



# Type 321/321H

## UNS S32100, UNS S32109

### General Properties

Type 321 is a titanium stabilized austenitic stainless steel commonly use for service in the 1000-1600F temperature range. For service temperatures up to about 1600F, a stabilizing heat treatment at 1550-1650F and an air cool may be used to provide optimum resistance to intergranular corrosion and to polythionic acid stress corrosion cracking.

Type 321 is non-magnetic in the annealed condition but may become slightly magnetic as a result of cold working or welding.

### Plate Product Sizes

Plate product is available up to 4 inches thick and up to 120 inches wide depending on the thickness.

### Specifications

Type 321 can be supplied to meet AMS, ASTM, ASME, and QQS specifications.

### Design Features

- Good corrosion resistance
- Oxidation resistant to 1600F
- High ductility and formability
- Excellent impact toughness even at cryogenic temperatures
- Good workability and weldability
- Stabilized against weld heat affected zone intergranular corrosion

### Applications

- Refinery equipment
- Thermal oxidizers
- High temperature chemical process equipment
- Pressure vessels
- Flanges and valves

Chemical Composition (wt%)

Table 1

	C	Mn	Cr	Ni	Mo	N	Other
Typical	0.044	1.4	17.2	9.1	0.4	0.01	
UNS S32100	≤0.08	≤2.00	17.00-19.00	9.00-12.00	...	≤0.10	
UNS S32109	0.04-0.10	≤2.00	17.00-19.00	9.00-12.00	...	≤0.10	

## Corrosion resistance

Type 321 is a versatile, general purpose stainless steel with good corrosion resistance similar to 304 stainless steel. The resistance of Type 321 to chloride pitting and crevice corrosion is similar to that of 304/304L due to similar chromium composition. A chloride concentration of 100 ppm is generally considered the maximum before pitting will occur, particularly if crevices are present.

Due to similar nickel contents, Types 321 and 304/304L are prone to chloride stress corrosion cracking, and should not be used in conditions where chloride induced SCC is a concern. Type 321 is particularly useful, however, to improve resistance to polythionic stress cracking in the thermally stabilized condition versus non-stabilized grades.

## Heat treatment

### Annealing

Type 321 should be heated to 1900°F minimum and water quenched or rapidly cooled by other means. Type 321 cannot be hardened by heat treatment.

When maximum resistance to intergranular corrosion is required, such as in the case of improving the resistance to polythionic stress corrosion cracking, a stabilization anneal may be employed. Stabilization annealing consists of heating material to 1550°F to 1650°F and holding for 4 to 5 hours depending on thickness. In this temperature range, any chromium carbides that may have been previously formed are dissolved and put into solution. Also, it is in this temperature range that titanium carbides are maximized, which reduces the propensity to form chromium carbides at service temperatures that within the sensitization range. It is ideal to perform this process after all thermal processing such as welding is complete.

**Mechanical Properties per ASTM A240** *Table 2*

	Typical	Requirement
<b>Yield Strength</b> $R_{p0.2}$ (KSI)	41	30 min
<b>Tensile Strength</b> $R_m$ (KSI)	84	75 min
<b>Elongation (%)</b>	55	40 min
<b>Hardness</b> (Rockwell B)	80	95 max

**Physical Properties**

*Table 3*

	Typical
<b>Density (lb/in<sup>3</sup>)</b>	0.286
<b>Modulus of Elasticity (psi)</b>	$29.0 \times 10^6$
<b>Coefficient of Thermal Expansion</b> 68-212°F [ $\mu\text{in}/(\text{in} \cdot ^\circ\text{F})$ ]	8.9
<b>Thermal Conductivity</b> [BTU/(hr <sup>2</sup> ·F)]	8.7
<b>Thermal Capacity [BTU/(lbm<sup>2</sup>·F)]</b>	0.12
<b>Electrical Resistivity (<math>\mu\Omega \cdot \text{in}</math>)</b>	28.7

## Workability

### Cold Working

Type 321 is readily formed and fabricated through a full range of cold working operations. It can be used in heading, drawing, bending, and upsetting. Any cold working operations will increase the strength and hardness of the material, and may leave it slightly magnetic.

