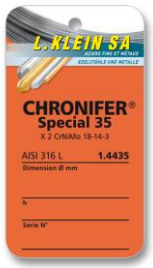

CHRONIFER® Special 35

1.4435/AISI 316L – Austenitic stainless steel

Features and Particularities

The high Cr, Ni and Mo contents of this steel make it nobler than the 1.4404 Grade. These additions provide a better corrosion resistance in non-oxidizing medium or non-containing halogen solutions. Its low S content reduces markedly the risk to be subjected to pitting corrosion. Similarly, its low C content renders it less subject to intercristaline corrosion after long exposures to in the 450-650°C temperature range. Its microstructural cleanliness and its surface qualities make it a material of choice for medical applications. It cannot be thermally hardened, but can be strengthened by cold working. In some cases.it can exhibit traces of ∂ (Delta) Ferrite as well as traces α (Alpha) Martensite after an intensive cold work. This steel can be easily welded, polished and be continuously used up to 400°C.

Uses

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

Standards

Material number	1.4435
EN 10083-3	X2CrNiMo18-14-3
DIN	X2CrNiMo18-14-3
AFNOR	X2CrNiMo 18-14-3 (formerly Z 3 CND 18-14-3)
AISI/SAE	316L
ASTM	A276
NF	S 94-090
JIS	SUS 316

Chemical composition (%wt.)

C	Si	Mn	P	S	Cr	Ni	Mo	N	Fe
max.	max.	max.	max.	max.	17.0	13.5	2.50	max.	balance
0.030	1.00	2.00	0.045	0.03	19.0	15.0	3.00	0.10	

Dimensions and Tolerances

Standard: Bars 3 m (+50/0 mm), coils for Escomatic

Strength UTS:	650-950 MPa
• Bars Ø < 0.8-18 mm:	ISO h8
• Bars Ø ≥ 2.00 mm:	ISO h6 (h7)
• Wires 0.80 < Ø < 3.00 mm:	ISO fg7, coils for Escomatic
• Out of roundness max:	½ Diameter tolerance

Other tolerance on request

Executions and Delivery conditions

Standard: Bars 3 m (+50/0 mm), coils for Escomatic

• Bars Ø ≥ 2.00 mm:	cold drawn, ground, polished, Ra (N5) Bar ends: pointed and chamfered
• Bars < 2.00 mm:	Surface condition: cold drawn
• Wires Ø < max. 3.00 mm:	cold drawn, coils for Escomatic

Other execution on request

Availability

Standard dimensions on stock: see: Sale program

Cutting conditions

Machinability:	fair to medium, better in the cold worked condition,
Cutting speed:	$V_c \approx 25$ - 40 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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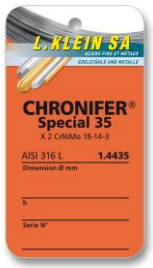


CHRONIFER® Special 35

1.4435/AISI 316L – Austenitic stainless steel

Cleanliness

The CHRONIFER® Special 35 steel has a relatively clean microstructure. As a consequence its polishing capabilities are de facto unlimited.

Grain size

According to ASTM E47:

- Hot rolled bars: ASTM Nr. ≥ 6-7, isolated grains > 5
- Cold drawn wires and bars: ASTM Nr. ≥ 7-8

δ (Delta) Ferrite

The CHRONIFER® Special 04 steel may contain of ∂ (Delta) Ferrite. Its probable 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. 26.8 / max. 30.7

Forming

Warm, forging: 960 – 1100°C, Quenching/rapid cooling

- If the forging temperature should drop below 900°C, a preventive 1060-1080°C Solution anneal is recommended to fully recover all capabilities of this steel.

Cold: no limitations see Figure 1, page 3

Solution anneal

1060-1080°C/Quenching or 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 1060-1080°C/quenching/rapid cooling solution anneal is recommended.

Hardening Strengthening

- The CHRONIFER® Special 35 steel cannot be thermally hardened.
- This steel can be strengthened by cold working, see Figure 1, page 3

Microstructure

For machining and polishing purposes:
Bars and Wires: annealed or cold worked austenite

Polishing

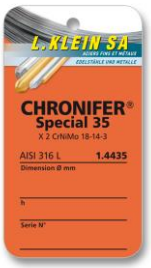
Adapted to all modes and techniques of polishing.
Electro-polishing: adapted

- This CHRONIFER Special 35 steel can contain traces of ∂ (Delta) Ferrite, which will, appears in relief after electro-polishing.
- In case of σ (Sigma) Phase formation or of sensitization, a 1060-1080°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

Feasible, no limitation



CHRONIFER® Special 35

1.4435/AISI 316L – Austenitic stainless steel

Strengthening

Figure 1 shows the strengthening curves UTS, $Y_{0.2}$ and the fatigue limit at 10^7 cycles of the similar 1.4441 Implant steel, in function of the cold deformation true strain. The CHRONIFER Special 35 steel is very similar to the 1.4441 steel grade.

