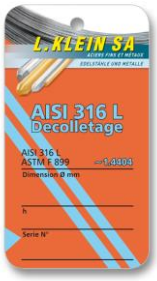

AISI 316L Decolletage

≈1.4404 improved/AISI 316L – Austenitic stainless steel, 316L improved

Features and Particularities

This austenitic stainless steel type 1.4404/"AISI 316L improved" has an addition of Cu to improve its machinability as well as its corrosion resistance. Its low C content lowers the threshold temperature of its sensitization to temperature lower than 650°C. Thence ensuring its good intercristaline corrosion resistance, polishing ability and weld ability. It has a good corrosion resistance in non-oxidizing acid medium and solutions non-containing halogen elements. This steel can continuously be used up to 430°C. Its machinability is satisfactory, although superior in the cold worked condition. This CHRONIFER 316l Decolletage steel cannot be thermally hardened, but it can be strengthened by cold work. It may contain traces of ferromagnetic ∂ (Delta) Ferrite that may limit its fine polishing capability. Its adequacy for forming is similar to this of the 1.4435 grade, CHRONIFER® Special 35 austenitic stainless steel.

Uses

This steel has a very broad field of applications. Such as the chemical, pharmaceutical, food petro- and petrochemical industries, paper pulp as well as paper industries and the colorant and textile industries; in the treatment of fresh water, its processing, transport, use and recycling; micromechanical engineering watch making industries.

Standards

Material number	≈ 1.4404
EN 10083-3	≈ X2CrNiMo 17-12-2
DIN /AFNOR	≈ X2CrNiMo 17-12-2
AISI/SAE	≈ 316L
ASTM	(F 899)
AMS	5648
	5653
JIS	SUS 316 L

Chemical composition ($\%_{wt.}$)

C	Si	Mn	P	S	Cr	Ni	Mo	Cu	N	Fe
max.	max.	max.	max.	max.	16.0	10.0	2.00	max.	max.	balance
0.030	1.00	2.00	0.045	0.03	18.0	14.0	3.00	1.00	0.10	

Dimensions and Tolerances

Standard: Bars 3 m (+50/0 mm)
Mechanical properties: UTS: 600-980 MPa, according to diameter
- Bars Ø < 10-40 mm: ISO h8

Other dimensions and tolerances on request

Executions and Delivery conditions

Standard: Bars 3 m (+50/0 mm)
- Bars Ø ≥ 10-40 mm: cold drawn, ground, polished, Ra max 0.8 µm
  Bar ends: pointed and chamfered

Other executions on request

Hardening Strengthening

- This steel cannot be thermally hardened.
- This steel can be strengthened by cold work

Availability

Standard dimensions on stock, see: Sale program

Cutting conditions

Machinability:	satisfactory, better in the cold worked condition
Cutting speed:	V_c ≈ > 40 -100 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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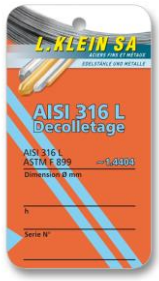

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Grain size

According to ASTM E47:

- Bars, hot rolled: ASTM Nr. ≥ 6-7, isolated grains: > 5, According to diameter
- Bars, cold worked: ASTM Nr. ≥ 7-8

δ (Delta) Ferrite

The CHRONIFER® Special 71 steel contains ∂ (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_{eq} und Ni_{eq} equivalent contents:

- $Cr_{eq} = 1.5Si + Cr + Mo + 2Ti + 0.5Nb$
- $Ni_{eq} = 30(C + N) + 0.5Mn + Ni + 0.5(Cu + Co)$
- Ferrite Number FN or $\%_{vol.}$ δ (Delta) Ferrite
  FN = ([{1.375 (Cr_{ew} – 16} + 10] - Ne_{il}) 2.586

Negative values of FN indicate the absence of δ (Delta) Ferrite.

PREN

- PREN = %Cr + 3.3%Mo + 18%N
- Computed basic parameters: min. 22.6 / max. 29.7

Forming

Warm, forging 950 – 1100°C, quenching/rapid cooling

- If the forging temperature should drop below 900°C, a preventive solution anneal is recommended to fully recover the cold forming capability and corrosion resistance.

