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**TYPE 203S — FREE MACHINING**

**STAINLESS BARS**

**UNS S20300**

**Color Marking:** Bars — Ends White with Red Stripe

Type 203S is a chromium — nickel — manganese — copper stainless steel modified by the addition of sulphur to improve machinability. It is austenitic and non-magnetic in the annealed condition. This grade is equivalent to 303 in regard to corrosion resistance. Machinability is equal to or better than 303 with higher speeds possible on automatic machines resulting in better finishes.

**ANALYSIS**

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>.08</td>
<td>5.00/6.50</td>
<td>.04</td>
<td>.18/.35</td>
<td>.20/.70</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Ni</th>
<th>Cr</th>
<th>Cu</th>
<th>Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>5.00/6.50</td>
<td>16.00/18.00</td>
<td>1.75/2.25</td>
<td>.50</td>
</tr>
</tbody>
</table>

**SPECIFICATIONS** — The following specifications are generally applicable:

AMS 5762, ASTM A 582, (XM1)

**APPLICATIONS** — The grade is used for parts requiring machining, grinding or polishing where good corrosion resistance is required. Provides an alternate choice to 303.

**PROPERTIES** — Mechanical properties, corrosion resistance, machinability, weldability, and formality are all equivalent to 303.

---

**TYPE 203S**

**Condition A — Annealed**

Stock Lengths 10' to 12'

<table>
<thead>
<tr>
<th>Size In Inches</th>
<th>Est. Wt., Lbs. Per Foot</th>
<th>Condition</th>
<th>Est. Wt., Lbs. Per Foot</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cold Drawn</td>
<td>Ground</td>
<td>Ground (Continued)</td>
<td></td>
</tr>
<tr>
<td>1/8</td>
<td>.0418</td>
<td>.0418</td>
<td>1 1/16</td>
<td>3.017</td>
</tr>
<tr>
<td>3/16</td>
<td>.0940</td>
<td>1.128</td>
<td>1/8</td>
<td>3.383</td>
</tr>
<tr>
<td>1/4</td>
<td>.1671</td>
<td>2.005</td>
<td>3/16</td>
<td>4.176</td>
</tr>
<tr>
<td>5/16</td>
<td>.2610</td>
<td>3.132</td>
<td>7/16</td>
<td>4.604</td>
</tr>
<tr>
<td>3/8</td>
<td>.3759</td>
<td>4.510</td>
<td>1/4</td>
<td>5.053</td>
</tr>
<tr>
<td>7/16</td>
<td>.5116</td>
<td>6.139</td>
<td>9/16</td>
<td>5/16</td>
</tr>
<tr>
<td>1/2</td>
<td>.6682</td>
<td>8.019</td>
<td>11/16</td>
<td>6/8</td>
</tr>
<tr>
<td>9/16</td>
<td>.8457</td>
<td>10.15</td>
<td>3/4</td>
<td>8/8</td>
</tr>
<tr>
<td>5/8</td>
<td>1.044</td>
<td>12.53</td>
<td>7/8</td>
<td>10.69</td>
</tr>
<tr>
<td>11/16</td>
<td>1.263</td>
<td>15.16</td>
<td>1 1/16</td>
<td>13.53</td>
</tr>
<tr>
<td>3/4</td>
<td>1.504</td>
<td>18.04</td>
<td>1/2</td>
<td>16.71</td>
</tr>
</tbody>
</table>

Sec. I Page 2
TYPE 301

High Tensile Stainless Sheets

UNS S30100

This is a “17-7” grade of chromium—nickel stainless steel, manufactured by the electric-furnace process. Sufficient discard is taken from each ingot to insure sound steel required to meet the exacting requirements of the aircraft industry. Type 301 is not hardenable by heat treatment, and the high tensile properties of the sheets are the result of cold working.

ANALYSIS

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
<th>Cr</th>
<th>Ni</th>
<th>Cu</th>
<th>Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>.15</td>
<td>2.00</td>
<td>.045</td>
<td>.030</td>
<td>1.00</td>
<td>16.00/18.00</td>
<td>6.00/8.00</td>
<td>.50</td>
<td>.50</td>
</tr>
</tbody>
</table>

SPECIFICATIONS — The following specifications are generally applicable:
- ASTM A 666, AMS 5518, AMS 5517.

APPLICATIONS — Structural parts where a corrosion-resisting steel is required but where gas or arc welding and elevated temperatures are not involved. This material is used in application requiring higher strength characteristics that are found in annealed sheets.

CORROSION RESISTANCE — The corrosion-resisting properties of Type 301 are comparable to those of Type 304, data for which will be found on Page 4.

MECHANICAL PROPERTIES

<table>
<thead>
<tr>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Min. Elongation in 2”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition 1/4 Hard</td>
<td>125,000 Min.</td>
<td>75,000 Min.</td>
</tr>
<tr>
<td>Condition 1/2 Hard</td>
<td>150,000 Min.</td>
<td>110,000 Min.</td>
</tr>
</tbody>
</table>

WELDABILITY — Easily welded by all the commercial processes except forge or hammer welding. The resulting weld has good toughness and ductility. Annealing is recommended after welding to maintain maximum corrosion resistance.

TYPE 301

HIGH TENSILE SHEETS — 1/4 AND 1/2 HARD

No. 2B Finish — Bright Cold Rolled

Stock Size 36” x 120”

<table>
<thead>
<tr>
<th>Thickness in Inches</th>
<th>Estimated Weight, Lbs.</th>
<th>Thickness in Inches</th>
<th>Estimated Weight, Lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Sq. Ft.</td>
<td>Per Sheet</td>
<td>Per Sq. Ft.</td>
</tr>
</tbody>
</table>

| .012                    | .504        | 15.1                  | .012                    | .504        | 15.1                  |
| .016                    | .672        | 20.2                  | .016                    | .672        | 20.2                  |
| .0161                   | .676        | 20.3                  | .0161                   | .676        | 20.3                  |
| .020                    | .840        | 25.2                  | .020                    | .840        | 25.2                  |
| .025                    | 1.050       | 31.5                  | .025                    | 1.050       | 31.5                  |
| .032                    | 1.344       | 40.3                  | .032                    | 1.344       | 40.3                  |
| .036                    | 1.512       | 45.4                  | .036                    | 1.512       | 45.4                  |
| .040                    | 1.680       | 50.4                  | .040                    | 1.680       | 50.4                  |
| .050                    | 2.100       | 63.0                  | .050                    | 2.100       | 63.0                  |
| .063                    | 2.646       | 79.4                  | .063                    | 2.646       | 79.4                  |
| .080                    | 3.360       | 100.8                 | .080                    | 3.360       | 100.8                 |
| .090                    | 3.780       | 113.4                 | .090                    | 3.780       | 113.4                 |
| .125                    | 5.250       | 157.5                 | .125                    | 5.250       | 157.5                 |

Sec. I Page 3
Types 304 and 304L
Sheets, Plates, Bars, Angles
UNS S30400, 30403

Color Marking
Type 304 Bars, Angles — Pink and White
Type 304L Bars — Pink with Brown Stripe

Type 304 is the basic "18 — 8" chromium-nickel stainless steel. It combines excellent mechanical properties with remarkable resistance to many corrosive agents encountered in domestic and industrial use. It is non-magnetic in the annealed condition and not hardenable by heat treatment. Both hardness and tensile strength can be increased by cold working. This is an electric-furnace product manufactured to meet the exacting standards of the aircraft industry.

The analysis of Type 304 is similar to that of Type 304L except that Type 304L is modified by lowered carbon content. This provides good resistance to corrosion in welded construction where subsequent heat treatment is not practicable. Bars and Plates are available not only in the regular Type 304 analysis, but also in an extra low carbon analysis Type 304L. The advantage of this analysis is that it precludes any harmful precipitation in the 800º — 1500ºF range, such as might otherwise occur in welding heavier sections.

<table>
<thead>
<tr>
<th>ANALYSIS</th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
<th>Cr</th>
<th>Ni</th>
<th>Cu</th>
<th>Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>304</td>
<td>.08</td>
<td>2.00</td>
<td>.040</td>
<td>.030</td>
<td>1.00</td>
<td>18.00/20.00</td>
<td>8.00/10.50</td>
<td>.75</td>
<td>.75</td>
</tr>
<tr>
<td>304L</td>
<td>.03</td>
<td>2.00</td>
<td>.040</td>
<td>.030</td>
<td>1.00</td>
<td>18.00/20.00</td>
<td>8.00/12.00</td>
<td>.75</td>
<td>.75</td>
</tr>
</tbody>
</table>

SPECIFICATIONS — The following specifications are generally applicable:
Sheets & Plates: AMS 5513, ASTM A 167, ASTM A 240
Bars: AMS 5639, ASTM A 276, ASTM A 479

APPLICATIONS — Used where corrosion resistance and good mechanical properties are primary requirements. These grades are widely accepted in such industries as dairy, beverage, and other food products where the highest degree of sanitation and cleanliness is of prime importance. Parts for handling acetic, nitric, and citric acids, organic and inorganic chemicals, dyestuffs, crude and refined oils, etc., are fabricated from this material. Because of its lack of magnetism it is highly desirable for instruments. It is also widely used for architectural trim. Type 304 sheets are used in aircraft applications where corrosion resistance is required, but where gas or arc welding and elevated temperatures are not involved. Type 304L, as noted above, finds particular use in applications requiring welding.

CORROSION RESISTANCE — Types 304 and 304L show good resistance to corrosion. They are highly resistant to strong oxidizing acids, such as nitric acid, and resist attack by a wide variety of organic and inorganic chemicals. Maximum corrosion resistance is obtained in the annealed condition. Intergranular corrosion may occur when material is heated within or cooled through the range of 800º to 1500ºF.

RESISTANCE TO SCALING — Excellent scale resistance at temperatures up to 1600ºF in continuous service. Chromium-nickel grades have a high coefficient of expansion, which should be considered in designing.

MECHANICAL PROPERTIES — Applicable specifications require the following properties of sheets in the annealed condition:

<table>
<thead>
<tr>
<th>Tensile Strength (psi)</th>
<th>Min. Elongation in 2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>.015&quot; Thick and Under</td>
<td>.016&quot; Thick to .030&quot;</td>
</tr>
</tbody>
</table>

Type 304 100,000 Max. 40% 40% 40%

In practice, annealed sheets and plates will average as follows:

<table>
<thead>
<tr>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Elongation in 2&quot;</th>
<th>Rockwell “B” Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>90,000</td>
<td>40,000</td>
<td>50%</td>
<td>85</td>
</tr>
</tbody>
</table>

MACHINABILITY — Types 304 and 304L have a machinability rating of approximately 45% with 1212 rated as 100%. Surface cutting speed on automatic screw machines is approximately 75 feet per minute.
TYPES 304 AND 304L STAINLESS (Continued)

WELDABILITY — Easily welded by all the commercial processes except forging or hammer welding. The resulting weld had good toughness and ductility. Annealing is recommended after welding to maintain maximum corrosion resistance.

FORMING — These grades have very good drawing and stamping properties.

FORGING — Forge between 2100° and 2350°F. Do not forge below 1700°F.

ANNEALING — Annealing range is between 1850° and 2050°F. Cool rapidly.

Water should be used for heavier sections; air for lighter sections. The stress relieving range is between 400° and 750°F.

---

### TYPES 304 & 304L STAINLESS SHEETS

<table>
<thead>
<tr>
<th>Annealed (Physical Condition A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 2B Finish — Bright Cold Rolled</td>
</tr>
<tr>
<td>No. 2D Finish — Dull Cold Rolled</td>
</tr>
<tr>
<td>No. 3 Finish — Polished One Side</td>
</tr>
<tr>
<td>No. 4 Finish — Polished One Side</td>
</tr>
</tbody>
</table>

#### Thickness

<table>
<thead>
<tr>
<th>Width &amp; Length</th>
<th>Est. Wt. per Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thick-ness</td>
<td>Inches</td>
</tr>
<tr>
<td>.016&quot; (28 Ga.)</td>
<td>.672 Lb. Sq. Ft.</td>
</tr>
<tr>
<td>.0176&quot; (24 Ga.)</td>
<td>1.624 Lb. Sq. Ft.</td>
</tr>
<tr>
<td>.0178&quot; (24 Ga.)</td>
<td>1.640 Lb. Sq. Ft.</td>
</tr>
<tr>
<td>.0179&quot; (24 Ga.)</td>
<td>1.650 Lb. Sq. Ft.</td>
</tr>
</tbody>
</table>

#### Width & Est. Wt.

<table>
<thead>
<tr>
<th>thick-ness</th>
<th>length lbs. per</th>
</tr>
</thead>
<tbody>
<tr>
<td>.016&quot;</td>
<td>Length</td>
</tr>
<tr>
<td>.0176&quot;</td>
<td>Length</td>
</tr>
<tr>
<td>.0178&quot;</td>
<td>Length</td>
</tr>
<tr>
<td>.0179&quot;</td>
<td>Length</td>
</tr>
</tbody>
</table>

#### Width & Est. Wt.

<table>
<thead>
<tr>
<th>.016&quot;</th>
<th>.0176&quot;</th>
<th>.0178&quot;</th>
<th>.0179&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
<td>.0179&quot;</td>
</tr>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
<td>.0179&quot;</td>
</tr>
</tbody>
</table>

#### Width & Est. Wt.

<table>
<thead>
<tr>
<th>Thick-ness</th>
<th>Width &amp; Length</th>
<th>Est. Wt. per Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
</tbody>
</table>

#### Width & Est. Wt.

<table>
<thead>
<tr>
<th>Thick-ness</th>
<th>Width &amp; Length</th>
<th>Est. Wt. per Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
</tbody>
</table>

---

### TYPES 304 & 304L PLATES

Hot Rolled, Annealed, and Pickled

Stocked in Thicknesses from 3/16" through 41/2", Widths from 48" to 96", and Lengths up to 20’.

