CHRONIFER® M-15X

1.4057/AISI 431 – Martensitic hardenable stainless steel – Round

Features and particularities

This CHRONIFER® M-15-X steel is a power metallurgy clean martensitic stainless steel hardenable to high hardness levels. It is VIM melted, N pressure atomized and consolidated by power metallurgy. This ensures a particularly fine micro-homogeneity and grain size, resulting in a complete range of improved properties compared to those achievable with the classical 1.4057, AISI 431, martensitic stainless steel.

Uses

The particular fine surface of the CHRONIFER® M-15-X steel permits to achieve extremely fine surface conditions. This steel is well adapted to plastic deformation and forming. It exhibits remarkably high hardening and polishing capabilities, and a good corrosion resistance. The reproducibility and uniformity of its properties is unique. They indicate it as the steel of choice for demanding medical, surgical and dental instruments, especially cutting instruments, and for components of the watch making industry, automotive industry and the micro mechanical engineering.

Standards

Material Nummer	1.4057
EN	X17CrNi16-2
AISI	431
ASTM	F899-09
NF	S94-090
SUS	≈431

Chemical composition (%wt)

C	Mn	Si	S	P	Cr	Ni	N	Fe
0.12	max.	max.	0.005	max.	15.0	1.5	max.	balance
0.20	1.0	1.00	0.015	0.030	17.0	2.0	0.10	

Dimensions, tolerances and properties

- Wires & bars: 0.75-3.50 mm: cold drawn ≥h5, Ra ≤ 0.2
- Bars: Ø 3.50 - 16 mm: cold drawn, ground h6

Other Tolerances on request

Bars for hard machining

- Bars Ø > 2.5 – 3.0 mm: hardened and tempered: HRc ≈ 45 – 55

UTS and hardness on request according to needs

Executions

- Bars Ø 1.0 – 3.50 mm: straightened 3 m, UTS/Rm max. ≈ 950 MPa
  Pointed and chamfered

Other executions on request

- Wires Ø 0.75 à 2.50 mm: coils for Escomatic, UTS/Rm max. 950 MPa

Availability

Dimensions courantes en stock, see: Delivery program

Cutting conditions

Machinability: acceptable to good
Forms long chips
Cutting speed: V_c ≈ 25 - 100 m/min.
Lubricant-coolant: 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.
- The applicable cutting conditions are to some extent similar to those of maraging steels.

Forging

- Temperature range: 900 – 1260°C, heating up to 1040 – 1150°C
- Finishing: 815 – 925°C, to obtain a fine microstructure and the targeted mechanical properties after tempering.
- Cooling in air, annealing and hardening.

Modifications will not be adjusted automatically.
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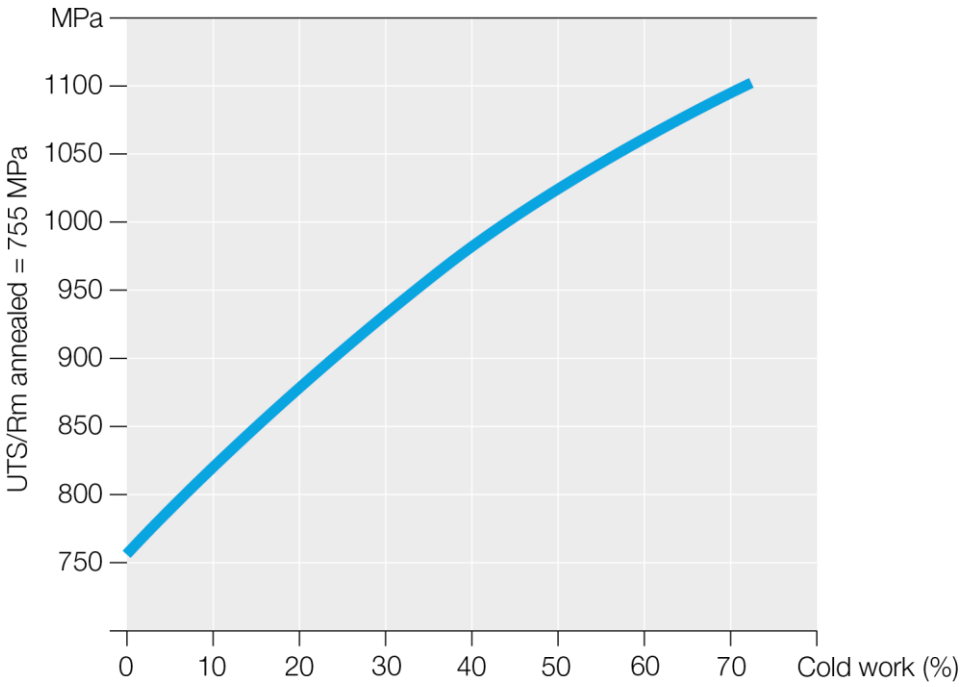
Cold deformation Forming

- The CHRONIFER® M-15X steel features a remarkably ductility in all conditions. This pivotal characteristic permits the users to target a large range of precise mechanical properties.
- In the annealed condition, this steel can be easily cold formed up to high deformations, >60-75% (true strain of ε = >1.0-1.4), without intermediate annealing. See Figure 1

Annealing

Soft anneal: 680-730°C °C / 0.5-1h

Figure 1 Cold deformation Wire cold drawing



Hardening

The CHRONIFER® M-15X steel can be easily hardened. However, it requires complying with the recommended hardening procedures in order to achieve the targeted properties. In this case a broad range of properties can be reach.
See figures 2 and 3, page 3.

