MATERION

Data Sheet

Alloy 360 Nickel-Beryllium Strip – High Strength at Elevated Temperature

Materion's nickel-beryllium strip Alloy 360 (UNS number N03360) combines unique mechanical and physical properties that are required in today's high-reliability electrical/electronic systems, fire protection sprinkler systems, heavy-duty controls, high pressure/high temperature connectors, electromechanical devices and other high-performance applications.

The properties of nickel-beryllium Alloy 360 strip that a designer can use include ultimate tensile strength approaching 300,000 psi (2000 MPa), yield strength up to 245,000 psi (1690 MPa), excellent formability, stress relaxation less than 5% at 400°F (200°C), and fatigue strength (in reverse bending) of 85,000-90,000 psi (586-655 MPa) at 10 million cycles. Alloy 360 strip has corrosion resistance surpassing stainless steel. Typically, this alloy is used for mechanical and electrical/electronic components that are subjected to elevated temperatures (up to 700°F/370°C for short times) and require good spring characteristics at these temperatures. Some applications for this alloy are Belleville washers for fire protection sprinkler heads, thermostats, bellows, diaphragms, connectors and burn-in and test sockets.

Chemical Composition (Weight Percent)

UNS Number	Beryllium (Be)	Titanium (Ti)	Nickel (Ni)
N03360	1.85 - 2.05	0.4 - 0.6	Balance

Typical Physical Properties (After Age Hardening)

Elastic Modulus	Density	Melting Range	Thermal Conductivity (25°C)	Thermal Expansion Coefficient (20 – 200°C)
28 - 30 x 10^6 psi 195 - 210 GPa	0.299 lb./in^3 8.27 g/cm^3	2185 - 2420°F 1195 - 1325°C	28 btu/hr·ft·°F 48 W/m·°C	8.0 x 10^{-6} in/in·°F 14.5 x 10^{-6} mm/mm·°C

Typical Electrical Properties

Tempers	Minimum Electrical Conductivity (% IACS)	Maximum Resistivity (Micro-ohm cm)
Cold Rolled (A, ¼ H, ½ H, H)	4	43.1
Age Hardened (AT, ¼ HT, ½ HT, HT)	6	28.7
Mill Hardened (MH2, MH4, MH6, MH8, MH10, MH12)	5	34.5

Typical Mechanical Properties

Temper	Heat Treatment	Tensile Strength		Yield Strength		Elongation	Hardness	
		ksi	MPa	ksi	MPa	%	HV	Rockwell
A	Before heat treatment	95 - 130	660 - 900	40 - 70	280 - 480	30 min.	106 - 200	A39 - 57
¼ H		110 - 150	760 - 1030	65 - 125	450 - 860	15 min.	153 - 293	A50 - 65
½ H		130 - 175	900 - 1210	115 - 170	790 - 1170	4 min.	160 - 383	A51 - 70
H		155 - 190	1070 - 1310	150 - 190	1030 - 1310	1 min.	180 - 491	A55 - 75
AT	After 2.5 hours at 925°F (500°C)	215 min.	1480 min.	150 min.	1030 min.	12 min.	343 - 528	15N 78 - 86
¼ HT		230 min.	1590 min.	175 min.	1210 min.	10 min.	383 - 598	15N 80 - 88
½ HT	After 1.5 hours at 925°F (500°C)	245 min.	1690 min.	200 min.	1380 min.	9 min.	395 - 695	15N 81 - 90
HT		270 min.	1860 min.	230 min.	1590 min.	8 min.	446 - 695	15N 83 - 90
MH2	Mill hardened (Pre-tempered)	155 - 180	1070 - 1240	100 - 125	690 - 860	14 min.	-	-
MH4		180 - 205	1240 - 1410	120 - 155	830 - 1070	12 min.	-	-
MH6		200 - 225	1380 - 1550	150 - 175	1030 - 1210	10 min.	-	-
MH8		220 - 245	1520 - 1690	170 - 205	1170 - 1410	9 min.	-	-
MH10		240 - 270	1660 - 1860	200 - 225	1380 - 1550	8 min.	-	-
MH12		260 - 290	1790 - 2000	220 - 245	1520 - 1690	8 min.	-	-

Properties may vary by thickness. Percent elongation valid for strip 0.004" (0.10 mm) and thicker.