Figure 1
Strength UTS, Yield strength $Y_{0.2}$ and Fatigue limit at 10^7 cycles

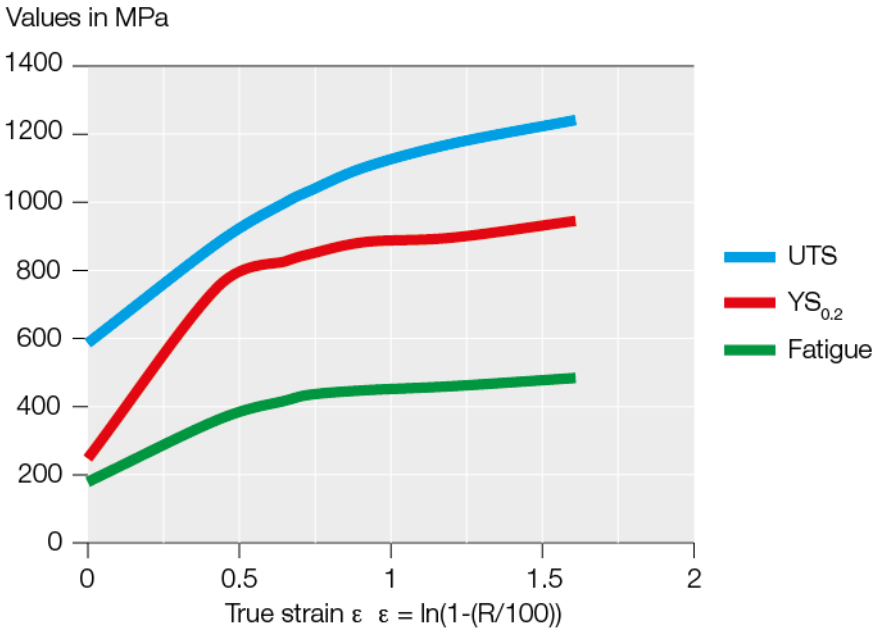
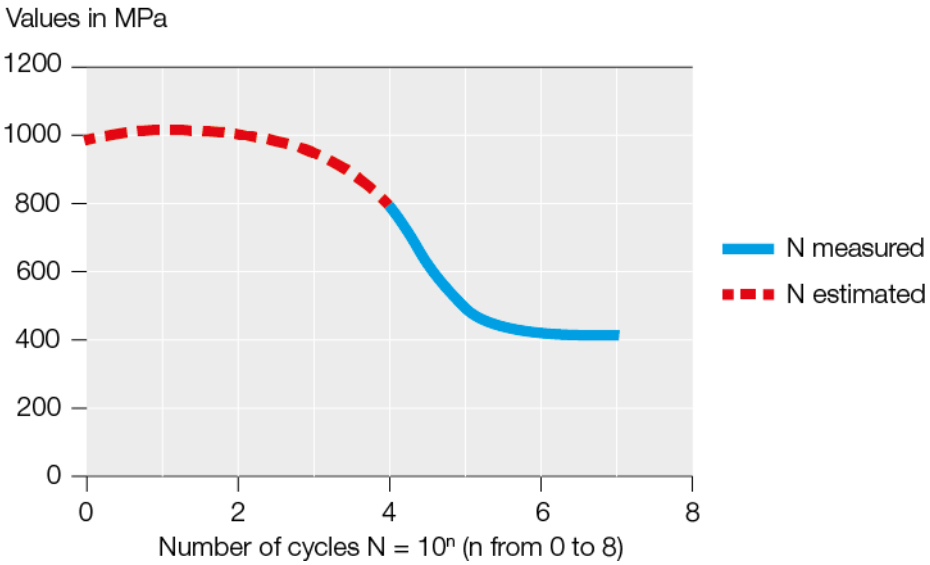
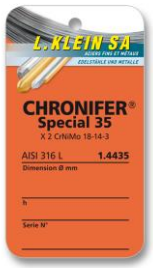


Figure 2
Wöhler curve (Fatigue curve)





CHRONIFER® Special 35

1.4435/AISI 316L – Austenitic stainless steel

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.

- Passivation is not necessary after electro-polishing.

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 table below.

Type of corrosion	Metal condition	Corrosion susceptibility
Pitting corrosion	all	resistant
Spray salt test	all	fair to medium
Seawater	all	fair to medium
Stress corrosion	annealed	resistant
	cold deformed ≤ 63% or ε=1	not susceptible up to high amount of cold work
	If necessary, a preventive 250-300°C/1h stress relieveing heat treatment can be made.	

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

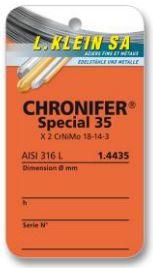
Ferromagnetism due to the presence of ∂ (Delta) Ferrite:

- This steel can contain small traces of ∂ (Delta) Ferrite, but rarely exhibit relative permeability µr >1.003.

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

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

More info.



CHRONIFER® Special 35

1.4435/AISI 316L – Austenitic stainless steel

Physical properties

Properties	Unit	Temperature (°C)				
		20	200	300	400	500
Density	g cm^{-3}	7.95				
Young modulus E	GPa	186.4				
Poisson Coefficient		0.29				
Electrical resistance	$\Omega.mm^2.m^{-1}$	0.74				
Thermal expansion	m m^{-1} K^{-1}	20–100°C	20–200°C	20–300°C	20–400°C	20–500°C
	10^{-6}	16.5	17.5	17.5	18.5	19
Thermal condustivity	$W.m^{-1}.K^{-1}$	16			15.2	
Specific heat	$J.kg^{-1}.K^{-1}$	500				
Melting range	°C	1370-1400				
Magnetism: annealed condition	Possible traces of ∂ (Delta) Ferrite Relative permeability: $\mu_r \geq 1.003$					
Magnetis: cold deformed codition	Possible traces of ∂ (Delta) Ferrite + Ferromagnetic α (Alpha) Martensite at high reduction Relative permeability: $\mu_r \geq 1.005$					

Disclaimer: The information and data of this informative “Data sheet“ are indicative only. They are not use instructions. The users must define and endorse them in each case.

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