P R O D U C T D A T A B U L L E T I N

316/316L STAINLESS STEEL

UNS S31600 AND S31603

AK 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.

Table of Contents

Type 316L is an extra-low carbon version of Type 316 that eliminates harmful carbide precipitation due to welding.

Composition

	Type 316 %	Type 316L %
Carbon	0.08 max.	0.03 max.
Manganese	2.00 max.	2.00 max.
Phosphorus	0.045 max.	0.045 max.
Sulfur	0.030 max.	0.03 max.
Silicon	0.75 max.	0.75 max.
Chromium	16.00 - 18.00	16.00 - 18.00
Nickel	10.00 - 14.00	10.00 - 14.00
Molybdenum	2.00 - 3.00	2.00 - 3.00
Nitrogen	0.10 max.	0.10 max.
Iron	Balance	Balance

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/m^2). 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/m^2) is used. The unit (N/m^2) has been desig-

nated a pascal (Pa). The relationship between the U.S. and the SI units for stress is: 1000 pounds/in^2 = 1 kip/in^2 = 6.8948 meganewtons/m^2(MN/m^2) = 6.8948 megapascals (MPa).

Mechanical Properties

Table 1
Typical Room Temperature Properties

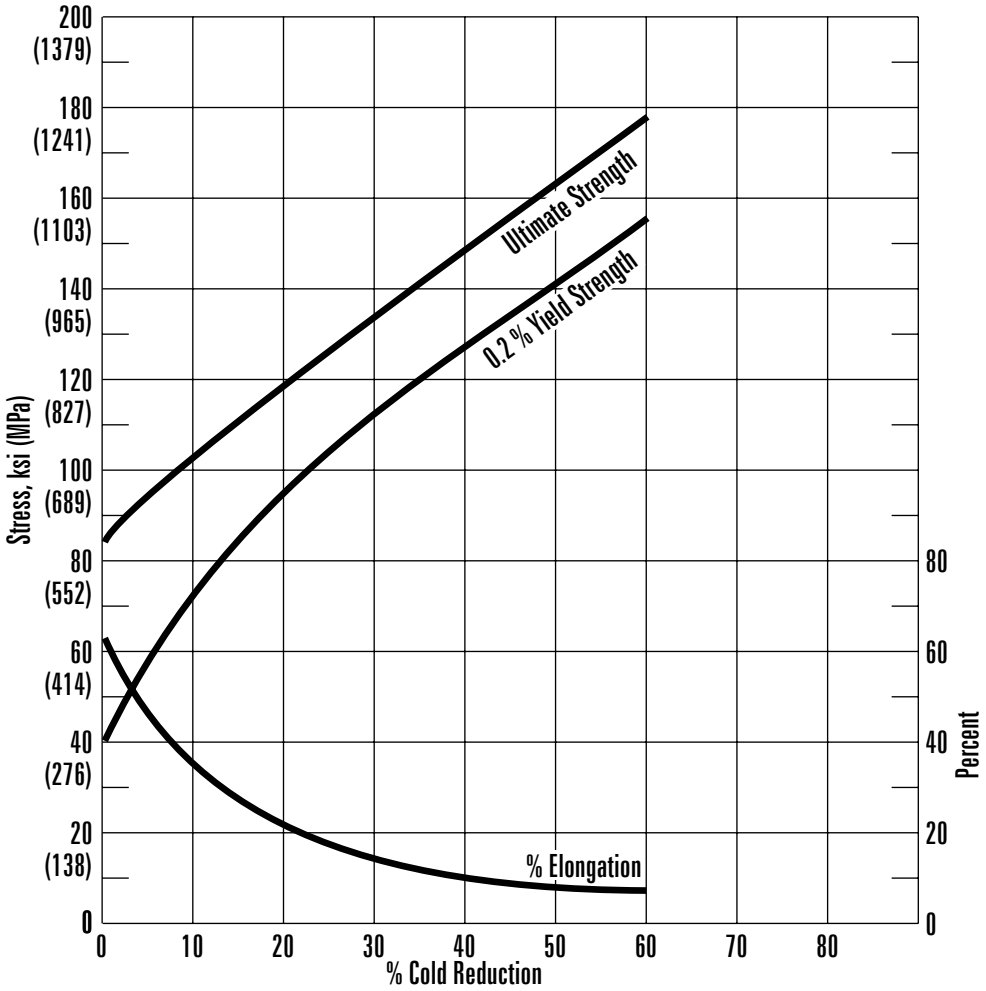
	UTS ksi (MPa)	0.2% YS ksi (MPa)	Elongation % in 2" (50.8 mm)	Hardness Rockwell
Type 316	84.0 (579)	42.0 (290)	50	B79
Type 316L	81.0 (558)	42.0 (290)	50	B79

Table 2
Elevated Temperature Properties

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

Table 3
Stress Rupture Properties

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



Physical Properties

Density, 0.29 lbs/in^3
7.99 g/cm^3

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/ft^2/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 10^3 (193 x 10^3) in tension
11.2 x 10^3 (77 x 10^3) 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 corrosion 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, textile 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 iodide 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 treatment.

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:

Type 316	Type 316L
AMS 5524	AMS 5507
ASTM A 240	ASTM A 240
QQ-S-766	QQ-S-766
MIL-S-5059	

Weldability

The austenitic class of stainless steels is generally considered 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 literature and more information can be obtained in the following ways:

1. ANSI/AWS A5.9, A5.22, and A5.4 (filler metals, minimum 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"]

Customer Service 800-331-5050

AK Steel Corporation
9227 Centre Pointe Drive
West Chester, OH 45069

www.aksteel.com

PD-140 7180-0127 PDF 7/07