ATI

Technical Data Sheet

# ATI 219™

## Austenitic Stainless Steel

(UNS S21904)

### INTRODUCTION

ATI 219™ alloy, also known by the more familiar 21-6-9 or XM-11 designations* is a nitrogen-bearing austenitic stainless steel that has substantially higher strength than standard austenitic stainless steels. The alloy remains non-magnetic even after substantial cold forming and exposure to subzero temperatures. Many of the applications for the ATI 219™ alloy make use of the combination of high strength and nonmagnetic properties of the alloy, even at very low temperatures.

The ATI 219™ alloy has good general corrosion resistance comparable to that of the familiar Type 304 stainless steel. The ATI 219™ alloy is produced to a lower carbon level and is more resistant to intergranular corrosion in the welded condition than higher carbon content alloys.

Weldability of the ATI 219™ alloy is very good. The alloy may be welded by all the standard methods used for stainless steels. Welding procedures should be designed to retain the nitrogen level of the alloy within the weld-fusion zone.

### PRODUCT FORMS

The ATI 219™ alloy is provided in plate, sheet and strip. All material is furnished in the solution heat treated condition.

| Product Form | Specification | | |
|---|---|---|---|
| | ASTM | ASME | AMS |
| Plate, Sheet and Strip | A 412<br>A 666 | SA-412<br>SA-666 | 5595 |
| Seamless and Welded Pipe, Tubing | A 269, A 312,<br>A 813, A 814 | SA-312 | 5562<br>5561 |
| Bar, Forgings, Wire | A 182, A 276,<br>A 314, A 473,<br>A 479, A 580,<br>A 965 | SA-182<br>SA-276<br>SA-479 | 5656 |



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| ASTM A 666 Composition Range | |
|---|---|
| **Element** | **Weight Percent** |
| Carbon | 0.04 max |
| Manganese | 8.0-10.0 |
| Phosphorus | 0.060 max |
| Sulfur | 0.030 max |
| Silicon | 0.75 max |
| Chromium | 19.0-21.5 |
| Nickel | 5.5-7.5 |
| Nitrogen | 0.15-0.40 |
| Iron | Balance |

## PHYSICAL PROPERTIES

| Density | Specific Gravity | Specific Heat | Elastic Modulus in Tension |
|---|---|---|---|
| 0.284 lb/in$^3$ | 7.85 | (32-212°F) 0.12 Btu/lb/°F | Room Temperature 28.5 x 10$^6$ psi |
| 7.85 g/cm$^3$ | | ( 0-100°C) 500 Joules/kg/°K | 195 GPa |

| Linear Coefficient of Thermal Expansion | | | |
|---|---|---|---|
| Temperature Range | | | |
| °F | °C | in/in/°F | cm/cm/°C |
| 70-200 | 20-93 | 6.3 x 10-6 | 11.3 x 10-6 |
| 70-800 | 20-427 | 9.3 x 10-6 | 16.7 x 10-6 |



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## MAGNETIC PERMEABILITY

The stable austenite produced by the high levels of manganese and nitrogen in the ATI 219™ alloy is not prone to martensite transformation despite substantial cold deformation. The table values below compare the magnetic permeability of Type 304, an alloy which produced some (magnetic) martensite upon deformation, to that of the more stable Type 305 and ATI 219™ alloy. The ATI 219™ alloy maintains the lowest magnetic permeability even after very heavy cold reduction.

| Percent Cold Reduction | Magnetic Permeability at 200 H | | |
|---|---|---|---|
| | Type 304 | Type 305 | ATI 219™ |
| 0 | 1.015 | 1.002 | 1.002 |
| 10 | 1.064 | 1.003 | 1.002 |
| 30 | 3.235 | 1.004 | 1.003 |
| 50 | 8.480 | 1.008 | 1.004 |
| 65 | 14.41 | 1.032 | 1.005 |

| Thermal Conductivity | | |
|---|---|---|
| Average from 70°F (21°C) to °F (°C) | Btu/ft/hr/°F | W/m°K |
| 200 (93) | 8.0 | 13.8 |
| 800 (427) | 11.7 | 20.2 |

## CORROSION RESISTANCE

The corrosion resistance of the ATI 219™ alloy is generally comparable to that of Type 304 stainless steel.



