Interlloy ENGINEERING STEELS AND ALLOYS

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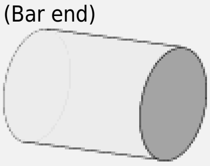
410 MARTENSITIC STAINLESS STEEL BAR

410 is a basic straight chromium high hardenability martensitic stainless steel with good strength and fairly good corrosion resistance as generally supplied hardened and tempered in the tensile range 700 - 850 Mpa (condition R) Brinell range 201 - 255.Characterised by good corrosion resistance in mild atmospheric industrial and domestic environments coupled with good strength and excellent toughness in the hardened and tempered condition. 410 due to its excellent hardenability is capable of being through hardened to over Rc40 depending upon carbon content and section size. Small sections can be air cooled and larger sections oil quenched for maximum through hardness.Pre hardened and tempered 410 will also respond readily to nitriding achieving a typical surface hardness of over Rc65. The nitriding process however reduces the corrosion resistance and is therefore not generally recommended except for critical applications where the benefit outweighs all other considerations.

Used for parts requiring a combination of good strength and toughness, plus reasonable corrosion resistance. Typical applications are: Bolts, Bushings, Fasteners, Gas Turbine Parts, Mine Equipment, Pump Parts, Petrochemical Equipment, Steam Turbine Parts, Studs, Valve Parts etc.

Material magnetic in all conditions.

Colour Code	Stocked Sizes	
Gray (Bar end)	Stock Sizes	38.1mm - 158.75mm Dia
	Bar Finish	
	Peeled Bar	



Related Specifications	
Australia	AS 2837-1986 410
Germany	W.Nr 1.4006 X10Cr13
Great Britain	BS970 Part3 1991 410S21 BS970 1955 EN56A
Japan	JIS G4303 SuS 410
USA	ASTM A276-98b 410 SAE 51410 AISI 410 UNS S41000

Chemical Composition

	Min. %	**Max %**
Carbon	0.09	0.15
Silicon	0	1.00
Manganese	0	1.00
*Nickel	0	1.00
Chromium	11.50	13.50
Phosphorous	0	0.04
Sulphur	0	0.03

*Nickel additional option

Mechanical Property Requirements For Material in the Annealed and Heat Treated - Condition R To AS2837 - 1986 410 and BS970 Part3 1991 410S21			
Condition Annealed			*R
Tensile Strength Mpa	Min		700
	Max		850
0.2% Yield Strength Mpa	Min		495
Elongation on 5.65√S0 %	Min		15
Impact Izod J	Min		34
Hardness HB	Min		201
	Max	207	255

*Material stocked generally in condition R.
NB. Check the mill certificate if critical for end use.

Typical Mechanical Properties At Room Temperature - *Hardened and Tempered to Condition R			
Tensile Strength Mpa		760	
Yield Strength Mpa		595	
Elongation on 5.65√S0 %		23	
Impact Charpy J J		53	90
Hardness	HB	230	
	Rc	22	

*Typical Hardening Temperatures	950°C - 1010°C
*Typical Tempering Temperatures	650°C - 680°C
	620°C - 660°C

Typical Mechanical Properties At Room Temperature - Hardened By Oil Quench at 1010°C and Tempered as Indicated							
Temperature °C		250	370	480	540	590	650
Tensile Strengt Mpa		1350	1295	1300	690	830	730
0.2% Yield Strength Mpa		1095	1070	1020	915	725	630
Elongation in 50mm %		17	17	18	19	20	21
Impact Charpy J		76	66	*38	*33	52	95
Hardness	HB	400	400	400	285	248	223
	Rc	43	43	43	30	24	20

High tensile strength and high yield strength plus fairly good impact properties obtained when tempered below 400°C.
*Note drop in impact properties.Tempering within the range 400°C - 580°C should be avoided.

Elevated Temperature Properties

410 displays good resistance to scaling in continuous service up to 650°C. Its use however at these higher working Temperatures results in a substantial drop in tensile strength and hardness with subsequent increase in ductility.

Typical Mechanical Properties at Elevated Temperatures, Hardened at 1010°C and Tempered at 30°C Above Working Temperature					
Tempering Temperature °C		510	570	620	680
Working Temperature °C		480	540	590	650
Tensile Strength Mpa		1200	540	350	220
Yield Strength Mpa		965	510	320	190
Elongation in 50mm %		15	24	30	39
Room Temperature Hardness After Test	HB	390	285	240	220
	Rc	43	31	24	19

NB. Creep and stress rupture strength is also substantially reduced at these higher working temperatures.

