CHRONIFER® 465 KL

1.4614 - Precipitation hardening martensitic stainless steel

Attributes and particularities

The CHRONIFER® 465 KL is a premium precipitation hardening martensitic stainless steel. It is VIM melted and VAR remelted. This steel has been designed to provide in the cold worked and H900 aged an UTS strength up to 2090 MPa with an excellent tensile notch resistance coupled to a high toughness. In the H1000 condition it has a most favorable combination of high strength, stress corrosion resistance and toughness. Its corrosion resistance is similar to this of the AISI 304 (1.4301) stainless steel.

Uses

This steel is the material of choice for high requirements for medical instruments, and in the aerospace, automotive, chemical, pharmaceutical, and the agro-food industries.

Applicable standards

Material Number	1.4614
AISI/SAE/ASTM	ASTM F899
ASTM	A564 Cap of H1000
UNS	S46500
AMS	5936 Cap of H1000 Rev. C

Chemical composition (%$_{wt}$)

C	Si	Mn	P	S	Cr	Mo	Ni	Ti	Fe
max.	max.	max.	max.	max.	11.00	0.75	10.75	1.50	balance
0.02	0.25	0.25	0.015	0.010	12.50	1.25	11.25	1.80	

Dimensions and tolerances

- Ø < 2.50 mm: cold drawn
- Ø ≥ 2.50 mm: cold drawn, ground h8, rugosity Ra 0.4 (N5)

Tighter tolerances on request

Executions and delivery conditions

Standard: 3 m bars in the annealed condition, Ø 1.50 to 63.5 mm
- Ø ≥ 6.00 mm: SWISSLINE execution

Other executions on request

Availability

Standard dimensions on stock, see: Sales program

Mechanical properties of wires

Mechanical properties of wires

Condition	Rm (MPa)	$R_{0.2}$ (MPa)	A_{4d} (%)	Reduction of area (%)	Hardness HRc
Solution annealed	950	770	20	75	29.5
71% cold drawn	1200	1125	12	74	38.5
Solution annealed + aged H900 (482°C)	1779	1703	14	51	50
Solution annealed KV CD + aged H900 (482°C)	2090	2020	10	57	53

Cutting conditions

Machinability: relatively difficult
The machinability of CHRONIFER® 465 KL is similar to those of maraging steels.
Cutting speed: $V_c \approx 20$ - 30 m/min.
Lubricant-coolant: individual choice

- An H1150M over aging treatment prior to machining improves the machinability. But, the machined parts must be annealed before the final age hardening treatment.
- 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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Forming

Warm: forging: 1010 – 1095°C, air cooling
- An annealing made after the hot forming operations permits to obtain an optimal combination of strength and corrosion resistance.

Cold deformation

Cold: Easy in the annealed condition
- In the annealed condition this steel has a low cold work hardening. High cold drawing reductions can easily be achieved, i.e. 90%, (true deformation $\varepsilon = 2.2$) without intermediate anneal.
- A prior cold deformation permits to reach still higher strength, < 2090 MPa, after age hardening.

Welding

Suitable.
- The parts to weld are usually in the solution anneal condition. In this case, the age hardening of the welded assembly can be carried out without any further treatments.
- Take care not to carburize the weld.
- Solution anneal made after welding permits to obtain an optimal combination of strength and corrosion resistance of the welded assemblies.
- If the welding should lead to excessive internal stresses, it would be preferable to first over aged the parts at 620°C before welding, and then solution anneal the welded structure before its final age hardening.

Annealing

Solution anneal: 982 ± 8°C / 1h / oil or water quench
Optimum: Solution anneal + refrigeration at -80°C/≥8h
- To obtain the best results, the refrigeration treatment should preferably be made within 24h after annealing.
- The purpose of the -80°C refrigeration treatment is to reduce the thermal sensitivity of the properties obtained by the previous treatments.

H1150M over aging for machinability improvement

H1150M: Suffix M stands for machining
1st age hardening treatment: 760 ± 8°C / 2h / air cooling
2nd age hardening treatment: 621 ± 8°C / 4h / air cooling
- After machining, an annealing must be made before the final age hardening.

Age hardening

Temperature comprised between: 480 – 620°C/ 4-8h, oil or water quench to obtain the optimal toughness achievable at each temperature.

Condition	Yield strength $R_{0.2\%}$ L - T (MPa)	UTS Rm L - T (MPa)	Elongation 4d L - T (%)	Contraction* L - T (%)
Solution annealed	683 – 683	951 - 951	20	–
H900 (482°C)	1641 – 1613	1772 – 1772	13 – 12	0.08 – 0.07
H950 (510°C)	1620 – 1586	1751 – 1724	14 – 12	0.11 – 0.10
H1000 (538°C)	1496 – 1455	1593 – 1585	15 – 15	0.14 – 0.13
H1050 (566°C)	1365 – 1351	1482 – 1469	18 – 17	0.16 – 0.16
H1075 (580°C)	1234 – 1241	1400 – 1393	20 – 19	–
H1100 (593°C)	1096 – 1089	1310 – 1310	22 – 21	0.23 – 0.23
H1150M (621°C)	531 – 538	1076 – 1096	25 – 22	0.53 – 0.53

*Contraction: L stands for longitudinal, T for transversal
The prefix H indicates age hardening at the XXXX temperature in °F
The numbers between brackets are the age hardening temperature in °C. Conversion °C = (°F-32)*0.5555