### Hot Working

Type 321 can be forged in the 1700-2200°F range. For maximum corrosion resistance, forgings should be annealed at 1900°F minimum and water quenched or rapidly cooled by other means after hot working operations.

## Welding

Type 321 is readily welded by a full range of conventional welding procedures (except oxyacetylene). AWS E347/ER347 filler metals should be used with Type 321 steel.

## Machinability

Type 321 is a tough austenitic stainless steel subject to work hardening during deformation and, unless modified for improved machining response, is resistant to chip breaking similar to Type 304. The best machining results are achieved with slower speeds, heavier feeds, excellent lubrication, sharp tooling, and powerful, rigid equipment.

## Lowest Temperature (°F) at Which the Corrosion Rate Exceeds 5 mpy

Corrosion Environment	654 SMO®	254 SMO®	904L	Type 316L (2.7 Mo)	Type 304	2507	2205 Code Plus Two®	2304
0.2% Hydrochloric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
1% Hydrochloric Acid	203	158	122	86	86p	>Boiling	185	131
10% Sulfuric Acid	158	140	140	122	—	167	140	149
60% Sulfuric Acid	104	104	185	<54	—	<57	<59	<<55
96% Sulfuric Acid	86	68	95	113	—	86	77	59
85% Phosphoric Acid	194	230	248	203	176	203	194	203
10% Nitric Acid	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling	>Boiling
65% Nitric Acid	221	212	212	212	212	230	221	203
80% Acetic Acid	>Boiling	>Boiling	>Boiling	>Boiling	212p	>Boiling	>Boiling	>Boiling
50% Formic Acid	158	212	212p	104	≤50	194	194	59
50% Sodium Hydroxide	275	239	Boiling	194	185	230	194	203
83% Phosphoric Acid + 2% Hydrofluoric Acid	185	194	248	149	113	140	122	95
60% Nitric Acid + 2% Hydrochloric Acid	>140	140	>140	>140	>140	>140	>140	>140
50% Acetic Acid + 50% Acetic Anhydride	>Boiling	>Boiling	>Boiling	248	>Boiling	230	212	194
1% Hydrochloric Acid + 0.3% Ferric Chloride	>Boiling, p	203ps	140ps	77p	68p	203ps	113ps	68p
10% Sulfuric Acid + 2000ppm Cl <sup>-</sup> + N <sub>2</sub>	149	104	131	77	—	122	95	<55
10% Sulfuric Acid + 2000ppm Cl <sup>-</sup> + SO <sub>2</sub>	167	140	122	<<59p	—	104	<59	<<50
WPA1, High Cl <sup>-</sup> Content	203	176	122	≤50	<<50	203	113	86
WPA2, High F <sup>-</sup> Content	176	140	95	≤50	<<50	167	140	95

ps = pitting can occur

ps = pitting/crevice corrosion can occur

WPA	P <sub>2</sub> O <sub>5</sub>	Cl <sup>-</sup>	F <sup>-</sup>	H <sub>2</sub> SO <sub>4</sub>	Fe <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	CaO	MgO
1	54	0.20	0.50	4.0	0.30	0.20	0.10	0.20	0.70
2	54	0.02	2.0	4.0	0.30	0.20	0.10	0.20	0.70

Type 321 has similar corrosion resistance to Type 304 in the above table.

### **Technical Support**

New Castle assists users and fabricators in the selection, qualification, installation, operation, and maintenance of Type 321 stainless steel. Technical personnel can draw on years of field experience with Type 321 to help you make the technically and economically correct materials decision. New Castle is prepared to discuss individual applications and to provide data and experience as a basis for selection and application of Type 321.

New Castle works closely with its distributors to ensure timely availability of Type 321 in the sizes, and quantities required by the user. For assistance with technical questions and to obtain top quality Type 321, please call New Castle at 1-800-349-0023.



# **New Castle**

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