#### Width & Est. Wt.

<table>
<thead>
<tr>
<th>Thick-ness</th>
<th>Width &amp; Length</th>
<th>Est. Wt. per Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
</tbody>
</table>

#### Width & Est. Wt.

<table>
<thead>
<tr>
<th>Thick-ness</th>
<th>Width &amp; Length</th>
<th>Est. Wt. per Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
</tbody>
</table>

#### Width & Est. Wt.

<table>
<thead>
<tr>
<th>Thick-ness</th>
<th>Width &amp; Length</th>
<th>Est. Wt. per Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
</tbody>
</table>

---

### TYPES 304 & 304L ANGLES

Hot Rolled, Annealed and Pickled

Stock Lengths 20’ to 22’

#### Size in Inches

<table>
<thead>
<tr>
<th>Thick-ness</th>
<th>Width &amp; Length</th>
<th>Est. Wt. per Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
</tbody>
</table>

#### Size in Inches

<table>
<thead>
<tr>
<th>Thick-ness</th>
<th>Width &amp; Length</th>
<th>Est. Wt. per Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
<tr>
<td>.016&quot;</td>
<td>.0176&quot;</td>
<td>.0178&quot;</td>
</tr>
</tbody>
</table>

---

Sec. 1 Page 5
### TYPES 304 AND 304L ROUNDS

**Conditioned A — Annealed**

**Stock Lengths 10' to 12' and 20' to 22'**

<table>
<thead>
<tr>
<th>Size Est. Wt., Lbs.</th>
<th>Hot Rolled, Ann., Rough Turned</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td><strong>Per 12-Ft. Bar</strong></td>
</tr>
<tr>
<td><strong>Inches</strong></td>
<td><strong>Foot</strong></td>
</tr>
<tr>
<td>3/8</td>
<td>.107</td>
</tr>
<tr>
<td>5/32</td>
<td>.129</td>
</tr>
<tr>
<td>7/32</td>
<td>.161</td>
</tr>
<tr>
<td>1/4</td>
<td>.193</td>
</tr>
<tr>
<td>5/16</td>
<td>.297</td>
</tr>
<tr>
<td>3/8</td>
<td>.367</td>
</tr>
<tr>
<td>1/2</td>
<td>.940</td>
</tr>
<tr>
<td>5/8</td>
<td>1.430</td>
</tr>
<tr>
<td>3/4</td>
<td>2.658</td>
</tr>
<tr>
<td>7/8</td>
<td>3.888</td>
</tr>
<tr>
<td>1</td>
<td>6.014</td>
</tr>
</tbody>
</table>

### TYPES 304 AND 304L C.D. HEXAGONS

**Cond. A — Annealed**

**Stock Lengths 10' to 12'**

<table>
<thead>
<tr>
<th>Size Est. Wt., Lbs.</th>
<th><strong>Ann. &amp; C.D.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td><strong>Per 12-Ft. Bar</strong></td>
</tr>
<tr>
<td><strong>Inches</strong></td>
<td><strong>Foot</strong></td>
</tr>
<tr>
<td>3/8</td>
<td>.631</td>
</tr>
<tr>
<td>1/2</td>
<td>9.026</td>
</tr>
<tr>
<td>7/8</td>
<td>10.364</td>
</tr>
<tr>
<td>11/16</td>
<td>14.92</td>
</tr>
<tr>
<td>3/4</td>
<td>20.31</td>
</tr>
<tr>
<td>13/16</td>
<td>24.36</td>
</tr>
</tbody>
</table>

### TYPES 304 AND 304L SQUARES

**Cond. A — Annealed**

**Stock Lengths 10' to 12'**

<table>
<thead>
<tr>
<th>Size Est. Wt., Lbs.</th>
<th><strong>Ann. &amp; C.D.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td><strong>Per 12-Ft. Bar</strong></td>
</tr>
<tr>
<td><strong>Inches</strong></td>
<td><strong>Foot</strong></td>
</tr>
<tr>
<td>1/4</td>
<td>.184</td>
</tr>
<tr>
<td>3/8</td>
<td>.572</td>
</tr>
<tr>
<td>1/2</td>
<td>9.026</td>
</tr>
<tr>
<td>1</td>
<td>11.79</td>
</tr>
<tr>
<td>3/4</td>
<td>18.42</td>
</tr>
<tr>
<td>1</td>
<td>26.53</td>
</tr>
</tbody>
</table>

### Notes

- Types 304 and 304L are stainless steel types.
- Dimensions and weights are provided for various sizes and conditions.
- Stock lengths vary from 10' to 12' and 20' to 22'.
- Table includes sizes and estimated weights per foot and per bar.
- Additional tables for hexagons and squares are also provided.

Sec. I Page 6
### TYPES 304 AND 304L STAINLESS

#### TYPES 304 & 304L FLATS

**Hot Rolled, annealed, & Pickled**

**Stock Lengths 10' to 12'**

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Sec. I Page 7
TYPES 303S and 303Se — FREE MACHINING

Stainless Bars

UNS S30300, S30323

Color Marking

Type 303S — Annealed Bars and Pump Shafting: Ends painted Red
High Tensile Bars (Condition B): Ends painted Gray & Orange

Type 303Se — Annealed Bars: Ends painted Purple
High Tensile Bars (Condition B): Ends painted Brown

Type 303 is “18-8” chromium-nickel stainless steel modified by the addition of selenium or sulfur, as well as phosphorus, to improve machinability and non-seizing properties. It is the most readily machinable of all the chromium-nickel grades and has good corrosion resistance. It is non-magnetic in the annealed condition and not hardenable by heat treatment. Tensile strength and hardness can be increased by cold working. It is manufactured by the electric-furnace process and meets the exacting requirements of the aircraft industry.

ANALYSIS

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<td>1.00</td>
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SPECIFICATIONS — The following specifications are generally applicable:
AMS 5640, ASTM A 314, ASTM A 320, ASTM A 582

APPLICATIONS — Used almost exclusively for parts requiring machining, grinding, or polishing where good corrosion resistance is also required. Its non-seizing and non-galling properties make it ideal for moving parts. Being an austenitic steel, it is useful where low magnetic permeability is desired.

CORROSION RESISTANCE — Because of the elements which are added to improve machinability, Type 303 has slightly less general corrosion resistance than the regular chromium-nickel grades such as Type 304. Maximum corrosion resistance is obtained in the annealed condition.

RESISTANCE TO SCALING — This grade has excellent scale resistance at temperatures up to 1600°F in continuous service. Like other chromium-nickel grades, it has a high coefficient of expansion which should be considered in designing.

MECHANICAL PROPERTIES

<table>
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<tr>
<th>Condition</th>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Elongation in 2&quot;</th>
<th>Reduction of Area</th>
<th>Brinell Hardness</th>
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<tr>
<td>Cond. A (Annealed)</td>
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<tr>
<td>½&quot; and under</td>
<td>125,000</td>
<td>Max</td>
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<td>140/255</td>
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<tr>
<td>Over ½&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>140/255</td>
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<td>Cond. B (High Tensile)</td>
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<td>Up to ¾&quot;</td>
<td>125,000 Min.</td>
<td>100,000</td>
<td>12%</td>
<td>35%</td>
<td>321 Max.</td>
</tr>
<tr>
<td>Over ¾&quot; to 1&quot;</td>
<td>115,000 Min.</td>
<td>80,000</td>
<td>15%</td>
<td>35%</td>
<td>321 Max.</td>
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<td>Over 1&quot; to 1¼&quot;</td>
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<td>65,000</td>
<td>20%</td>
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<td>321 Max.</td>
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<td>Over 1¼&quot; to 1½&quot;</td>
<td>100,000 Min.</td>
<td>50,000</td>
<td>28%</td>
<td>45%</td>
<td>321 Max.</td>
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<td>Over 1½&quot; to 2&quot;</td>
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<td>45,000</td>
<td>28%</td>
<td>45%</td>
<td>321 Max.</td>
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In practice, annealed bars will average as follows:

<table>
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<th>Condition</th>
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<th>Yield Strength (psi)</th>
<th>Elongation in 2&quot;</th>
<th>Reduction of Area</th>
<th>Izod Impact Ft. Lbs.</th>
<th>Brinell Hardness</th>
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<td>55%</td>
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<td>53%</td>
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MACHINABILITY — Type 303 has considerably better machining characteristics than the other chromium-nickel grades. It has machinability rating of approximately 78% with 1212 rated 100%. Surface cutting speed on automatic screw machines is approximately 130 feet per minute.

WELDABILITY — This grade has only fair welding properties.

FORMING — This grade has fairly good forming properties.

FORGING — Forge between 2100° and 2350°F. Do not forge below 1700°F.

ANNEALING — Annealing range is between 1850° and 2050°F. Cool rapidly. Water should be used for heavier sections; air for lighter sections. The stress relieving range is between 400° and 750°F.
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<th>Size In</th>
<th>Est. Wt., Lbs.</th>
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### TYPE 303 STAINLESS (Continued)

| Size In Inches | Est. Wt., Lbs. Per Foot | Est. Wt., Lbs. Per 12-Ft. Bar | Cold Drawn | Cond. A — Annealed
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### TYPE 303S & 303Se SQUARES

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### TYPE 303S & 303Se FLATS — CONDITION A — ANNEALED

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(Continued)
Types 316 and 317 are “18-8” chromium-nickel stainless steels modified by the addition of molybdenum, which greatly increases the corrosion resistance as well as the mechanical properties at elevated temperatures. These grades are non-magnetic in the annealed condition and not hardenable by heat treatment. Since they have good cold forming and drawing properties, these grades are outstanding stainless steels suitable for a large number of applications. Manufactured by the electric-furnace process, these grades meet the exacting standards of the aircraft industry. Bars and Plates are available not only in the regular Type 316 analysis, but also in an extra low carbon analysis known as Type 316L. The advantage of the reduced carbon content is that it precludes any harmful precipitation in the 800º-1500ºF range, such as might otherwise occur in welding heavier sections. Types 317 and 317L are available in plate and with increased chromium, nickel, and molybdenum contents can be used in even more severe corrosive and high temperature applications.

**ANALYSIS**

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<td>3.00/4.00</td>
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**SPECIFICATIONS** — The following specifications are generally applicable:

**Types 316 and 316L:**
- Sheets & Plates: ASTM A 167, ASTM A 240, QQ-S-766, AMS 5524, AMS 5507
- Bars & Angles: AMS 5648, AMS QQ-S-763, ASTM A 276, ASTM A 479

**Types 317 and 317L:**
- Plates: ASTM A 240

**APPLICATIONS** — Widely used in the paper, textile, and chemical industries, where parts are subjected to the corrosive effects of salts and reducing acids. Also used in the manufacture of pharmaceuticals in order to avoid excessive metallic contamination. Because Type 316 possesses the highest creep and tensile strength at elevated temperatures than any of the more commonly used stainless steels, it finds extensive use where the combination of high strength and good corrosion resistance at elevated temperatures is required. In aircraft applications, Type 316 is used for parts requiring good corrosion resistance and low magnetic permeability. Types 317 and 317L, with higher alloy content, would be suitable for the more severe corrosion applications.
TYPES 316 AND 317 STAINLESS (Continued)

CORROSION RESISTANCE — Types 316 and 317 are more resistant to atmospheric and general corrosive conditions than any of the other standard stainless steels. They have good resistance to the corrosive effects of sulphates, phosphates, and other salts as well as reducing acids such as sulphuric, sulphurous, and phosphoric. These grades are less susceptible to pitting in applications where acetic acid vapors or solutions of chlorides, bromides, or iodides are encountered. When heated to within the temperature range of 800º-1500ºF, or when slowly cooled through this range, these grades are subject to intergranular corrosion. If the application requires this, then the low carbon version, Types 316L and 317L, should be used.

RESISTANCE TO SCALING — Excellent scale resistance at temperatures up to 1650ºF in continuous service.

