1.4006

X12Cr13

Stainless martensitic, chromium steel

C 0.08 – 0.15 **Cr** 11.50 – 13.50

General comments

1.4006 is a martensitic grade which exhibits good mechanical properties coupled with good corrosion resistance in moderately corrosive environments.

Relevant current and obsolete standards

EN 10088-3	1.4006	X12Cr13
AISI	410	
BS	410S21	
JIS	410	
AFNOR	Z10C13 / Z13C13	
DIN 17440	1.4006	
SIS	2302	

General properties

corrosion resistance	average
mechanical properties	good
forgeability	average
weldability	very good
machinability	good

Special properties

can be used to temperatures of 600 °C
ferromagnetic grade
resistant to embrittlement

Physical properties

density (kg/dm³)	7.70
electrical resistivity at 20 °C (Ω mm²/m)	0.60
magnetizability	yes
thermal conductivity at 20 °C (W/m K)	30
specific heat capacity at 20 °C (J/kg K)	460
thermal expansion (K^{-1})	20 – 100 °C: 10.5 x 10^{-6}
	20 – 200 °C: 11.0 x 10^{-6}
	20 – 300 °C: 11.5 x 10^{-6}
	20 – 400 °C: 12.0 x 10^{-6}

Typical applications

decorative applications and kitchen utensils/fittings
petrochemical industry
pump components
mechanical engineering

Note: available from stock
1.4021 can be used as an alternative

Processing properties

automated machining	yes
machinable	yes
hammer and die forging	not common
cold forming	seldom
cold heading	not common
suited to polishing	yes

Conditions

annealed, tempered

Demand tendency

rising

Corrosion resistance (PRE = 12.0 – 14.0)

As a result of its nominal chromium content, 1.4006 displays moderate corrosion resistance to slightly aggressive, non chloride containing environments such as soap, detergents and organic acids. This steel is also resistant to oxidising atmospheres up to temperatures of about 600 °C.

Heat treatment and mechanical properties

1.4006 is delivered in both the annealed and quenched and tempered conditions. The annealed condition is obtained by heating in the temperature range 745 °C to 825 °C, followed by slow cooling in a furnace. In this condition, the following mechanical properties can be expected:

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Property		Specification
tensile strength (N/mm²)	R_m	≤ 730
hardness	HB	≤ 220

Note: the HB values could be 60 units higher and the tensile strengths 150 N/mm² higher due to cold work during straightening of profiles ≤ 35 mm.

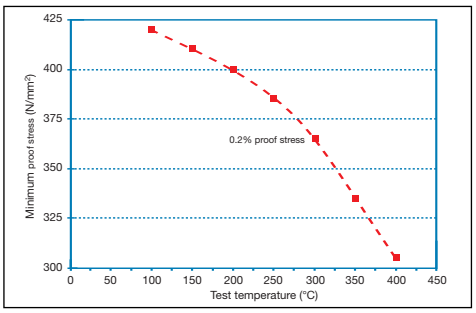
This steel may be heat treated by hardening in air or oil after holding at a temperature between 950 and 1000°C. Although a range of mechanical properties may be obtained by tempering at different temperatures, the QT 650 condition is usually specified and may be obtained by tempering in the temperature range 680 °C to 780 °C. In this condition, the following mechanical properties can be expected:

Property		Specification	Typical
yield strength (N/mm²)	$R_{p0.2}$	≥ 450	480
tensile strength (N/mm²)	R_m	650 – 850	720
tensile elongation (%)	A_5	≥ 15	20
impact energy (J) 25 °C	ISO-V	≥ 25	

The mechanical properties (d ≥ 160 mm) have to be agreed on for thicker dimensions, or the delivered product is based on the values given.

Elevated temperature properties

Due to the possibility of 475 embrittlement, processing or service in the temperature range between 425 °C and 525 °C is to be avoided, or at least minimised. In the QT 650 heat treated condition, the following elevated temperature strengths can be expected:



Welding

The work piece is usually pre-heated to a temperature of between 100 to 300 °C and welding is usually followed by a tempering treatment when 1.4006 is welded with a matching filler material. When an austenitic filler material such as Novonit® 4370 (AISI 307Si), is used, then no preheating of the work piece is necessary. Tempering at a temperature of 650 °C is recommended to ensure that some ductility returns to the weld region. Due to the high strengths that can be attained with this steel and the possible detrimental effects of hydrogen embrittlement, care must be taken to avoid ingress of hydrogen into the weld pool from the shielding gas, or from moisture from the work piece and/or welding consumables used. Nitrogen containing shielding gasses may also not be used.

Forging

Care should be taken when forging 1.4006, since gradual heating to a temperature of about 800 °C is recommended prior to more rapid heating to a temperature of between 1150 °C and 1180 °C. Forging then takes place between 1180 °C – 950 °C followed by slow cooling in an oven or in dry ash or similar material to promote slow cooling.

Machining

The machinability of this grade of stainless steel is directly related to its hardness. 1.4006 machines similar to carbon steels of the same hardness. Although it must be realised that the machining parameters will vary depending on the structure/hardness of the steel, the following parameters can be used as a guideline when machining with coated hardmetal tools:

	Depth of cut (mm)	6	3	1
	Feed rate (mm/r)	0.5	0.4	0.2
Annealed R_m **600 – 750 N/mm²**	Cutting speed (m/min)	170	240	300
Tempered R_m **780 – 930 N/mm²**	Cutting speed (m/min)	160	230	280

DEUTSCHE EDELSTAHLWERKE GMBH
Auestraße 4
58452 Witten
www.dew-stahl.com

Tel. +49 2302 29 0
Fax +49 2302 29 4000
stainless@dew-stahl.com

