CHRONIFER® Labor 13%

1.4005/AISI 416 - Ferritic free machining stainless steel

Attributes and particularities

The ferritic CHRONIFER® Labor 13% free machining stainless steel has an increased S content to further improve and enhance its excellent machinability. This grade exhibits the best machinability of all stainless steels. But, it also exhibits the lowest corrosion resistance of all. However, its corrosion resistance in water can still satisfactorily be met if the parts are previously heat treated in the Condition T (26-32 HRc), polished and passivized.

Uses

This steel is well adapted for numerous applications. More particularly, in the production of bolts and nuts, screws, turned parts in general, and gears. It finds many applications in the agricultural and food industries as well as in mechanical engineering.

Applicable standards

Material number	1.4005, Condition T
ISO	X12CrS13
Euro Norm EN	X12CrS13
DIN	X12CrS13
ASTM	F899
AISI/SAE/ASTM	AISI 416, AISI 416 MOD
AFNOR	X12CrS13 (formerly Z12CF13)
JIS	SUS 416

Chemical composition (%wt)

C	Si	Mn	P	S	Cr	Mo	Fe
0.08	max.	max.	max.	0.15	12.00	max.	balance
0.15	1.00	1.25	0.04	0.35	14.00	0.60	

Dimensions and tolerances

- Ø < 2.00 mm: cold drawn, polished, ISO h8
- Ø ≥ 2.00 mm: cold drawn, ground, polished, ISO h8

Other tolerances on request

Executions et Delivery conditions

Standard: round bars 3 m
coils for Escomatic

- Bar ends > 2.00 mm: pointed and chamfered
- Bar ends < 2.00 mm: cut or sheared

Others executions on request

Availability

Standard dimensions on stock, see: Delivery program

Mechanical properties

Standard delivery condition: Condition T (26 – 32 HRc)

- Strength UTS: 880 – 990 MPa, function of diameter

Hardening capability: ≈ 38 - 42 HRc

Machinability

The CHRONIFER® Labor 13%, (1.4005), steel has the best machinability of all stainless steels. It is even superior to this of the1.4305 (AISI 303) steel grade.

Cutting conditions

Machinability: very good to excellent
build short chips

Cutting speed: V_c ≈ 45 - 60 m/min.

Lubricant-coolant: Individual choice

- The optimal cutting conditions depend on the machine tool, the cutting tools, the chip dimensions, the lubricant-cooling fluid, as well as the tolerances and surface the roughness to be achieved.

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Examples of cutting conditions for CNC turning

Condition	UTS (MPa)	Cutting depth (mm)	6	3	1
		Feed (mm/r)	0.5	0.4	0.2
Annealed	600 – 685	Cutting speed (m/min)	160	200	300
Hardened	750 – 950		200	250	350

Examples of cutting conditions for the machining of large diameters

Conditions	UTS (MPa)	Cutting depth (mm)	6	3	1
		Feed (mm/r)	0.5	0.4	0.2
Annealed	600 – 685	Cutting speed (m/min)	155	165	195
Annealed + cold dawn	695 – 780		140	165	175
Hardened	750 – 950		175	200	240

Forming

Warm: forging: 1150 – 950°C (pre-heating to 1150 – 1230°C)
Not recommended below 930°C.
- The numerous manganese sulfides inclusions may lead to hot forming cracks.

Cold: Limited. Not recommended.

Welding

Not advisable.
- The numerous manganese sulfides (MnS) inclusions can significantly hamper or even impede the welding process.

Annealing

Soft anneal: 815 – 900°C, slow cooling 30°C/h down to 600°C, then air-cooling.
Typical hardness: H_B 155
Softening anneals (sub-critical): 650 – 760 °C, air-cooling.
Typical hardness: H_B 185, UTS 490 - 690 MPa
Intermediary anneals during cold working: preferably 650 - 680°C, air-cooling
- To prevent any excessive grain growth, the minimum amount of cold work prior to annealing should preferably be ≥ ≈10-15%.

Quenching

Primary quenching: 950 – 1050°C, oil
Option: Secondary quenching by sub-zero cooling:
- -20 down to -80°C/12 – 48h, preferably -80°C/12 – 24h

Or by cryogenic cooling:
- -196°C/12 – 24h, a progressive or step by step cooling is recommended, to prevent the formation of thermal cracks.
- The secondary quenching should be carried out as soon as possible. More info

Tempering

Tempering: according to needs, see Table below
- Not recommended temperature range: 400 – 580°C (risk of brittleness development)

Mechanical properties Heat treated condition

Tempering temperature (°C)	Strength UTS (MPa)	Yield strength $R_{0.2\%}$ (MPa)	Elongation $A_{50\ mm}$ (%)	Brinell hardness H_B
annealed	517	276	30	< 262
condition T				272-314
300	1350	1050	10	410
400	1390	1090	12	420
600	870	720	20	280
700	710	500	22	210

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Microstructures

Delivery conditions: “annealed“ and “annealed + cold drawing“: Ferrite + carbides
- Machining microstructure: Ferrite + carbides

Quenched and tempered condition: Martensite + carbides
- Hard machining microstructure: Plain martensite or Martensite + carbides
- Microstructure at optimal hardness for polishing: Stress relieved martensite
- Polishing microstructure: Martensite + carbides

Polishing

Optimal in the quenched and tempered < 200°C condition
Not appropriate for mirror polishing.
- The numerous inclusions of manganese sulfide (MnS) impair the polishing ability of this steel and decrease significantly its yield and process economy.

Laser marking

- The numerous manganese sulfide (MnS) inclusions impair the laser marking.
- The Heat Affected Zone (HAZ) alters locally the microstructure and may reduce its corrosion resistance. More info

Passivation

The adequacy of the selected passivation process should be checked with respect to the numerous manganese sulfide (MnS) inclusions of this free machining steel grade.
- The numerous manganese sulfide (MnS) inclusions may significantly impair the quality of the passivation process.
- A pickling prior to passivation is highly recommended. It should not be skipped.

More info

Corrosion resistance

Optimum: Clean, quenched, tempered, fine polished, and passivized surfaces.
- The numerous inclusions of manganese sulfide (MnS) increase the sensitivity to pitting corrosion.
- Not recommended conditions: “annealed“ and “annealed + cold deformed”. These conditions increase the corrosion risk. They should be avoided.
- The formation of oxides and scaling can strongly decrease the corrosion resistance. These oxidations must be eliminated either mechanically or chemically, by pickling.

Simple precautions

- The simplest and easiest precaution is always to keep the parts clean, free of working residues, polished, and correctly dried.
- Use only chlorine free disinfection solutions, cleaning and washing solutions and products. More info.

Physical properties

Properties	Units	Temperature (°C)				
		20	200	300	400	500
Density	g cm^{-3}	7.70				
Young modulus E	GPa	215			190	
Electrical resistance	Ω mm^2 m^{-1}	0.60				
Thermal expansion	m m^{-1} K^{-1}	20–100°C	20–200°C	20–300°C	20–400°C	20–500°C
	10^{-6}	10.5	11.0	12.0		
Thermal conductivity	W m^{-1} K^{-1}	24.9				28.7
Specific heat	J kg^{-1} K^{-1}	460				
Melting range	1515 – 1460°C					
Magnetism	Ferromagnetic, can be magnetized. More info.					