

High Performance Metal Solutions

High Performance Solutions with MP35N[®] Alloy

H.C.Starck 

High Performance Metal Solutions

Our Commitment to Engineering Excellence

H.C. Starck Solutions delivers superior quality with material consistency and product reliability. H.C. Starck Solutions achieves world class quality through continuous research of new products, development of engineering solutions, and applying them in H.C. Starck Solutions' manufacturing environment to deliver premium products for the most challenging applications.

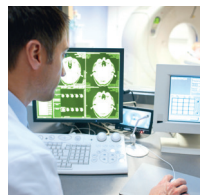
Nearly 100 years of powder metallurgical experience is the cornerstone of H.C. Starck Solutions' success in producing advanced technology metals for fast growing industries including aerospace, chemical processing, electronics, industrial, medical, and energy. As one of the world's leading suppliers of molybdenum, tungsten, tantalum, niobium, and their alloys, H.C. Starck Solutions is at the forefront of creating solutions with next-generation materials and fabricates engineered components for a diverse spectrum of markets.

> **Product Quality and Service**

> **Research and Development**

> **Manufacturing Excellence**

> **Reclamation and Recycling**



Strategic Advantages of Working with H.C. Starck Solutions

H.C. Starck Solutions understands market trends and the latest cutting-edge technologies providing us the opportunity to create value-added solutions for complex applications. In addition, our robust and sustainable vertically integrated supply chain enables us to deliver high performance materials and products seamlessly to the marketplace.

A recognized leader in refractory metal technology, H.C. Starck Solutions' knowledge and technical expertise benefit customers through joint collaborations with our dedicated team of research engineers. This collaborative effort facilitates new and improved product designs through a study of the product's life-cycle. Extensive in-house state-of-the-art laboratory facilities with the latest in analytical tools, testing equipment, modeling and simulation software assist engineers in evaluating product performance. Innovative material solutions provide texture control thus enhancing the uniformity and performance consistency.

With over 30 sales locations worldwide including Asia, Europe, and the Americas, H.C. Starck Solutions offers exceptional customer care with local sales and technical support. Our local presence coupled with multiple global manufacturing sites permits us to effectively respond to our customer's requests.

Ultra High Strength and Corrosion Resistance

MP35N® Nickel/Cobalt/Chromium/Molybdenum Alloy

MP35N is a nickel-cobalt based alloy of the Multiphase® alloy system that has a unique combination of properties – ultra high strength, toughness, ductility, biocompatibility, and outstanding corrosion resistance. H.C. Starck Solutions offers MP35N alloy in flat rolled plate, sheet, and foil products.

MP35N is produced by vacuum induction melting and consumable vacuum arc re-melting containing 35 % nickel, 35 % cobalt, 20% chromium, and 10% molybdenum. Strengthened by work hardening and aging to levels of 260 to 300 ksi (1790 to 2070 MPa), MP35N has good ductility with greater than 40% reduction in area, and good toughness. MP35N can be effectively utilized at cryogenic temperatures without embrittlement and up to 600 °F without loss in performance.

The high strength and corrosion resistance, high modulus, ease of fabrication, and other mechanical properties make MP35N an ideal candidate for high performance products, where emphasis is placed upon dependability for demanding applications. H.C. Starck Solutions's flat rolled MP35N products are used in diverse applications:

- > **Orthodontic and Prosthetic devices**
- > **Oil Industry, Chemical and Marine equipment – Valve components, springs, high pressure door dogs**
- > **Aircraft and Aerospace components – Springs, leading edge strips**
- > **High Pulse Magnet Research**



Resistant in Corrosive Environments

With outstanding corrosion resistance at high strength levels, the MP35N alloy resists most mineral acids, hydrogen sulfide, seawater and salt spray environments, and exhibits excellent resistance to stress corrosion cracking (SCC) and hydrogen embrittlement. NACE Standard MR-01, "Metallurgy of Oil Field Equipment for Resistance to Sulfide Stress Cracking" approves the use of MP35N in the cold reduced or cold reduced and aged condition up to hardness levels of Rockwell C60 for springs and diaphragms. MP35N is one of only a few alloys approved for use as springs at hardness levels above RC50.