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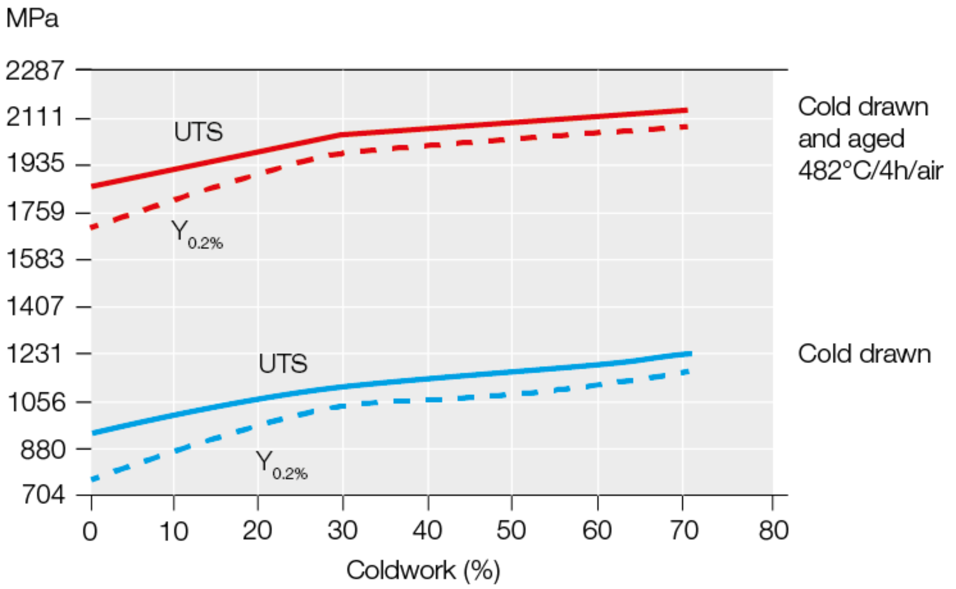
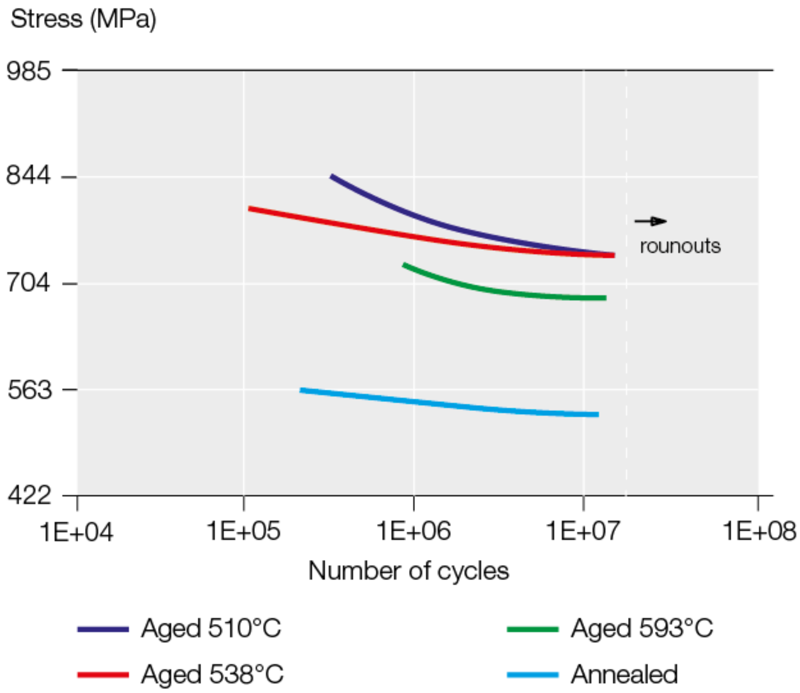
Effect of Cod Work and aging on the yield strength and UTS



Smooth Rotating Beam Fatigue Behavior (RR Moore)



Modifications will not be adjusted automatically.
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Microstructures

Delivery conditions: “Solution annealed“ or “annealed + cold drawn“: Martensite
Machining microstructure: Martensite and age hardening precipitates

Polishing

Well suited for mirror polishing

Laser marking

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

Pickling and passivation

It is strongly recommended to use pickling and passivation procedures and products effectively adapted to the treatment of age hardening martensitic stainless steels.

- To avoid staining by a “flash back“ reaction, it is strongly recommended to always pickle the surfaces before the passivation procedure. More info.

Corrosion resistance

Surface oxidation:

- The possible formation of colored oxides or scaling during heat treatments may drastically reduce the corrosion resistance. These oxidations should be eliminated, either mechanically or chemically.

Elementary precautions

Elementary precautions:

- The simplest and easiest precautions to apply are to always keep the parts clean, free of working residues, polished, and properly dried.
- Use only chloride free disinfection solutions, cleaning and washing solutions and products. More info.

Physical properties

Properties	Units	Condition				
		Annealed	H900	H1000	H1050	H1100
Density	g cm^{-3}	7.82	7.83	7.85	7.85	7.87
Elastic modulus E	GPa			202.7		199.8
Electrical resistivity	µohm-mm	946	824	822		772
Thermal expansion:	10^{-6} (m m^{-1} K^{-1})					
20 – 100°C		10.30	10.40	10.60		11.30
20 – 200°C		10.80	11.10	11.10		12.00
20 – 400°C		11.10	11.70	11.70		12.70
20 – 600°C		9.86	11.20	12.20		13.10
Thermal conductivity at 23°C	W m^{-1} K^{-1}	14.06	14.85	15.83		15.80
Magnetic properties:						
- Coercivity Hc	Oe	25.5	23.3	28.1	34.2	53.0
- Saturation induction Bs	kG	13.4	13.8	13.3	12.4	10.1

Reference

ALLOY Data, Custom 465® Stainless, Carpenter Technology Corporation

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