Low Temperature Properties

410 is not recommended for use at sub-zero temperatures due to a substantial drop in impact properties consistent with most steels other than the austenitic steel types.

Cold Bending

In the hardened and tempered as supplied condition, it will be more difficult due to the high yield strength which must be taken into account.

Hot Bending

In the hardened and tempered as supplied condition, it is not recommended due to its affect on the mechanical properties within the heat affected zone.

Corrosion Resistance

410 has better corrosion resistance than 416 grade, but lower than 431 grade. Also lower than most of the 400 series ferritic stainless steels, and all of the 300 series austenitic stainless steels.NB. It has optimum corrosion resistance in the hardened and tempered condition and is not therefore recommended for use in the annealed condition. 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 corrosion resistance surfaces must be free of scale and foreign particles.
Finished parts should be passivated.

Forging

Heat uniformly to 1100℃ - 1200℃, hold until temperature is uniform throughout the section.
Do not soak but commence forging immediately.Do not overheat as this can cause a loss of toughness and ductility. Do not forge below 900℃Finished forgings should be cooled slowly in ashes or warm dry lime etc. until hand warm and annealed immediately.

Heat Treatment

Sub-Critical Annealing

Heat uniformerly to 650℃ - 750℃ as required, hold until temperature is uniform throughout the section.*Soak as required, cool in air. Note: For best machinability use the low end of the range.

Annealing

Heat uniformerly to 820℃ - 900℃, hold until temperature is uniform throughout the section.*Soak as required. Cool in furnace.

Hardening

Heat to 950℃ - 1020℃, hold until temperature is uniform throughout the section. *Soak as required.Quench in oil or air cool. Temper immediately while still hand warm.

Nitriding

Prior to nitriding, the chrome oxide film which protects the surface must be broken down by pickling or fine sand blasting.Nitriding is carried out at 500℃ - 550℃ followed by slow cooling (no quench) reducing the problem of distortion. Parts can therefore be machined to near final size, leaving a grinding tolerance only. Always ensure that the tempering temperature employed during the initial heat treatment was higher than the nitriding temperature otherwise the core strength will be affected.

Tempering (Condition R)

Heat to 600℃ - 700℃ as required, hold until temperature is uniform throughout the section. *Soak as required.Cool in air. A double tempering treatment as follows is recommended for optimum toughness.Heat to 650℃ - 680℃. *Soak as required. Cool in air
Followed by:
Re-heat to 620℃ - 660℃. *Soak as required. Cool in air

410 can of course be tempered at much lower temperatures, producing much higher tensile strengths, but with subsequent lower impact properties.

NB. Tempering however within the range 400℃ - 580℃ should be avoided due to temper brittleness, resulting in a considerable reduction in impact properties and loss of corrosion resistance.

*Heating temperatures, rate of heating, cooling and soaking times will vary due to factors such as work piece size/shape, also furnace type employed, quenching medium and work piece transfer facilities etc.

Please consult your heat treater for best results.

Machining

410 machines best in the hardened and tempered as supplied condition R, and is regarded as being readily machineable with all operations such as turning, milling and reaming etc. capable of being carried out as per machine manufacturers recommendations for suitable tool type, feeds and speeds.It does not work harden to the same extent as the 300 series austenitic stainless steels, but is more similar in this respect to the low alloy high tensile steels such as 4140 etc.

Welding

Welding 410 in the hardened and tempered condition as supplied condition or in the annealed condition requires special attention due to its air hardening capability which can lead to the formation of brittle martensite, resulting in cold cracking due to contraction stresses within the weld and heat affected zone. Welding in the annealed condition can be beneficial in accommodating some of these contraction stresses in the base material when a high degree of restraint applies or with large sections. However problems can still occur. The higher the carbon content the higher the hardening capability and the greater the risk of cracking.Pre-heating and interpass temperature control during welding, plus very slow cooling and post-weld annealing is the best method to prevent cracking. The following welding procedure and post-weld heat treatment may be taken as a guide only.

Welding Procedure

Welding can be carried out using most of the standard welding processes.Welding electrodes or rods should be low hydrogen types 410 or *similar when strength is required or when post-weld hardening and tempering, otherwise an austenitic stainless electrode or rod such as 308 or *similar may be used to give a more ductile weld, when strength is not so critical and post-weld annealing is not possible or intended. Pre-heat at 200℃ - 300℃ and maintain a high heat input during welding. On completion of welding cool slowly as possible until hand warm and as required:Post-weld sub-critical anneal at 630℃ - 680℃ or full anneal and harden and temper as required.

*Please consult your welding consumables supplier.

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.