

Stainless Steel - Grade 410 (UNS S41000)

Chemical Formula

Fe, <0.15% C, 11.5-13.5% Cr, >0.75% Ni, <1.0% Mn, <1.0% Si, <0.04% P, <0.03% S

Introduction

Grade 410 stainless steels are general-purpose martensitic stainless steels containing 11.5% chromium, which provide good corrosion resistance properties. However, the corrosion resistance of grade 410 steels can be further enhanced by a series of processes such as hardening, tempering and polishing. Quenching and tempering can harden grade 410 steels. They are generally used for applications involving mild corrosion, heat resistance and high strength.

Martensitic stainless steels are fabricated using techniques that require final heat treatment. These grades are less resistant to corrosion when compared to that of austenitic grades. Their operating temperatures are often affected by their loss of strength at high temperatures, due to over-tempering and loss of ductility at sub-zero temperatures.

Key Properties

The properties displayed below are applicable to bar products of ASTM A276. Other products such as forgings, wire and plate may not have similar properties.

Composition

The compositional ranges of grade 410 stainless steels are displayed below.

Table 1 - Composition ranges of grade 410 stainless steels

Grade		C	Mn	Si	P	S	Cr	Ni
410	min.	-	-	-	-	-	11.5	0.75
	max.	0.15	1	1	0.04	0.03	13.5	

Mechanical Properties

The typical mechanical properties of grade 410 stainless steels are listed in the following table:

Table 2 - Mechanical properties of grade 410 stainless steels

Tempering Temperature (°C)	Tensile Strength (MPa)	Yield Strength Proof (MPa)	0.2% Elongation (% 50 mm)	Hardness Brinell (HB)	Impact Charpy V (J)
Annealed *	480 min	275 min	16 min	-	-
204	1475	1005	11	400	30
316	1470	961	18	400	36
427	1340	920	18.5	405	#
538	985	730	16	321	#
593	870	675	20	255	39
650	300	270	29.5	225	80

* Annealed properties of cold finished bar, which pertain to Condition A of ASTM A276.

Tempering of grade 410 steels should be avoided at temperatures of 425-600 °C, owing to associated low impact resistance.

Physical Properties

The physical properties of grade 410 stainless steels in the annealed condition are tabulated below:

Table 3 - Physical properties of annealed grade 410 stainless steels

Grade	Density (kg/m ³)	Elastic Modulus (GPa)	Mean Coefficient of Thermal Expansion			Conductivity (W/m.K)	Specific Heat 0-100 °C (J/kg.K)	Electrical Resistivity (nΩ.m)	
			0-100 °C	0-315 °C	0-538 °C at 100 °C at 500 °C				
410	7800	200	9.9	11	11.5	24.9	28.7	460	570

Grade Specification Comparison

Grade comparisons of 410 stainless steels are outlined in the following table:

Table 4 - Grade specifications of 410 grade stainless steels

Grade	UNS No	Old British		Euronorm		Swedish SS	Japanese JIS
		BS	En	No	Name		
410	S41000	410S21	56A	1.4006	X12Cr13	2302	SUS 410

Possible Alternative Grades

The table below provides the suitable alternative grades to 410 stainless steels:

Table 5 - Possible alternative grades to 410 grade stainless steels

Grade	Reasons for choosing the grade
416	High machinability is required, and the lower corrosion resistance of 416 is acceptable.
420	A higher hardened strength or hardness than can be obtained from 410 is needed.
440C	A higher hardened strength or hardness than can be obtained even from 420 is needed.

Corrosion Resistance

Grade 410 stainless steels are resistant to hot gases, steam, food, mild acids and alkalies, fresh water and dry air. These steels obtain maximum corrosion and heat resistance through hardening. However, grade 410 steels are less corrosion resistant than austenitic grades and grade 430 ferritic alloys containing 17% chromium. Smooth surface finish offers improved performance of steels.

Heat Resistance

Grade 410 steels have good scaling resistance at temperatures of up to 650 °C. However, the mechanical properties of the material will tend to reduce at temperatures ranging from 400 to 580 °C.

Heat Treatment

Annealing - Grade 410 steels can be fully annealed at temperatures from 815 to 900 °C, followed by slow furnace cooling and air-cooling. Process annealing of grade 410 steels can be carried out at temperatures ranging from 650 to 760 °C and air-cooled.

Hardening – Hardening of grade 410 steels can be performed at 925 to 1010 °C, followed by air and oil quenching. Heavy sections of grade 410 need to be oil quenched. Tempering, to enhance the mechanical properties and hardness of grade 410 steels, follows this process. It is not recommended to perform tempering at temperatures from 400 to 580 °C.

Welding

Grade 410 steels can be welded using all conventional welding techniques, but the materials should pre-heated at 150 to 260 °C followed by post-weld annealing treatment, to mitigate cracking. Grade 410 welding rods are recommended for tempering and post-hardening. In the "as welded" conditions, grade 309 filler rods can be used to achieve a ductile joint.

According to AS 1554.6 standards, grade 309 electrodes or rods are preferred for welding 410 steels.