CHRONIFER® 455 KL

Precipitation hardenable martensitic stainless steel

Attributes and Particularities

This precipitation hardenable martensitic stainless steel is ESR remelted. Its main attribute is its simplicity to use. Its forming is easy and the parts made out of it present a good corrosion resistance, similar to this of 15-17%Cr martensitic stainless steels. Furthermore, its stress corrosion resistance increases with the age hardening intensity. In the age hardened condition it has a high strength coupled with an excellent toughness.

Uses

The CHRONIFER 455 KL steel is well adapted to the making of medical, surgical and dental instruments, and other applications with similar requirements. Its age hardening requires a single treatment only and its aging dimensional contraction is ≤ 0.1%.

Applicable standards

Material Number	1.4543
DIN	X3CrNiCuTiNb12-9
AISI/SAE/ASTM	AISI XM-16, ASTM F899
AFNOR	Z 3 Cnut 12.9
Euro Norma EN	X3CrNiCuTiNb12-9
NF	S 94-090
UNS	S45500

Chemical composition (%wt)

C	Si	MN	P	S	Cr	Mo	Ni	Cu	Ti	Nab/Ta	Fe
Max.	Max.	Max.	Max.	Max.	11.0	max.	7.50	1.5	0.90	0.10	balance
0.03	0.50	0.50	0.015	0.015	12.5	0.50	9.50	2.5	1.40	0.50	

Dimensions and tolerances

- Bars Ø < 2.00 mm: cold drawn ISO h8
- Bars Ø ≥ 2.00 mm: cold drawn, ground ISO h6 (h7), Ra 0.4 (N5)
- Wires Ø ≥ 2.00 mm: cold drawn, rings for Escomatic

Tighter tolerances on request

Execution and Delivery condition

Standard: round bars 3 m

- Bar ends > 2.00 mm: pointed and chamfered
- Bar > 6.0 mm: SWISSLINE execution
- Wires < 2.00 mm: rings for Escomatic

Other executions on request

Availability

Standard dimensions on stock, see: Sale program

Mechanical properties

Standard delivery condition:

- Strength UTS: 950-1200 MPa (30-40 HRc), depends on diameter

Cutting conditions

Machinability: relatively difficult
Cutting speed: $V_c \approx 20 - 30$ m/min.

- Lubricant i.e.: INOX or ORTHO NFX
- Machining microstructure: Martensite

The cutting conditions of the CHRONIFER 455 KL steel are similar to those of the maraging steels.

The optimal cutting conditions depend on the machine tool, the cutting tools, the chip dimensions (cutting depth and feed), the cutting speed, the lubricant-cooling fluid, as well as the tolerances, surface roughness to be produced and, off course, on the experience of the user.

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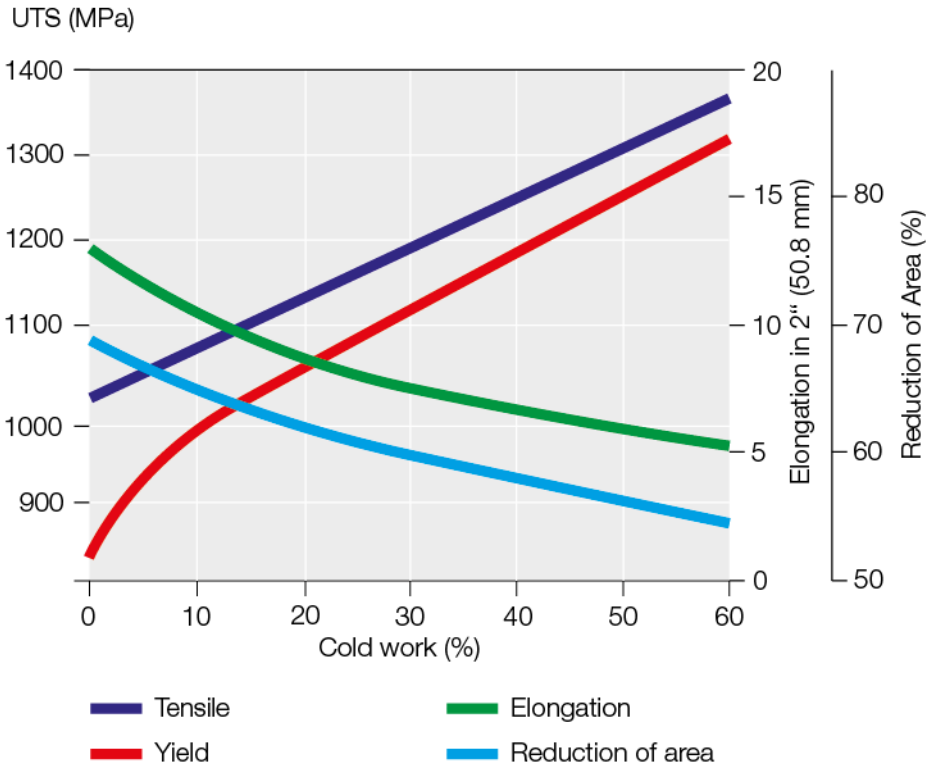
Forming

