Technical Data Sheet

ATI 316LN™

Stainless Steel: Austenitic

(UNS S31653)

GENERAL PROPERTIES

ATI 316LN (UNS S31653) stainless is a low-carbon, nitrogen-enhanced version of Type 316 molybdenum-bearing austenitic stainless steel. It is also known as DIN/EN designation No. 1.4406. The Type 316 alloys are more resistant to general corrosion and pitting/crevice corrosion than the conventional chromium-nickel austenitic stainless steels such as Type 304. They also offer higher creep, stress-rupture and tensile strength at elevated temperature. ATI 316 stainless steel can be susceptible to sensitization – the formation of grain boundary chromium carbides at temperatures between approximately 900 and 1500 °F (425 to 815 °C) – which can result in rapid corrosion. Reduced carbon ATI 316L alloy is resistant to sensitization; however, extended exposures in this temperature range will eventually result in sensitization of even the low carbon grade. The nitrogen in ATI 316LN alloy adds additional resistance to sensitization in some circumstances. The nitrogen content of ATI 316LN stainless steel also provides some solid solution hardening, raising its minimum specified yield strength compared to ATI 316L stainless steel. Like ATI 316 and ATI 316L alloys, the ATI 316LN alloy also offers excellent resistance to general corrosion and pitting/crevice corrosion.

SPECIFICATION COVERAGE

ATI 316LN alloy is included in ASTM A 240 for plate, sheet, and strip products made by ATI.

COMPOSITION

Element	Minimum*	Maximum*
Chromium	16.0	18.0
Molybdenum	2.00	3.00
Nickel	10.0	14.0
Manganese		2.00
Phosphorus		0.045
Sulfur		0.030
Silicon		0.75
Carbon		0.030
Nitrogen	0.10	0.16
Iron	balance	

* ASTM Specification A 240

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

PHYSICAL PROPERTIES

Property	Value	Units
Density at 72°F (22°C)	8.00 0.289	g/cm^3 lb/in^3
Melting Range	2450°F-2630°F	1345°C-1440°C
Thermal Conductivity at 212 °F (100°C)	8.4 14.6	BTU/hr·ft·°F W/m·K
Thermal Expansion coefficient at 68-212°F (20-100°C)	9.2 16.5	µ in/in/°F µ m/m/°C
Thermal Expansion coefficient at 68-932°F (20-500°C)	10.1 18.2	µ in/in/°F µ m/m/°C
Thermal Expansion coefficient at 68-1832°F (20-1000°C)	10.8 19.5	µ in/in/°F µ m/m/°C

ATI 316LN stainless is a single phase austenitic (face centered cubic) stainless steel at all temperatures up to the melting point. The alloy can not be hardened by heat treatment. The alloy is nonmagnetic in the annealed condition. Its magnetic permeability is typically less than 1.02 at 200 H (Oersteds). Permeability values for cold de-formed material vary with composition and the amount of cold deformation, but are usually higher than that for annealed material.

MECHANICAL PROPERTIES

Typical Room Temperature properties

Property	ASTM A 240
Yield Strength, 0.2% offset	30 ksi* 205 MPa*
Ultimate Tensile Strength	75 ksi* 515 MPa*
Elongation in 2" (51 mm)	40%*
Hardness	217 Brinell** 95 HRB**

* minimum, ** maximum

Fatigue Resistance

The fatigue strength or endurance limit is the maximum stress below which a material is unlikely to fail in 10 million cycles in an air environment. For austenitic stainless steels as a group, the fatigue strength is typically about 35 percent of the tensile strength. However, substantial variability in service results is experienced since additional variables such as corrosive conditions, type of loading and mean stress, surface condition, and other factors affect fatigue properties. For this reason, no definitive endurance limit value can be given which is representative of all operating conditions.

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

OXIDATION RESISTANCE

ATI 316LN alloy exhibits excellent resistance to oxidation and a low rate of scaling in air atmospheres at temperatures up to 1600-1650°F (870-900°C). The performance of ATI 316LN stainless is slightly inferior to that of ATI 304 stainless steel, which has slightly higher chromium content (18% vs. 16% for ATI 316LN stainless). The rate of oxidation is greatly influenced by the atmosphere en-countered in service and by operating conditions. For this reason, no data can be presented that is applicable to all service conditions.

Like other molybdenum bearing alloys, ATI 316LN stainless is subject to catastrophic oxidation at high temperatures in stagnant air atmospheres, such as in the heat treatment of closely packed items. This occurs due to the formation of low melting molybdenum trioxide (MoO_3), which reacts with the alloy causing deep pitting and metal loss. When air is allowed to circulate, the MoO_3 will evaporate from the metal surface and excessive oxidation is avoided.

CORROSION PROPERTIES

General Corrosion Resistance

The molybdenum bearing grades such as ATI 316 and ATI 316LN stainless steels are more resistant to atmospheric and other mild types of corrosion than the 18Cr-8Ni stainless steels. In general, media that do not corrode 18-8 stainless steels will not attack the molybdenum-containing grades. One known exception is highly oxidizing acids such as nitric acid to which the molybdenum bearing stainless steels are less resistant. ATI 316 and ATI 316LN stainless are considerably more resistant than any of the other chromium-nickel types to solutions of sulfuric acid. Where condensation of sulfur-bearing gases occurs, these alloys are much more resistant than other types of stainless steels. In sulfuric acid solutions, the acid concentration has a strong influence on the rate of attack.