MECHANICAL PROPERTIES — Applicable specifications require the following properties of material in the annealed condition:

<table>
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<th>Tensile Strength (psi)</th>
<th>Yield Strength Min. (psi)</th>
<th>Elongation in 2&quot; Min.</th>
<th>Reduction of Area Min.</th>
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<td>30,000</td>
<td>40%</td>
<td>——</td>
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<tr>
<td>H.R. Bars</td>
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<td>50%</td>
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<td>75,000 Min.</td>
<td>30,000</td>
<td>35%</td>
<td>50%</td>
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MACHINABILITY — Types 316 and 317 have a machinability rating of approximately 45%, with 1212 rated 100%. Surface cutting speed on automatic screw machines is approximately 75 feet per minute.

WELDABILITY — Easily welded by all the commercial processes except forge or hammer welding. Annealing after welding is recommended to obtain maximum corrosion resistance.

FORMING — These grades have good drawing and stamping properties.

FORGING — Forge between 2100º and 2300ºF. Do not forge below 1700ºF.

ANNEALING — Annealing range is between 1850º and 2050ºF. Cool rapidly. Water should be used for heavier sections; air for lighter sections. The stress relieving range is between 400º and 750ºF.
### Types 316 & 317 Stainless

#### Types 316 & 316L Angles

Hot Rolled, Annealed, and Pickled
Stock Lengths 20’ to 22’

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<th>Size</th>
<th>Est. Weight, Lbs.</th>
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<td>Per Foot</td>
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<td>2.34</td>
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<tr>
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<td>x 1 1/4 x 1/8</td>
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<tr>
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<td>x 1 1/2 x 1/8</td>
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#### Types 316 Squares

Annealed
Stock Lengths 10’ to 12’

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#### Types 316, 316L, 317, & 317L Sheets

No. 2B Finish
Bright Cold Rolled
Annealed and Pickled

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#### Types 316, 316L, 317, & 317L Plates

Hot Rolled, Annealed, and Pickled

Stocked in Thickness from 3/16” through 4”, Widths from 48” to 72”, and Lengths up to 20’.
### TYPES 316 & 317 STAINLESS

#### TYPES 316 & 316L ROUNDS

**Annealed**

Stock Lengths 10' to 12' and 20' to 22'

<table>
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<tr>
<th>Size Est. Wt., Lbs.</th>
<th>Per Foot</th>
<th>12-Ft. Bar</th>
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<tbody>
<tr>
<td>In Inches</td>
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<tr>
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<td>.5012</td>
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<td>15.16</td>
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### Cold Drawn

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### Hot Rolled & Rough Turned

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### Precision Pump Shafting

**Annealed & Cold Drawn**

Stock Lengths 20' to 22'

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Type 321
Sheets, Plates, and Bars
UNS S32100

Color Marking
Bars: Ends painted Black
Plates: Corner Striped Black

Type 321 is “18-8” chromium-nickel stainless steel modified by the addition of titanium to overcome the danger of intergranular corrosion, common to other austenitic stainless steels during or after exposure to temperatures of 800º to 1500ºF. This type is non-magnetic in the annealed condition and not hardenable by heat treatment. It is manufactured by the electrical-furnace process to meet the rigid requirements of the aircraft industry.

ANALYSIS

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<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
<th>Cr</th>
<th>Ni</th>
<th>Ti</th>
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SPECIFICATIONS — The following specifications are generally applicable:
Sheets & Plates: QQ-S-766, AMS 5510, ASTM A 240
Bars: AMS QQ-S-763, AMS 5645, ASTM A 276, ASTM A 314, ASTM A 479

APPLICATIONS — Used where freedom from intergranular corrosion is desired and milder corrosive conditions exist. It is used in parts subjected to sustained heating in or slow cooling through the range of 800º to 1500ºF. It is well suited for cold-drawing and forming operations. In aircraft, it is used particularly for such applications as exhaust stacks, manifolds, and ring collectors.

CORROSION RESISTANCE — Type 321 is resistant to intergranular corrosion. Its general corrosion resistance is somewhat less than that of type 304. It tends to form a light rust film in corrosive atmospheres, but this rusting is not progressive.

RESISTANCE TO SCALING — Excellent scale resistance at temperatures up to 1650ºF in continuous service.

MECHANICAL PROPERTIES — Applicable specifications require the following properties of material in the annealed condition:

| Tensile Yield Elongation Reduction |
| Strength | Min. Strength in 2” of Area | Min. | Min. |
| Sheets & Plates | 100,000 Max. | 30,000 | 40% | —— |
| H.R. Bars | 75,000 Min. | 30,000 | 40% | 50% |
| C.F. Bars | 90,000 Min. | 45,000 | 35% | 45% |
| Up to 1/2” incl. | 75,000 Min. | 30,000 | 35% | 50% |

MACHINABILITY — Type 321 has a machinability rating of approximately 36% with 1212 rated 100%. Surface cutting speed on automatic screw machines is approximately 60 feet per minute.

WELDABILITY — Easily welded by all the commercial processes except forge or hammer welding.

FORMING — This grade has good forming and stamping properties.

FORGING — Forge between 2125º and 2275ºF. Cool slowly. Do not forge below 1800ºF.

ANNEALING — Annealing range is 1750º-1950ºF. Cool rapidly. Water should be used for heavier sections; air for lighter sections. The stress relieving range is between 400º and 750ºF.
### TYPE 321 STAINLESS (Continued)

#### TYPE 321 ROUNDS

**Condition A (Annealed)**

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<td>2.78</td>
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<tr>
<td>1/16</td>
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<td>5.21</td>
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<tr>
<td>1/8</td>
<td>4.206</td>
<td>6.25</td>
<td>8.84</td>
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**Size est. Wt., lbs.**

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#### TYPE 321 FLATS

**Size est. Wt., lbs.**

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**Sec. I Page 17**
# TYPE 321 STAINLESS

## TYPE 321 SHEETS

### NO. 2D FINISH

Dull Cold Rolled, Annealed, & Pickled

<table>
<thead>
<tr>
<th>Thickness and Width</th>
<th>Est. Wt., Lbs.</th>
<th>Per Sq. Ft.</th>
<th>Per Sheet</th>
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<tbody>
<tr>
<td>.012&quot; (30 Ga.) 36x120</td>
<td>.504</td>
<td>15.1</td>
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<td>.016&quot; (28 Ga.) 36x120</td>
<td>.672</td>
<td>20.2</td>
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<td>.0161&quot; (27 Ga.) 36x120</td>
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<tr>
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<td>31.5</td>
<td></td>
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<tr>
<td>.032&quot; (22 Ga.) 36x120</td>
<td>1.344</td>
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<td>1.512</td>
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<td>.040&quot; (20 Ga.) 36x120</td>
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<tr>
<td>.045&quot; (19 Ga.) 36x120</td>
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<td>.090&quot; (13 Ga.) 36x120</td>
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<tr>
<td>.156&quot; (9 Ga.) 36x120</td>
<td>6.552</td>
<td>196.6</td>
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Stocked in Thickness from 3/16" through 1-1/2", Widths from 48" to 96", and Lengths up to 20'.

## TYPE 321 SQUARES

### Condition A (Annealed)

3/4" & Under — Brinell 170-255
Over 3/4" — Brinell 140-241

Stock Lengths 10' to 12'

<table>
<thead>
<tr>
<th>Size In Inches</th>
<th>Estimated Weight, Lbs.</th>
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</thead>
<tbody>
<tr>
<td>Per Foot</td>
<td>12-Ft. Length</td>
</tr>
<tr>
<td>Per Foot</td>
<td>12-Ft. Length</td>
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<tr>
<td>Per Foot</td>
<td>12-Ft. Length</td>
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<td>Per Foot</td>
<td>12-Ft. Length</td>
</tr>
<tr>
<td>Per Foot</td>
<td>12-Ft. Length</td>
</tr>
</tbody>
</table>

### Annealed and Cold Drawn

1/4
.2127 2.552
3/8
.4786 5.743
1/2
.8508 10.21
5/8
1.329 15.95
3/4
1.914 22.97
7/8
2.606 31.27

1
3.403 40.84
1/4
5.318 63.81
1/2
7.657 91.89

### Hot Rolled, Annealed, & Pickled

1
8.987 107.8
3/8
10.42 125.1
1/2
13.61 163.4
1/4
17.23 206.7
1/2
21.27 255.2
3/4
25.74 308.8
3
30.63 367.5
1/2
41.69 500.3
4
54.45 653.4

## TYPE 321 COLD DRAWN HEXAGONs

### Condition A (Annealed)

Brinell same as shown above for squares.

Stock Lengths 10' to 12'

<table>
<thead>
<tr>
<th>Size In Inches</th>
<th>Est. Wt., Lbs.</th>
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</thead>
<tbody>
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</tr>
<tr>
<td>Per Foot</td>
<td>20-Ft. Bar</td>
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<tr>
<td>Per Foot</td>
<td>20-Ft. Bar</td>
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<tr>
<td>Per Foot</td>
<td>20-Ft. Bar</td>
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<td>Per Foot</td>
<td>20-Ft. Bar</td>
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<td>Per Foot</td>
<td>20-Ft. Bar</td>
</tr>
<tr>
<td>Per Foot</td>
<td>20-Ft. Bar</td>
</tr>
</tbody>
</table>

1/4 .1843 2.210
3/8 .4145 4.973
1/2 .7388 8.842
5/16 .9325 11.19

5/8 1.151 13.82
11/16 1.393 16.72
3/4 1.658 19.89
13/16 1.946 23.35

7/8 2.257 27.08
1 2.947 35.37
1 3.730 44.76
1 4.605 55.26
1 9.026 108.3
1 10.36 124.3
1 11.79 141.5

Sec. I Page 18
The material described is Type 347, a stainless steel modified to prevent intergranular corrosion, suitable for use in high-temperature environments.

**Type 347**

**Sheets, Plates, and Bars**

**UNS S34700**

**Color Marking**

**Bars:** Ends painted White  
**Plates:** Corner striped White

Type 347 is “18-8” chromium-nickel stainless steel modified by the addition of columbium and tantalum to overcome the dangers of intergranular corrosion common to other austenitic stainless steels during or after exposure to temperatures of 800º to 1500ºF. It is non-magnetic in the annealed condition and not hardenable by heat treatment. This is an electric-furnace product and meets the exacting requirements of the aircraft industry.

### ANALYSIS

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<tr>
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<tbody>
<tr>
<td></td>
<td>.08</td>
<td>2.00</td>
<td>.040</td>
<td>.030</td>
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<td>9.00/12.00</td>
<td>10XC/1.00</td>
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<td>.75</td>
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</table>

**SPECIFICATIONS** — The following specifications are generally applicable:

- **Sheets & Plates:** QQ-S-766, AMS 5512, ASTM A 240, ASTM A 167  
- **Bars:** AMS QQ-S-763, AMS 5646, ASTM A 276, ASTM A 314, ASTM A 479

**APPLICATIONS** — Used for heavy welding assemblies which cannot be annealed after welding. Also used where operating conditions cause exposure within the temperature range between 800º and 1500ºF and where corrosive conditions are severe, such as aircraft exhaust stacks, manifolds and ring collectors. It is used to advantage in combatting corrosion cracking resulting from stress in corrosive media due to vibration or other causes.

**CORROSION RESISTANCE** — Type 347 is resistant to intergranular corrosion. It has about the same general corrosion resistance as Type 304.

**RESISTANCE TO SCALING** — Excellent scale resistance at temperatures up to 1650ºF in continuous service.

**MECHANICAL PROPERTIES** — Applicable specifications require the following properties of material in the annealed condition.

<table>
<thead>
<tr>
<th></th>
<th>Tensile Strength (psi)</th>
<th>Yield Strength Min. (psi)</th>
<th>Elongation in 2” Min.</th>
<th>Reduction of Area Min.</th>
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</thead>
<tbody>
<tr>
<td>Sheets &amp; Plates</td>
<td>100,000 Max.</td>
<td>30,000</td>
<td>40%</td>
<td>———</td>
</tr>
<tr>
<td>H.R. Bars</td>
<td>75,000 Min.</td>
<td>30,000</td>
<td>40%</td>
<td>50%</td>
</tr>
<tr>
<td>C.F. Bars</td>
<td>Up to 1/2” incl.</td>
<td>90,000 Min.</td>
<td>45,000</td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>Over 1/2”</td>
<td>75,000 Min.</td>
<td>30,000</td>
<td>35%</td>
</tr>
</tbody>
</table>

**MACHINABILITY** — Type 347 has a machinability rating of approximately 36% with 1212 rated 100%. Surface cutting speed on automatic screw machines is approximately 60 feet per minute.

