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316L Austenitic Stainless Steel Bar

316L is a low carbon-chromium-nickel-molybdenum 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 marine and industrial atmospheres, it exhibits excellent resistance to chloride attack and against complex suphur compounds employed in the pulp and paper processing industries. The addition of 2% to 3% of molybdenum increases its resistance to pitting corrosion and improves its creep resistance at elevated temperatures. The low carbon content reduces the risk of intergranural corrosion (Due to carbide precipitation) during welding, reducing the need for post weld annealing. Finally it displays good oxidation resistance at elevated temperatures.

316L cannot be hardened by thermal treatment, but strength and hardness can be increased substantially by cold working, with susequent reduction in ductility.

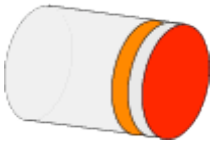
It is now available with improved machinability (by calcium injection treatment), which has little effect on corrosion resistance and weldability while greatly increasing feeds and/or speeds, plus extending tool life.

It is used extensively by the Marine, Chemical, Pulp and Paper, Textile, Transport, Manufacturing and allied industries.

Typical uses are:
Architectural Components, Textile Equipment, Pulp and Paper Processing Equipment, Marine Equipment and Fittings, Photographic Equipment and X-Ray Equipment 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  Red (Bar end) With Orange Band	Stocked Sizes	Rounds	3.18 mm to 325 mm diameter.
		Hexagons	7.94 mm to 63.5 mm A/F
		Squares	6.35 mm to 50 mm A/F
		Hollow Bar	32 mm - 250 mm OD
	Bar Finish	Peeled, Cold Drawn Turned and Polished, and Centreless Ground.	

Related Specifications		
	Australia	AS 2837-1986-316L
	Germany	W.Nr 1.4404 X2CrNiMo17 13 2 W.Nr 1.4435 X2CrNiMo 18 14 3
	Great Britain	Bs970 Part 3 1991 316S11/316S13
	Japan	JIS G4303 SuS 316L
	USA	ASTM A276-98b 316L SAE 30316L AISI 316L UNS S31603

Chemical Composition	**Min%**	**Max%**
Carbon	0	0.03
Silicon	0	1.00
Manganese	0	2.00
Nickel	10.00	14.00
Chromium	16.00	18.00
Molybdenum	2.00	3.00
Nitrogen	0	0.10
Phosphorous	0	0.045
Sulphur	0	0.03

Mechanical Property Requirements - Annealed to ASTM A276-98b 316L

	Finish	Dia. Or	Tensile	Yield	Elongation	

	Thickness mm	Strength Mpa Min.	Strength Mpa Min.	in 50mm % Min.
Hot Finished	All	485	170	40
Cold Finished	up to 12.7	620	310	30
	over 12.7	485	170	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	42	190	195	13
Other	590	280	55	180	155	

Elevated Temperature Properties

316L displays good oxidation resistance in continuous service up to 930 ^{o}C, and in intermittent service up to 870 ^{o}C.

Due to its low carbon content it is also less susceptable to carbide precipitation resulting in intergranular corrosion when heated or slow cooled through the temperature range 430 ^{o}C - 870 ^{o}C either in service or during welding.

There is however a reduction in mechanical properties as temperature increases.

Typical 0.2% Yield Strength at Elevated Temperatures

Temperatures ^{o}C	50	100	150	200	250	300	400	450	500	550
0.2% Yield Strength	182	166	152	137	127	118	108	103	100	98
Mpa Min.										

Low Temperature Properties

316L as with all of the 300 series austenitic stainless steels has excellent low temperature properties, with increased tensile and yield strength without 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 Izod J
0	670	310	67	150
-40	715	280	60	150
-60	800	300	59	150
-200	1250	510	61	
-250	1430	560	55	

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. 316L even when cold worked will still have good high strength and ductility at sub-zero temperature.

Cold Bending

Cold bending can be carried out without too much difficulty, however due to the high work hardening ability of this grade any cold working causing more than 15% deformation should be followed by annealing.

Hot Bending

Hot bending should be performed at 900 ^{o}C - 1100 ^{o}C, followed by annealing to restore optimum corrosion resistance.

Corrosion Resistance

General Corrosion

316L has better resistance to general corrosion in most media than 310, 304, 321, 302 and 303 grades.

Pitting Corrosion

316L has higher resistance to pitting corrosion than the non molybdenum bearing grades such as 304, 321, 310 and 303 etc..

Stress Corrosion Cracking

316L has a better resistance to stress corrosion cracking in chloride solutions than 302 or 304 grades, however it can also fail if subjected to high stresses in an environment conducive to stress corrosion.

Intergranular Corrosion

316L due to its low carbon content has greater resistance to intergranular corrosion than all the austenitic stainless steel grades except 304L grade and 321 titanium stabilized grade.

Crevice Corrosion

316L has a higher resistance to crevice corrosion than the non molybdenum bearing grades such as 304, 321, 310 and 303 etc..

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 1020 ^{o}C - 1100 ^{o}C, hold until temperature is uniform throughout the section. *Soak as required. Quench in water to obtain optimum corrosion resistance.

*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

316L improved machinability is slightly more difficult to machine than improved machinability 304 grade. More difficult to machine than 303 free machining grade and most of the 400 series stainless steels. It has a typical machinability rating around 50% - 55% 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 maunfacturers recommendations for suitable tool type, feeds and speeds.

Welding

316L is readily weldable by shielded fusion and resistance welding processes, followed by air cooling giving good toughness.

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

The low carbon content in 316L allows it to 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.

Welding Procedure

Welding should be carried out using 316L or *similar electrodes or rods (depending upon application).

No pre heat or post heat is generally required.

*Please consult your welding consumables supplier.