STAINLESS STEEL

• Excellent Corrosion Resistance
• Good Elevated Temperature Strength
• Good Pitting Resistance

Applications Potential

Type 316 Stainless Steel is widely used in applications requiring corrosion resistance superior to Type 304, or good elevated temperature strength. Typical uses include exhaust manifolds, furnace parts, heat exchangers, jet engine parts, pharmaceutical and photographic equipment, valve and pump trim, chemical equipment, digesters, tanks, evaporators, pulp, paper and textile processing equipment, parts exposed to marine atmospheres and tubing. Type 316L is used extensively for weldments where its immunity to carbide precipitation due to welding assures optimum corrosion resistance.
Type 316L is an extra-low carbon version of Type 316 that eliminates harmful carbide precipitation due to welding.

## Composition

<table>
<thead>
<tr>
<th></th>
<th>Type 316</th>
<th>Type 316L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.08 max.</td>
<td>0.03 max.</td>
</tr>
<tr>
<td>Manganese</td>
<td>2.00 max.</td>
<td>2.00 max.</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.045 max.</td>
<td>0.045 max.</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.030 max.</td>
<td>0.03 max.</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.75 max.</td>
<td>0.75 max.</td>
</tr>
<tr>
<td>Chromium</td>
<td>16.00 - 18.00</td>
<td>16.00 - 18.00</td>
</tr>
<tr>
<td>Nickel</td>
<td>10.00 - 14.00</td>
<td>10.00 - 14.00</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>2.00 - 3.00</td>
<td>2.00 - 3.00</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.10 max.</td>
<td>0.10 max.</td>
</tr>
<tr>
<td>Iron</td>
<td>Balance</td>
<td>Balance</td>
</tr>
</tbody>
</table>

## Available Forms

AK Steel produces Types 316 and 316L Stainless Steels in thicknesses from 0.01" to 0.25" (0.25 to 6.35 mm) max. and widths up to 48" (1219 mm). For other thicknesses and widths, inquire.

## Metric Practice

Values shown in this bulletin were established in U.S. customary units. The metric equivalents of U.S. customary units shown may be approximate. Conversion to the metric system, known as the International System of Units (SI), has been accomplished in accordance with ASTM E380.

The newton (N) has been adopted by the SI as the metric standard unit of force as discussed in the AISI Metric Practice Guide. The term for force per unit of area (stress) is the newton per square metre (N/m²). Since this can be a large number, the prefix mega is used to indicate 1,000,000 units and the term meganewton per square metre (MN/m²) is used. The unit (N/m²) has been desig-
Table 1
Typical Room Temperature Properties

<table>
<thead>
<tr>
<th></th>
<th>UTS ksi (MPa)</th>
<th>0.2% YS ksi (MPa)</th>
<th>Elongation % in 2&quot; (50.8 mm)</th>
<th>Hardness Rockwell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 316</td>
<td>84.0 (579)</td>
<td>42.0 (290)</td>
<td>50</td>
<td>B79</td>
</tr>
<tr>
<td>Type 316L</td>
<td>81.0 (558)</td>
<td>42.0 (290)</td>
<td>50</td>
<td>B79</td>
</tr>
</tbody>
</table>

Table 2
Elevated Temperature Properties

<table>
<thead>
<tr>
<th>Temperature °F (°C)</th>
<th>UTS ksi (MPa)</th>
<th>0.2% YS ksi (MPa)</th>
<th>Elongation % in 2&quot; (50.8 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 (204)</td>
<td>81.0 (558)</td>
<td>35.0 (241)</td>
<td>51</td>
</tr>
<tr>
<td>600 (316)</td>
<td>78.0 (538)</td>
<td>31.0 (214)</td>
<td>48</td>
</tr>
<tr>
<td>800 (427)</td>
<td>76.0 (524)</td>
<td>27.5 (190)</td>
<td>47</td>
</tr>
<tr>
<td>1000 (538)</td>
<td>70.0 (483)</td>
<td>24.0 (165)</td>
<td>44</td>
</tr>
<tr>
<td>1200 (649)</td>
<td>57.0 (393)</td>
<td>21.0 (145)</td>
<td>40</td>
</tr>
<tr>
<td>1400 (760)</td>
<td>35.0 (241)</td>
<td>18.0 (124)</td>
<td>37</td>
</tr>
<tr>
<td>1600 (871)</td>
<td>24.0 (165)</td>
<td>16.0 (110)</td>
<td>44</td>
</tr>
</tbody>
</table>

Table 3
Stress Rupture Properties

<table>
<thead>
<tr>
<th>Test Stress, ksi (MPa), for rupture in:</th>
<th>Temperature °F (°C)</th>
<th>1,000 hours</th>
<th>10,000 hours</th>
<th>100,000 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1100 (593)</td>
<td>36.0 (248)</td>
<td>28.0 (193)</td>
<td>25.0 (172)</td>
</tr>
<tr>
<td></td>
<td>1200 (649)</td>
<td>24.0 (165)</td>
<td>16.5 (114)</td>
<td>13.5 (94)</td>
</tr>
<tr>
<td></td>
<td>1300 (704)</td>
<td>15.5 (106)</td>
<td>10.0 (69)</td>
<td>7.0 (48)</td>
</tr>
<tr>
<td></td>
<td>1400 (760)</td>
<td>10.0 (69)</td>
<td>6.0 (41)</td>
<td>3.5 (24)</td>
</tr>
<tr>
<td></td>
<td>1500 (816)</td>
<td>6.0 (41)</td>
<td>3.5 (24)</td>
<td>2.0 (14)</td>
</tr>
<tr>
<td></td>
<td>1600 (871)</td>
<td>3.5 (24)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>
**Physical Properties**