**WELDABILITY** — Easily welded by all the commercial processes except forge of hammer welding.

**FORMING** — This grade has good drawing and stamping properties.

**FORGING** — Forge between 2100º and 2300ºF. Do not forge below 1800ºF.

**ANNEALING** — Annealing range is between 1850º and 2050ºF. Cool rapidly. Water should be used for heavier sections; air for lighter sections. The stress relieving range is between 400º and 750ºF.
### TYPE 347 STAINLESS (Continued)

#### TYPE 347 ROUNDS

- **3\(\frac{3}{4}\)" & under** — Brinell 170-255
- **7/8" to 1\(\frac{1}{2}\)" — Brinell 163-255
- **Over 1\(\frac{1}{2}\)" — Brinell 140-241

Stock Lengths 10' to 12'

<table>
<thead>
<tr>
<th>Size</th>
<th>Estimated Weight, Lbs.</th>
<th>Size</th>
<th>Estimated Weight, Lbs.</th>
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<tbody>
<tr>
<td></td>
<td>Per Foot</td>
<td>12-Ft. Bar</td>
<td></td>
</tr>
<tr>
<td>Annealed &amp; Cold Drawn</td>
<td></td>
<td></td>
<td>Hot Rolled, Ann., &amp; Rough Turned</td>
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<td>.5116</td>
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<tr>
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#### TYPE 347 HEXAGONS

Condition A (Annealed)

Brinell same as shown above for rounds.

Stock Lengths 10' to 12'

<table>
<thead>
<tr>
<th>Size</th>
<th>Estimated Weight, Lbs.</th>
<th>Size</th>
<th>Estimated Weight, Lbs.</th>
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<tbody>
<tr>
<td></td>
<td>Per Foot</td>
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<td></td>
</tr>
<tr>
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<td></td>
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### TYPE 347 STAINLESS (Continued)

#### TYPE 347 SHEETS
**NO. 2D FINISH**
- Dull Cold Rolled, Annealed, & Pickled

<table>
<thead>
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<th>Thickness</th>
<th>Width and Length</th>
<th>Per Sq. Ft.</th>
<th>Per Sheet</th>
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<tbody>
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<td>.012&quot; (30 Ga.)</td>
<td>36x120</td>
<td>.504</td>
<td>15.1</td>
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<tr>
<td>.016&quot; (28 Ga.)</td>
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<td>20.2</td>
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<td>.040&quot; (20 Ga.)</td>
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<tr>
<td>.080&quot; (14 Ga.)</td>
<td>36x120</td>
<td>3.360</td>
<td>100.8</td>
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<tr>
<td>.090&quot; (13 Ga.)</td>
<td>36x120</td>
<td>3.780</td>
<td>113.4</td>
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<tr>
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<td>48x120</td>
<td>5.250</td>
<td>210.0</td>
<td></td>
</tr>
</tbody>
</table>

#### TYPE 347 FLATS
- Dull Cold Rolled, Annealed, & Pickled

<table>
<thead>
<tr>
<th>Size in Inches</th>
<th>Per Foot</th>
<th>12-Ft. Bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4 x 1</td>
<td>8.508</td>
<td>10.21</td>
</tr>
<tr>
<td>1 1/2</td>
<td>1.276</td>
<td>15.31</td>
</tr>
<tr>
<td>2</td>
<td>1.702</td>
<td>20.42</td>
</tr>
<tr>
<td>3/8 x 1</td>
<td>1.276</td>
<td>15.31</td>
</tr>
<tr>
<td>2</td>
<td>2.552</td>
<td>30.63</td>
</tr>
<tr>
<td>1/2 x 1</td>
<td>1.702</td>
<td>20.42</td>
</tr>
<tr>
<td>1 1/2</td>
<td>2.552</td>
<td>30.63</td>
</tr>
<tr>
<td>2</td>
<td>3.403</td>
<td>40.84</td>
</tr>
<tr>
<td>3</td>
<td>5.105</td>
<td>61.26</td>
</tr>
<tr>
<td>5/8 x 1</td>
<td>2.127</td>
<td>25.52</td>
</tr>
<tr>
<td>3/4 x 1</td>
<td>2.552</td>
<td>30.63</td>
</tr>
<tr>
<td>2</td>
<td>5.105</td>
<td>61.26</td>
</tr>
<tr>
<td>3</td>
<td>7.657</td>
<td>91.89</td>
</tr>
<tr>
<td>1 x 1 1/2</td>
<td>5.105</td>
<td>61.26</td>
</tr>
<tr>
<td>2</td>
<td>6.806</td>
<td>81.68</td>
</tr>
<tr>
<td>1 1/2 x 2</td>
<td>10.21</td>
<td>122.5</td>
</tr>
</tbody>
</table>

Stocked in Thicknesses from .012" through 1".

Widths from 48" to 96".

and Lengths up to 20'.

Thicknesses from .012" through 1".

Widths from 48" to 96".

and Lengths up to 20'.
Nitronic 50® is a chromium-nickel-manganese-molybdenum austenitic stainless steel that remains completely nonmagnetic after severe cold working or exposure to low temperatures. Its unique feature is the combination of higher strength and better corrosion resistance than the more widely used austenitic stainless grades.

**Analysis**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitronic 50®</td>
<td>.06</td>
<td>4.00/6.00</td>
<td>.040</td>
<td>.030</td>
<td>1.00</td>
<td>20.5/23.5</td>
</tr>
</tbody>
</table>

**Specifications** — The following specifications are generally applicable:

ASTM A276 & A479 Grade XM19, AMS 5764

**Applications** — This grade is used for components and equipment where general corrosion resistance superior to that of Type 316 is required. Applications include pump and boat shafting, valves, fasteners, etc. It may be used in Food Contact Surfaces under the Provisions of various National Sanitation Foundation standards. Its low magnetic permeability, good mechanical properties, and corrosion resistance are useful in instrumentation components.

**Corrosion Resistance** — Corrosion resistance to industrial and marine environments is generally better than that of Type 316 and 316L. Its resistance to intergranular attack in the heat affected zone of heavy weldments is excellent.

**Resistance to Scaling** — Excellent at temperatures up to 2000°F in continuous service.

**Mechanical Properties** — Applicable specifications require the following minimum properties in the annealed condition:

<table>
<thead>
<tr>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Elongation in 2” Min.</th>
<th>Reduction of Area</th>
<th>Brinell</th>
</tr>
</thead>
<tbody>
<tr>
<td>100,000</td>
<td>55,000</td>
<td>35%</td>
<td>55%</td>
<td>293 Max.</td>
</tr>
</tbody>
</table>

**Machinability** — Machinability rating of Nitronic 50® is approximately 45% based on 1212 rated as 100%. Surface cutting speed on automatic screw machines is approximately 75 feet per minute.

**Weldability** — Easily fusion welded by conventional methods with welded joints in the as-welded condition having a strength approaching that of the base metal.

**Forming** — The same fabricated equipment and techniques that apply to the 300 series stainless grades may be used.

**Annealing** — Heat to 1950°F and cool rapidly. If as-welded material is to be used in strongly corrosive media, 2050°F is recommended.
Type 410 is the basic chromium grade of stainless steel. It combines good corrosion resistance with the ability to develop hardness and mechanical properties by conventional heat treating methods that are similar to those of 4130 alloy steel. It is magnetic in all conditions.

**Analysis**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>.10/.15</td>
<td>1.00</td>
<td>.040</td>
<td>.030</td>
<td>1.00</td>
<td>11.50/13.50</td>
<td>.75</td>
<td>.50</td>
<td>.50</td>
</tr>
</tbody>
</table>

**Specifications** — The following specifications are generally applicable:

Sheets & Plates: AMS 5504, QQ-S-766, ASTM A 176, ASTM A 240
Bars: AMS 5613, AMS QQ-S-763, ASTM A 276, ASTM A 479

**Applications** — This grade is used for applications requiring good mechanical properties and involving corrosive conditions that are not too severe, such as valve parts, cutlery, food industry machine parts, screws, bolts, pump rods and pistons, etc. In the annealed condition, it may be drawn or formed. In the aircraft industry, Type 410 is used for parts such as compressor shrouds, where oxidation resistance is required up to 1000°F. Useful at high temperatures only when stresses are low.

**Corrosion Resistance** — This material is resistant to corrosion from the atmosphere, fresh water, iron-bearing mine waters, food acids, neutral and basic salts, mild acids and alkalis. Maximum corrosion resistance of this grade is obtained by hardening and polishing.

**Resistance to Scaling** — Resists scaling at temperatures up to approximately 1200° - 1300°F in continuous service. Over 1300°F it has relatively low strength, and resistance to oxidation is reduced.

**Mechanical Properties** — Specification AMS 5504 requires the following properties of sheets and plates in the annealed condition:

<table>
<thead>
<tr>
<th>Tensile Strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>95,000 Max.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elongation in 2”</th>
</tr>
</thead>
<tbody>
<tr>
<td>.030” thick and under</td>
</tr>
<tr>
<td>Over .030” thick</td>
</tr>
</tbody>
</table>

**Hardenability** — Specification AMS 5504 requires that material 3/8” thick and under, and 3/8” specimens from heavier material, shall be capable of attaining hardness of Rockwell “C” 35-45 after being heated to 1750°F, held at heat to 15-30 minutes, and cooled in still air.

**Machinability** — Type 410 has better machining characteristics than the chromium-nickel grades. It has a machinability rating of 54%, with 1212 rated 100%. Surface cutting speed on automatic screw machines is approximately 90 feet per minute.

**Weldability** — May be welded by all the commercial processes except forge or hammer welding. Large sections should be preheated prior to welding. Because of its air-hardening properties, annealing after welding is recommended to obtain maximum ductility and toughness.

**Forming** — This grade has fair forming and stamping properties.

**Forging** — Forge between 2000° and 2200°F. Do not forge below 1650°F. Cool slowly.

**Annealing** — Full annealing range is between 1550° and 1650°F. Cool slowly in furnace. Low annealing range is between 1200° and 1400°F. Cool in air.

**Hardening** — Hardening range is between 1750° and 1850°. Quench large sections in oil. Small sections may be quenched in air. Temper to required hardness.
TYPE 410 STAINLESS (Continued)

### TYPE 410 ROUNDS

#### Annealed

**Stock Lengths 10' to 12'**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3/16</td>
<td>.0940</td>
<td>1.128</td>
<td>3/16</td>
<td>1.044</td>
<td>12.07</td>
<td>5</td>
</tr>
<tr>
<td>1/4</td>
<td>.1671</td>
<td>2.005</td>
<td>1/4</td>
<td>1.504</td>
<td>15.08</td>
<td>1/2</td>
</tr>
<tr>
<td>5/16</td>
<td>.2610</td>
<td>3.132</td>
<td>5/16</td>
<td>1.765</td>
<td>18.09</td>
<td>1/2</td>
</tr>
<tr>
<td>7/16</td>
<td>.5116</td>
<td>6.139</td>
<td>7/16</td>
<td>2.349</td>
<td>20.21</td>
<td>1/4</td>
</tr>
<tr>
<td>1/2</td>
<td>.6682</td>
<td>8.019</td>
<td>1/2</td>
<td>3.017</td>
<td>24.06</td>
<td>1</td>
</tr>
<tr>
<td>9/16</td>
<td>.8457</td>
<td>10.15</td>
<td>9/16</td>
<td>4.176</td>
<td>28.23</td>
<td>4/8</td>
</tr>
<tr>
<td>5/8</td>
<td>1.044</td>
<td>12.53</td>
<td>5/8</td>
<td>5.053</td>
<td>35.12</td>
<td>1/2</td>
</tr>
<tr>
<td>3/4</td>
<td>.6822</td>
<td>8.019</td>
<td>3/4</td>
<td>6.014</td>
<td>42.77</td>
<td>1/4</td>
</tr>
<tr>
<td>7/8</td>
<td>.8457</td>
<td>10.15</td>
<td>7/8</td>
<td>7.058</td>
<td>51.32</td>
<td>4</td>
</tr>
<tr>
<td>11/16</td>
<td>1.263</td>
<td>15.16</td>
<td>11/16</td>
<td>8.186</td>
<td>48.28</td>
<td>1/2</td>
</tr>
</tbody>
</table>

#### Heat Treated — Brinell 248-302

**Stock Lengths 10' to 12'**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>.1671</td>
<td>2.005</td>
<td>1/4</td>
<td>4.176</td>
<td>24.06</td>
<td>.04</td>
<td>24.06</td>
<td>.04</td>
</tr>
<tr>
<td>1/2</td>
<td>.5116</td>
<td>6.139</td>
<td>1/2</td>
<td>7.058</td>
<td>37.59</td>
<td>1/2</td>
<td>37.59</td>
<td>1/2</td>
</tr>
<tr>
<td>9/16</td>
<td>.8457</td>
<td>10.15</td>
<td>9/16</td>
<td>8.186</td>
<td>42.77</td>
<td>5/8</td>
<td>42.77</td>
<td>5/8</td>
</tr>
<tr>
<td>5/8</td>
<td>1.044</td>
<td>12.53</td>
<td>5/8</td>
<td>9.397</td>
<td>48.28</td>
<td>1/2</td>
<td>48.28</td>
<td>1/2</td>
</tr>
<tr>
<td>3/4</td>
<td>.6822</td>
<td>8.019</td>
<td>3/4</td>
<td>10.69</td>
<td>51.32</td>
<td>4</td>
<td>51.32</td>
<td>4</td>
</tr>
<tr>
<td>11/16</td>
<td>1.263</td>
<td>15.16</td>
<td>11/16</td>
<td>12.69</td>
<td>57.93</td>
<td>1/2</td>
<td>57.93</td>
<td>1/2</td>
</tr>
<tr>
<td>15/16</td>
<td>1.504</td>
<td>18.04</td>
<td>15/16</td>
<td>13.69</td>
<td>61.20</td>
<td>3/4</td>
<td>61.20</td>
<td>3/4</td>
</tr>
<tr>
<td>7/8</td>
<td>2.673</td>
<td>32.07</td>
<td>7/8</td>
<td>15.39</td>
<td>171.10</td>
<td>1/2</td>
<td>171.10</td>
<td>1/2</td>
</tr>
</tbody>
</table>

### TYPE 410 PLATES

**Hot Rolled, Annealed, and Pickled**

Stocked in Thicknesses from 3/16" through 3", Widths from 48" to 96", and Lengths up to 20'.

