CarTech® MP35N Alloy

High strength and corrosion resistance Co-Ni-Mo based multiphase alloy

Caractéristiques et Particularities

The multiphase Co-Ni-Mo-based alloy CarTech® MP35N is melted VIM and remelted VAR. It allows obtaining very mechanical properties by cold working and aging preserving its very good corrosion resistance. Its high work-hardening capacity is due to the progressive micro-structural transformation of its annealed cfc-cubic phase into a twinned hcp-hexagonal phase. The final aging stabilizes its microstructure. The high corrosion resistance, fatigue resistance, designates it as implant for joint replacement, and in aerospace, medical, surgical and dental applications. The high elastic properties show it for high quality springs and components for watch movements and their exterior. This alloy is biocompatible and paramagnetic. As wires, it is well adapted for stimulation and pacer lines, drilling lines working in aggressive mediums, marine lines.

Uses

The CarTech® MP35N Alloy is the alloy of choice when toughness, ductility, fatigue, corrosion and wear resistances are required, as in the chemical industry, or for applications as orthopedic implants, or for medical, surgical and dental instruments, and components for watches, or the aerospace industry, micro-engineering etc.

Standards

Material number	2.4782
ASTM/ANSI	F562
AMS	5758, 5844 and 5845
UNS	R30035

Chemical composition (%wt)

C	Si	Mn	P	S	Cr	Mo	Ni	B	Fe	Co
max.	max.	max.	max.	max.	19.00	9.00	33.00	max.	max.	balance
0.02	0.15	0.15	0.015	0.010	21.00	10.50	37.00	0.010	1.00	

Dimensions Executions Delivery conditions

- Bars: ø 6.35 - 26 mm, cold drawn, 3 m straightened and ground
  UTS/Rm and A% see Figure 2
- Wires: cold drawn, on spools <1.10 mm
  UTS/Rm < 1100 MPa, A% according to cold reduction rate
  cold dawn surface « skin pass »
- Tolerances: h6 – h8

Availability

Standard dimensions on stock, see: Delivery program

Machining Strength

- The CarTech® MP35N Alloy is (relatively) difficult to machine.
- In the annealed condition: not advisable, strong tendency to galling
- UTS/RM “optimal“ range for the classical machining is typically ≈1200-1400 MPa up to 1050-1600 MPa.

Machine-tools

- The CarTech® MP35N Alloy is though.
- The toughness of this alloy is somewhat comparable to high Nitrogen stainless steel, like CHRONIFER 108. Consequently, the machining requires particularly rigid machining equipment like machine-tools, tool-fixtures and tools. High damping tool-fixtures are recommended

Machinability

- Machinability: difficult
  Cutting speed: low, Vc ≈ 20-40 m/min
  Feed: moderate to high
  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 the surface roughness to be achieved.

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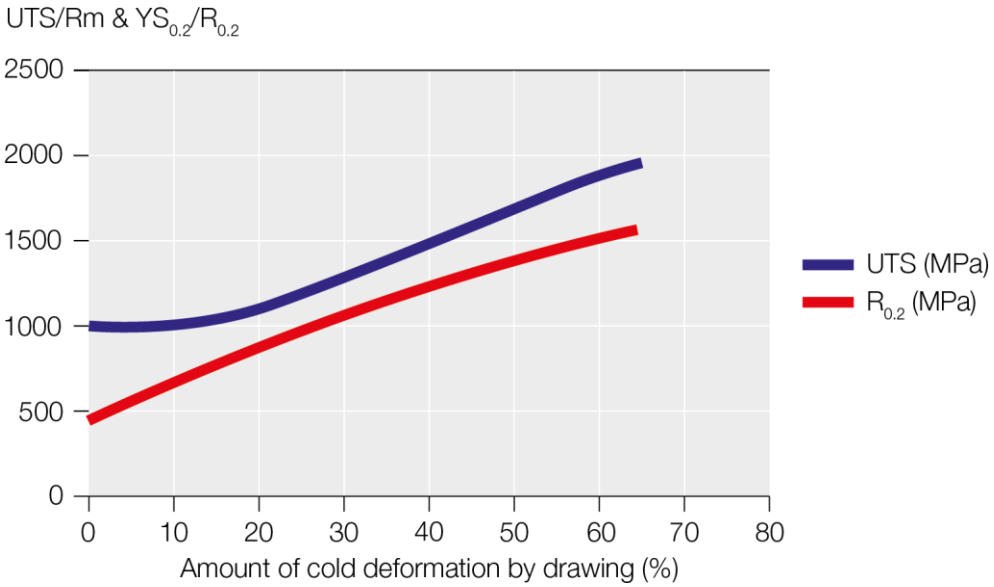
Melting and Remelting

