ENGINEERING STEELS + ALLOYS

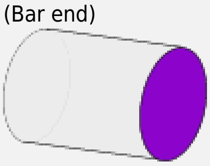
431 MARTENSITIC STAINLESS STEEL BAR

431 is a high chromium-low nickel high hardenability Martensitic stainless steel with high strength and good corrosion resistance, as generally supplied hardened and tempered in the tensile range 850 - 1000 Mpa (condition T) Brinell range 248 - 302.Characterised by very good corrosion resistance in general atmospheric corrosive environments, good resistance to mild marine and industrial atmospheres, resistant to many organic materials, nitric acid and petroleum products coupled with high tensile and high yield strength plus excellent toughness in the hardened and tempered condition. 431 due to its excellent hardenability is capable of being through hardened up to Rc44, 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 431 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 extensively for parts requiring a combination of high tensile strength, good toughness and good corrosion resistant properties.

Typical applications are: Aircraft Parts and Components, Bolts and Nuts, Fasteners, Pump Shafts, Propellor Shafts, Studs, Valve Parts etc.

Material magnetic in all conditions.

Colour Code	Stocked Sizes	
Purple (Bar end) 	Stocked Sizes	6.35 to 260 mm diameter.
	Bar Finish	
	Peeled, Cold Drawn Turned and Polished, and Centreless Ground.	

Related Specifications	
Australia	AS 2837-1986 431
Germany	W.Nr 1.4057 X20CrNi17 2
Great Britain	BS970 Part3 1991 431S29 BS970 - 1955 EN57
Japan	JIS G4303 SuS 431
USA	ASTM A276-98b 431 SAE 51431 AISI 431 UNS S43100

Chemical Composition

	Min. %	**Max %**
Carbon	0.12	0.20
Silicon	0	1.00
Manganese	0	1.00
Nickel	1.25	3.00
Chromium	15.00	18.00
Phosphorous	0	0.04

Sulphur	0	0.03

*Carbon range can vary considerably
*Nickel addition optional.

Mechanical Property Requirements For Material in the Annealed and Heat Treated - Condition T To AS2837 - 1986 431 and BS970 Part3 1991 431S29

Condition		Annealed	*T
Tensile Strength Mpa	Min		850
	Max		1000
0.2% Yield Strength Mpa	Min		635
Elongation on 5.65√S0 %	Min		11
Izod Impact Valua J mm	Min		63 34 63 20
Hardness HB	Min		248
	Max	277	302

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

Typical Mechanical Properties At Room Temperature - *Hardened and Tempered to Condition T

Tensile Strength Mpa		940
0.2% Yield Strength Mpa		750
Elongation in 50mm %		19
Impact Izod J		65
Hardness	HB	280
	Rc	30

*Typical Hardening Temperatures	980℃ - 1020℃
*Typical Tempering Temperatures	640℃ - 660℃
	590℃ - 610℃

Typical Mechanical Properties At Room Temperature - Hardened By Oil Quench at 980℃ and Tempered as Indicated

Tempering Temperature ℃		250	370	480	590	650		
Tensile Strengt Mpa		1370	1390	1410	980	920		
0.2% Yield Strength Mpa		1030	1130	1200	790	690		
Elongation in 50mm %		16	16	16	19	20		
Impact Charpy J		54	*34	*16	65	70		
Hardness	HB	410	420	425	295	270		
	Rc	44	45	46	32	29		

High tensile strength and high yield strength with slightly lower impact properties when tempered below 370℃.
Section Size 30mm
*Note drop in impact properties.Tempering within the range 370℃ - 565℃ should be avoided.

Elevated Temperature Properties

431 displays good resistance to scaling in continuous service up to 700℃. 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℃ and Tempered at 30℃ Above Working Temperature

Tempering Temperature ℃	510	570	620
Working Temperature ℃	480	540	590
Tensile Strengt Mpa	1350	720	435
Elongation in 50mm %	15	20	26

Room Temperature Hardness after Test	HB	440	330	280
	Rc	47	37	30

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

Low Temperature Properties

431 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 will be extremely difficult due to the high yield strength and is not generally recommended.

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

431 has the highest corrosion resistance of all the Martensitic stainless steels, and while not as high as the austenitic stainless steels it is in certain corrosive environments similar to that of 301 and 302 grades.NB. It has optimum corrosion resistance in all environments 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 1150℃ - 1200℃, hold until temperature is uniform throughout the section. Do not soak but commence forging immediately.Do not overheat as this will cause a loss of toughness and ductility. Do not forge below 900℃Finished forgings should be cooled as slowly as possible in dry lime or ashes to room temperature and sub-critical annealed immediately

Heat Treatment

Sub-Critical Annealing

Heat uniformerly to 620℃ - 660℃ hold until temperature is uniform throughout the section.
*Soak as required - suggested time 6 to 12 hours but can be longer, cool in air.

Annealing

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.Note: Best impact properties achieved by hardening from above 1020℃. Best corrosion resistance plus mechanical properties achieved by hardening from about 980℃ and tempering above 590℃.

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. Note: Hardening from 1020℃ - 1060℃ will give optimum corrosion resistance, but hardening from about 980℃ will give the best combination of corrosion resistance and mechanical properties.

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 T)

Heat to 590℃ - 680℃ 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 640℃ - 680℃. *Soak as required, cool in air.
Followed by:
Re heat to 590℃ - 610℃. *Soak as required, cool in air.431 can of course be tempered at much lower temperatures producing much higher tensile strengths with subsequent lower impact properties. NB. Tempering however within the range 370℃ - 565℃ 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

431 machines best in the hardened and tempered as supplied condition and is regarded as being readily machineable with all operations such as turning and drilling etc. capable of being carried out satisfactorily. 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.Allowing therefore for its high tensile properties, all machining should be carried out as per machine manufacturers recommendations for suitable tool type, feeds and speeds.

Welding

431 is not generally recommended for welding in either the annealed or hardened and tempered condition, 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. 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 if welding is necessary.

Welding Procedure

Welding electrodes or rods should be low hydrogen types 410 or *similar when good strength is required otherwise an austenitic stainless electrode or rod such as 308 or *similar may be used resulting in 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 interpass temperature at 200℃ minimum. On completion of welding cool slowly as possible until hand warm if possible: Post-weld sub-critical anneal at 620℃ - 660℃, and cool in air.*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.