Optimum quenching temperature

The optimum hardening conditions to obtain the full-targeted mechanical properties are as follows:

- Primary gas quenching: 1025 ± 5°C/Vacuum, N_2 gas quenching.
  The quenching temperature of 1025°C is the highest recommended temperature. It should not be exceeded (no overshoot!).

Sub-Zero treatment Cryo-cooling

This sub-zero operation is recommended in order to obtain the highest hardening. Recommended secondary immersion-quenching is -80°C /12h

- This cryo-cooling, or secondary quenching should be made as soon as possible - within a delay of maximum 2 hours - after the primary gas quenching.
- This condition should be satisfied to obtain the best possible achievable hardening gain. Especially with small size parts.
- A sub-zero treatment made according tot he above recommendations, permits to achieve a hardening gain of 1-3 points on the HRc scale.

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Grain growth

High quenching temperatures such as 1050°C and more, lead to a strong grain growth up to ASTM No. 6-8, thereby compromising definitively the excellent polishing ability of this steel. The ductility can also be negatively affected as well.

- Simultaneously, the achievable UTS/Rm and hardness number be reduced by as much as 7%, compared those achievable at the recommended optimum quenching temperature of 1025 ± 5°C.

Figure 2
Quenching temperature

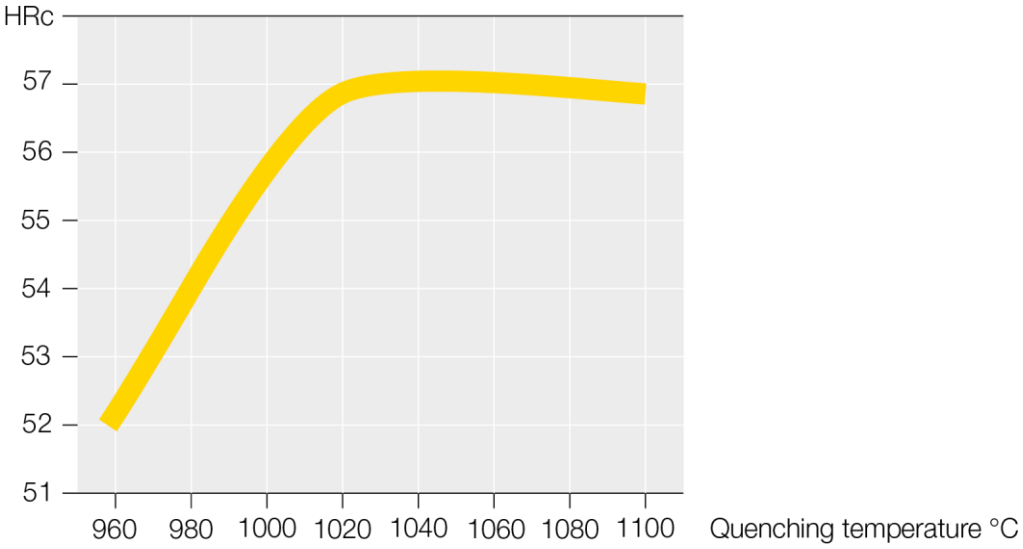
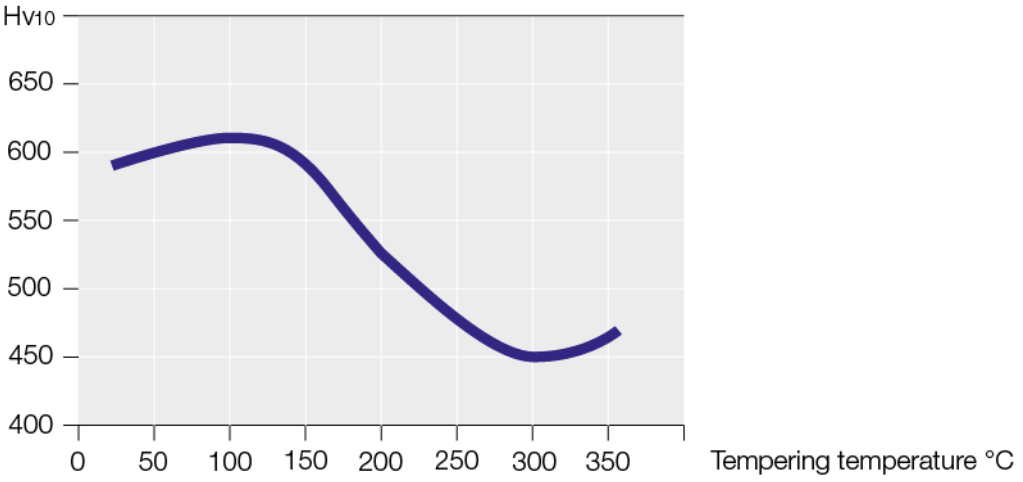


Figure 3
Anlass Temperatur



IMORTANT NOTICE: The data of the curves above have been measured on probes of 5 und 6 mm. They are reference only. The measured properties on parts or other probes may diverge; according to the probe dimensions, part shapes and sizes, and from the applied heat treatments and conditions.