- Melting: VIM (Vacuum Induction Melting) + Remelting: VAR (Vacuum Arc Remelting)

Cleanliness

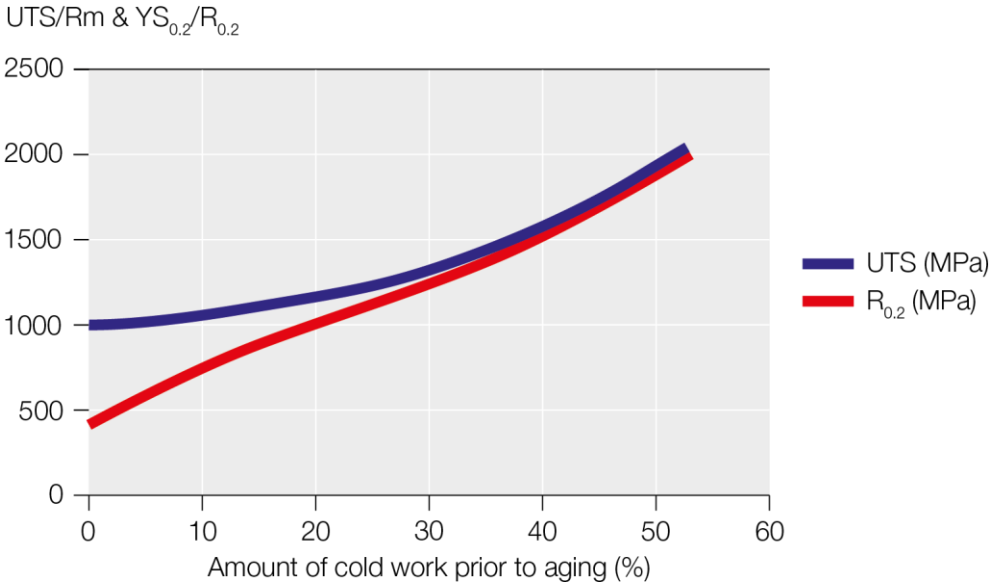
- Clean alloy melted and remelted in vacuum

Figure 1
Cold deformation



- The hardening of the CarTech® MP35N Alloy during cold working is based on the microstructural transformation from a cfc - cubic face centered - into an hcp - hexagonal compact – microstructure with twins formation.

Figure 2
UTS/Rm & $YS_{0.2}/R_{0.2}$
Cold working hardening + aging



- Figures 1 and 2 show that an aging treatment contributes marginally only to the strengthening as measured by UTS/Rm but much more strongly the $YS_{0.2}/R_{0.2}$ elastic propreties up to 35 ca 35% prior cold reduction.

