

# CHRONIFER<sup>®</sup> Special 04

1.4404/AISI 316L – Austenitic stainless steel with low S content

## Features and Particularities

The CHRONIFER<sup>®</sup> Special 04 steel is a 316L (1.4404) type austenitic stainless steel with a S content limited to max. 0.015% and C of max. 0.030%. This composition constellation limits the risk of sensitization to the temperature range of 450-650°C. Thence, this steel exhibits a good intergranular corrosion resistance, welding capability, and a good amenability to all polishing techniques. It has a good general corrosion resistance in non-oxidizing acid medium, and solutions not containing halogen elements. It can continuously be used up to 430°C. Its machinability is fair to medium, but better in the cold worked condition. This steel cannot be thermally hardened, but similarly to the CHRONIFER<sup>®</sup> Special 35, it can be strengthened by cold deformation. This steel can contain traces of ferromagnetic  $\delta$  (Delta) Ferrite.

## Uses

This steel is used in numerous industrial branches. Such as the chemical, pharmaceutical, food, and oil related industries, as well as in the paper and textile industries. It is used in the fine mechanical engineering and the mechatronic industries. It is also used for watch components for movements as well as for the watch exterior.

## Standards

Material number	1.4404
EN 10083-3	X2CrNiMo 17-12-2
ISO	7153-1 (P)
DIN /AFNOR	X2CrNiMo 17-12-2
AISI/SAE	316L
ASTM	F 899
NF	S 94-090
JIS	SUS 316

## Chemical composition (%wt.)

C	Si	Mn	P	S	Cr	Ni	Mo	N	Fe
max. 0.030	max. 1.00	max. 2.00	max. 0.045	max. 0.015	16.5 - 18.0	10.0 - 13.0	2.00 - 2.50	max. 0.10	balance

## Dimensions and Tolerances

Standard: Bars 3 m (+50/0 mm), coils for Escomatic  
 Strength UTS: 650-950 MPa  
 • Bars  $\varnothing < 1.0 - 9.0$  mm: ISO h8  
 • Bars  $\varnothing \geq 2.00$  mm: ISO h6 (h7)  
 • Wires 0.80 - 3.00 mm: ISO fg7, coils for Escomatic  
 • Out of roundness max.  $\frac{1}{2}$  diameter tolerance  
 Other tolerances on request

## Executions and Delivery conditions

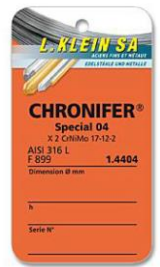
Standard: Bars 3 m (+50/0 mm), coils for Escomatic  
 • Bars  $\varnothing \geq 2.00$  mm: cold drawn, ground, polished, Ra (N5)  
 Bar ends: pointed and chamfered  
 Surface condition: cold drawn  
 • Bars  $< 2.00$  mm: [SWISSLINE](#) execution  
 •  $\varnothing \geq 6.00$  mm:  
 • Wires  $\varnothing$  max. 3.00 mm: cold drawn, coils for Escomatic  
 Other executions on request

## Availability

Standard dimensions on stock: see [Sale program](#)

