Stainless Steel 416 Grade Data Sheet

Grade 416

Grade 416 has the highest machinability of any stainless steel, at about 85% of that of a free-machining carbon steel. As for most other free-machining steels the improvement in machinability is achieved by addition of sulphur which forms manganese sulphide inclusions; this sulphur addition also lowers the corrosion resistance, weldability and formability to below that of its non-free machining equivalent Grade 410.

Grade 416 is sometimes used in the unhardened or hardened and highly tempered condition because of its low cost and ready machinability.

Martensitic stainless steels are optimised for high hardness, and other properties are to some degree compromised. Fabrication must be by methods that allow for poor weldability and usually also allow for a final harden and temper heat treatment. Corrosion resistance is lower than the common austenitic grades, and their useful operating temperature range is limited by their loss of ductility at sub-zero temperatures and loss of strength by over-tempering at elevated temperatures.

Corrosion Resistance

Grade 416 has useful resistance to dry atmospheres, fresh water and mild alkalies and acids, but less resistant than the equivalent non-free-machining grades. Less corrosion resistant than the austenitic grades and less than 17% chromium ferritic alloys such as Grade 430. High sulphur content free machining grades such as 416 are totally unsuitable for marine or other chloride exposure.

Maximum corrosion resistance is achieved in the hardened condition, with a smooth surface finish.

Heat Resistance

Fair resistance to scaling in intermittent service up to 760°C and up to 675°C in continuous service. Not recommended for use in temperatures above the relevant tempering temperature, if maintenance of mechanical properties is important.

Heat Treatment

Full Annealing

Heat to 815-900°C for ½ hour per 25mm of thickness. Cool at 30°C per hour maximum to 600°C and air cool.

Sub-Critical Annealing

Heat to 650-760°C and air cool.

Hardening

Hardened by heating to 925-1010°C, quenching in oil, and tempering to suit the mechanical requirements. See accompanying table.

Note: The tempering range 400-580°C should be avoided, due to poor ductility.

Welding

Grade 416 has poor weldability. If welding is necessary ... use Grade 410 low hydrogen electrodes. Pre-heat to 200-300°C. Follow immediately with annealing or re-hardening, or

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a stress relief at 650-675°C.

A better option if the weld is not required to be hard is to use a Grade 309 austenitic stainless steel filler rod.

Machining

Grade 416 offers exceptionally good machinability, the highest of any of the commonly available stainless steels. Best machinability is in the sub-critical annealed condition.

Typical Applications

Valve parts, pump shafts, automatic screw machined parts, motor shafts and washing machine components. Bolts, nuts, studs and gears.

Specified Properties

These properties are specified for bar product in ASTM A582/A582M. Similar but not necessarily identical properties are specified for other products such as wire and forgings in their respective specifications.

Composition Specification (%)

Grade		C	Mn	Si	P	S	Cr	Mo	Ni	N
416	min.	-	-	-	-	0.15	12.0	-	-	-
	max.	0.15	1.25	1.00	0.06	-	14.0			

Mechanical Property Specification (Typical and specified values)

Tempering Temperature (°C)	Tensile Strength (MPa)	Yield Strength 0.2% Proof (MPa)	Elongation (% in 50mm)	Hardness Brinell (HB)	Impact Izod (J)
Annealed *	517	276	30	262 max. *	-
Condition T **	-	-	-	248-302**	-
300	1350	1050	10	410	50
400	1390	1090	12	420	43
500	1400	1100	17	420	15 #
600	870	720	20	280	45
700	710	500	22	210	65

* Annealed Condition A of ASTM A582M - Brinell Hardness is specified maximum, other properties are typical only, and will depend upon exact composition and heat treatment details.

** Hardened and tempered Condition T of ASTM A582M – specified hardness range.

Due to associated low impact resistance this steel should not be tempered in the range 400-580°C.

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Physical Properties (Typical values in the annealed condition)

Grade	Density (kg/m³)	Elastic Modules (GPa)	Mean Coefficient of Thermal Expansion			Thermal Conductivity		Specific Heat	Electrical Resistivity
			0-100°C (µm/m/°C)	0-315°C (µm/m/°C)	0-538°C (µm/m/°C)	at 100°C (W/m.K)	at 500°C (W/m.K)	0-100°C (J/kg.K)	(nΩ.m)
416	7700	200	9.9	11.0	11.6	24.9	28.7	460	570

Grade Specification Comparison

Grade	UNS No	Euronorm		Swedish SS	Japanese JIS
		No	Name		
416	S41600	1.4005	X12CrS13	2380	SUS 416

These comparisons are approximate only. The list is intended as a comparison of functionally similar materials **not** as a schedule of contractual equivalents. If exact equivalents are needed original specifications must be consulted.

Possible Alternative Grades

Grade	Why it might be chosen instead of 416
410	The high machinability of 416 can be sacrificed to gain better corrosion resistance and formability.
303	A slight drop in machinability to gain better availability. Grade 303 is non-hardenable.
182	A free-machining ferritic grade with better "soft magnetic" performance for solenoid shafts. Grade 182 is non-hardenable.