Polishing

The unique fineness of the CHRONIFER® M-15X of the microstructure, attributes it an excellent polishing ability with all polishing methods. This steel fulfills all polishing requirements whatever, such as in the case of the "Poli-bloqué" quality.

- The particularly fine grain size of ASTM No >11 of this steel, permits to achieve most economically of the most stringent requirements, by lowering the necessary effort involved, decreasing the wastes and the total cost.

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Austenite expansion

The CHRONIFER® M-15X steel is well adapted to the processes of the ist für die austenite expansion such as:

- The austenite expansion with N_2 can carried out simultaneously with the heating and holding time at the quenching temperature or higher. Like with the SolNit process.
- Simultaneous diffusion of N_2+C at an intermediate temperature.
- Austenite expansion with N_2 increases the PREN number (or Pitting corrosion indices) by increasing the N2 concentration on the surface layer. Thereby, it van increase the surface hardness up to ≈ 57 HRc, (≈ ≥ 650 Hv_1).
- The austenite expansion modifies also the perceived color of the surface.

Welding
Laser marking

- Welding and laser marking can both lead to a N loss by evaporation in their HAZ (Heat Affected Zone). Due to this, an N depletion may take place locally, reducing the hardening capability and corrosion resistance.

Indicative Corrosion resistance

Medium	Resistance	Medium	Resistance
Nitric acid	good	Sulfuric acid	limited
Phosphoric acid	limited	Vinegar acid	limited
Na Hydroxide	passable	Salt spray (NaCl)	passable
Sea water	limited	Humidity	good

Optimum surface condition

Clean surfaces, quenched and tempered condition + fine polished + passivized

Pickling and Passivation

It is always recommended to select pickling and passivation procedures and products correctly adapted to the treatment of martensitic stainless steels.

- In order to avoid any potential “flash back“ reactions it is highly recommended to pickle the surface before passivation. More info.

Scaling and oxidation

- The formation of oxides and oxidation scale during heat treatment may considerably reduce the corrosion resistance.
  This oxidation must be totally removed either mechanically or chemically by pickling.

Elementary precautions

The simplest elementary protection precautions against corrosion are:

- To always keep the surfaces clean and polished.
- Avoid the drying of working/use residues on the surface of the parts or instruments before due washing and cleaning
- Use only chloride free solutions to wash, clean and disinfect the parts or instruments. More info.

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Heat treatments

Type of parts:	Standard parts Heat treatments in conventional furnaces	Highly Recommended heat treatments for highly stressed parts
Temperature (°C) Holding time (min) Atmosphere Quenching medium Surface condition	1025 ± 5 30 - 40 Ar or H2 fast, oil for example can be oxidized (colored)	1025 ± 5 30 – 40 < ≈ 600°C: vacuum > ≈ 600°C: 100 – 200 mb N2 gas: N2 ≥ 3b white, no oxidation
Temperature (°C) Holding time (h)	-80 recommended 12	-80 recommended 12
Temperature (°C) Holding time (h) Atmosphere	150 – 170 2 H2 or Ar	150 – 170 or according to needs 2 H2
Temperature (°C) Holding time (h) Atmosphere	90 – 170 2 H2 or Ar	90 – 120 or according to needs 2 H2
HRc surface Hv_{10}	max. ≈ 52-53 max. ≈ 550	up to 55 HRc max. ≈ 600
UTS/Rm (MPa) A (%)	> ≈ 1750 > 10	≥ 1900 ≥ 8

Physical properties

Properties	Unit	Temperature (°C)				
		20	200	300	400	500
Density	g cm^{-3}	7.85				
Young modulus E	GPa	200			190	
Poisson coefficient		0.28				
Electrical resistance	nΩ m	432				
Thermal expansion	m m^{-1} K^{-1} 10^{-6}	20–100°C 10.8	20–200°C 10.5	20–300°C 10.5	20–400°C 10.5	
Thermal conductivity	W m^{-1} K^{-1}	25	20.2		15.2	
Specific heat	J kg^{-1} K^{-1}	460				
Melting	°C	solidus	1450			
Magnetism	Ferromagnetic, can be magnetized. More info					

Magnetism

Tempering temperatures between 220°C and 300-350°C make progressively this CHRONIFER® M-15X steel hard magnetic (similar to permanent magnet). That is, more and more difficult to demagnetize. More info

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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