Cold: no limitations see Figure 1 page 3

Solution anneal

1040-1070°C, quenching/rapid cooling

- 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.
- 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.
- The formation of σ (Sigma) phase leads to brittleness; drop of ductility and corrosion resistance.

In such case, a 1040-1070°C solution anneal is recommended.

Hardening Strengthening

- This steel cannot be thermally hardened.
- This steel can be strengthened by cold working, see Figure 1, page 3

Microstructures

Delivery condition, hot rolled: annealed austenite
For machining and polishing: cold worked wires and bars: Annealed or cold worked austenite

Polishing

Adapted to all modes and techniques of polishing.
Electro-polishing: adapted

- The “AISI 316L Decolletage“ steel can contain traces of ∂ (Delta) Ferrite.
- ∂ (Delta) Ferrite appears in relief after electro-polishing
- In the case of the formation of a σ (Sigma) Phase or 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.
- σ (Sigma) Phase will appear in relief after electro-polishing

More info.

Welding

Easily feasible

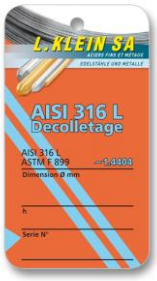

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Figure 1
Strengthening
Cold working curves

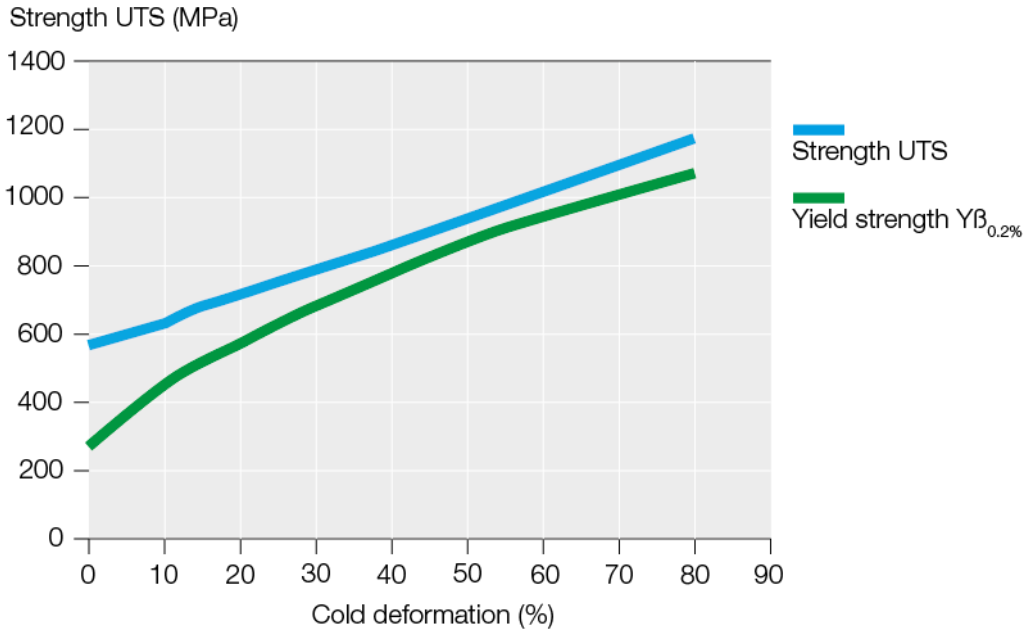
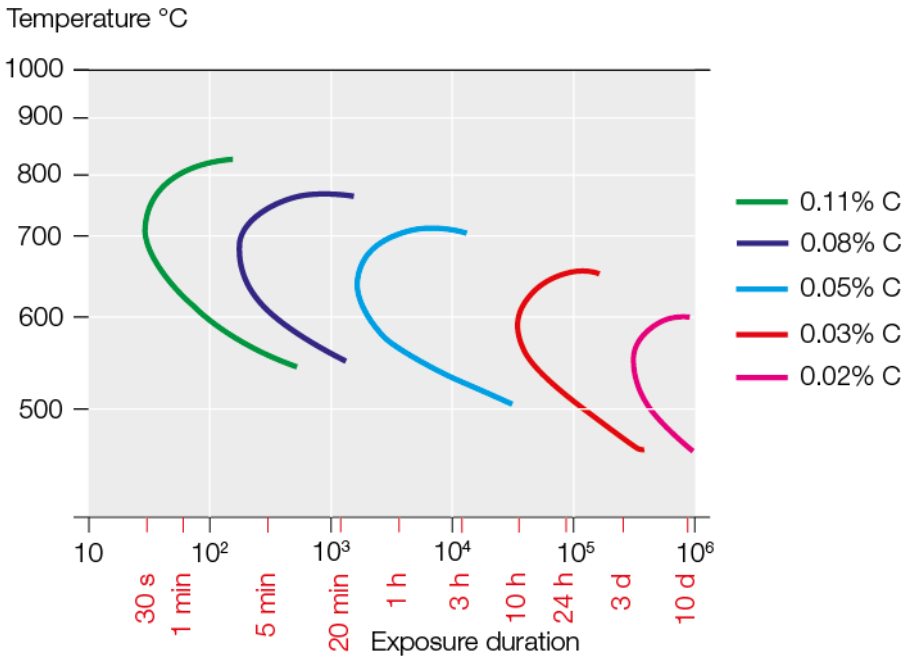
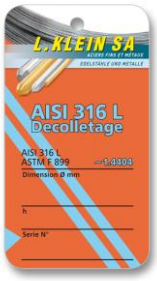