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Width and Length</th>
<th>Est. Wt., Lbs. Per Sq. Ft.</th>
<th>Per Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>.032&quot; (22 Ga.)</td>
<td>36x120</td>
<td>1.318</td>
<td>39.5</td>
</tr>
<tr>
<td>.036&quot; (20 Ga.)</td>
<td>36x120</td>
<td>1.483</td>
<td>44.5</td>
</tr>
<tr>
<td>.040&quot; (20 Ga.)</td>
<td>36x120</td>
<td>1.648</td>
<td>49.4</td>
</tr>
<tr>
<td>.050&quot; (18 Ga.)</td>
<td>36x120</td>
<td>2.060</td>
<td>61.8</td>
</tr>
<tr>
<td>.063&quot; (16 Ga.)</td>
<td>36x120</td>
<td>2.596</td>
<td>77.9</td>
</tr>
<tr>
<td>.080&quot; (14 Ga.)</td>
<td>36x120</td>
<td>3.296</td>
<td>98.9</td>
</tr>
<tr>
<td>.090&quot; (13 Ga.)</td>
<td>36x120</td>
<td>3.708</td>
<td>112.2</td>
</tr>
<tr>
<td>.105&quot; (12 Ga.)</td>
<td>36x120</td>
<td>4.326</td>
<td>129.8</td>
</tr>
<tr>
<td>.125&quot; (11 Ga.)</td>
<td>36x120</td>
<td>5.150</td>
<td>154.5</td>
</tr>
<tr>
<td>.135&quot; (10 Ga.)</td>
<td>36x120</td>
<td>5.562</td>
<td>166.9</td>
</tr>
</tbody>
</table>

Sec. I Page 24
Type 416 is a chromium grade of stainless steel modified by the addition of phosphorus and sulphur to produce a free-machining steel. It is the most readily machinable of all stainless steels. A wide range of mechanical properties may be obtained by conventional heat treating methods. It is magnetic in all conditions. Manufactured by the electric-furnace process, it is quality steel, free from all injurious defects, and meets the requirements of the aircraft industry.

**Analysis**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>.15</td>
<td>1.25</td>
<td>.060</td>
<td>.15/.40</td>
<td>1.00</td>
<td>12.00/13.50</td>
<td>.75</td>
<td>.60</td>
<td>.50</td>
</tr>
</tbody>
</table>

**Specifications** — The following specifications are generally applicable: AMS 5610, ASTM A 314, ASTM A 582

**Applications** — Type 416 is used for applications demanding the mechanical properties and corrosion resistance of Type 410 combined with free machining properties. It can be turned, threaded, formed or drilled at speeds approaching those of screw stock.

**Corrosion Resistance** — Corrosion resistance is similar to Type 410, and is resistant to atmosphere, fresh water, food acids, and neutral and basic salts. Maximum corrosion resistance of this grade is obtained by hardening and polishing.

**Resistance to Scaling** — Resists scaling at temperatures up to approximately 1200º - 1300ºF in continuous service.

**Mechanical Properties** — Applicable specifications require the following properties of material in the annealed condition:

<table>
<thead>
<tr>
<th>Tensile Strength (psi)</th>
<th>Brinell Hardness Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Rolled Annealed</td>
<td>241</td>
</tr>
<tr>
<td>Annealed &amp; Cold Finished</td>
<td>85,000/120,000</td>
</tr>
<tr>
<td>Over 1/2&quot; incl.</td>
<td>241</td>
</tr>
<tr>
<td>Over 1/2&quot;</td>
<td>241</td>
</tr>
</tbody>
</table>

**Hardenability** — A 3/8" section quenched in oil from 1825ºF will harden to a minimum of Rockwell "C" 35.

**Machinability** — Type 416 has a very good machining characteristics. It has a machinability rating on approximately 110%, with 1212 rated 100%. Surface cutting speed on automatic screw machines is approximately 180 feet per minute.

**Weldability** — This grade has poor welding properties. Welds are brittle, with tendency to crack.

**Forging** — Forge between 2100º and 2300ºF. Do not forge below 1700ºF. Cool slowly.

**Annealing** — Full annealing range is between 1550º and 1650ºF. Cool Slowly in furnace. Low annealing range is between 1200º and 1400ºF. Cool in air.

**Hardening** — Hardening range is between 1750º and 1850ºF. Quench large sections in oil. Small sections may be quenched in air. Temper to required hardness.
<table>
<thead>
<tr>
<th>Size In</th>
<th>Cold Drawn</th>
<th>Cold Finished (Cont.)</th>
<th>Hot Rolled, Annealed &amp; Rough Turned</th>
<th>Precision Pump Shafting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>Per Foot</td>
<td>12-FT. Bar</td>
<td>Per Foot</td>
<td>20-FT. Bar</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>⅛</td>
<td>.0104 .1253</td>
<td>10.69 128.3</td>
<td>20.10 240.3</td>
<td>5/8 1.044 20.88</td>
</tr>
<tr>
<td>3/32</td>
<td>.0235 .2819</td>
<td>11.37 136.4</td>
<td>20.88 246.4</td>
<td>3/4 1.504 30.07</td>
</tr>
<tr>
<td>⅜</td>
<td>.0418 .5012</td>
<td>12.07 144.8</td>
<td>21.60 252.0</td>
<td>7/16 1.765 35.29</td>
</tr>
<tr>
<td>⅜</td>
<td>.0653 .7831</td>
<td>12.79 153.5</td>
<td>22.35 258.2</td>
<td>7/8 2.046 40.93</td>
</tr>
<tr>
<td>⅛</td>
<td>.0940 1.128</td>
<td>13.53 162.4</td>
<td>23.05 264.1</td>
<td>⅛ 2.673 53.46</td>
</tr>
<tr>
<td>⅜</td>
<td>.1279 1.535</td>
<td>15.08 180.9</td>
<td>24.06 270.2</td>
<td>⅜ 3.383 67.66</td>
</tr>
<tr>
<td>⅝</td>
<td>.1671 2.005</td>
<td>15.88 189.6</td>
<td>25.07 276.2</td>
<td>⅝ 3.769 75.38</td>
</tr>
<tr>
<td>⅜</td>
<td>.2114 2.537</td>
<td>16.71 200.5</td>
<td>26.08 282.2</td>
<td>⅝ 4.176 83.53</td>
</tr>
<tr>
<td>⅝</td>
<td>.2610 3.132</td>
<td>18.42 221.0</td>
<td>27.08 288.2</td>
<td>⅝ 5.053 101.1</td>
</tr>
<tr>
<td>⅝</td>
<td>.3158 2.790</td>
<td>20.21 242.6</td>
<td>28.09 294.2</td>
<td>⅞ 5.523 110.5</td>
</tr>
<tr>
<td>⅛</td>
<td>.3759 4.510</td>
<td>22.09 265.1</td>
<td>29.09 300.2</td>
<td>⅞ 6.014 120.3</td>
</tr>
<tr>
<td>⅝</td>
<td>.4411 5.293</td>
<td>24.06 288.7</td>
<td>30.09 306.2</td>
<td>⅞ 6.712 152.2</td>
</tr>
<tr>
<td>⅝</td>
<td>.5116 6.139</td>
<td>25.07 300.2</td>
<td>31.09 312.2</td>
<td>⅞ 7.886 163.7</td>
</tr>
<tr>
<td>⅛</td>
<td>.5873 7.048</td>
<td>26.08 313.2</td>
<td>32.09 318.2</td>
<td>15/16 10.03 200.7</td>
</tr>
<tr>
<td>⅝</td>
<td>.6882 8.019</td>
<td>27.08 326.2</td>
<td>33.09 324.2</td>
<td>⅛ 6.14 120.3</td>
</tr>
<tr>
<td>⅞</td>
<td>.7544 9.052</td>
<td>28.09 339.2</td>
<td>34.09 330.2</td>
<td>15/16 7.612 152.2</td>
</tr>
<tr>
<td>⅛</td>
<td>.8457 10.15</td>
<td>29.09 352.2</td>
<td>35.09 336.2</td>
<td>⅝ 8.186 163.7</td>
</tr>
<tr>
<td>⅝</td>
<td>1.044 12.53</td>
<td>30.09 365.2</td>
<td>36.09 342.2</td>
<td>15/16 10.03 200.7</td>
</tr>
<tr>
<td>⅛</td>
<td>1.263 15.16</td>
<td>31.09 378.2</td>
<td>37.09 348.2</td>
<td>2 10.69 213.8</td>
</tr>
<tr>
<td>⅝</td>
<td>1.504 18.04</td>
<td>32.09 391.2</td>
<td>38.09 354.2</td>
<td>⅛ 12.79 255.8</td>
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<td>1.631 19.58</td>
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<td>39.09 360.2</td>
<td>⅛ 13.53 276.0</td>
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<td>40.09 366.2</td>
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<tr>
<td>⅝</td>
<td>1.903 22.83</td>
<td>35.09 430.2</td>
<td>41.09 372.2</td>
<td>⅝ 16.71 334.1</td>
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<td>42.09 378.2</td>
<td>15/16 19.31 386.1</td>
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<td>⅝</td>
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<td>44.09 390.2</td>
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<td>⅝</td>
<td>2.508 30.10</td>
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<td>48.09 414.2</td>
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<td>49.09 420.2</td>
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<tr>
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### TYPE 416 COLD DRAWN FLATS

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<tr>
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<th>Size in Inches</th>
<th>Estimated Weight, Lbs.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Per Foot</td>
<td>12-Ft. Bar</td>
<td></td>
</tr>
<tr>
<td>3/16 x 1</td>
<td>.6381</td>
<td>7.657</td>
<td>1/2 x 3/4</td>
</tr>
<tr>
<td>1/2</td>
<td>.9572</td>
<td>11.49</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1.276</td>
<td>15.31</td>
<td>1/2</td>
</tr>
<tr>
<td>1/4 x 1/2</td>
<td>.4254</td>
<td>5.105</td>
<td>1/2</td>
</tr>
<tr>
<td>3/4</td>
<td>.6381</td>
<td>7.657</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>.8508</td>
<td>10.21</td>
<td>1/2</td>
</tr>
<tr>
<td>1 1/2</td>
<td>1.276</td>
<td>15.31</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>1.702</td>
<td>20.42</td>
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<tr>
<td>3/8 x 1 1/2</td>
<td>1.276</td>
<td>15.31</td>
<td>2</td>
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<tr>
<td></td>
<td>1.914</td>
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### TYPE 416 HEXAGONS

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<th>Size in Inches</th>
<th>Estimated Weight, Lbs.</th>
<th>Size in Inches</th>
<th>Estimated Weight, Lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Foot</td>
<td>12-Ft. Bar</td>
<td></td>
<td>Per Foot</td>
<td>12-Ft. Bar</td>
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<tr>
<td>1/4</td>
<td>.1842</td>
<td>2.210</td>
<td>13/16 1/4</td>
<td>1.946</td>
<td>23.35</td>
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<td>7/16</td>
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<tr>
<td>1/2</td>
<td>.7368</td>
<td>8.842</td>
<td>1/4</td>
<td>3.327</td>
<td>39.93</td>
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<td>9/16</td>
<td>.9325</td>
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<td>3/8</td>
<td>3.730</td>
<td>44.76</td>
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<tr>
<td>9/8</td>
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<td>13.82</td>
<td>3/4</td>
<td>4.605</td>
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<td>7/8</td>
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### TYPE 416 SQUARES

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<tr>
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<th>Estimated Weight, Lbs.</th>
<th>Size in Inches</th>
<th>Estimated Weight, Lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Foot</td>
<td>12-Ft. Bar</td>
<td></td>
</tr>
<tr>
<td>3/16</td>
<td>.1196</td>
<td>1.436</td>
<td>15/16 3/16</td>
</tr>
<tr>
<td>1/4</td>
<td>.2127</td>
<td>2.552</td>
<td>1</td>
</tr>
<tr>
<td>5/16</td>
<td>.3323</td>
<td>3.988</td>
<td>1/4</td>
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<td>3/8</td>
<td>.4786</td>
<td>5.743</td>
<td>3/8</td>
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<td>7/16</td>
<td>.6514</td>
<td>7.817</td>
<td>1/2</td>
</tr>
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<td>1/2</td>
<td>.8508</td>
<td>10.21</td>
<td>3/4</td>
</tr>
<tr>
<td>5/8</td>
<td>1.329</td>
<td>15.95</td>
<td>2</td>
</tr>
<tr>
<td>3/4</td>
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<td>7/8</td>
<td>2.606</td>
<td>31.27</td>
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</table>

Sec. 1  Page 27
TYPE 418
(Greek Ascoloy)
Stainless Bars
UNS S41800

Color Marking: Annealed Bars —— Purple with Green Stripe

Type 418 is a chromium grade of stainless steel similar in many respects to the basic 410 grade but modified by the addition of nickel and tungsten to improve high temperature properties. Up to 1100°F, its stress rupture strength is equal to or superior to the austenitic grades. A wide range of mechanical properties is available with conventional heat treated methods.

