321 Austenitic Stainless Steel Bar

321 is a titanium stabilised chromium-nickel austenitic stainless steel with good strength and excellent corrosion resistance, as supplied in the annealed condition with a typical brinell hardness of 175.

Characterised by high corrosion resistance in general atmospheric corrosive environments it exhibits excellent resistance to most oxidizing agents, general foodstuffs, sterilizing solutions, dyestuffs, most organic chemicals plus a wide variety of inorganic chemicals, also hot petroleum gases, steam combustion gases, nitric acid, and to a lesser extent sulphuric acid. It displays good oxidation resistance at elevated temperatures has excellent resistance to intergranular corrosion and has excellent weldability.

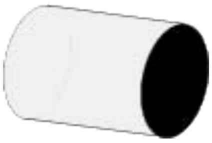
321 cannot be hardened by thermal treatment, but strength and hardness can be increased substantially by cold working, with subsequent reduction in ductility.

Used extensively for applications where the addition of titanium and its stabilizing effect as a carbide forming element allows it to be welded and/or used within the carbide precipitation range 430 °C - 870 °C without the risk of intergranular corrosion. These include Food Processing, Dairy Equipment, Chemical, Petrochemical, Transport and associated industries etc.

Material non magnetic in the annealed condition, but can become mildly magnetic following heavy cold working. Annealing is required to rectify if necessary.

N.B. Optimum corrosion resistance is achieved in the annealed condition.

Colour Code



Black (Bar end)

Stocked Sizes	7.94mm to 155 mm diameter
Bar Finish	Peeled, Cold Drawn and Centreless Ground.

Related Specifications

Australia	AS 2837-1986-321
Germany	W.Nr 1.4541 X6CrNiTi18 10
Great Britain	BS970 Part 3 1991 321S31 BS970 - 1955 EN58B/EN58C
Japan	JIS G4303 SuS 321
USA	ASTM A276-98b 321 SAE 30321 AISI 321 UNS S32100

Chemical Composition	Min. %	Max. %
Carbon	0	0.08
Silicon	0	1.00
Manganese	0	2.00
Nickel	9.00	12.00
Chromium	17.00	19.00
Titanium	5 x Carbon	0.80
Phosphorous	0	0.045
Sulphur	0	0.03

Mechanical Property Requirements - Annealed to ASTM A276-98b 321

Finish	Dia. Or Thickness mm	Tensile Strength Mpa Min.	Yield Strength Mpa Min.	Elongation in 50mm % Min.
Hot Finished	All	515	205	40
Cold Finished	up to 12.7	620	310	30

		over 12.7	515	205	30	

Typical Mechanical Properties At Room Temperature - Annealed

Finish	Tensile Strength Mpa	Yield Strength Mpa	Elongation in 50 mm %	Impact Charpy V J	Hardness	
					HB	Rc
Cold Drawn	680	500	40		200	15
Other	600	280	55	180	165	

Elevated Temperature Properties

321 displays good oxidation resistance in continuous service up to 930 ^{o}C, and in intermittent service up to 870 ^{o}C.

It can also be used within the carbide precipitation range 430 ^{o}C - 870 ^{o}C without the risk of intergranular corrosion.

Mechanical properties are reduced as temperature increases.

Typical Mechanical Properties - Annealed at Elevated Temperatures

Temperature ^{o}C	Short - Time Tensile Tests			Creep Tests
	Tensile Strength Mpa	Yield Strength Mpa	Elongation in 50 mm %	Stress for 1% Creep in 10,000 Hours Mpa
20	580	240	60	
430	425	170	38	
550	365	150	35	115
650	310	135	32	50
760	205	105	33	14
870	140	70	40	

Low Temperature Properties

321 has excellent low temperature properties with increased tensile and yield strengths with little loss of toughness in the annealed condition.

Typical Mechanical Properties - Annealed at Zero and Sub-Zero Temperatures

Temperature ^{o}C	Tensile Strength Mpa	Yield Strength Mpa	Elongation in 50 mm %	Impact Charpy J
0	740	300	57	190
-70	900	340	55	190
-130	1135	370	50	186
-180	1350	400	45	186
-240	1600	450	35	150

The combination of high strength and toughness at low temperatures allows this grade to be used in extremely cold climates or high altitudes, also for storage of liquified gasses etc. at very low temperatures.

N.B. 321 even when cold worked will still have good high strength and ductility at sub-zero temperature.

Cold Bending

321 has excellent cold working properties and cold bending can generally be carried out without too much difficulty. After cold working it will be mildly magnetic. Annealing is generally not required except following very severe cold working.