Figure 2
Sensitization
TTS curves



Limitations

Figure 2 shows that this steel can be sensitized by exposures longer than 10h in the temperature range of 450 to 650°C. This sensitization leads to the precipitation of detrimental intergranular carbides at the grains boundaries causing brittleness and intergranular corrosion.



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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 muss 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 “AISI 316L Decolletage“ steel in various typical medium prevailing in the use of watch exterior components are given in the following table.

Type of corrosion	Condition	Corrosion resistance
Pitting corrosion	all	Small at middle to long-term
Salt spray	all	Medium at long term
Seawater	all	Medium at long term
Stress corrosion cracking	Annealed	Small
	Cold worked	Small at middle term

Galvanic corrosion

This stainless steel is less noble than the CHRONIFER® Special 35 and Special 35 P Grades. Therefore, in particular assembly configuration with these steels in contact with an electrolytic medium, such as watch exterior assemblies, this “AISI 316L Decolletage” steel grade could be subjected 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

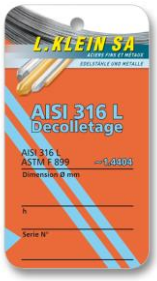
Ferromagnetism due to the presence of ∂ (Delta) Ferrite:

- This steel can contain small traces of ∂ (Delta) Ferrite and exhibit in the annealed condition values of its magnetic relative permeability μr >1.003.

Ferromagnetism due to the presence of α (Alpha) Martensite:

- This steel can form α (Alpha) ferromagnetic martensite after heavy cold working. This ferromagnetism can exhibit relatively strong relative permeability values μr > 1.005

More info.



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Physical properties

Properties	Unit	Temperature (°C)				
		20	200	300	400	500
Density	g cm^{-3}	7.98				
Modulus of elasticity E	GPa	200	186	179	172	165
Shear modulus G*	GPa	117				
Poisson coefficient ν		0.27-0.28				
Electrical resistance	Ω.mm^2.m^{-1}	0.75				
Thermal expansion	m m^{-1} K^{-1}	20–100°C	20–200°C	20–300°C	20–400°C	20–500°C
	10^{-6}	16	16.5	17	17.5	18
Thermal conductivity	W.m^{-1}.K^{-1}	15			15.2	
Specific heat	J.kg^{-1}.K^{-1}	500				
Range of melting	°C	1375-1400				
Magnetism	Annealed condition: traces of ∂ (Delta) Ferrite Relative Permeability: ≥ 1.003					
Magnetism	Heavy cold deformed condition: traces of α (Alpha) Martensite Relative Permeability:> 1.005					

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