ANALYSIS

<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
<th>Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>.15</td>
<td>.50</td>
<td>.04</td>
<td>.03</td>
<td>.50</td>
<td>12.00/14.00</td>
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<tr>
<td>Min.</td>
<td>.20</td>
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<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>Element</th>
<th>Ni</th>
<th>Mo</th>
<th>Al</th>
<th>Cu</th>
<th>Sn</th>
</tr>
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<tbody>
<tr>
<td>Max.</td>
<td>1.80/2.20</td>
<td>2.50/3.50</td>
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<td>.15</td>
<td>.50</td>
</tr>
<tr>
<td>Min.</td>
<td>1.50</td>
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<td></td>
<td></td>
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</table>

SPECIFICATIONS — The following specifications are generally applicable:
AMS 5616, AMS 2303, ASTM A 565

APPLICATIONS — Type 418 is used for applications requiring the mechanical properties and corrosion resistance of 410 as well as strength and oxidation resistance at elevated temperatures. Typical applications would be steam and gas turbine parts, jet engine components, compressor vanes and blades, fasteners, etc.

CORROSION RESISTANCE — Similar to Type 410 which means excellent resistance to corrosion in atmosphere, fresh water, food acids, neutral and basic salts, and mild acids and alkalis.

RESISTANCE TO SCALING — Resists scaling up to 1400°F and may be used in continuous service at 1100°F.

MECHANICAL PROPERTIES — Typical properties in the annealed condition:

<table>
<thead>
<tr>
<th>Strength (psi)</th>
<th>Tensile Strength (psi)</th>
<th>Elongation in 2”</th>
<th>Yield Rockwell C</th>
<th>Hardness</th>
</tr>
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<tbody>
<tr>
<td>115,000/150,000</td>
<td>85,000/120,000</td>
<td>18-22%</td>
<td>Rc 23 - 33</td>
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</table>

A wide range of mechanical properties is obtainable by hardening and tempuring. Hardness of Rockwell “C” 25-50 is possible with corresponding tensile strength.

HARDENABILITY — Specification AMS 5616 requires that material 3/8” thick and under, and 3/8” specimens from heavier sections shall be capable of attaining hardness of Rockwell “C” 45 minimum after being heated to 1750°F, held 25-30 minutes, and quenched in commercial paraffin oil at room temperature.

MACHINABILITY — Type 418 has fair machining characteristics in the annealed condition.

WELDABILITY — Type 418 can be welded by any of the commonly used processes; but since it is an air hardening grade, welded sections should be annealed or tempered for maximum ductility.
FORGING — Forge between 2000º - 2100ºF. Do not forge below 1600ºF. Cool slowly.

ANNEALING — Because of the sluggish transformation characteristics of Type 418, a full anneal is impractical. For maximum softness the material should be heated to 1215º-1255ºF and held for six hours at temperature followed by air cooling. If a somewhat higher hardness of 277/311 BHN is not objectionable, a simpler treatment is to heat the material to 1300º-1350ºF and air cool.

HARDENING — Hardening range is between 1750º-1900ºF. Quench large sections in oil. Small sections may be quenched in air. Temper to required hardness.

TYPE 418 ROUNDS

CONDITION A — ANNEALED

<table>
<thead>
<tr>
<th>Size</th>
<th>Estimated Wt., Lbs.</th>
<th>Size</th>
<th>Estimated Wt., Lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>In</td>
<td>Per Foot</td>
<td>12-Ft. Bar</td>
<td>In</td>
</tr>
<tr>
<td>Inches</td>
<td></td>
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<td>Inches</td>
</tr>
<tr>
<td>¼</td>
<td>.1671</td>
<td>2.005</td>
<td>1¼</td>
</tr>
<tr>
<td>⅝</td>
<td>.3759</td>
<td>4.510</td>
<td>9/16</td>
</tr>
<tr>
<td>7/16</td>
<td>.5116</td>
<td>6.139</td>
<td>5/8</td>
</tr>
<tr>
<td>1/2</td>
<td>.6682</td>
<td>8.019</td>
<td>¾</td>
</tr>
<tr>
<td>9/16</td>
<td>.8457</td>
<td>10.15</td>
<td>7/8</td>
</tr>
<tr>
<td></td>
<td>Cold Drawn</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Ground</td>
<td>7.037</td>
<td>1/8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.53</td>
<td>¾</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.16</td>
<td>5/8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18.04</td>
<td>3/4</td>
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<td></td>
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<td>24.56</td>
<td>7/8</td>
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<td>40.59</td>
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<td></td>
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<td>¼</td>
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<tr>
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<td></td>
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</table>

Hot Rolled, Rough Turned

42.77
54.13
56.82

Sec. 1 Page 29
Type 431 is a “16 chromium” stainless steel modified by the addition of nickel. It is designed to develop high mechanical properties by conventional heat treating methods. Its corrosion resistance is superior to such straight chromium grades as Types 410 and 416. It is magnetic in all conditions. Manufactured by the electric-furnace process, it meets the rigid requirements of the aircraft industry, particularly for parts which may be subject to magnetic (magna flux) inspection.

**ANALYSIS**

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>P Max.</th>
<th>S Max.</th>
<th>Si</th>
<th>Cr</th>
<th>Ni</th>
</tr>
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<tbody>
<tr>
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<td>.30/.80</td>
<td>.040</td>
<td>.030</td>
<td>.20/.60</td>
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<td>2.00/3.00</td>
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**SPECIFICATIONS** — The following specifications are generally applicable:
AMS-S-18732, ASTM A 276, AMS 5628

**APPLICATIONS** — Type 431 is used for applications requiring higher mechanical properties than can be obtained from Type 410 and where corrosive conditions are not to severe, such as valve parts, centrifuge bowls, chemical equipment, bolts, and screws.

**CORROSION RESISTANCE** — The corrosion resistance of Type 431 is superior to that of Type 410. This grade has excellent resistance to corrosion in all conditions of heat treatment from mild acids and alkalis, neutral and basic salts, food acids, and atmosphere. Maximum resistance is obtained by hardening and polishing.

**RESISTANCE TO SCALING** — Resists scaling at temperatures up to approximately 1400°F in continuous service.

**MECHANICAL PROPERTIES** — As required by Specification AMS-S-18732, this grade can be heat treated to meet the following minimum properties:

| HT-200 —— Quenched in oil from 1875°F, cool to —100°F and double temper at 550°F | Tensile Strength (psi) | Yield Strength (psi) | Elongation in 2” | Reduction of Area |
|——|——|——|——|——|
| 200,000 | 150,000 | 10% | 40% |

For further information, refer to Section Q.

**MACHINABILITY** — Type 431 has better machining characteristics than the chromium-nickel grades. It has a machinability rating of 45%, with 1212 rated 100%. Surface cutting speed on automatic screw machines is approximately 75 feet per minute.

**WELDABILITY** — May be welded by all the commercial processes except forge or hammer welding. Large sections should be preheated prior to welding. Because of air-hardening properties, this grade should be annealed after welding.

**FORGING** — Forge between 2100°F and 2250°F. Cool slowly. Do not forge below 1700°F.

**ANNEALING** — Full annealing is impractical. The low annealing range is between 1150°F and 1225°F.

**HARDENING** — Hardening range is between 1850°F and 1950°F. Quench large sections in oil. Small sections may be quenched in air. Temper to required hardness.
This is a high carbon chromium stainless steel, capable of developing high hardness and mechanical properties by conventional heat treating methods. It exhibits best corrosion resistance in the hardened condition. It has excellent resistance to wear and abrasion and is magnetic in all conditions. It develops the highest hardness of the stainless steels.

**ANALYSIS**

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<td>.030</td>
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**SPECIFICATIONS** — The following specifications are generally applicable:
AMS 5630, AMS QQ-S-763, ASTM A 276

**APPLICATIONS** — Used for severe abrasion service such as in needle valves, balls and seats for check valves and ball bearings. Well adapted for pump parts which must resist corrosion encountered in the oil industry.

**CORROSION RESISTANCE** — Type 440C resists corrosion from fresh water steam, crude oil, gasoline, etc., and resists staining from fruit and food acids. Maximum resistance is obtained by hardening and polishing.

**RESISTANCE TO SCALING** — Resists scaling up to 1200°F in continuous service.

**MECHANICAL PROPERTIES** — Refer to Sec. Q.

**MACHINABILITY** — Type 440C has fair machining characteristics, with a machinability rating of 40%, with 1212 rated as 100%. Surface cutting speed on automatic screw machines is approximately 65 feet per minute.

**WELDABILITY** — Poor welding properties, due to high carbon content.

**FORMING** — This grade has poor forming and stamping properties.

**FORGING** — Forge between 1900° and 2100°F, not below 1650°F. Cool slowly.

**HARDENING** — Hardening range is between 1850° and 1950°F. Quench large sections in oil. Small sections may be quenched in air. Temper as required.

### TYPE 440C ROUNDS

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<tr>
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<td>.0418 .5012</td>
<td>3/32</td>
<td>.0653 .7836</td>
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<td>.1279 1.535</td>
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<td>.3158 3.790</td>
<td>11/16</td>
<td>.4412 5.294</td>
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<tr>
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<td>.2610 3.132</td>
<td>15/16</td>
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<td>1/2</td>
<td>.6682 8.019</td>
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<tr>
<td>3/4</td>
<td>.5116 6.313</td>
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</tbody>
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**Annealed & Cold Drawn**

- 1/8
- 3/32
- 7/32
- 1/4
- 5/32
- 3/8
- 1/2

**Annealed & Ground (Cont.):**

- 3/16
- 1/4
- 5/16
- 3/8
- 1/2

**Annealed & Ground**

- 17/32 .7544 9.052
- 9/16 .8457 10.15
- 19/32 .8021 9.927
- 15/16 .8021 9.927
- 11/16 .8021 9.927
- 13/16 .8021 9.927
- 1/4

**Hot Rolled Annealed, Rough Turned — Brinnell 255 Max.**

- 1/16
- 1/8
- 3/16
- 1/4
- 5/16
- 3/8
- 1/2

**Stock Lengths 10’ to 12’ and 20’ to 22’**

- 13/16 .8021 9.927
- 15/16 .8021 9.927
- 19/16 .8021 9.927
- 11/16 .8021 9.927
- 13/16 .8021 9.927
- 1/4

- 17/32 .7544 9.052
- 9/16 .8457 10.15
- 19/32 .8021 9.927
- 15/16 .8021 9.927
- 11/16 .8021 9.927
- 13/16 .8021 9.927
- 1/4

- 17/32 .7544 9.052
- 9/16 .8457 10.15
- 19/32 .8021 9.927
- 15/16 .8021 9.927
- 11/16 .8021 9.927
- 13/16 .8021 9.927
- 1/4
13-8 VAR is another in the family of precipitation hardening stainless steels. It possesses the same advantages of 17-4 and 15-5 in that high strength may be developed by a single low temperature thermal treatment while retaining excellent corrosion resistance. It offers the same excellent transverse toughness and ductility, even in large sections, as 15-5. Due to the composition and controlled melting practice, 13-8 VAR has an essentially ferrite-free microstructure.

**ANALYSIS**

<table>
<thead>
<tr>
<th>Element</th>
<th>Max.</th>
<th>Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>.05</td>
<td>.10</td>
</tr>
<tr>
<td>Mn</td>
<td>.010</td>
<td>.010</td>
</tr>
<tr>
<td>P</td>
<td>.008</td>
<td>.008</td>
</tr>
<tr>
<td>Si</td>
<td>.10</td>
<td>.10</td>
</tr>
<tr>
<td>Cr</td>
<td>12.25/13.25</td>
<td>12.25/13.25</td>
</tr>
<tr>
<td>Ni</td>
<td>7.50/8.50</td>
<td>7.50/8.50</td>
</tr>
<tr>
<td>Mo</td>
<td>2.00/2.50</td>
<td>2.00/2.50</td>
</tr>
<tr>
<td>Al</td>
<td>.90/1.35</td>
<td>.90/1.35</td>
</tr>
</tbody>
</table>

**SPECIFICATIONS** — AMS 5629, AMS 2300, ASTM A 564 Type XM-13 are generally applicable.

**APPLICATIONS** — 13-8 is produced as a consumable electrode, vacuum arc remelted product and is ideal for applications requiring very high strength and toughness in light through heavy cross sections. This alloy is used when good general and stress corrosion cracking resistance and minimal property directionality are required. Suitable for aircraft structural parts, landing gear parts, shafts, valves, fittings, fasteners, and parts used in the petrochemical industry.

