

MP35N ALLOY

**Nickel-cobalt base
alloy of the
Multiphase alloy system**

- ULTRA HIGH STRENGTH
- TOUGHNESS
- DUCTILITY
- CORROSION RESISTANCE



**LATROBE SPECIALTY
STEEL COMPANY**

MP35N* ALLOY

TYPICAL ANALYSIS	Ni	Co	Cr	Mo
	35	35	20	10

INTRODUCTION

MP35N is a nickel-cobalt base alloy of the Multiphase* alloy system that has a unique combination of properties—ultra high strength, toughness, ductility *and* outstanding corrosion resistance. The alloy is work-strengthened and aged to obtain strength levels of 260 to 300 ksi (1793-2068 MPa). MP35N alloy resists corrosion in hydrogen sulfide, salt water and other chloride solutions, as well as the mineral acids (nitric, hydrochloric, sulfuric). In addition, it has exceptional resistance to crevice and stress corrosion cracking in sea water and other hostile environments.

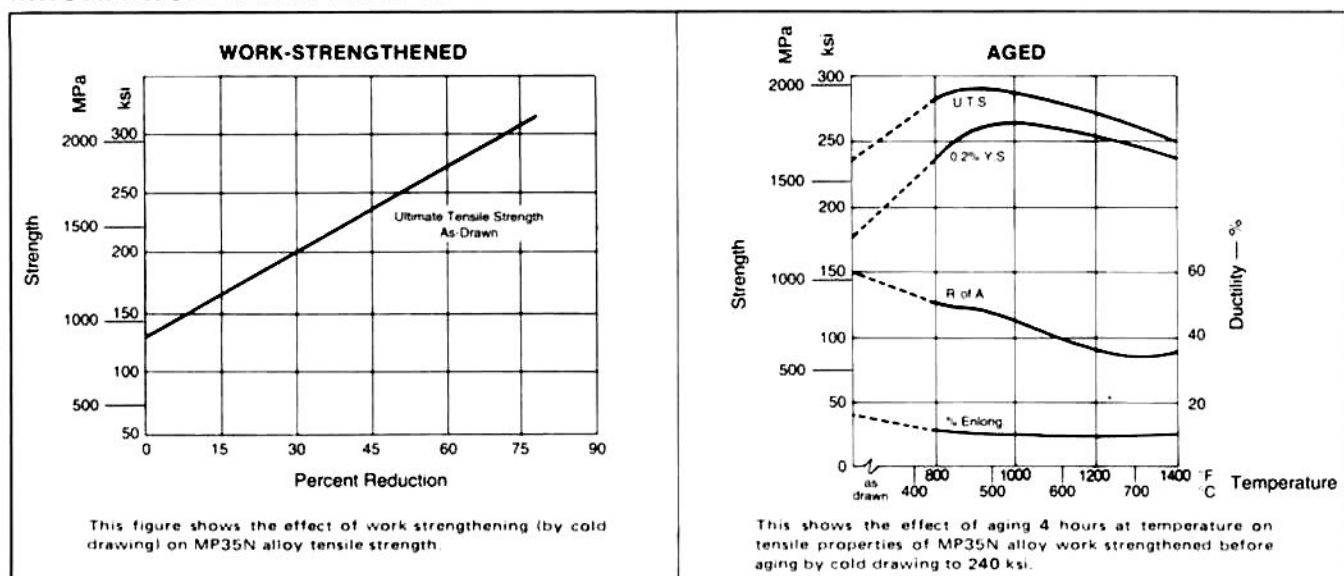
METALLURGY

MP35N alloy has a face-centered cubic matrix of cobalt and nickel in which the chromium and molybdenum are soluble at elevated temperatures. The face-centered cubic structure persists upon cooling to room temperature and below. Working the alloy at temperatures below the equilibrium transformation temperature of approximately 850° F (454° C) causes local shear transformation to form very small platelets of the hexagonal close-packed structure. The transformation does not appear to have an M_s temperature at which it occurs on cooling, as does martensite in steel. It does occur, however, as a strain-induced transformation—the amount of transformed product being a function of the amount of strain deformation and working temperature.

Work-strengthening can be accomplished by extruding, rolling, swaging, drawing or a combination of these manufacturing processes. The transformation occurs readily with work at room temperature, but will also occur at elevated temperatures to the upper limit of the transformation zone. The amount of strain deformation obtainable, and thus the strength level, will be limited in some cases by the size and configuration of the product. The hexagonal close-packed platelets that are formed are stable in the face-centered cubic matrix and the resultant structures exhibit the unique combination of excellent mechanical properties and corrosion resistance. Work-strengthened material is usually aged to obtain even higher strength levels through precipitation strengthening.

MP35N alloy is produced by vacuum induction melting followed by VAC-ARC® remelting (VIM-VAR) to provide optimum control of chemistry and preferred ingot solidification.

MECHANICAL PROPERTIES



*Registered Trademark of SPS Technologies, Inc.

MECHANICAL PROPERTIES

	Typical Properties of Solution Treated (Annealed) MP35N	Typical Properties of AMS 5844 Product after 4 Hour Age at 1050°F (566°C)*	AMS 5844 Specification Requirements after Aging 4 Hours at 1000-1200°F (538-648°C)
Ultimate Tensile Strength	130 ksi (896 MPa)	290 ksi (2000 MPa)	260 ksi (1795 MPa), min.
0.2% Offset Yield Strength	55 ksi (379 MPa)	280 ksi (1931 MPa)	230 ksi (1585 MPa), min.
Elongation in 4D	65%	10%	8%, min.
Reduction of Area	75%	45%	35%, min.
Hardness	90 HRB	51 HRC	—
Shear Strength**	—	—	150 ksi (1034 MPa), min.