Warm: 900 - 1260°C, heating to 1040 - 1150°C, holding at temperature.
Finishing: 815 - 925°C, to obtain a fine grain and the desired mechanical properties after aging. Air-cooling of the forged parts, final anneal and aging.
Cold: Easy after an 815 - 845 °C anneal, fast cooling.
UTS after annealing: 950 - 1050 MPa (HRc 30-35)

- The CHRONIFER 455 KL steel can easily be heavily cold deformed, without intermediate anneal. The cold plastic deformation by cold drawing after an 815°C/30min /water quench anneal, increases the mechanical properties as shown on the graph below (source: Data sheet Custom 455 stainless, Carpenter Technology Corp).



- A plastic deformation made before aging, permits to reach still higher mechanical properties. A heavy cold deformation like for springs (Condition C) permits to reduce the duration of a 455°C aging to 30 minutes.

Welding

- Feasible, mostly in the annealed condition. In this case, the precipitation hardening treatment, aging, can be made directly after welding, without any other necessary intermediate heat treatments.
- If the welding may contribute to he formation of strong internal stresses, it is preferable to weld the components in the 620°C over-aged condition, and then to anneal the welded assembly before aging it.
- Take care to not use processes, which might increase the C content.
- An annealing after welding permits to obtain the optimum between the mechanical properties and the corrosion resistance of the welded components.

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Annealing

Typical anneal: 815-845°C, fast cooling.

Precipitation hardening Aging

Typical mechanical properties at the room temperature

Condition*	Yield strength $R_{0.2}$ (MPa)	UTS (MPa)	UTS notched Kt=10 (MPa)	Elongation 4d (%)
A, annealed	795	1000	1585	14
H900 (482°C)	1690	1725	1790	10
H950 (510°C)	1550	1620	2070	12
H1000 (538°C)	1380	1450	2000	14
H1050 (566°C)	1205	1310	1790	15

*The prefix H of the American designation indicates the aging temperature in °F.
°C = (°F-32) * 5/9.

Microstructures

Delivery conditions: annealed and « annealed + cold drawn»: Martensite
Machining microstructure: Martensite

Polishing

Well adapted to mirror polish

Laser marking

- The laser marking heat in the Heat Affected Zone (HAZ) may modify the local microstructure and affect negatively its corrosion resistance. More info.

Pickling and Passivation

Il It is strongly recommended to use passivation procedures adapted to the treatment of precipitation hardened martensitic stainless steels.

Surface oxidation, scaling:
- The formation of a scaling layer during the heat treatments can strongly reduce the corrosion resistance. Therefore, this oxidation must be eliminated, either by mechanical or by chemical means, pickling.

Chemical descaling:
- 50%$_{vol}$ chlorhydric acid: 2 min à 82°C
- 15%$_{vol}$ nitric acid + 3%$_{vol}$ hydrofluoric acid: 4 min à $T_{ambiante}$
- Repeat if necessary; reduce the exposure time to 1 and 2 minutes respectively.

Surface coloration by oxidation:
Chemical pickling of a colored oxidation:
- 15%$_{vol}$ nitric acid + 3%v_{ol} hydrofluoric acid: 4 to 6 minutes at room temperature before rinsing.
- Repeat if necessary; reduce the exposure time to 2 to 3 minutes respectively.

Final desmut treatment:
- Desmut with 20%$_{vol}$ nitric acid at room temperature
- Bake 1 to 3h at 150/175°C to remove any hydrogen pickup during the acid treatments.

More info.

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Physical properties

Proprerties	Units	Temperatur (°C)				
		20	200	300	400	500
Density	g cm^{-3}	7.76-7.79				
Elastic modulus E/G	GPa	200/75.8				
Electrical resistance	Ω mm^2 m^{-1}	0.70				
Thermal expansion	m m^{-1} K^{-1}	20–100°C	20–200°C	20–300°C	20–400°C	20–500°C
	10^{-6}	10.4	10.8	11.2	11.6	
Thermal conductivity	W m^{-1} K^{-1}	18.0	19.8	21.3	23.4	24.8
Specific heat	J kg^{-1} K^{-1}					
Melting range	average melting-cristallisation range:					
Magnetism	Ferromagnetic, can be magnetized More info.					

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Modifications will not be adjusted automatically.
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