**MECHANICAL PROPERTIES** — The following may be considered as typical room temperature properties:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Elongation in 2&quot; %</th>
<th>Reduction of Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>H 950</td>
<td>225</td>
<td>210</td>
<td>12</td>
<td>50 Long 40 Trans</td>
</tr>
<tr>
<td>H 1050</td>
<td>190</td>
<td>180</td>
<td>15</td>
<td>55 Long 55 Trans</td>
</tr>
<tr>
<td>H 1100</td>
<td>160</td>
<td>150</td>
<td>18</td>
<td>60 Long 60 Trans</td>
</tr>
<tr>
<td>H 1150</td>
<td>145</td>
<td>105</td>
<td>20</td>
<td>63 Long 63 Trans</td>
</tr>
<tr>
<td>H 1150M</td>
<td>130</td>
<td>85</td>
<td>22</td>
<td>70 Long 70 Trans</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AMS 5629 requires the following after precipitation hardening at 950°F:

<table>
<thead>
<tr>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Elongation in 4D</th>
<th>Reduction of Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>220,000 Min.</td>
<td>205,000 Min.</td>
<td>10% Min.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>45 Min.</td>
<td>35 Min.</td>
</tr>
</tbody>
</table>
### ANNEALING (Condition A) —
The solution annealing temperature is 1700°F. Oil or rapid air quench to below 60°F. Maximum Brinell hardness is 363.

### HARDENING —
- Condition H 950 — 950°F for 4 hours, air cool. Rockwell “C” 48 Average.
- Condition H 1050 — 1050°F for 4 hours, air cool. Rockwell “C” 43 Average.
- Condition H 1100 — 1100°F for 4 hours, air cool. Rockwell “C” 36 Average.
- Condition H 1150 — 1150°F for 4 hours, air cool. Rockwell “C” 33 Average.
- Condition H 1150M — 1400°F for 2 hours, air cool. + 1150°F for 4 hours, air cool. Rockwell “C” 28 Average.

### MACHINABILITY, WELDABILITY, CORROSION RESISTANCE, AND FORGING —
Similar to 17-4, for which see Page 34 of this section.

---

**13-8 VAR ROUNDS**

**Condition A — Ground**

Stock Lengths 12’ Approx.

<table>
<thead>
<tr>
<th>Size in Inches</th>
<th>Estimated Wt., Lbs.</th>
<th>12-Ft. Bar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Foot</td>
<td></td>
</tr>
<tr>
<td>3/16</td>
<td>.0940</td>
<td>1.128</td>
</tr>
<tr>
<td>1/4</td>
<td>.1671</td>
<td>2.005</td>
</tr>
<tr>
<td>.2600</td>
<td>.1807</td>
<td>2.168</td>
</tr>
<tr>
<td>9/16</td>
<td>.2610</td>
<td>3.132</td>
</tr>
<tr>
<td>.3225</td>
<td>.2780</td>
<td>3.336</td>
</tr>
<tr>
<td>3/8</td>
<td>.3759</td>
<td>4.510</td>
</tr>
<tr>
<td>.3850</td>
<td>.3961</td>
<td>4.753</td>
</tr>
<tr>
<td>7/16</td>
<td>.5116</td>
<td>6.139</td>
</tr>
<tr>
<td>1/2</td>
<td>.6682</td>
<td>8.019</td>
</tr>
<tr>
<td>.5100</td>
<td>.6952</td>
<td>8.342</td>
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<tr>
<td>9/16</td>
<td>.8457</td>
<td>10.15</td>
</tr>
<tr>
<td>.5725</td>
<td>.8762</td>
<td>10.51</td>
</tr>
<tr>
<td>5/8</td>
<td>1.044</td>
<td>12.53</td>
</tr>
<tr>
<td>.6350</td>
<td>1.078</td>
<td>12.94</td>
</tr>
<tr>
<td>11/16</td>
<td>1.263</td>
<td>15.16</td>
</tr>
<tr>
<td>3/4</td>
<td>1.504</td>
<td>18.04</td>
</tr>
<tr>
<td>13/16</td>
<td>1.765</td>
<td>21.17</td>
</tr>
<tr>
<td>7/8</td>
<td>2.046</td>
<td>24.56</td>
</tr>
<tr>
<td>19/16</td>
<td>2.349</td>
<td>28.19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size in Inches</th>
<th>Estimated Wt., Lbs.</th>
<th>12-Ft. Bar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Foot</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.673</td>
<td>32.07</td>
</tr>
<tr>
<td>1/8</td>
<td>3.383</td>
<td>40.59</td>
</tr>
<tr>
<td>9/16</td>
<td>3.769</td>
<td>45.23</td>
</tr>
<tr>
<td>1/4</td>
<td>4.176</td>
<td>50.12</td>
</tr>
<tr>
<td>3/8</td>
<td>5.053</td>
<td>60.64</td>
</tr>
<tr>
<td>7/16</td>
<td>5.523</td>
<td>66.28</td>
</tr>
<tr>
<td>1/2</td>
<td>6.014</td>
<td>72.17</td>
</tr>
<tr>
<td>9/8</td>
<td>7.058</td>
<td>84.70</td>
</tr>
<tr>
<td>3/4</td>
<td>8.186</td>
<td>98.23</td>
</tr>
<tr>
<td>7/8</td>
<td>9.397</td>
<td>112.8</td>
</tr>
<tr>
<td>2</td>
<td>10.69</td>
<td>128.3</td>
</tr>
<tr>
<td>1/8</td>
<td>12.07</td>
<td>144.8</td>
</tr>
<tr>
<td>1/4</td>
<td>13.53</td>
<td>162.4</td>
</tr>
<tr>
<td>1/2</td>
<td>16.71</td>
<td>200.5</td>
</tr>
<tr>
<td>3/4</td>
<td>20.21</td>
<td>242.6</td>
</tr>
<tr>
<td>3</td>
<td>24.06</td>
<td>288.7</td>
</tr>
<tr>
<td>1/4</td>
<td>28.23</td>
<td>338.8</td>
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<tr>
<td>1/2</td>
<td>32.74</td>
<td>392.9</td>
</tr>
<tr>
<td>3/4</td>
<td>37.59</td>
<td>451.0</td>
</tr>
<tr>
<td>4</td>
<td>42.77</td>
<td>513.2</td>
</tr>
<tr>
<td>1/4</td>
<td>48.28</td>
<td>579.3</td>
</tr>
</tbody>
</table>
This is a chromium-nickel grade of stainless steel that may be hardened by a single low-temperature precipitation-hardening heat treatment. Excellent mechanical properties at a high strength level may be obtained by such treatment. Scaling and distortion are minimized. This material should not be used in the solution treated condition.

The strength and corrosion resistance properties of 17-4 hold up well in service temperatures up to 800°F. Fabrication techniques for this steel are similar to those established for the regular stainless steel grades. This material machines well, has excellent welding characteristics, and forges easily. The combination of excellent mechanical and processing properties makes this grade adaptable to a wide variety of applications.

### ANALYSIS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>.07</td>
<td>1.00</td>
<td>.04</td>
<td>.03</td>
<td>1.00</td>
<td>15.00/17.50</td>
<td>3.00/5.00</td>
<td>3.00/5.00</td>
<td>5XC/.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SPECIFICATIONS

- AMS 5643 and ASTM A 564 Type 630 are generally applicable.

### APPLICATIONS

- Used where high strength and good corrosion resistance are required, as well as for applications requiring high fatigue strength, good resistance to galling, seizing and stress corrosion. Suitable for intricate parts requiring machining and welding, and/or where distortion in conventional heat treatment is a problem.

### CORROSION RESISTANCE

- The corrosion resistance of 17-4 is superior to that of hardenable straight chromium grades such as Type 410. It approaches the corrosion resistance of the chromium nickel grades. In many corrosive media it is equal to such grades as Type 304. Corrosion resisting properties will be affected by such conditions as surface finish and aging heat treatment.

### MECHANICAL PROPERTIES

- The following may be considered as average or typical room-temperature properties:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Elongation in 2&quot;</th>
<th>Reduction of Area</th>
<th>Rockwell &quot;C&quot; Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Annealed)</td>
<td>150,000</td>
<td>110,000</td>
<td>10%</td>
<td>40%</td>
<td>34</td>
</tr>
<tr>
<td>H 900 (Hardened at 900º)</td>
<td>200,000</td>
<td>185,000</td>
<td>14%</td>
<td>50%</td>
<td>44</td>
</tr>
<tr>
<td>H 1150 (Hardened at 1150º)</td>
<td>145,000</td>
<td>125,000</td>
<td>19%</td>
<td>60%</td>
<td>33</td>
</tr>
</tbody>
</table>

AMS 5643 requires the following after precipitation heat treating at 900°F.

<table>
<thead>
<tr>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Elongation in 2&quot;</th>
<th>Reduction of Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>190,000 Min.</td>
<td>170,000 Min.</td>
<td>10% Min.</td>
<td>40% Min.</td>
</tr>
</tbody>
</table>

### MACHINABILITY

- This grade has a machinability rating of 48% in the annealed condition (Condition A), with surface cutting speed of 80 feet per minute. In the overaged condition (H 1150-M), the machinability rating is 76%, with surface cutting speed of 125 feet per minute.

### WELDING

- Readily weldable by all the commercial processes. Preheating and post-heating practices used for the standard hardenable stainless grades are not required.

### FORGING

- Forge between 2050º and 2150ºF. Do not forge below 1850ºF. Forgings are air cooled to 90ºF or lower. Large or intricate forgings should be equalized at some temperature between 1900ºF and the forging temperature before air cooling.

### ANNEALING (Condition A)

- The annealing (solution treatment) temperature is 1900ºF, followed by air cooling. Maximum Brinell hardness at mid-radius is 363.

### HARDENING

- Condition H 900 —— 900ºF for 1 hour, air cool. Rockwell "C" 44 Average.
- Condition H 1025 —— 1025ºF for 4 hours, air cool. Rockwell "C" 38 Average.
- Condition H 1150 —— 1150ºF for 4 hours, air cool. Rockwell "C" 33 Average.
### 17-4 Stainless (Continued)

#### 17-4 Rounds

**Condition A or Hardened**

Stock Lengths 10' to 12'

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cold Finished</strong></td>
<td></td>
<td></td>
<td><strong>Cold Finished</strong></td>
<td></td>
<td></td>
<td><strong>Rough Turned</strong></td>
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<td></td>
</tr>
<tr>
<td>3/32</td>
<td>.0235</td>
<td>.2820</td>
<td>1/4</td>
<td>4.176</td>
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<td>3/8</td>
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<td>60.64</td>
</tr>
<tr>
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<td>.0418</td>
<td>.5012</td>
<td>5/32</td>
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<td>3/8</td>
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<td>72.17</td>
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<td>.0653</td>
<td>.7831</td>
<td>7/32</td>
<td>.1279</td>
<td>1.535</td>
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<td>7.058</td>
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<td>1/4</td>
<td>.1671</td>
<td>2.005</td>
<td>9/32</td>
<td>.2114</td>
<td>2.537</td>
<td>9/32</td>
<td>7.612</td>
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<td>.4611</td>
<td>5.293</td>
<td>13/32</td>
<td>.5116</td>
<td>6.139</td>
<td>13/32</td>
<td>8.871</td>
<td>105.4</td>
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<td>6.139</td>
<td>15/32</td>
<td>.5873</td>
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<td>15/32</td>
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<td>120.4</td>
</tr>
<tr>
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<td>8.019</td>
<td>1/4</td>
<td>.8457</td>
<td>10.15</td>
<td>1/4</td>
<td>10.69</td>
<td>128.3</td>
</tr>
<tr>
<td>9/16</td>
<td>.9423</td>
<td>11.31</td>
<td>1/4</td>
<td>1.042</td>
<td>12.53</td>
<td>1/4</td>
<td>11.37</td>
<td>136.4</td>
</tr>
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<td>5/8</td>
<td>1.263</td>
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<td>3/8</td>
<td>1.504</td>
<td>18.04</td>
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<td>12.07</td>
<td>144.8</td>
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<td>11/16</td>
<td>1.765</td>
<td>21.17</td>
<td>1/2</td>
<td>1.847</td>
<td>20.21</td>
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<td>12.79</td>
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<td>13/16</td>
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<td>36.21</td>
<td>1/2</td>
<td>2.673</td>
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<td>40.59</td>
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<td>16.71</td>
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<td><strong>17-4 Hexagons</strong></td>
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<td><strong>17-4 Squares</strong></td>
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<td><strong>17-4 Hexagons</strong></td>
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<tr>
<td><strong>Condition A</strong></td>
<td></td>
<td></td>
<td><strong>Ann. &amp; Cold Drawn</strong></td>
<td></td>
<td></td>
<td><strong>Ann. &amp; Pickled</strong></td>
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</tr>
<tr>
<td>Stock Lengths 10' to 12'</td>
<td></td>
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<td>Stock Lengths 10' to 14'</td>
<td></td>
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<td>Stock Lengths 10' to 14'</td>
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<td>2.552</td>
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<td>3.988</td>
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<td>79.56</td>
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<td>141.5</td>
<td>1/2</td>
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<td>7.657</td>
<td>91.89</td>
<td>1/2</td>
<td>5.318</td>
<td>63.81</td>
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</tbody>
</table>

Sec. 1  Page 35
### 17-4 STAINLESS (Continued)

#### 17-4 FLATS
Hot Rolled, Annealed & Pickled
Stock Lengths 10' to 14'

<table>
<thead>
<tr>
<th>Size in Inches</th>
<th>Est. Weight, Lbs. Per foot</th>
<th>Size in Inches</th>
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#### 17-4 PLATES
Hot Rolled, Annealed, and Pickled
Stocked in Thicknesses from 3/16" through 2"; Widths from 48" to 72", and Lengths up to 20'
15-5 VAR (CEVM)

Precipitation Hardening Stainless Bars

UNS S15500

Color Marking: Ends painted Gold with Blue Stripe

15-5 VAR is an improved version of the highly successful 17-4. It possesses the advantages of 17-4, in that high strength can be developed by a single low temperature thermal treatment. In addition it offers excellent transverse toughness and ductility, better mechanical properties in larger sections, and better forgeability.

