



E STEEL SDN BHD (891338-A)

NO 3, Lorong Sungai Puloh 7/KU 6,
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Tel : 03-3292 8686 / 32928666 / 32928777
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Stainless Steel - Grade 416 (UNS S41600), SUS416

SUS416 is a free machining basic straight chromium high hardenability martensitic stainless steel with excellent machinability, reasonable strength and corrosion resistance. Generally supplied either hardened and tempered in the tensile range 550 - 700 Mpa (condition P) Brinell range 152 - 207, or in the annealed condition with a maximum Brinell hardness of 207.

Characterised by excellent machinability, non-galling and non-seizing properties due to its higher sulphur content which has the effect of lowering its corrosion resistance. It is however resistant to mild corrosive atmospheres, fresh water, steam, organic materials, many mild acids and petroleum products, coupled with reasonable strength in the hardened and tempered condition.

SS416 due to its excellent hardenability is capable of being through hardened up to 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 stainless steel 416 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.

Material magnetic in all conditions.

Chemical Composition		Min. %	Max. %
	Carbon	0.09	0.15
	Silicon	0	1.00
	Manganese	0	1.50
	*Nickel	0	1.00
	Chromium	11.50	14.00
	*Molybdenum	0	0.60
	Phosphorous	0	0.06
	Sulphur	0.15	0.35

*Nickel & Molybdenum addition optional.

Grade Specification Comparison

Grade	UNS No	Old British		Euronorm		Swedish SS	Japanese JIS
		BS	En	No	Name		
ss416	S41600	416S21	56AM	1.4005	X12CrS13	2380	SUS 416



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Mechanical Properties

Tempering Temperature (°C)	Tensile Strength (MPa)	Yield Strength 0.2% Proof (MPa)	Elongation (% in 50mm)	Hardness Brinell (HB)	Impact Charpy V (J)
Annealed *	517	275	30	262	-
Condition T **	758	586	18	248-302	-
204	1340	1050	11	388	20
316	1350	1060	12	388	22
427	1405	1110	11	401	#
538	1000	795	13	321	#
593	840	705	19	248	27
650	796	670	17.5	253	38

Tempering of this steel at temperatures of 400 to 580°C should be avoided due to low impact resistance.

Elevated Temperature Properties

While sus416 displays a reasonable resistance to scaling in continuous service up to 650 °C, it does however experience a substantial drop in tensile strength, creep and stress rupture strength at relatively low working temperatures. It is also susceptible to hot cracking due to its high sulphur content.

NB. High temperature use is therefore not generally recommended.



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Low Temperature Properties

416SS 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.

Corrosion Resistance

S41600 due to its higher sulphur content has lower resistance to all corrosion types than grade SUS410, and indeed all of the 400 series martensitic stainless steels.

Its selection therefore is generally based upon its excellent machinability coupled with its lower corrosion resistance capabilities.

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.

Heat Treatment of SUS416 , S41600

Sub-Critical Annealing

Heat uniformly to 650 °C - 750 °C as required, hold until temperature is uniform throughout the section.

*Soak as required, cool in air.

Annealing

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

Hardening

Heat to 950 °C - 1020 °C, 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 °C - 550 °C 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.



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Tempering (Condition P)

Heat to 650 °C - 750 °C as required, hold until temperature is uniform throughout the section. *Soak as required. Cool in air.

S41600 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 °C - 580 °C should be avoided due to the 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

S41600 was developed as a free machining grade and has by far the best machinability of all the 400 series martensitic stainless steels. It also has much better machinability than grade 303 free machining austenitic stainless steel and all operations such as turning, drilling, broaching, tapping, milling, reaming and threading etc. can be readily carried out as per machine manufacturers recommendations for suitable tool type, feeds and speeds.

Welding

S41600 is not generally recommended for welding in either the annealed or hardened and tempered condition, due to its high sulphur content resulting in hot cracking or its hardening capability resulting in cold cracking.

If it is really necessary to weld in either condition the following procedure may be taken as a guide only.

Welding Procedure

Welding electrodes or rods should be low hydrogen types 410 or *similar when strength is required or 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 °C - 300 °C and keep heat input to a minimum to reduce dilution of sulphur and filler metal. On completion of welding cool slowly as possible until hand warm and as required:

Post-weld sub-critical anneal at 650 °C - 750 °C or full anneal and harden and temper as required.

*Please consult your welding consumables supplier.