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Figure 3
Influences of cold working
Elongation A (%)
Reduction of aera RA (%)

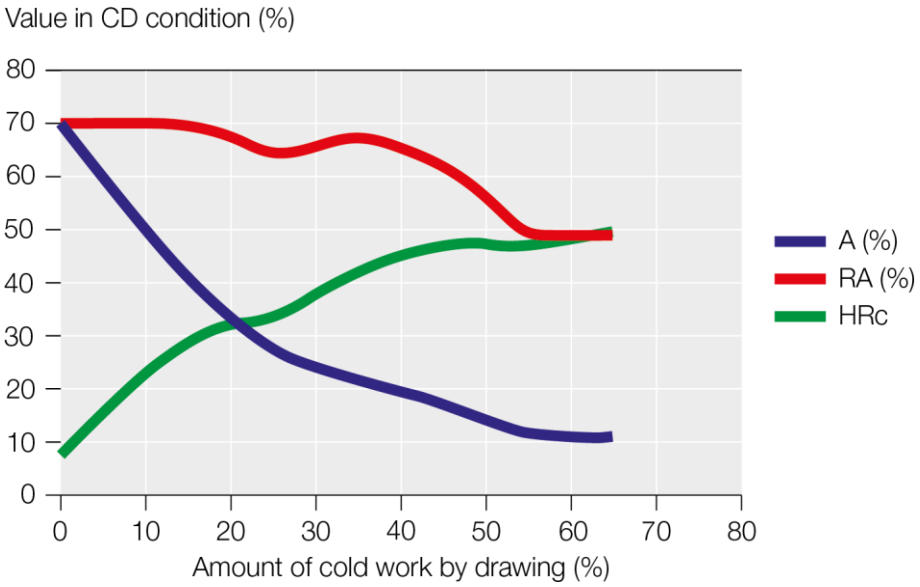
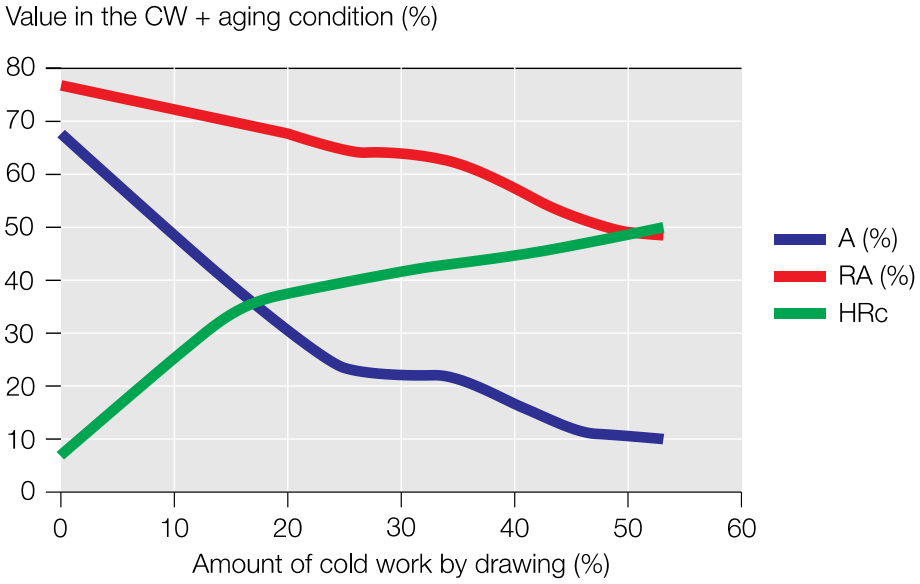


Figure 4
Influences of cold working and aging
Elongation A (%)
Striction RA (%)
Hardness HRc



- The CarTech® MP35N Alloy exhibits a high ductility during cold working and after aging.
- The HRc hardness follows a similar pattern as the UTS/Rm and $YS_{0.2}/R_{0.2}$ strengths.

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Cold forming

- Warm: Forging: 1175°C
  minimum: 870°C
- Cold: The temperature of the cold deformation is limited to <425°C

Heat teatments

- Annealing: 1040-1095°C/1-4h/slow air cooling, air or protective atmosphere
- Aging: The aging activation is independent of a prior cold deformation
- Aging: 425-650°C / 2-5h preferably in vacuum 10^{-5} T or argon
  A heat treatment in air forms a yellowish oxidation layer on the surface.
- Aging: Optimal treatment after cold working <425°C:
  535-590°C/4h/slow cooling in air or protective atmosphere

Susceptibilité à la fragilisation par H_2

- The CarTech® MP35N Alloy is not sensitive to hydrogen

Microstructure

Delivery condition: annealed and annealed + cold working: multiphase cfc-hcp
Microstructure for machining: cold worked >15-25%, up to ≈ 1350 MPa
Optimal structure for polishing: cold deformed microstructure >15% reduction

Polissage

- Well adapted to the « haut de gamme » requirements of the watch making.