The composition of 15-5 VAR results in an essentially ferrite-free microstructure, which accounts for the improved properties.

Fabrication practices for 15-5 VAR are generally the same as those established for 17-4.

15-5 VAR is produced as a consumable electrode, vacuum arc remelted product. Where the ultimate in quality and uniformity of properties, and transverse notch toughness in particular, are required, this product is recommended.

ANALYSIS

<table>
<thead>
<tr>
<th>C Max.</th>
<th>Mn Max.</th>
<th>P Max.</th>
<th>S Max.</th>
<th>Si Max.</th>
<th>Cr</th>
<th>Ni</th>
<th>Cu</th>
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<td>.03</td>
<td>.015</td>
<td>1.00</td>
<td>14.00/15.50</td>
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<td>2.50/4.50</td>
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SPECIFICATIONS — Specifications AMS 5659 is generally applicable.

APPLICATIONS, CORROSION RESISTANCE, MECHANICAL PROPERTIES, & FABRICATION — Similar to 17-4, for which see Page 37 of this section.

### 15-5 VAR ROUNDS

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<td>6.014</td>
<td>72.17</td>
<td>¾</td>
<td>28.23</td>
<td>338.8</td>
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Sec. I Page 37
17-7 is a chromium-nickel stainless steel that has the easy-to-work advantages of the chromium-nickel stainless grades, and yet is capable of being hardened. In the annealed (Condition A) state, it has excellent fabricating properties, and it can be precipitation hardened by a simple heat treatment.

In the hardened condition, it possesses excellent mechanical properties both at room temperature and elevated temperatures up to 800°F.

Its corrosion resistance is definitely superior to that of the straight chromium grades, and in some environments it approaches the chromium-nickel grades.

**ANALYSIS**

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**SPECIFICATIONS** — The following specifications are generally applicable:

AMS 5528, AMS 5529.

**APPLICATIONS** — 17-7 is used for applications requiring high strength and corrosion resistance and/or good mechanical properties at temperatures up to 800°F. It lends itself to fabrication of intricate parts, because they may be formed, drawn, or welded and then hardened with a minimum of distortion.

**CORROSION RESISTANCE** — In the precipitation hardened condition, the corrosion resistance of 17-7 is superior to such grades as Type 410. It is generally not quite as good as the Type 304. This applies to general atmospheric corrosion as well as corrosive chemical media, and such factors as aging heat treatment and surface condition have an effect.

**MECHANICAL PROPERTIES** —

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<th>Condition</th>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Elongation in 2&quot;</th>
<th>Rockwell Hardness</th>
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<td>A (Annealed)</td>
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<td>55,000 Max.</td>
<td>20% Min.</td>
<td>Rb 92 Max.</td>
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<td>TH 1050</td>
<td>180,000 Min.</td>
<td>150,000 Min.</td>
<td>6% Min.</td>
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<td>RH 950</td>
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<td>190,000 Min.</td>
<td>5% Min.</td>
<td>Rc 44 Min.</td>
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**MACHINABILITY** — 17-7 in Condition A has a machinability rating of approximately 45%, with 1212 rated as 100%. Surface cutting speed approaches 75 feet per minute. When machining material in the annealed condition, allowance must be made for dimensional changes occurring in heat treatment. When machining material in the hardened condition, lower speeds and more power are required.

**WELDING** — Easily welded by the arc and resistance techniques applicable to stainless steels. No preheating or other complex welding procedures are required. Excellent properties are obtained in weldments, and the choice of weld metal depends upon the properties desired at the weld.

Sec. I Page 38
FORMING — 17-7 in Condition A has good forming and drawing characteristics.

FORGING — Heat to 2150º/2250ºF, air cool.

ANNEALING (Condition A) — Heat to 1950ºF ± 25º and air cool. For forgings, heat to 1900ºF ± 25º and water quench.

HARDENING —

Condition TH 1050 — Heat Condition A material to 1400ºF and hold for 90 minutes. Cool to 60º within one hour and hold one-half hour. Heat to 1050ºF and hold for 90 minutes. Cool in air to room temperature.

Condition RH 950 — Heat Condition A material to 1750º and hold for 10 minutes. Cool to minus 100ºF and hold for 8 hours. Heat to 950º and hold for one hour. Cool in air to room temperature.

For more information, ask for literature on Precipitation Hardening Steels.

### 17-7 SHEETS

No. 2D finish

Condition A

Dull Cold Rolled, Annealed, & Pickled

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<th>Thickness</th>
<th>Width and Length</th>
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<td>.676 20.3</td>
<td>.071”</td>
<td>(15 Ga.) 36x120</td>
<td>2.982 89.5</td>
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<td>.020”</td>
<td>(25 Ga.) 36x120</td>
<td>.840 25.2</td>
<td>.080”</td>
<td>(14 Ga.) 36x120</td>
<td>3.360 100.8</td>
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<tr>
<td>.025”</td>
<td>(24 Ga.) 36x120</td>
<td>1.050 31.5</td>
<td>.090”</td>
<td>(13 Ga.) 36x120</td>
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<td>1.344 40.3</td>
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Sec. I Page 39
A-286 VAR (CEVM)
UNS S66286
Premium Quality High Temperature Bars

Color Marking: Solution Treated and Aged —— Ends painted Aluminum with Brown Stripe
Solution Treated —— Aluminum and Orange

This grade is one of the most popular high temperature alloys and is widely used in jet engine and gas turbine applications. It is a precipitation hardening alloy and thus soft and ductile in the solution treated condition but develops high strength and hardness with a single precipitation or aging treatment. This grade is designed to provide high strength up to 1300°F and oxidation resistance up to 1500°F. Being austenitic in all conditions, it may be used in high strength non-magnetic applications due to its low magnetic permeability consumable electrode vacuum melting practice is used for this alloy resulting in a premium quality steel.

ANALYSIS

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<tr>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Si</th>
<th>Cr</th>
<th>Ni</th>
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<td>.025</td>
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<td>V</td>
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<td>Max.</td>
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SPECIFICATIONS — The following specifications are generally applicable:
AMS 5731, AMS 5732, PWAS 5732

APPLICATIONS — Used where high strength at elevated temperature is required. Also used in applications where oxidation resistance at elevated temperatures is a requirement. Suitable for parts such as buckets, bolts, fittings, rings and jet engine and steam turbine parts.

CORROSION RESISTANCE — Excellent resistance up to 1300°F in all atmospheres encountered in jet engine and turbo-supercharged applications. This alloy also has reasonably good resistance to salt spray corrosion.

OXIDATION RESISTANCE — This alloy has good oxidation resistance for intermittent service up to 1500°F and continuous service up to 1800°F. It is comparable to type 310 Stainless at 1800°F.

MECHANICAL PROPERTIES — AMS 5731 and AMS 5732 require the following after solution treatment at 1800°F, quenched in oil or water followed by precipitation heat treatment at 1325°F for a minimum of 16 hours and air cooled:

<table>
<thead>
<tr>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Elongation in 4D</th>
<th>Reduction of Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>130,000 Min.</td>
<td>85,000 Min.</td>
<td>15% Min.</td>
<td>20% Min.</td>
</tr>
</tbody>
</table>

Solution Treated Hardness —— 201, BHN max. Typical Hardness for solution treated at 1800°F and aged at 1325°F - 248/341 BHN

MACHINABILITY — This grade may be machined using the techniques and equipment employed for austenitic stainless grades. Since the material is soft and gummy in the solution treated condition, it is usually machined after complete heat treatment.

WELDABILITY — Material should be in the solution treated condition for welding. Small sections can be satisfactorily welded using spot, flash, butt welding and metallic arc utilizing coated electrodes or inert gas shielding. Large sections under restraint can lead to cracking.

FORGING — Forge between 1650°F and 2150°F. “Critical reductions” must be avoided to prevent excessive grain growth. To assist in this problem, as a general guide, all forging temperatures should be kept well in excess of 1800°F or heavy reductions during the final hot working operation of at least 15% must be given below 1800°F.

ANNEALING — Same as solution treating temperature of 1800°F, followed by quenching in oil or water.

A-286 VAR ROUNDS
Stock Lengths 10’ TO 12’

Available in diameters 1/2” through 6”

Sec. I Page 40
6 AL — 4 V
Titanium Alloy
UNS R56400
AMS 4928

Color Marking: Ends painted Olive with Black Stripe

6AL-4V is an alpha-beta type titanium base alloy with 120,000 psi minimum yield strength in the annealed condition. This alloy has good forming characteristics, is weldable with proper shielding and can be heat treated to higher strength levels by a solution treatment and aging process. It has good elevated temperature strength, good creep resistance, and low temperature impact strength.

ANALYSIS

<table>
<thead>
<tr>
<th>Al</th>
<th>V</th>
<th>Fe</th>
<th>O</th>
<th>C</th>
<th>N</th>
<th>H</th>
<th>Ti</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.50/6.75</td>
<td>3.50/4.50</td>
<td>.30</td>
<td>.20</td>
<td>.10</td>
<td>.05</td>
<td>.0125 Remainder</td>
<td></td>
</tr>
</tbody>
</table>

SPECIFICATIONS — The following specifications are generally applicable: AMS 4928, MIL-T-9047, PWAS 4928.

APPLICATIONS — Aircraft structural parts, ordnance and missile components, gas turbine disks, rings and blades, and other uses where a high strength to weight ratio is required.

CORROSION RESISTANCE — Comparable to commercially pure titanium. Shows good resistance to sea water and marine atmospheres, as well as wet chlorine and chlorine dioxide.

MECHANICAL PROPERTIES — AMS 4928 requires the following minimum properties in the annealed condition:

<table>
<thead>
<tr>
<th>Size</th>
<th>Tensile Strength (psi)</th>
<th>Yield Strength (psi)</th>
<th>Elongation in 2&quot;</th>
<th>Reduction of Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thru 2&quot;</td>
<td>135,000 min.</td>
<td>125,000 min.</td>
<td>10% min.</td>
<td>25% min.</td>
</tr>
<tr>
<td>Over 2&quot; thru 4&quot;</td>
<td>130,000 min.</td>
<td>120,000 min.</td>
<td>10% min.</td>
<td>25% min.</td>
</tr>
<tr>
<td>Over 4&quot; thru 6&quot;</td>
<td>130,000 min.</td>
<td>120,000 min.</td>
<td>10% min.</td>
<td>20% min.</td>
</tr>
</tbody>
</table>

Depending upon section size, this material can be solution treated and aged to produce typical properties of 140/170,000 psi tensile strength and 130/150,000 psi yield strength.

MACHINABILITY — To machine satisfactorily, care must be taken to use sharp tools, the correct tool angles, heavy feeds, slow speeds and sufficient coolant.

WELDABILITY — This alloy can be satisfactory welded provided the weld is properly shielded from the atmosphere. In addition to the inert gas-shielded metal-arc welding, other methods, such as spot, seam, flash and pressure welding may also be used with excellent success.

ANNEALING — Annealing is accomplished by holding at 1350°F for one-half to two hours and air cooling.

6 AL - 4 V TITANIUM ROUNDS
Stock Lengths 10' TO 12'
Available in diameters ½” through 4”
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