## Cutting conditions

Machinability: fair to medium, better in the cold worked condition,  
 Cutting speed:  $V_c \approx 40 - 65$  m/min.  
 Lubricant-coolant fluid: 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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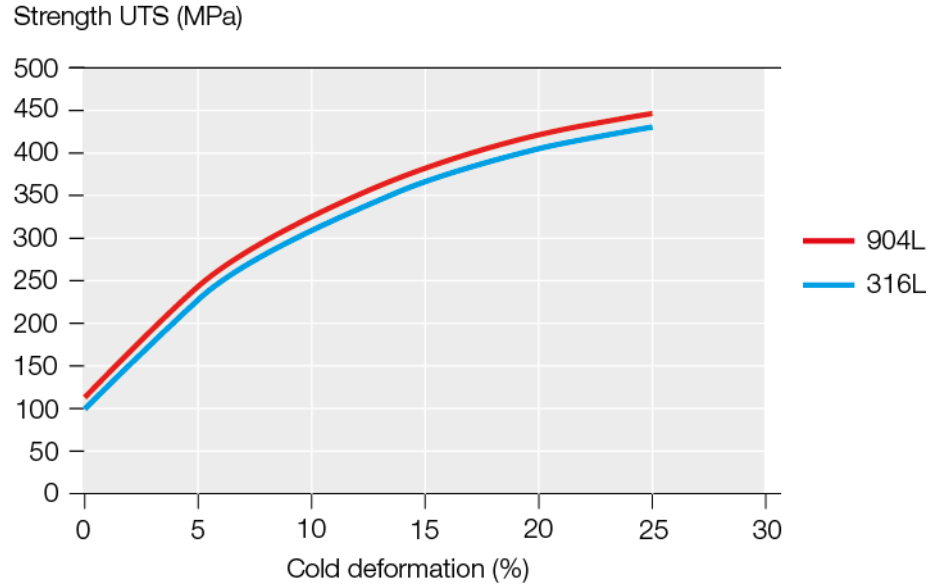
<b>Cleanliness</b>	The CHRONIFER <sup>®</sup> Special 04 steel is a clean steel. It can be successfully be polished with polishing techniques.
<b>Grain size</b>	According to ASTM E47: <ul style="list-style-type: none"> <li>• Cold worked wires                      ASTM Nr. ≥ 7-8</li> </ul>
<b>δ (Delta) Ferrite</b>	The CHRONIFER <sup>®</sup> Special 04 steel may contain δ (Delta) Ferrite. Its Ferrite content can be determined graphically with the Schaeffler-De Long Diagram modified by Outokumpu, or computed with the aid of the Cr <sub>eq</sub> und Ni <sub>eq</sub> equivalent contents: <ul style="list-style-type: none"> <li>• Cr<sub>eq</sub> = 1.5Si + Cr + Mo + 2Ti + 0.5Nb</li> <li>• Ni<sub>eq</sub> = 30(C + N) + 0.5Mn + Ni + 0.5(Cu + Co)</li> <li>• Ferrite Number FN or %<sub>vol.</sub> δ (Delta) Ferrite  <math>FN = ([1.375 (Cr_{ew} - 16) + 10] - Ni_{eq}) / 2.586</math></li> </ul> Negative values of FN indicate the absence of δ (Delta) Ferrite.
<b>PREN</b>	<ul style="list-style-type: none"> <li>• PREN = %Cr + 3.3%Mo + 18%N</li> <li>• Computed basic parameters: min. 23.1 / max. 28.0</li> </ul>
<b>Forming</b>	Warm, forging                      950 – 1120°C, quenching/rapid cooling <ul style="list-style-type: none"> <li>• If the forging temperature should drop below 900°C, a preventive 1040-1070°C solution anneal is recommended to fully recover all capabilities of this steel.</li> </ul> Cold:      no limitation, see Figure 1, page 3
<b>Solution anneal</b>	1040-1070°C/quenching or rapid cooling <ul style="list-style-type: none"> <li>• A 10 – 15% cold working reduction is recommended prior to a solution anneal in order to reduce the risk of a too fast and uncontrolled grain growth.</li> <li>• The temperature range of 650 - 450°C should be avoided as it leads to sensitization and the formation and precipitation of a σ (Sigma) phase.</li> <li>• The formation of σ (Sigma) phase leads to brittleness; drop of ductility and corrosion resistance.                  In such case, a 1040-1070°C/quenching/rapid cooling solution anneal is recommended.</li> </ul>
<b>Hardening Strengthening</b>	<ul style="list-style-type: none"> <li>• This steel cannot be thermally hardened.</li> <li>• This steel can be strengthened by cold working, see Figure 1, page 3</li> </ul>
<b>Microstructures</b>	For machining and polishing: <ul style="list-style-type: none"> <li>• Bars and wires: annealed or cold deformed austenite</li> </ul>
<b>Polishing</b>	Adapted to all modes and techniques of polishing. Electro-polishing:                      adapted <ul style="list-style-type: none"> <li>• This CHRONIFER Special 04 steel can contain traces of δ (Delta) Ferrite.</li> <li>• δ (Delta) Ferrite appears in relief after electro-polishing</li> <li>• In case of σ (Sigma) Phase formation or of sensitization, a 1040-1070°C solution anneal is recommended in order to fully recover the polishing ability and capability and the corrosion resistance of this steel.</li> <li>• σ (Sigma) Phase will appear in relief after electro-polishing</li> </ul> <a href="#">More info.</a>
<b>Welding</b>	Feasible, no limitation



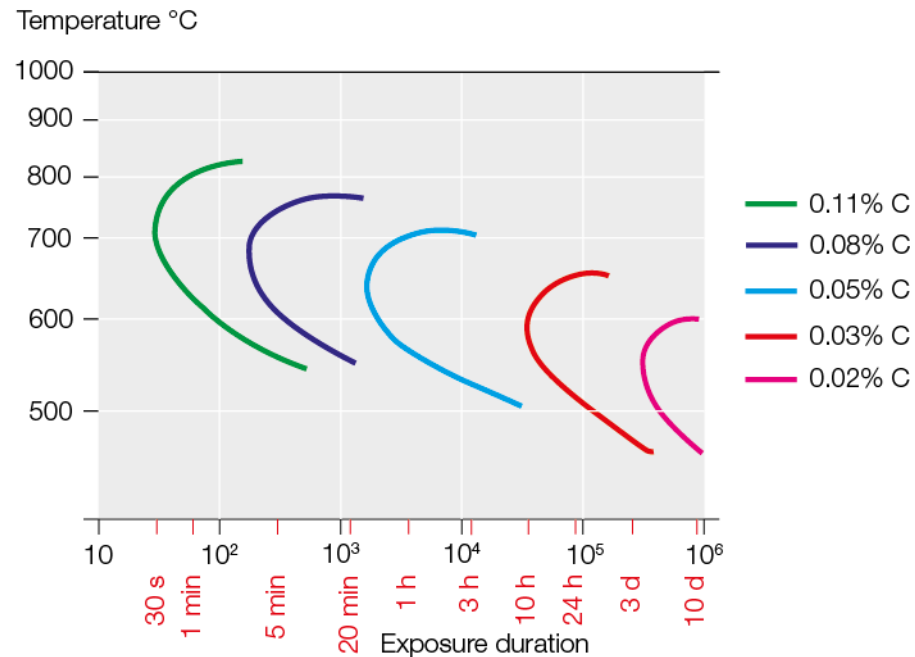
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**Figure 1**  
Strengthening  
Cold working curves