The elemental components of MP35N impart excellent corrosion resistance to the alloy as all four alloying elements: nickel, cobalt, chromium, and molybdenum enhance corrosion resistance in almost every stainless steel, nickel base and cobalt base alloy commonly used in industry. The 20% chromium improves the resistance to elevated temperature oxidation, sulfidation, and chemical salt reaction.

MP35N has excellent resistance to pitting, grain boundary attack and stress corrosion cracking, because vacuum arc melting produces low levels of oxygen and nitrogen that is free of undesirable secondary phases along with very low levels of carbon and other residual elements.

Overall corrosion resistance in environments like sea water is enhanced by its cobalt: nickel ratio as well as the molybdenum content. Additionally, MP35N shows excellent service in sour well conditions, where hydrogen sulfide is present.

The excellent corrosion resistance properties of MP35N are independent of microstructure and tensile strength. Therefore, MP35N is one of the few alloys applied at high strength levels in severe environments without occurrence of stress-corrosion cracking where other alloys are susceptible.



H.C. Starck Solutions' MP35N Alloy Products

Combining high strength and high modulus values with outstanding corrosion resistance, MP35N is an excellent material for severe spring applications – both flat and torsional.

MP35N is used for diverse applications including medical and surgical spring clips. The surgical spring clips are cut from MP35N sheet and then subsequently formed in sequential steps into very precise “alligator” clips for closing veins and arteries during surgery. Other major applications are for orthodontics, oil industry valve components, marine high pressure door dogs and National Laboratory magnet projects.

H.C. Starck Solutions offers MP35N alloy in flat rolled plate, sheet, and foil products.

MP35N FLAT ROLLED PRODUCT SIZES

Product	Thickness inches	mm	Width in.	mm
Hot Rolled Plate	.187–2.00	4.75-50.8	24 max.	610
Hot Rolled Sheet	.040–.186	1.02-4.74	24 max.	610
Cold Rolled Plate	.187–.500	4.75-12.7	24 max.	610
Cold Rolled Sheet	.005–.186	.127-4.74	24 max.	610
Cold Rolled Foil	.002–.0049	.0508-.124	12 max.	305

Inquire regarding Length

WIDTH TOLERANCE

Thickness inches	mm	½-6 in.	12.7-152 mm	6-12 in.	152-305 mm	12-24 in.	305-610 mm
.002 to .010	.0508-0.254	± .005	± 0.127	± .010	± 0.254	± .031	± 0.787
over .010 to .020	0.254-0.508	± .010	± 0.254	± .010	± 0.254	± .031	± 0.787
over .020 to .035	0.508-0.889	± .015	± 0.381	± .015	± 0.381	± .031	± 0.787
over .035 to .060	0.889-1.524	± .031	± 0.787	± .031	± 0.787	± .031	± 0.787
over .060 to .1875	1.524-4.763	± .062	± 1.57	± .062	± 1.57	± .031	± 0.787
over .187 to .500	4.763-12.70	± .062	± 1.57	± .062	± 1.57	± .031	± 0.787

Inquire regarding tolerances for width less than ½ in. / 12.7mm tolerances

THICKNESS TOLERANCE

Thickness inches	mm	Up to 12 in. Wide	305 mm	12 – 24 in. Wide	305-610 mm
.002 to .005	.0508-0.127	± .0006	± 0.0152	N/A	N/A
over .005 to .008	0.127-0.203	± .0007	± 0.0178	± .0009	± 0.0229
over .008 to .010	0.203-0.254	± .0008	± 0.0203	± .0010	± 0.0254
over .010 to .018	0.254-0.457	± .0010	± 0.0254	± .0012	± 0.0305
over .018 to .035	0.457-0.889	± .0017	± 0.0432	± .0020	± 0.0508
over .035 to .1875	0.889-4.760	± 5 %	N/A	± 6 %	N/A

