| 37.50 to 50.00, incl                              | 0.08                                      | 0.15                                                              |
| Over 50.00 to 75.00, incl                         | 0.08                                      | 0.20                                                              |
| Over 75.00 to 100.00, incl                        | 0.08                                      | 0.25                                                              |

2.1.1.1 Size tolerances for round bars are plus and minus as shown in Table 1. When required, however, they may be specified all plus and nothing minus, or all minus and nothing plus, or any combination of plus and minus, if the total spread in size tolerance for a specified size is not less than the total spread shown in Table 1.

2.1.1.2 For titanium and titanium alloys, the difference among the three measurements of the distance between opposite faces of hexagons shall be not greater than one-half the size tolerance and the difference among the measurements of the distance between opposite faces of octagons shall be not greater than the size tolerance.

2.1.2 Flats (See 2.1.3): See Table 2.

TABLE 2 - Thickness and Width Tolerances

| Specified Width<br>Millimeters | Thickness<br>Tolerance, Millimeter<br>Plus and Minus | Width<br>Tolerance, Millimeter<br>Plus and Minus |
|--------------------------------|------------------------------------------------------|--------------------------------------------------|
| 3.00 to 6.00, incl             | 0.05                                                 | 0.10                                             |
| Over 6.00 to 25.00, incl       | 0.05                                                 | 0.05                                             |
| Over 25.00 to 50.00, incl      | 0.08                                                 | 0.08                                             |
| Over 50.00 to 75.00, incl      | 0.10                                                 | 0.10                                             |
| Over 75.00 to 115.00, incl     | 0.12                                                 | 0.12                                             |

2.1.3 If cold finished bars are ordered heat treated or heat treated and pickled after cold finishing, tolerances shall be double those of Table 1 and Table 2.

## 2.2 Cold Finished Wire:

2.2.1 Rounds, Squares, Hexagons, and Octagons (See 2.2.1.1): See Table 3.

TABLE 3 - Diameter of Thickness Tolerances

| Specified Diameter<br>or Thickness<br>Millimeters | Tolerance, Millimeters<br>Plus and Minus<br>Rounds and Squares | Tolerance, Millimeter<br>Minus Only<br>(See 2.2.1.3) |
|---------------------------------------------------|----------------------------------------------------------------|------------------------------------------------------|
|                                                   |                                                                | Hexagons and Octagons                                |
| 0.08 to 0.12, excl                                | 0.002                                                          | -                                                    |
| 0.12 to 0.20, excl                                | 0.005                                                          | -                                                    |
| 0.20 to 0.30, excl                                | 0.008                                                          | -                                                    |
| 0.30 to 0.60, excl                                | 0.010 (See 2.2.1.2)                                            | -                                                    |
| 0.60 to 0.85, excl                                | 0.012 (See 2.2.1.2)                                            | -                                                    |
| 0.85 to 1.10, excl                                | 0.020                                                          | -                                                    |
| 1.10 to 3.15, excl                                | 0.02                                                           | -                                                    |
| 3.15 to 7.80, excl                                | 0.02                                                           | 0.05                                                 |
| 7.80 to 12.50, excl                               | 0.038                                                          | 0.08                                                 |
| 12.50                                             | 0.05                                                           | 0.10                                                 |

2.2.1.1 If cold finished wire is ordered heat treated or heat treated and pickled after cold finishing, tolerances shall be double those of Table 3 for nominal sizes 0.60 millimeters and over.

2.2.1.2 For titanium and titanium alloys, tolerances for these sizes are  $\pm 0.019$  millimeter.

2.2.1.3 For titanium and titanium alloys, the difference among the three measurements of the distance between opposite faces of hexagons shall be not greater than one-half the size tolerance and the difference among the four measurements of the distance between opposite faces of octagons shall be not greater than one-half the size tolerance.

2.2.1.4 Out-of-Round: Round wire shall not be out-of-round by more than one-half of the total tolerance shown in Table 3.

2.2.2 Flats: See Table 4.

TABLE 4 - Thickness Tolerances

| Specified Thickness<br>Millimeters | Tolerance, Millimeter<br>Plus and Minus |
|------------------------------------|-----------------------------------------|
| Up to 0.70, excl                   | 0.02                                    |
| 0.70 to 0.90, excl                 | 0.038                                   |
| 0.90 to 4.75, excl                 | 0.04                                    |

2.2.2.1 Width tolerances shall be  $\pm 0.12$  millimeter for specified widths 1.56 to 9.38 millimeters, exclusive.

2.3 Hot Finished Bars:

2.3.1 Hot Rolled:

2.3.1.1 Rounds and Squares: See Table 5. Out-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same cross section. Out-of-square is the difference in the two dimensions at the same cross section of a square bar, each dimension being the distance between opposite faces.