Laser marking

- The heat developed in the HAZ (Heat affected Zone) (ZAT) by a typical laser marking without over heating, does normally not affect the microstructure and its mechanical properties and more particularly its fatigue properties. More info

Surface cleaning

- It is highly recommended to select cleaning, pickling and passivation procedures and products adapted to Co base alloys.

Pickling

- Strong pickling solution:
  5% Fluor hydric acid + 12% nitric acid / boiling solution
  + intensive rinsing with warm or cold water and final drying
- Pickling solution for finished or fine products:
  1. Phosphoric acid 6%/ 70°C / 15-20 minutes
  2. Nitric acid 30%/40°C / 2 to 3 minutes
  3. Hydrochloric acid 40% + nitric acid 5% / room temperature
  4. Passivation: nitric acid 40% / 25°C
  1-4. + intensive rinsing with warm or cold water and final drying

Corrosion resistance

- The CarTech® MP35N Alloy exhibits a good to very good corrosion resistance in the human body, marine, drilling and oil and gas extraction.

Medium	Resitance	Medium	Resitance
Sea water	excellent	Sodium hydroxide	good
NaCl spray	excellent	Nitric acid	good
Humidity	excellent	Sulfuric acid	good
Acidic Oil/gas	excellent	Phosphoric acid	good
Vinegar acid	excellent		

Biocompatibility

- The CarTech® MP35N Alloy is biocompatible.

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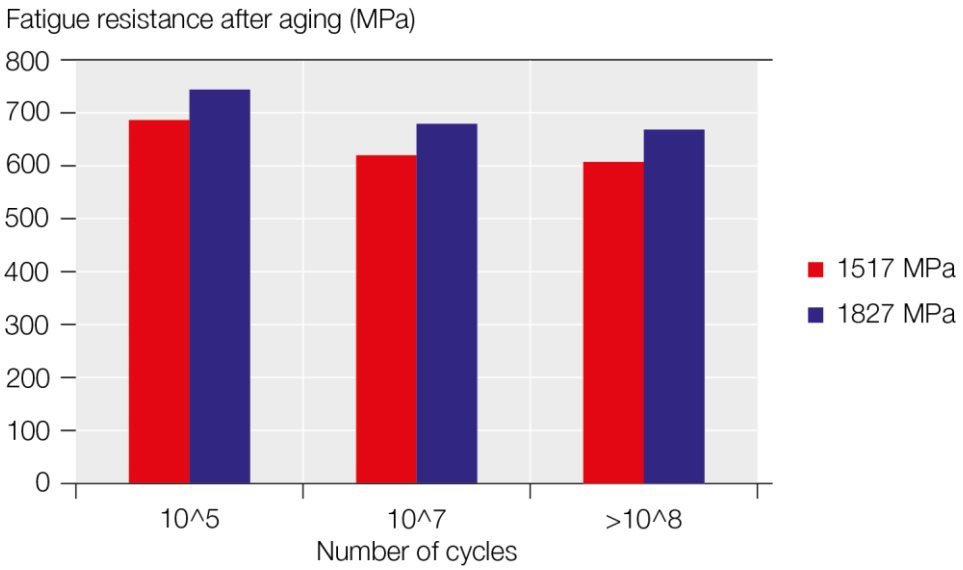
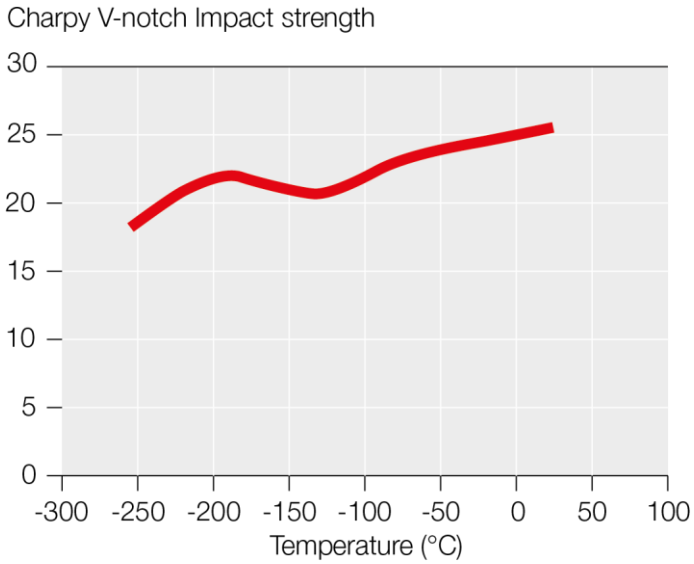
Figure 5
Condition cold worked + aging
Rotating fatigue resistance according to Moore