Density, 0.29 lbs/in³

7.99 g/cm³

Electrical Resistivity, microhm-in (microhm-cm)

68°F (20°C) – 29.4 (74)

Specific Heat, BTU/lb/°F (kJ/kg•K)

32 - 212°F (0-100°C) – 0.12 (0.50)

Thermal Conductivity, BTU/hr/ft²/ft/°F (W/m•K)

at 212°F (100°C) – 9.4 (16.2)

at 932°F (500°C) – 12.4 (21.4)

Mean Coefficient of Thermal Expansion, in/in/°F(µm/m•K)

32 - 212°F (0 - 100°C) – 8.9 x 10⁻⁶ (16.0)

32 - 600°F (0 - 315°C) – 9.0 x 10⁻⁶ (16.2)

32 - 1000°F (0 - 538°C) – 9.7 x 10⁻⁶ (17.5)

32 - 1200°F (0 - 649°C) – 10.3 x 10⁻⁶ (18.5)

32 - 1500°F (0 - 871°C) – 11.1 x 10⁻⁶ (19.9)

Modulus of Elasticity, ksi (MPa)

28.0 x 10³ (193 x 10³) in tension

11.2 x 10³ (77 x 10³) in torsion

Magnetic Permeability, H = 200 Oersteds

Annealed – 1.02 max.

Melting Range, °F (°C) – 2500 - 2550 (1371 - 1399)
Corrosion Resistance
Types 316 and 316L Stainless Steels exhibit better cor-
rosion resistance than Type 304. They provide excellent
resistance to pitting type corrosion such as encountered
in a sea coast environment. They also provide good
resistance to most chemicals involved in the paper, tex-
tile and photographic industries. They are particularly
useful in one to five percent sulfuric acid solutions up to
150°F (66°C) as well as acetic, phosphoric, formic and
tartaric acids, and in certain chloride, bromide and io-
dide solutions.

Oxidation Resistance
The maximum temperature to which Types 316 and 316L
can be exposed continuously without appreciable scaling
is about 1700°F (927°C). For intermittent exposure, the
maximum exposure temperature is about 1600°F (871°C).

Heat Treatments
Types 316 and 316L are non-hardenable by heat treat-
ment.

Annealing: Heat to 1900 - 2100°F (1038 - 1149°C), then
rapidly quench.

Cold Working
Due to the higher nickel content, these grades work
harden at a lower rate than Type 304. In the annealed
condition, they exhibit excellent ductility and may be
readily roll formed, deep drawn, and bent. Annealing is
essential to restore ductility and to lower hardness for
subsequent forming operations. Severely formed parts
should be annealed to remove stresses.

Formability
Types 316 and 316L can be readily formed and drawn.

Specifications
Types 316 and 316L Stainless Steel sheet and strip
are covered by the following specifications:

<table>
<thead>
<tr>
<th>Type 316</th>
<th>Type 316L</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMS 5524</td>
<td>AMS 5507</td>
</tr>
<tr>
<td>ASTM A 240</td>
<td>ASTM A 240</td>
</tr>
<tr>
<td>QQ-S-766</td>
<td>QQ-S-766</td>
</tr>
<tr>
<td>MIL-S-5059</td>
<td></td>
</tr>
</tbody>
</table>

Weldability
The austenitic class of stainless steels is generally con-
sidered to be weldable by the common fusion and
resistance techniques. Special consideration is required
to avoid weld “hot cracking” by assuring formation of
ferrite in the weld deposit. These particular alloys are
generally considered to have poorer weldability than
Types 304 and 304L. A major difference is the higher
nickel content for these alloys which requires slower
arc welding speed and more care to avoid hot cracking.
When a weld filler is needed, AWS E/ER 316L and 16-
8-2 are most often specified. Types 316 and its
low-carbon “L” version are well known in reference lit-
erature and more information can be obtained in the
following ways:

1. ANSI/AWS A5.9, A5.22, and A5.4 (filler metals, mini-
mum UTS and elongation)

2. “Welding of Stainless Steels and Other Joining
Methods,” SSINA, (800:982-0355)

3. “Welding Stainless Steels,” FDB #SF-71

4. ANSI/AWS B2.1.009-90 [GTAW 300’s @ .050" -
   0.14"]

5. ANSI/AWS B2.1-8-024-94 [GTAW 300’s @ 1/8" -
   1-1/2”]

6. ANSI/AWS B2.1.013-91 [SMAW 300’s .050" - 0.14”]

7. ANSI/AWS B2.1-8-023-94 [SMAW 300’s @ 1/8" -
   1-1/2”]

8. ANSI/AWS B2.1.005-90 [GMAW 300’s @ .050" -
   0.14”]