TABLE 5 - Diameter or Thickness Tolerances

| Specified<br>Diameter or Thickness<br>Millimeters | Tolerance<br>Millimeters<br>Plus | Tolerance<br>Millimeter<br>Minus | Out-of-Round<br>or Out-of-Square<br>Millimeters |
|---------------------------------------------------|----------------------------------|----------------------------------|-------------------------------------------------|
| 6.25 to 7.80, incl                                | 0.12                             | 0.12                             | 0.20                                            |
| Over 7.80 to 11.00, incl                          | 0.15                             | 0.15                             | 0.22                                            |
| Over 11.00 to 15.75, incl                         | 0.18                             | 0.18                             | 0.25                                            |
| Over 15.75 to 22.00, incl                         | 0.20                             | 0.20                             | 0.30                                            |
| Over 22.00 to 25.00, incl                         | 0.22                             | 0.22                             | 0.32                                            |
| Over 25.00 to 28.00, incl                         | 0.25                             | 0.25                             | 0.38                                            |
| Over 28.00 to 31.00, incl                         | 0.28                             | 0.28                             | 0.40                                            |
| Over 31.00 to 34.00, incl                         | 0.30                             | 0.30                             | 0.45                                            |
| Over 34.00 to 37.50, incl                         | 0.35                             | 0.35                             | 0.52                                            |
| Over 37.50 to 50.00, incl                         | 0.40                             | 0.40                             | 0.58                                            |
| Over 50.00 to 62.50, incl                         | 0.80                             | 0                                | 0.58                                            |
| Over 62.50 to 87.50, incl                         | 1.20                             | 0                                | 0.88                                            |
| Over 87.50 to 115.00, incl                        | 1.60                             | 0                                | 1.15                                            |
| Over 115.00 to 138.00, incl                       | 2.00                             | 0                                | 1.45                                            |
| Over 138.00 to 165.00, incl                       | 3.15                             | 0                                | 1.75                                            |
| Over 165.00 to 200.00, incl                       | 3.90                             | 0                                | 2.12                                            |

2.3.1.2 Hexagons and Octagons: See Table 6.

TABLE 6 - Thickness Tolerances

| Specified Thickness<br>Millimeters | Tolerance<br>Millimeters<br>Plus and Minus | Maximum Difference<br>3 Measurements<br>Hexagons Only<br>Millimeters |
|------------------------------------|--------------------------------------------|----------------------------------------------------------------------|
| 6.25 to 12.50, incl                | 0.18                                       | 0.28                                                                 |
| Over 12.50 to 25.00, incl          | 0.25                                       | 0.38                                                                 |
| Over 25.00 to 37.50, incl          | 0.52                                       | 0.62                                                                 |
| Over 37.50 to 50.00, incl          | 0.78                                       | 0.78                                                                 |
| Over 50.00 to 62.50, incl          | 1.18                                       | 1.18                                                                 |
| Over 62.50 to 87.50, incl          | 1.56                                       | 1.56                                                                 |

2.3.1.3 Flats: See Table 7 and Table 8.

TABLE 7 - Thickness Tolerances, Millimeters; For Thickness Ranges, Millimeters

| Specified Width<br>Millimeters |  | 3.10 to<br>12.50,<br>Inc.<br>Plus<br>and<br>Minus | Over<br>12.5 to<br>25.00,<br>Incl<br>Plus<br>and<br>Minus | Over<br>25.00 to<br>50.00,<br>Incl<br>Plus<br>and<br>Minus | Over<br>50.00 to<br>100.00,<br>Incl<br>Plus | Over<br>50.00 to<br>100.00,<br>Incl<br>Minus | Over<br>100.00 to<br>150.00,<br>Incl<br>Plus | Over<br>100.00 to<br>150.00,<br>Incl<br>Minus | Over<br>150.00 to<br>200.00,<br>Incl<br>Plus | Over<br>150.00 to<br>200.00,<br>Incl<br>Minus |
|--------------------------------|--|---------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------|---------------------------------------------|----------------------------------------------|----------------------------------------------|-----------------------------------------------|----------------------------------------------|-----------------------------------------------|
|                                |  |                                                   |                                                           |                                                            |                                             |                                              |                                              |                                               |                                              |                                               |
| Up to 25.00, incl              |  | 0.20                                              | 0.25                                                      | -                                                          | -                                           | -                                            | -                                            | -                                             | -                                            | -                                             |
| Over 25.00 to 50.00, incl      |  | 0.30                                              | 0.38                                                      | 0.78                                                       | -                                           | -                                            | -                                            | -                                             | -                                            | -                                             |
| Over 50.00 to 100.00, incl     |  | 0.38                                              | 0.50                                                      | 0.78                                                       | 1.55                                        | 0.78                                         | -                                            | -                                             | -                                            | -                                             |
| Over 100.00 to 150.00, incl    |  | 0.38                                              | 0.50                                                      | 0.78                                                       | 1.55                                        | 0.78                                         | 2.32                                         | 1.55                                          | -                                            | -                                             |
| Over 150.00 to 200.00, incl    |  | 0.40                                              | 0.62                                                      | 0.78                                                       | 1.55                                        | 0.78                                         | 2.32                                         | 1.55                                          | 3.12                                         | 3.90                                          |
| Over 200.00 to 250.00, incl    |  | 0.52                                              | 0.78                                                      | 0.78                                                       | 1.55                                        | 0.78                                         | 2.32                                         | 1.55                                          | 3.12                                         | 3.90                                          |

TABLE 8 - Width Tolerances

| Specified Width<br>Millimeters | Tolerance, Millimeters |       |
|--------------------------------|------------------------|-------|
|                                | Plus                   | Minus |
| Up to 25.00, incl              | 0.38                   | 0.38  |
| Over 25.00 to 50.00, incl      | 0.78                   | 0.78  |
| Over 50.00 to 100.00, incl     | 1.55                   | 0.78  |
| Over 100.00 to 150.00, incl    | 2.32                   | 1.55  |
| Over 150.00 to 200.00, incl    | 3.12                   | 3.90  |
| Over 200.00 to 250.00, incl    | 3.90                   | 4.68  |

2.3.2 Forged: Tolerances shall be as agreed upon by purchaser and vendor.

### 3. LENGTH:

Tolerances in Table 9 and Table 10 shall apply only when definite lengths are ordered.

#### 3.1 Hot or Cold Finished Bars:

See Table 9.