ATI

Technical Data Sheet

ATI 2304™

Stainless Steel: Duplex

(UNS S32304)

GENERAL PROPERTIES

ATI 2304 alloy is a lean duplex stainless steel (LDSS) that contains 23% Cr, 4% Ni, and very little Mo. The corrosion resistance of ATI 2304 LDSS is similar to that of Type 316L, but its strength is much higher. The strength advantage that duplex alloys have compared to austenitic grades often allows for significant weight savings to be realized in applications where the design thickness is related to yield or tensile strength. If an alloy with similar corrosion resistance and even higher strength than ATI 2304 LDSS is desired, ATI 2102® and ATI 2003® lean duplex alloys should be considered. ATI 2304 LDSS has a duplex microstructure that consists of a nearly equal mixture of ferrite and austenite. The microstructure and composition of ATI 2304 alloy provide stress-corrosion cracking resistance that is superior to that of Types 304 or 316.

TYPICAL COMPOSITION

Element	Weight %
Carbon	0.030 max
Manganese	2.50 max
Phosphorus	0.040 max
Sulfur	0.030 max
Silicon	1.00 max
Chromium	21.5 — 24.5
Nickel	3.00 – 5.50
Molybdenum	0.05 – 0.60
Copper	0.05 – 0.60
Nitrogen	0.05 — 0.20
Iron	Balance

PRODUCT FORMS

ATI 2304 LDSS is available from ATI as a plate-mill plate product in widths up to 96" (2438 mm), lengths up to 300" (7620 mm) and thickness between 0.1875" and 1.00" (4.76 and 25.4 mm).

SPECIFICATIONS

ATI 2304 alloy is approved for ASME Boiler and Pressure Vessel Code use and is covered by ASTM Standards A240, A276, A480, A789, A790, A928, and A949, and SAE Standard J405. ATI 2304 LDSS is also included in Appendix X of API Standard 650 and has been certified as acceptable for use in drinking water treatment and distribution systems in Appendix C of NSF/ANSI Standard 61:2005.

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PHYSICAL PROPERTIES

Density 0.28 lb/in^3 (7.8 g/cm^3)

Elastic Modulus 29 x 10^6 psi (200 GPa)*

Magnetic Permeability Ferromagnetic

Thermal Expansion (mean coefficient over range)

Temperature Range		Coefficients	
°F	°C	in/in°F•10^{-6}	cm/cm°C•10^{-6}
68 - 212	20 - 100	7.2	13
68 - 392	20 - 200	7.5	13.5
68 - 572	20 - 300	7.8	14

Thermal Conductivity

Temperature			
°F	°C	Btu-in/ft^2•hr-°F	W/m•K
68 - 212	20 - 100	7.2	13
68 - 392	20 - 200	7.5	13.5
68 - 572	20 - 300	7.8	14

CORROSION RESISTANCE

The high Cr content of ATI 2304 LDSS gives it excellent resistance to general corrosion, which is comparable to that of Type 316L in most environments. A relative estimate of an alloy's resistance to chloride-ion pitting and crevice corrosion can be determined by calculating its pitting resistance equivalence number (PRE_N) according to the equation PRE_N = %Cr + 3.3(% Mo) + 16(%N). The table below shows how the typical PRE_N of ATI 2304 LDSS compares to those of other stainless steels. A higher PRE_N corresponds to higher pitting resistance.

Alloy	Typical PRE_N
Type 316L	24
ATI 2304™	26
ATI 2102®	26
ATI 2003®	30
ATI 2205™	36

As a duplex alloy, ATI 2304 LDSS will have greater resistance to chloride stress corrosion cracking (CSCC) than austenitic grades such as Types 304L and 316L.