Tolerance

Thickness (Inches)		Thickness Tolerance	Thickness (mm)		Thickness Tolerance
Over	Including	(Inches)	Over	Including	(mm)
	0.0020	± 0.00010		0.05	± 0.003
0.0020	0.0040	± 0.00015	0.05	0.10	± 0.004
0.0040	0.0060	± 0.00020	0.10	0.20	± 0.006
0.0060	0.0090	± 0.00025	0.20	0.30	± 0.008
0.0090	0.0130	± 0.00030	0.30	0.70	± 0.010
0.0130	0.0260	± 0.00040	0.70	1.0	± 0.016
0.0260	0.0370	± 0.00060	1.0	1.3	± 0.020
0.0370	0.0500	± 0.00080	1.3	2.0	± 0.025
0.0500	0.0750	± 0.00100			

Tolerances apply to both cold rolled (heat treatable) and mill hardened (pre-heat treated) strip.

Formability

Both heat treatable and mill hardened nickel beryllium demonstrate exceptional formability as measured by R/t (punch radius/stock thickness). The annealed temper is most easily formed. It withstands severe bending and can be deep drawn. As the temper increases from annealed to hard, the mechanical properties increase, but the formability is reduced. To take advantage of the highest properties obtainable and to minimize shrinkage during age hardening, material with the highest temper that will properly form the part should be selected. The formability table below should be used as a relative guide.

The die progression and the resulting methods used to make the bends are critical factors with regard to strip formability. Stamping and forming practices that are used on other nickel base alloys can also be applied to Alloy 360.

Formability Rating	Cold Rolled Tempers	90° Bend R/t Ratio		Mill Hardened Tempers	90° Bend R/t Ratio	
		Long.	Trans.		Long.	Trans.
Excellent - Used for deep-drawn and severely cupped or formed parts; can be bent flat through 180° angle in any direction	A ¼ H	0 0	0 0	MH2	0	0
Very Good - Used for moderately drawn and severely cupped parts; can be formed to a 90° angle around a radius	½ H	0.7	1.2	MH4	0.5	0.5
Good - Slightly reduced formability - can be formed to a 90° angle around a radius	H	1.2	2.0	MH6 MH8 MH10 MH12	1.0 1.2 1.5 2.0	1.2 1.6 2.2 3.0

Age Hardening

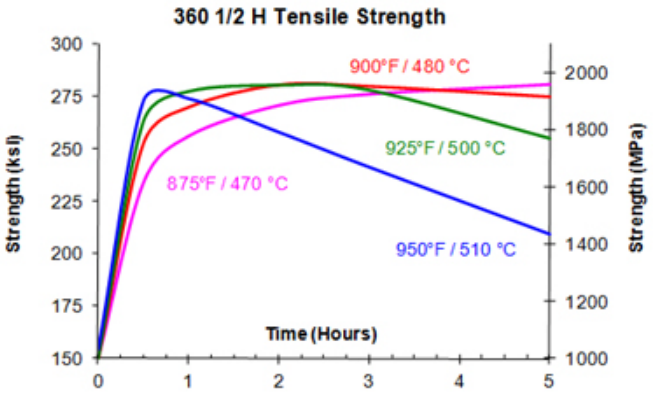
Age hardening is achieved by a simple heat treatment, generally 1.5 to 2.5 hours at 900°F - 950°F (480°C - 510°C). To obtain specific properties, heat treatment can be performed outside this range. Controlled atmosphere is not required but if a bright surface is desired, a protective atmosphere or simple cleaning process may be employed.

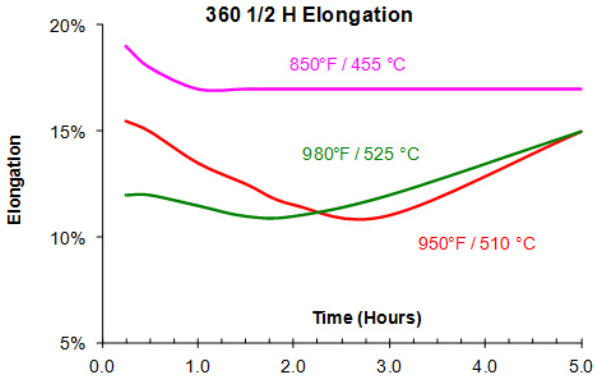
Strip can be supplied with a copper plated surface for increased tool life. The copper should be removed before age hardening (see Pickling section, below).