- The CarTech® MP35N Alloy has a good to very good fatigue resistance

Figure 6
Impact resistance Charpy V-notch (J)



- The CarTech® MP35N Alloy exhibits a good impact resistance and ductility in the complete range of the cryogenic temperatures.

Low temperatures

- Continuous use from -269°C (liquid helium) to max 400°C

Galvanic corrosion

- The CarTech® MP35N Alloy is nobler than the 1.4435 (316L) or inferior stainless steels. Its assembly with such metals may form a galvanic cell leading to the corrosion of the less corrosion resistance metals.

Magnetism

- The CarTech® MP35N Alloy is paramagnetic.

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Magnetic permeability

- The magnetic relative permeability is <1.0010 of the CarTech® MP35N Alloy is most favorable. It permits to obviate the danger of implants or components displacements in the strong magnetic fields of up to 6-8 T encountered in the last generation of scanners for magnetic resonance imaging.

Passivation

- The CarTech® MP35N Alloy can be passivized.
  Passivation treatment: nitric acid 40% / room temperature

Tribological properties

- The fretting resistance of the CarTech® MP35N Alloy improves with the cold deformation rate.

Physical properties

Properties	Unit	Temperature (°C)				
		20	200	300	400	500
Density	g cm^{-3}	8.5				
E Young modulus	$m/m^{-1}.K^{-1}$	26°C	232°C	482°C		
E modulus annealed	GPa	233	216			
E modulus CW + aging	GPa	219		201		
Shear modulus G		26°C annealed	26°C aged	232°C annealed	232°C aged	
	GPa	83.4	81.0	77.8	74.7	
		482°C annealed	482°C aged			
	GPa	70.6	67.8			
Poisson coefficient	-	0.34				
Thermal conductivity	$W.m^{-1}.K^{-1}$	-184°C	-73°C	21°C	93°C	204°C
	10^{-6}	6.48	9.1	11.24	12.7	15.0
		316°C	427°C	649°C		
Electrical resistance	10^{-6} µΩ.cm	17.0 -184°C	19.2 -73°C	23.4 21°C	93°C	204°C
	10^{-6}	986 316°C	1010 427°C	1032 538°C	1050 49°C	1077
	10^{-6}	1104	1128	1153	1179	
Thermal expansion coefficient	$m/m^{-1}.K^{-1}$ 10^{-6}	21–93°C 12.8	21–204°C 13.7	21–316°C 14.8	21–421°C 14.9	21–538°C 15.7
Specific heat	$J.kg^{-1}.K^{-1}$	450				
Melting range	°C	1320-1440				
Relative magnetic permeability	µr	-195°C 1.0014	-73°C 1.0010	-27°C 1.0010	25°C 1.0009	119°C 1.0009