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MECHANICAL PROPERTIES

Room Temperature Mechanical Properties

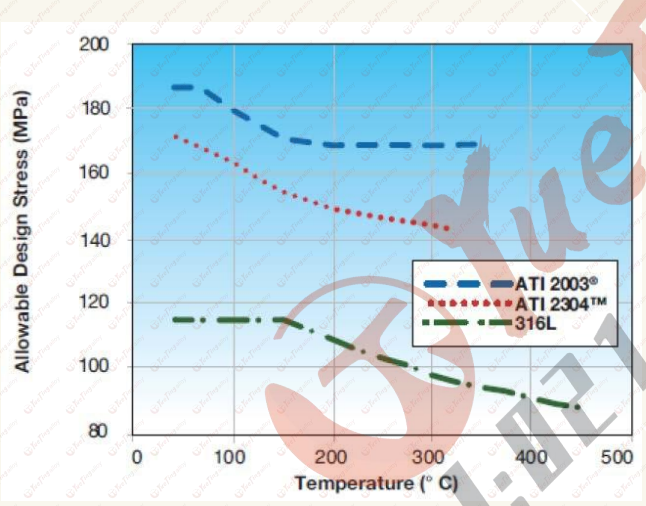
ASTM A 240 specification limits for annealed ATI 2304 plate material are shown in the table below. Other alloys are also shown for comparison.

Minimum Room Temperature Mechanical Properties for Plate

Alloy	Ultimate Strength		0.2% Yield Strength		Elongation in 2" or 50 mm (%)	Hardness (Max)	
	ksi	MPa	ksi	MPa		BHN	Rc
Type 316L	70	485	25	170	40	217	95 R_B
ATI 2304™	87	600	58	400	25	290	32
ATI 2102®	95	655	65	450	30	293	31
ATI 2003®	95	655	65	450	25	293	31
ATI 2205™	95	655	65	450	25	293	31

Elevated Temperature Mechanical Properties

The ASME Boiler and Pressure Vessel Code places an upper temperature limit of 600°F (315°C) on the use of ATI 2304 lean duplex stainless steel. This is because duplex stainless steels are subject to a phenomenon known as 885°F (475°C) embrittlement following exposure at temperatures above about 600°F. The chart below shows the ASME Section VIII Division I maximum allowable stress levels for ATI 2304 plate material. The maximum allowable stress levels for ATI 2003 LDSS and Type 316L are shown for comparison.



Maximum allowable design stress levels permitted for the use of ATI 2304™, ATI 2003®, and Type 316L plate under the ASME Boiler and Pressure Vessel Code Section VIII Division 1.

Low-Temperature Impact Properties

Duplex stainless steels such as ATI 2304 LDSS will undergo a ductile to brittle transition at low temperatures. However, ATI 2304 LDSS retains sufficient low-temperature toughness to exceed the commonly required Charpy impact energy of 40 J at -40°C.

FORMABILITY

ATI 2304 LDSS can be successfully cold-formed to the same extent as other duplex stainless steels. Because of the higher strength of duplex grades, greater loads and more generous bend radii are required for forming compared to conventional austenitic materials. It is suggested that bend radii of at least two times the metal thickness be used when forming duplex stainless steels. Allowances may also need to be made for a larger springback than is seen with lower strength materials.

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HEAT TREATMENT

The minimum annealing temperature for ATI 2304 LDSS listed in ASTM Standard A480 is 1800°F (980°C). Annealing at higher temperatures is acceptable, but this will increase the amount of ferrite present in the microstructure compared to that resulting from annealing near 1800°F (980°C). Heat treatment should be followed by rapid cooling to prevent the precipitation of deleterious phases.

WELDING

ATI 2304 LDSS can be welded by most methods used to weld stainless steels. These include GMAW, GTAW, SAW, and FCAW. Welding parameters should be optimized to obtain an acceptable level of ferrite in the weld and in its heat-affected-zone, and to minimize the formation of deleterious phases. Commercially available overmatched filler metals are suggested for welding ATI 2304 alloy. Such filler metals contain more nickel than the base metal in order to produce a phase balance within the weld that is approximately the same as that of the base metal. When ATI 2304 alloy is welded to different metals, a filler metal should be chosen that contains a sufficient quantity of austenite forming elements.

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