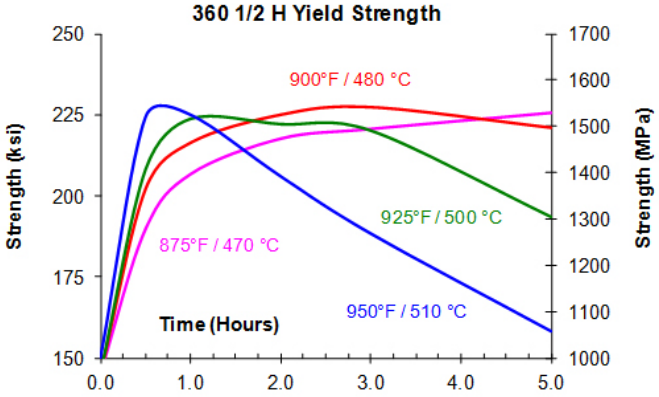
The graph shows typical aging response for ½ hard nickel-beryllium strip. If your aged property requirements are different from those shown in the Mechanical and Electrical Properties tables, consult your local Materion sales engineer or use nickel-beryllium test specimens to establish exact age hardening parameters.

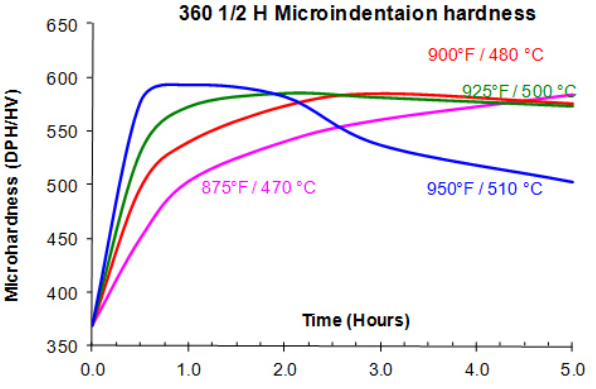
Since the age hardening process increases density by approximately 0.5%, a corresponding decrease in length (shrinkage) of approximately 0.2% will occur. Fixtures may be needed for age hardening when dimensional accuracy must be closely controlled.

Mechanical properties of the mill hardened tempers (MH2 – MH12) are achieved with a proprietary heat treatment performed by Materion. With mill hardened material, heat treatment and associated cleaning steps are unnecessary, and shrinkage is eliminated.









Stress Relaxation

The stress relaxation characteristic of a material is its resultant loss in spring force over time at constant strain and elevated temperature. Nickel-beryllium resists stress relaxation better than most other spring materials. Testing of nickel-beryllium strip at stress levels of 50% and 100% of the 0.2% offset yield strength and at temperatures of 400° F (200°C) for more than 10,000 hours has shown a loss in spring force of only 2% and 5% respectively.

Plating

Alloy 360 strip when properly cleaned exhibits surface chemistry characteristics similar to other commercial nickel base alloys. Techniques and procedures for plating and joining commercial nickel base alloys can be used on nickel-beryllium.

Pickling

Removing Copper Plating

Alloy 360 purchased with a copper electroplated surface should be pickled to remove this surface before heat treatment. A 2- to 5-minute soak in a 125°F (50°C) solution of 20 volume percent sulfuric acid plus 2 volume percent hydrogen peroxide followed by water rinsing will remove the copper without harming the nickel-beryllium. Removal of the copper plating minimizes the formation of oxides during age hardening.

Pickling After Heat Treatment

To restore the original surface luster after age hardening, a simple procedure can be used. Soak for one hour in a 160°F (70°C) solution of 50 volume percent sulfuric acid followed by a thorough water rinse. This process leaves a smooth, bright metallic surface which requires no additional mechanical cleaning and typically removes less than 0.0001 inch (2.54 microns) per side.

Health and Safety

Processing beryllium-containing alloys poses a health risk if safe practices are not followed. Inhalation of airborne beryllium can cause serious lung diseases in some individuals. Occupational safety and health regulatory agencies worldwide have set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Safety Data Sheet (SDS) before working with this material. The SDS and additional important beryllium health and safety information and guidance can be found at berylliumsafety.com, berylliumsafety.eu and Materion.com. For questions on safe practices for beryllium-containing alloys, contact the Materion Product Stewardship Group at +1.800.862.4118 or by email at Materion-PS@Materion.com.

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