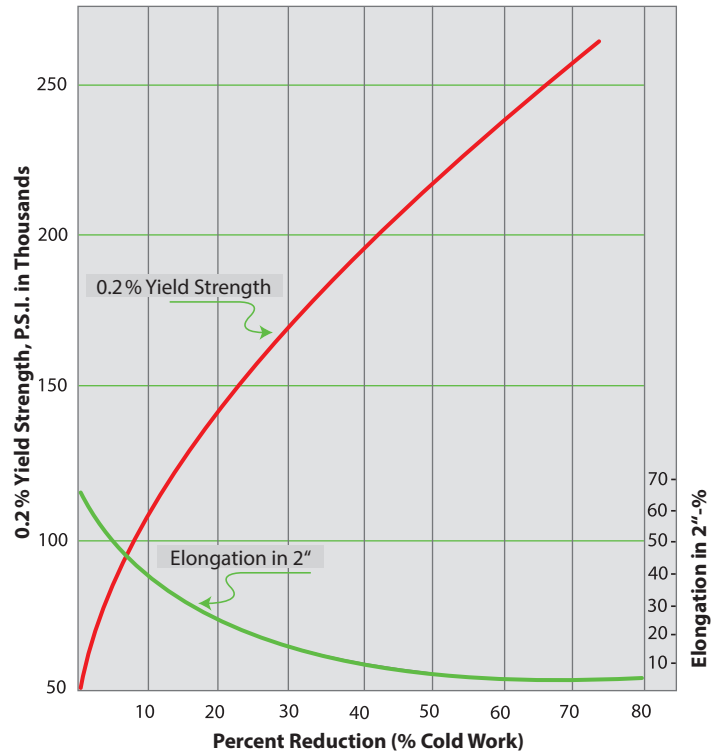
Mechanical and Physical Properties

The strength of MP35N is principally enhanced by mechanical working.

Tensile and yield strength are affected by processing conditions. Minimum values are achieved in the hot rolled or annealed condition and are increased in the cold worked condition. Strengths are increased with an aging heat treatment. Hardness of MP35N increases from approximately Rockwell C7 in the fully annealed condition to Rockwell C50 in the cold worked and aged condition.

Typical properties for MP35N are presented in the following tables at various processing conditions.

TYPICAL PROPERTIES OF MP35N AS-ROLLED



PHYSICAL PROPERTIES OF MP35N

THERMAL AND ELECTRICAL CONDUCTIVITY

Temperature		Thermal Conductivity		Electrical Resistivity	
°F	°C	Btu in./hr/ft. ² /°F	watt./cm °C	μ ohm in	μ ohm cm
-300	-184	45	0.065	38.82	99
-100	-73	63	0.091	39.79	101
70	21	78	0.112	40.67	103
200	93	88	0.127	41.37	105
400	204	104	0.150	42.43	108
600	316	118	0.170	43.45	110
800	427	133	0.192	44.44	113
1000	538	148	0.213	45.44	115
1200	649	162	0.234	46.43	118

MAGNETIC PROPERTIES

Temperature		Magnetic Susceptibility	Magnetic Permeability
°F	°C	μ emu/g	μ
-319	-195	13.47	1.00142
-220	-140	11.07	1.00117
-99	-73	9.81	1.00104
-17	-27	9.22	1.00096
77	25	8.70	1.00092
246	119	8.03	1.00085

SPECIFIC GRAVITY

8.43 g/cc

DENSITY

0.304 lbs./cu. in

MELTING RANGE

2400-2600 °F

1315-1440 °C

TYPICAL PROPERTIES – RANGES

Condition	Tensile					Hardness	
	Ultimate		Yield		EL	RC	HVI
	ksi	MPa	ksi	MPa			
Annealed	110	760	50	345	60%	7	220
50% Cold Rolled	220	1518	200	1380	10%	44	420
50% Cold Rolled Plus Aged*	265	1830	225	1550	3%	47	480

* 4 hours at 1025 °F (550 °C)

MODULUS

Temperature		Elastic Modulus (Modulus of Elasticity)				Shear Modulus (Modulus of Rigidity)			
°F	°C	Annealed		Cold Worked		Annealed		Cold Worked	
		psi x 10 ⁶	GPa	psi x 10 ⁶	GPa	psi x 10 ⁶	GPa	psi x 10 ⁶	GPa
78	25.6	33.8	233	34.1	235	12.1	83	11.7	81
450	232	31.3	216	31.8	219	11.3	78	10.8	75
900	482	29.2	201	29.2	201	10.2	71	9.8	68

COEFFICIENT OF THERMAL EXPANSION

Temperature			
°F	°C	in./in./ °F X 10 ⁻⁶	cm/cm/ °C X 10 ⁻⁶
70-200	21-93	7.1	12.8
70-400	21-204	7.6	13.7
70-600	21-316	8.2	14.8
70-800	21-427	8.3	14.9
70-1000	21-538	8.7	15.7

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The values in this publication are typical values and do not constitute a specification.