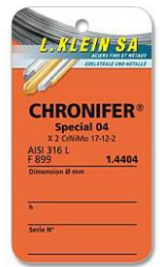


**Figure 2**  
Sensitization  
TTT curves



**Limitations**

- Figure 2 shows that this steel can be sensitized by long exposures in the temperature range of 450 to 650°C. This sensitization leads to the precipitation of detrimental intergranular carbides causing brittleness and intergranular corrosion.
- The intergranular carbides precipitated at the grain boundaries will be etched in relief by electropolishing.



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- Laser marking**
- The HAZ Zone (Heat Affected Zone) of a normal laser marking should not significantly influence its local microstructure.
- [More info.](#)

- Surface oxidation**
- A thermal oxidation forms colored oxides or scaling on the surface. These must be eliminated, is it chemically by pickling or by mechanical means like grinding.
- Colored surface oxidation and/or scaling can massively reduce the corrosion resistance.

- Pickling - Passivation**
- The pickling and passivation processes and the products used therefore, should always be adapted to the requirements of the pickling and passivation of austenitic stainless steels.
- [More info.](#)

- Corrosion resistance**
- Optimal surface condition: Very clean surface, polished and passivized.
- [More info.](#)
- The indicative corrosion resistance of the “CHRONIFER Special 04” steel in various typical medium in the use of watch exterior components are given in the following table.

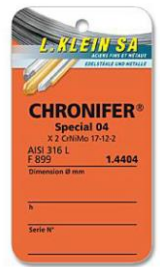
Type of corrosion	Condition	Corrosion resistance
Pitting corrosion	all	good
Spray salt test	all	fair to medium
Seawater	all	fair to medium
Stress corrosion	annealed	good
	cold worked	sensitivity increasing with the amount of cold work

- Galvanic corrosion**
- This stainless steel is less noble than the 1.4435 “CHRONIFER<sup>®</sup> Special 35” and “CHRONIFER Special 35 P” steels. Therefore, in particular assembly configurations, such as watch exterior assemblies, this steel in contact with these steels in an electrolytic medium, this “CHRONIFER Special 04” steel could be exposed to galvanic corrosion.

- Elementary precautions**
- The most elementary protection is to always keep the surfaces very clean, polished and passivized.
  - The parts should always be very well cleaned (no usage residual) and dried.
  - Only use adapted chlorine free disinfection, cleaning and washing products.

- Magnetism**
- Ferromagnetism due to the presence of  $\delta$  (Delta) Ferrite:
- This steel can contain small traces of  $\delta$  (Delta) Ferrite and exhibit in the annealed condition values of its magnetic relative permeability  $\mu > 1.003$ .
- Ferromagnetism due to the presence of  $\alpha$  (Alpha) Martensite:
- This steel can form  $\alpha$  (Alpha) ferromagnetic martensite after heavy cold working. This ferromagnetism can exhibit relatively strong relative permeability values  $\mu > 1.005$

[More info.](#)



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## Physical properties

Properties	Unit	Temperature (°C)				
		20	200	300	400	500
Density	g cm <sup>-3</sup>	7.98				
Young modulus E	GPa	200	186	179	172	165
Shear modulus G	GPa	117				
Poisson Coefficient ν		0.27-0.28				
Electrical resistance		0.75				
Thermal expansion	m m <sup>-1</sup> K <sup>-1</sup>	20-100°C	20-200°C	20-300°C	20-400°C	20-500°C
	10 <sup>-6</sup>	16	16.5	17	17.5	18
Thermal conductivity	W.m <sup>-1</sup> .K <sup>-1</sup>	15			15.2	
Specific heat	J.kg <sup>-1</sup> .K <sup>-1</sup>	500				
Melting range	°C	1375-1400				
Magnetism: annealed condition	Traces of δ (Delta) Ferrite Relative permeability: μ <sub>r</sub> ≥ 1.003					
Magnetism: cold deformed condition	Traces of δ (Delta) Ferrite + Ferromagnetic α (Alpha) Martensite produced by intense cold deformation Relative permeability: μ <sub>r</sub> ≥ 1.005					

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