440C Martensitic Stainless Steel Bar

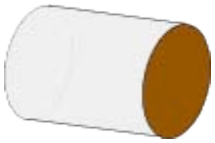
440C is a high carbon straight chromium high hardenability martensitic stainless steel, generally supplied in the annealed condition with a maximum Brinell hardness of 269 (Rc29) or annealed and cold drawn with a maximum Brinell hardness of 285 (Rc31).

Characterised by good corrosion resistance in mild domestic and industrial environments, including fresh water, organic materials, mild acids, various petroleum products, coupled with extreme high strength, hardness and wear resistance when in the hardened and tempered condition.

440C due to its excellent hardenability is capable of being through hardened up to Rc60 depending upon carbon content and section size. Small sections can be air cooled and quite large sections oil quenched for maximum through hardness.

Used for parts requiring a combination of excellent wear resistance, plus reasonable corrosion resistance. Typical applications are: Ball Bearings and Races, Bushings, Cutlery, Chisels, Knife Blades, Pump Parts, Surgical Instruments, Valve Seats etc.

Material magnetic in all conditions.

Colour Code  Dark Brown (Bar end)	Stocked Sizes	45 mm to 160 mm diameter.
	Bar Finish	Peeled Bar

Related Specifications		
	Australia	AS 2837-1986 440C
	Germany	W.Nr 1.4125 X105CrMo17
	Japan	JIS G4303 SuS 440C
	USA	ASTM A276-98b 440C SAE 51440C AISI 440C UNS S44004

Chemical Composition		**Min. %**	**Max. %**
	Carbon	0.95	1.20
	Silicon	0	1.00
	Manganese	0	1.00
	*Nickel	0	1.00
	Chromium	16.00	18.00
	Molybdenum	0.00	0.75
	Phosphorous	0	0.04
*Nickel addition optional.	Sulphur	0	0.03

Mechanical Property Requirements For Material in the Annealed Condition to 1) AS2837 - 1986 440C and 2) ASTM A276-98b 440C

	Specification	Finish	Brinell Hardness
1)	AS2837-1986 440C		269 Max

Capable of attaining Rc59 minimum in 10mm test bar oil quenched from 1010 °C - 1070 °C.

2)	ASTM A276-98b 440C	Hot Finished	269 Max
		Cold Finished	285 Max

Capable of attaining Rc58 minimum in 9.50mm test bar air cooled 1020 °C.

Typical Mechanical Properties At Room Temperature in the Annealed Condition (AS Supplied)

Tensile Strength Mpa	Yield Strength Mpa	Elongation in 50mm %	Impact Charpy J	Hardness	
				HB	Rc

785	420	15	6	240	24

Typical Mechanical Properties At Room Temperature - Hardened By Oil Quench at 1030 °C and Tempered as Indicated

Tempering Temperature °C	Tensile Strength Mpa	Yield Strength Mpa	Elongation in 50mm %	Impact Charpy J	Hardness RC
150	2050	1930	4	9	60
200	2020	1896	4	9	59
250	1980	1845	4	9	57
300	1890	1760	4	9	56
350	1820	1675	4	9	56
400	1780	1635	4	9	56

Section Size 25mm
High tensile strength, high yield strength and high hardness but low impact properties.

Elevated Temperature Properties

440C is not generally recommended for elevated temperature applications due to a reduction in corrosion resistance when tempered above 400 °C.

Low Temperature Properties

440C is also not recommended for use at sub-zero temperatures due to a further drop in impact properties.

Cold Bending

Moderate cold bending is possible when fully annealed to maximum softness.

Hot Bending

Not generally recommended due to the high hardenability - air hardening capabilities of this grade. If really necessary then work piece following operation should be cooled as slowly as possible either in a furnace or in warm dry lime or ashes to room temperature prior to annealing.

Corrosion Resistance

440C has a corrosion resistance somewhat similar to 410 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 when tempered below 400 °C. Hardening from 1090 °C will ensure better carbide solution, and therefore better corrosion resistance, but minimum soaking time should be allowed at this temperature otherwise excessive grain growth can occur. Polishing will further develop its corrosion resistance.

It is not 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

Preheat to 760 °C - 820 °C, then heat slowly and uniformly to 1050 °C - 1150 °C, hold until temperature is uniform throughout the section and commence forging immediately.

Do not overheat as this can cause a loss of toughness and ductility.

Do not forge below 900 °C

Finished forgings should be cooled slowly in a furnace, warm dry lime or ashes to room temperature and annealed immediately.

NB. Air cooling after forging may cause cracking.

Heat Treatment

Sub-Critical Annealing

Heat uniformerly to 730 °C - 770 °C hold until temperature is uniform throughout the section.
*Soak as required. Cool in air.

Annealing

Heat uniformerly to 840 °C - 900 °C, hold until temperature is uniform throughout the section.
*Soak as required. Cool in furnace.

Hardening

Heat to 1010 °C - 1070 °C, hold until temperature is uniform throughout the section. *Soak as required. Quench in warm oil or air cool. Do not overheat. Temper immediately while still hand warm.

NB. This grade can be hardened from 1090 °C for optimum corrosion resistance but this will result in a lower hardness level obtained.

Tempering

Heat to 100 °C - 400 °C, as required, hold until temperature is uniform throughout the section. *Soak as required. Cool in air.

Tempering within the range 100 °C - 200 °C will give optimum corrosion resistance and maximum hardness - up to Rc60 depending upon section size.

NB. Tempering above 400 °C is not recommended as it will result in a reduction in corrosion resistance and impact properties.

*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

440C due to its high carbon content has low machinability. It machines best in the fully annealed condition and chip curlers and breakers are recommended as chips tend to be strong and stringy. All operations such as drilling, turning and milling etc. should be carried out as per machine manufacturers recommendations for suitable tool type, feeds and speeds.

Grinding and Polishing

440C in the hardened and tempered condition requires care with finish grinding and polishing to avoid overheating as this can lower the hardness and corrosion resistance.

Welding

Welding 440C in the annealed as supplied condition is not recommended due to its high 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 440C in the hardened and tempered condition should not be attempted.

If welding is really necessary in the annealed condition the following welding procedure and post-weld heat treatment may be taken as a guide only.

Welding Procedure

Welding electrodes or rods should be low hydrogen types and as *similar to the base metal as possible when high strength is required, otherwise an austenitic stainless *electrode or rod may be used, resulting in a more ductile weld if strength is not so critical.

Pre-heat at 260 °C and maintain interpass temperature at 260 °C minimum. On completion of welding cool slowly as possible to 260 °C minimum, followed immediately by:

Post-weld sub-critical anneal at 730 °C - 770 °C or full anneal at 840 °C - 900 °C and harden and temper as required.

*Please consult your welding consumables supplier.