Hot Bending

Hot bending should be performed at 950 ^{o}C - 1100 ^{o}C, followed by annealing to restore optimum corrosion resistance.

Corrosion Resistance

General Corrosion

321 has similar resistance to general corrosion in most media as 304, but not as good as 316.

Pitting Corrosion / Crevice Corrosion

321 has similar resistance to pitting and crevice corrosion as 304, but not as good as 316.

Stress Corrosion Cracking

321 has similar resistance to stress corrosion cracking as 304, but not as good as 316.

Intergranular Corrosion

321 has better resistance to intergranular corrosion than most of the standard 300 grades other than the low carbon types 304L, 316L and 317L due to its titanium content.

N.B. It is most important that oxygen is always allowed to circulate freely on all stainless steel surfaces to ensure that a chrome oxide film is always present to protect it. If this is not the case, rusting will occur as with other types of non stainless steels.

For optimum corrosive resistance, surfaces must be free of scale and foreign particles.
Finished parts should be passivated.

Forging

Heat uniformly to 1150 ^{o}C - 1200 ^{o}C, hold until temperature is uniform throughout the section.

Do not forge below 900 ^{o}C

Finished forgings should be air cooled.

Finally forgings will require to be annealed in order to obtain optimum corrosion resistance.

Heat Treatment

Annealing

Heat to 1000 ^{o}C - 1100 ^{o}C, hold until temperature is uniform throughout the section.
*Soak as required. Quench in water to obtain optimum corrosion resistance.

Stabilizing Treatment

For optimum intergranular corrosion resistance at working temperatures up to 870 ^{o}C, heat to 840 ^{o}C - 900 ^{o}C, hold until temperature is uniform throughout the section.
*Soak as required. Cool in still air.

*Actual soaking time should be long enough to ensure that the part is heated thoroughly throughout its section to the required temperature, 30 minutes per 25 mm of section may be used as a guide.

Please consult your heat treater for best results.

Machining

321 is more difficult to machine than most of the standard austenitic stainless steels, due to its titanium addition resulting in the formation of extremely hard and abrasive titanium carbonitride inclusions. It has a typical machinability rating around 45% - 50% of free machining (S1214) mild steel.

Due to the high work hardening rate of this grade, cutting or drilling tools etc. must be kept sharp at all times and not cause unnecessary work hardening of the surface etc..

All machining should be carried out as per machine manufacturers recommendations for suitable tool type, feeds and speeds.

Welding

321 is readily weldable by shielded fusion and resistance welding procedures, followed by air cooling giving good toughness.

Oxyacetylene welding is not recommended due to possible carbon pick up in the weld area.

It can be welded without loss of corrosion resistance due to intergranular carbide precipitation, and post-weld annealing is not generally required, except for service in the more extreme conditions.

A post weld stabilizing treatment however, is recommended when being used at elevated temperature.

Welding Procedure

Welding should be carried out using 347 or *similar electrodes or rods (depending upon application). No pre heat or post heat is generally required.

*Please consult your welding consumables supplier.

Notes on Carbide Precipitation and the Stabilizing Action of Titanium

Austenitic stainless steels during annealing are heated to fairly high temperatures, typically 1050 ^{o}C - 1100 ^{o}C to ensure that all chromium carbides present are dissolved and all of the chromium is taken into solution in the austenite. The steel is then quench-annealed as rapidly as possible generally in clean water, but thin sections (sheet etc.) can be air cooled, this being necessary to suppress any re-formation of chromium carbide which would occur if the material was allowed to slow cool in the furnace etc. as with standard annealing procedures.

The resultant austenitic structure at room temperature has optimum corrosion resistance containing as it does all of the chromium in solution. If subsequently used in service at room temperature while some slight precipitation of chromium carbide can occur over an extended period this will generally have little affect on corrosion resistance.

This situation changes drastically when heat is applied either in service, or during welding, especially when heating through the range 430 ^oC - 850 ^oC, then the carbon and chromium atoms will move (precipitate) coming together to form chromium carbide (Cr^{23} C^6), depleting the structure of chromium and its corrosion resistance.

To overcome this problem, two methods have been adopted:
1) Use a low carbon grade - 304L or 316L etc.
2) Use a titanium stabilized grade - 321 etc.

Low carbon grades have insufficient carbon to deplete the chromium content generally throughout the structure, However local depletion within the weld area can still be a problem leading to some intergranular corrosion if later exposed to severe corrosive conditions.

Titanium acts as a stabilizer because the carbon has more affinity to it than it has to the chromium, thus titanium carbide is formed instead and the chromium is unaffected giving the material optimum corrosion resistance.