Pitting Corrosion

Resistance of austenitic stainless steels to pitting and/ or crevice corrosion in the presence of chloride or other halide ions is enhanced by higher chromium (Cr) and molybdenum (Mo) content. A relative measure of pitting resistance is given by the PRE_N (Pitting Resistance Equivalent with nitrogen) calculation, where:

$PRE_N = Cr + 3.3Mo + 16N$

The PRE_N of ATI 316LN alloy (25.0) is higher than that of ATI 304 (PRE_N =20.0), reflecting the better pitting resistance which ATI 316LN alloy offers due to its Mo and N content. ATI 304 stainless steel is considered to resist pitting and crevice corrosion in waters containing up to about 100 ppm chloride. ATI 316LN alloy on the other hand, due to its Mo-content, will handle waters with up to about 2000 ppm chloride. This alloy is not recommended for use in seawater (~19,000 ppm chloride). ATI 316LN alloy is considered adequate for some applications that are exposed to salt spray. ATI 316LN stainless steel exhibits no evidence of corrosion in the 100-hour, 5% salt spray (ASTM B117) test.

Intergranular Corrosion

ATI 316 stainless steel is susceptible to precipitation of chromium carbides in grain boundaries when exposed to temperatures in the 800°F to 1500°F (425°C to 815°C) range. Such “sensitized” steels are subject to inter-granular corrosion when exposed to aggressive environments. ATI 316L alloy is available to avoid the hazard of intergranular corrosion. ATI 316L alloy provides resistance to intergranular attack even after short periods of exposure in the 800-1500°F (425-815°C) temperature range. Stress relieving treatments falling within these limits can be employed without affecting the corrosion resistance of the metal. Accelerated cooling from higher temperatures for the “L” grades is not needed when very heavy or bulky sections have been annealed.
ATI 316LN alloy possesses the same mechanical properties as the corresponding higher-carbon ATI 316, and offers the resistance to intergranular corrosion of ATI 316L alloy. Although the short duration heating encountered during welding or stress relieving does not produce susceptibility to intergranular corrosion, continuous or prolonged exposure at 800-1200°F (422- 650°C) can produce sensitization of ATI 316LN (and of ATI 316L) stainless steels.

The influence of molybdenum reduces the resistance of ATI 316LN stainless steel to highly oxidizing environments including the nitric acid environment of the ASTM A 262 practice C "Huey" test.

Stress Corrosion Cracking

Austenitic stainless steels are susceptible to stress corrosion cracking (SCC) in halide environments. Although the ATI 316, ATI 316L and ATI 316Ti alloys are more resistant to SCC than the 18 Cr-8 Ni alloys, they still are quite susceptible. Conditions that produce SCC are:

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com

(1) Presence of halide ion (generally chloride),

(2) Residual tensile stresses, and

(3) Temperature in excess of about 140°F (60°C).

Stresses result from cold deformation or thermal cycles during welding. Annealing or stress relieving heat treatments may be effective in reducing stresses, thereby reducing sensitivity to halide SCC. Although the low carbon ATI 316L and ATI 316LN alloys offer no advantage as regards SCC resistance, they are better choices for service in the stress relieved condition in environments which might cause intergranular corrosion. If SCC resistance is desired, use of duplex stainless steels such as ATI 2205™ or ATI 2003® duplex stainless alloys should be considered.

FABRICATING AND WELDING

Fabrication

The austenitic stainless steels, including the ATI 316LN alloy, are routinely fabricated into a variety of shapes ranging from the very simple to very complex. These alloys are blanked, pierced, and formed on equipment essentially the same as used for carbon steel. The excellent ductility of the austenitic alloys allows them to be readily formed by bending, stretching, deep drawing and spinning. However, because of their greater strength and work hardenability, the power requirements for the austenitic grades during forming operations are considerably greater than for carbon steels. Attention to lubrication during forming of the austenitic alloys is essential to accommodate the high strength and galling tendency of these alloys.

Annealing

The austenitic stainless steels are provided in the mill-annealed condition ready for use. Heat treatment may be necessary during or after fabrication to remove the effects of cold forming or to dissolve precipitated chromium carbides resulting from thermal exposures. For the ATI 316LN alloy the solution anneal is accomplished by heating in the 1900- 2150°F (1040-1175°C) temperature range followed by air cooling or a water quench, depending on section thickness. ATI 316LN stainless cannot be hardened by heat treatment.

Welding

The austenitic stainless steels are considered the most weldable of the stainless steels. They are routinely joined by all fusion and resistance welding processes. Two important considerations for weld joints in these alloys are (1) avoidance of solidification cracking, and (2) preservation of corrosion resistance of the weld and heat-affected zones. ATI 316LN stainless steel often is welded autogenously. If filler metal must be used for welding ATI 316LN stainless, it is advisable to utilize the low carbon ATI 316L or E318 filler metals. Contamination of the weld region with copper or zinc should be avoided, since these elements can form low melting point compounds, which in turn can create weld cracking.

Allegheny Technologies Incorporated
1000 Six PPG Place
Pittsburgh, PA 15222-5479 U.S.A.
www.ATImetals.com