MATERION

DATA SHEET

Alloy 360 Nickel Beryllium Strip
High Strength at Elevated Temperature

Materion Brush Performance Alloys' nickel beryllium strip Alloy 360 (UNS number N03360) combines unique mechanical and physical properties required in today's high reliability electrical /electronic systems, heavy duty controls, electromechanical devices and in other high performance applications.

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 400º F (200°C), and fatigue strength (in reverse bending) of 85,000-90,000 psi (586-655 MPa) at 10 million cycles.

Typically, this alloy is used for mechanical and electrical / electronic components that are subjected to elevated temperatures (up to 700º F / 370°C for short times), and require good spring characteristics at these temperatures. Some applications for this alloy are thermostats, bellows, diaphragms, connectors and burn-in and test sockets.

CHEMICAL COMPOSITION (weight percent)

Beryllium (Be)	Titanium (Ti)	Copper (Cu)	Nickel
1.85 – 2.05	0.4 – 0.6	0.25 maximum	Balance

Note: Ni + Be+ Ti + Cu = 99.5% minimum

PHYSICAL PROPERTIES (AFTER AGE HARDENING)

Elastic Modulus	Density	Melting Range	Thermal Conductivity	Coefficient of Thermal Expansion
28 – 30X10^6 psi 195 – 210 GPa	0.299lb/in^3 8.27 g/cm^3	2185 – 2420°F 1195 – 1325°C	28 BTU/hr·ft·°F 48 W/m·K	8.0 x 10^{-6} in/in·°F 14.5 x 10^{-6} mm/mm·°C

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

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MECHANICAL PROPERTIES

Temper	Heat Treatment	Tensile Strength		Yield Strength		Elongation	Hardness	
		ksi	MPa	ksi	MPa	%	HV	Rockwell
A	Not Heat Treated	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	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	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.

AGE HARDENING

Age hardening is achieved by a simple heat treatment, generally 1-1/2 to 2-1/2 hours at 900 - 950° F (480 - 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).

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 table, consult your local Materion Brush Performance Alloys 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 Brush Performance Alloys. With mill hardened material, heat treatment and associated cleaning steps are unnecessary and shrinkage is eliminated.

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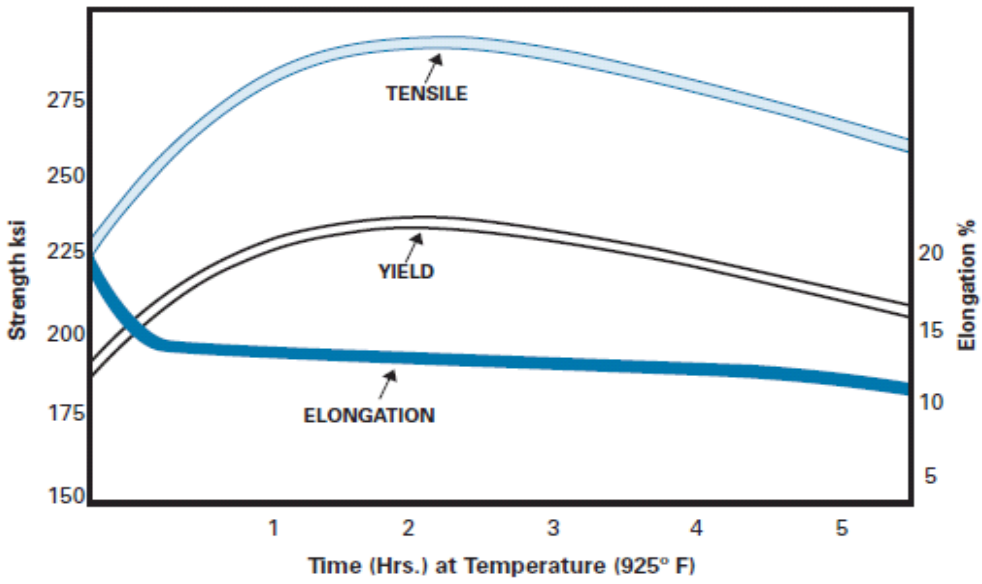

Beryllium Nickel Aging Curves

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 MH4	0 0.5	0 0.5
Very Good - Used for moderately drawn and severely cupped parts; can be formed to a 90° angle around a radius	½ H	1.0 1.2	1.2 1.2	MH6 MH8	1.0 1.2	1.2 1.6
Good - Slightly reduced formability - can be formed to a 90° angle around a radius	H	1.5 2.0	2.0 2.0	MH10 MH12	1.5 2.0	2.2 3.0

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STRESS RELAXATION

The stress relaxation characteristic of a material is its resultant loss in spring force with 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 – 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.

SAFE HANDLING OF NICKEL BERYLLIUM

Handling nickel beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on nickel beryllium, contact Materion Brush Performance Alloys, Technical Service Department at 1-800-375-4205.

North American Service Centers – Sales Inquiries

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For plate, tube, bar, and rod 0.4" (10 mm) diameter and over
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