The above data are longitudinal properties.

*Tensile properties will change depending on product size.

**Not required by AMS 5844, but this is the guaranteed shear strength.

PHYSICAL PROPERTIES

	DENSITY		MELTING RANGE			
	0.309 lbs./in ³ (8.55 g/cc)		2400-2600° F (1315-1440° C)			
COEFFICIENT OF THERMAL EXPANSION (Work-strengthened plus aged)	Temperature Range ° F (° C)		in./in./° F x 10 ⁻⁶	mm/mm/° C x 10 ⁻⁶		
	-148-250 (-100-121)		6.2	(11.2)		
	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)			
MODULUS	Temperature ° F (° C)	Elastic Modulus psi x 10 ⁶ (MPa x 10 ³)		Temperature ° F (° C)	Shear Modulus psi x 10 ⁶ (MPa x 10 ³)	
		Annealed	Cold Worked and Aged		Annealed	Cold Worked and Aged
	78 (26)	33.76 (232.8)	34.05 (234.8)	78 (26)	12.09 (83.86)	11.74 (80.95)
450 (232)	31.33 (216.0)	31.76 (219.0)	450 (232)	11.29 (77.84)	10.84 (74.74)	
900 (482)	29.15 (201.0)	29.19 (201.3)	900 (482)	10.24 (70.60)	9.83 (67.78)	
THERMAL AND ELECTRICAL CONDUCTIVITY	Temperature ° F (° C)		Thermal Conductivity Btu/in./hr./ft. ² /° F (w/m/° C)		Electrical Resistivity μΩ/in. (μΩ/mm)	
	-300 (-184)		45 (6.5)		38.82 (986)	
	-100 (-73)		63 (9.1)		39.79 (1011)	
	70 (21)		78 (11.2)		40.67 (1033)	
	200 (93)		88 (12.7)		41.37 (1051)	
	400 (204)		104 (15.0)		42.43 (1078)	
	600 (316)		118 (17.0)		43.45 (1104)	
	800 (427)		133 (19.2)		44.45 (1129)	
1000 (538)		148 (21.3)		45.44 (1154)		
1200 (649)		162 (23.4)		46.43 (1179)		
MAGNETIC PROPERTIES (In a magnetic field of 9,800 Oersteds)	Temperature ° K	Magnetic Susceptibility μ emu/g	Temperature ° K	Magnetic Permeability μ		
	78	13.47	78	1.00142		
	133	11.07	133	1.00117		
	200	9.81	200	1.00104		
	246	9.22	246	1.00096		
	298	8.70	298	1.00092		
392	8.03	392	1.00085			

CORROSION RESISTANCE

MP35N alloy has outstanding corrosion resistance at high strength levels. This alloy is resistant to most mineral acids, hydrogen sulfide, sea water and salt spray environments. Data developed in marine exposures have been verified by both accelerated and long-term studies. Additionally, the alloy has exhibited excellent resistance to stress corrosion and hydrogen embrittlement. Some specific data follow:

HYDROGEN EMBRITTLEMENT TEST OF MP35N ALLOY Unnotched C-ring Specimens stressed to 0.2% yield point. Coupled to carbon steel. Room Temperature Tests	Solution 5% NaCl + .5% Acetic Acid Sat. with H ₂ S.	Condition Aged at 1425-1450° F (774-787° C) to 180-200 ksi .2YS (1241-1379 MPa)	Results No cracking or evidence of corrosion in 720 days.
	5% H ₂ SO ₄ + 4 mg As ₂ O ₃ /liter charged with H ₂ at 20 ma/cm ²	Annealed Cold Worked to 200 ksi .2YS (1379 MPa) Aged at 1425-1450°F (774-787°C) to 230 ksi .2YS (1586 MPa)	No evidence of cracking in 72 hours.
STRESS CORROSION TEST OF MP35N ALLOY U-Bend Specimens 192 Hour Test	Solution Boiling 42% MgCl ₂	Condition Aged to 300 ksi, UTS (2068 MPa)	Results No cracks or visible effects.
MARINE CORROSION TEST OF MP35N ALLOY Open crevice samples at 122° F (50° C)	Solution Simulated Marine Environments	Corrosion Rate in Mills/Year	
		10% NaCl + HCl (pH 2) 0.00	10% FeCl ₃ 0.00

AVAILABLE PRODUCT FORMS

Bar, Rod, Billet, Tubing—Timken Latrobe Steel, Latrobe, PA, 724-537-7711

Sheet, Strip, Plate—CSM Industries, Inc., Cleveland, OH, 216-692-3990

Tubing 1.00" (25.4 mm) O.D. and under—Dearborn Precision Tubular Products, Inc., Fryeburg, ME, 207-935-2171

SPECIFICATIONS

AMS 5758 Solution heat treated and centerless ground bars.

AMS 5844 Solution heat treated and cold drawn bars.

AMS 5845 Solution heat treated, cold drawn and aged bars.

AMS 7468 Bolts and screws, forged head, roll threaded after aging.

ANS/ASTM F562 Surgical implant applications.

NACE Standard MR-01-75 Sulfide Stress Cracking Resistant Material For Oil Field Equipment.



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