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## MECHANICAL PROPERTIES

Effect of Cold Reduction on Room Temperature Mechanical Properties of ATI 219™ Strip Compared with Type 304 Strip

| Percent Cold Reduction | 0.2% Yield Strength psi (MPa) | | Tensile Strength psi (MPa) | | Elongation % in 2" (51 mm) | | Hardness Rockwell | |
|---|---|---|---|---|---|---|---|---|
| | T 304 | ATI 219™ | T 304 | ATI 219™ | T 304 | ATI 219™ | T 304 | ATI 219™ |
| 0 | 33,500 (230) | 67,500 (465) | 87,000 (600) | 113,500 (780) | 57 | 46 | 72 $R_B$ | 93 $R_B$ |
| 10 | 68,500 (460) | 110,000 (760) | 102,500 (705) | 136,500 (940) | 39 | 28 | 93 $R_B$ | 27 $R_C$ |
| 30 | 127,500 (880) | 150,500 (1,035) | 146,000 (1,005) | 182,000 (1,255) | 17 | 9 | 36 $R_C$ | 36 $R_C$ |
| 50 | 166,500 (1,145) | 175,000 (1,205) | 182,000 (1,255) | 209,500 (1,445) | 3 | 8 | 41 $R_C$ | 41 $R_C$ |
| 60 | 193,500 (1,335) | 185,000 (1,275) | 209,000 (1,440) | 225,000 (1,550) | 1 | 6 | 44 $R_C$ | 42 $R_C$ |

## COLD FORMING

The ATI 219™ alloy is readily cold formed and exhibits similar forming behavior typical of the more stable austenitic stainless steels. The strength of the alloy is higher than that of standard austenitic stainless steels and nickel alloys in the solution annealed condition. During cold deformation, the alloy hardens solely through the mechanism of lattice strain hardening. The alloy is not hardenable by heat treatment. Cold working is the only method for increasing the strength of the ATI 219™ alloy.

## MACHINEABILITY

Tooling and set-up for machining ATI 219™ alloy are the same as that employed for standard austenitic stainless steels. The ATI 219™ alloy is not a free machining grade. Consequently, chip curlers should be used. Because the strength of the annealed material is high, cutting speed is approximately 50% of the speed used for Type 304 for equivalent drill life.

The ATI 219™ alloy strain hardens rapidly; therefore, tools must not ride the surface without cutting. Heavy feeds and slow speeds should be used to get under the strain hardened surface.

## WELDABILITY

Nitrogen is important to the performance of the ATI 219™ alloy. Welding processes should be designed to maintain the nitrogen content of the material within the weld-fusion zone.

The ATI 219™ alloy has welding characteristics similar to standard austenitic stainless steels. The gas tungsten arc and gas metal arc processes are most commonly used to fabricate the material. A common application for the material is gas tungsten arc welded tubing.

Preheating is not required. Post weld heat treating of low carbon ATI 219™ alloy is optional, but is not required to restore corrosion resistance for most applications.

Weld ductility is comparable to the base metal.



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## HEAT TREATMENT

The ATI 219™ alloy is non-hardenable by thermal treatments.

Solution heat treatment is used to remove the effects of cold work and to restore cold formed material to the typical strength and ductility of annealed material. The standard solution anneal is done in the temperature range 1800 to 2150°F (982 to 1177°C). The most common heat treatment is at approximately 1950°F (1065°F) as specified, for example, by AMS 5595.

Stress relief is conducted in the range 900 to 1400°F (482 to 760°C). Below about 1250°F (677°C), little change in mechanical properties is produced by the stress relief heat treatment. Above 1250°F (677°C) more rapid softening occurs. Long time periods of stress relief heat treatment are detrimental to corrosion resistance and should be avoided.



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