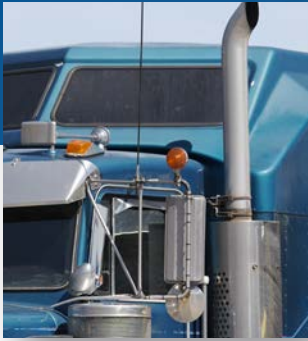


# 321

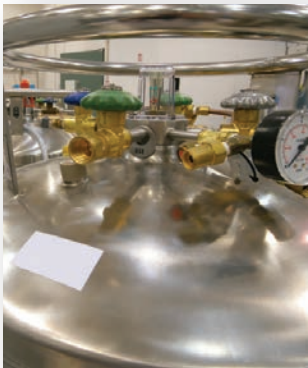
## STAINLESS STEEL



**Jet Aircraft  
Components**

**Oil Refinery Equipment**

**Stock Liners**



**TYPE 321** is a stabilized austenitic stainless steel similar to Type 304 but with a titanium addition of at least five times the carbon content. This titanium addition reduces or prevents carbide precipitation during welding and in 800 – 1500 °F (427 – 816 °C) service. It also improves the elevated temperature properties of the alloy.



# 321 STAINLESS STEEL

## Product Description

Type 321 provides excellent resistance to oxidation and corrosion and possesses good creep strength. It is used primarily in applications involving continuous and intermittent service temperatures within the carbide precipitation range of 800 – 1500 °F (427 – 816 °C).

Typical uses include annealing covers, high-temperature tempering equipment, diesel and heavy duty automotive exhaust systems, firewalls, stack liners, boiler casings, welded pressure vessels, jet aircraft components, radiant superheaters, bellows and oil refinery equipment.

### SPECIFICATIONS

Type 321 is covered by the following specifications:

- AMS 5510
- ASTM A240

### METRIC PRACTICE

Values shown in this bulletin were established in U.S. customary units. The metric equivalents may be approximate.

Composition	(wt %)
Carbon (C)	0.08 max.
Manganese (Mn)	2.00 max
Phosphorus (P)	0.045 max.
Sulfur (S)	0.030 max.
Silicon (Si)	0.75 max.
Chromium (Cr)	17.00 – 19.00
Nickel (Ni)	9.00 – 12.00
Titanium (Ti)	5 x (C + N) min., 0.70 max.
Nitrogen (N)	0.10 max.
Iron (Fe)	Balance

### AVAILABLE FORMS

Cleveland-Cliffs produces Type 321 in thicknesses from 0.01 – 0.125 in. (0.25 – 3.175 mm) and widths up to 36 in. (914 mm). For other thicknesses and widths, contact your Cleveland-Cliffs sales representative.

### PHYSICAL PROPERTIES

Density, lbs/in. <sup>3</sup> (g/cm <sup>3</sup> )	0.29 (8.09)
Electrical Resistivity, $\mu\Omega \cdot \text{in.}$ ( $\mu\Omega \cdot \text{cm}$ ) 68 °F (20 °C)	28.4 (72)
Thermal Conductivity, BTU/hr./ft. <sup>2</sup> /°F W/(m·K) 212 °F (100 °C) 932 °F (500 °C)	9.3 (16.0) 12.8 (22.0)
Coefficient of Thermal Expansion, in./in./°F ( $\mu\text{m}/\text{m}/\text{K}$ ) 32 – 212 °F (0 – 100 °C) 32 – 600 °F (0 – 315 °C) 32 – 1000 °F (0 – 538 °C) 32 – 1200 °F (0 – 649 °C) 32 – 1500 °F (0 – 871 °C)	9.2 x 10 <sup>-6</sup> (16.6) 9.5 x 10 <sup>-6</sup> (17.1) 10.3 x 10 <sup>-6</sup> (18.5) 10.7 x 10 <sup>-6</sup> (19.3) 11.2 x 10 <sup>-6</sup> (20.2)
Modulus of Elasticity, ksi. (MPa) in tension in torsion	28.0 x 10 <sup>3</sup> (193 x 10 <sup>3</sup> ) 11.2 x 10 <sup>3</sup> (78 x 10 <sup>3</sup> )
Magnetic Permeability Annealed, (H/m at 200 Oersteds)	1.02 max.
Specific Heat, BTU/lbs./°F (kJ/kg/K) 32 – 212 °F (0 – 100 °C)	0.12 (0.50)
Melting Range, °F (°C)	2500 – 2550 (1371 – 1399)

# 321 STAINLESS STEEL

## Properties

TABLE 1 – TYPICAL ROOM TEMPERATURE MECHANICAL PROPERTIES

UTS, ksi. (MPa)	0.2% YS, ksi. (MPa)	Elongation % in 2 in. (50.8 mm)	Rockwell Hardness, B
85 (586)	35 (241)	55	70

### CORROSION RESISTANCE

Type 321 has similar corrosion behavior to Type 304, with the exception of improved intergranular corrosion resistance due to the titanium addition for stabilization. Resistance to organic acids and some inorganic acids is excellent. However, long-term exposure to temperatures between 900 – 1500 °F (482 – 816 °C) may reduce its overall general corrosion resistance but remains improved compared to unstabilized grades.

### FORMABILITY

Type 321 can be readily formed and drawn. However, higher pressures are required and more springback is encountered than for carbon steel and ferritic stainless steels. Like other austenitic stainless steels, Type 321 work hardens quickly and may require annealing after severe forming. The presence of certain alloying elements can make Type 321 more difficult to form than other austenitic grades such as Type 301, Type 304 and Type 305.

### 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. This particular alloy is generally considered to have comparable weldability to Types 304 and 304L. A major difference is the titanium addition that reduces or prevents carbide precipitation during welding. When a weld filler is needed, either AWS E/ER 347 or E/ER 321 is most often specified. Type 321 is well known in reference literature and more information can be obtained in this way.

### HEAT TREATMENT

Type 321 is non-hardenable by heat treatment.

**Annealing:** Heat to 1750 – 2050 °F (954 – 1121 °C), then water quench or air cool.

## 321 STAINLESS STEEL



### **About Cleveland-Cliffs Inc.**

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, Cliffs also is the largest manufacturer of iron ore pellets in North America. The Company is vertically integrated from mined raw materials and direct reduced iron to primary steelmaking and downstream finishing, stamping, tooling, and tubing. The Company serves a diverse range of markets due to its comprehensive offering of flat-rolled steel products and is the largest steel supplier to the automotive industry in North America. Headquartered in Cleveland, Ohio, Cleveland-Cliffs employs approximately 25,000 people across its mining, steel and downstream manufacturing operations in the United States and Canada.



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