BRUSH WELLMAN ALLOY PRODUCTS

Data Sheet

BERYLLIUM NICKEL STRIP
ALLOY 360

High Strength at Elevated Temperature

Brush Wellman's Alloy 360 (UNS no. N03360) beryllium nickel strip 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 beryllium nickel Alloy 360 strip that a designer can use include ultimate tensile strength approaching 300,000 psi, yield strength up to 245,000 psi, excellent formability, stress relaxation less than 5% at 400° F, and fatigue strength (in reverse bending) of 85,000-90,000 psi at 10 million cycles.

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

Composition (Weight Percent)

Alloy	Beryllium	Titanium	Nickel
360	1.85-2.05	0.4-0.6	Balance

NOTE: Ni + Be + Ti + Cu = 99.5% min., Cu = 0.25% max.

Physical Properties (After Age Hardening)

DENSITY lb./cu. in. (gm./cc.)	THERMAL EXPANSION 68-1020° F (20-550° C)	THERMAL CONDUCTIVITY BTU/ft•hr•F (cal./cm. sec. C)	ELASTIC MODULUS Psi (MPa)	MELTING TEMPERATURE SOLIDUS F (C)	MELTING TEMPERATURE LIQUIDUS F (C)
0.299 (8.27)	8.0×10^{-6} / F 14.5×10^{-6} / C	28 (0.12)	$28\text{-}30 \times 10^{6}$ $195\text{-}210 \times 10^{6}$	2185 (1195)	2420 (1325)

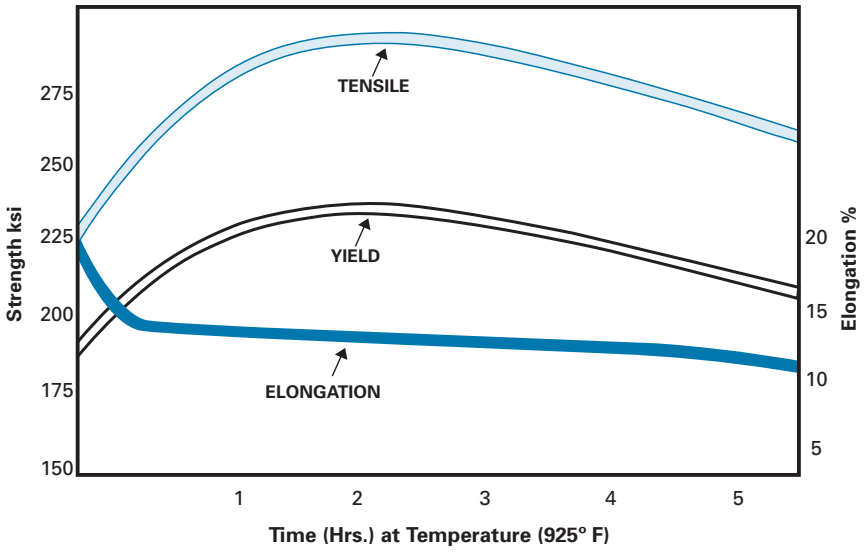
Mechanical and Electrical Properties

Temper	Heat Treatment	Tensile Strength (ksi)	Yield Strength 0.2% Offset (ksi)	Elongation in 2 inches Minimum (%)	HARDNESS		ELECTRICAL PROPERTIES	
					Diamond Pyramid	Rockwell	Minimum Conduct. (% IACS)	Max. Resistivity (Micro Ohm-Cm)
A	------	95-130	40-70	30	106-200	A39-57	4	43.1
1/4H	------	110-150	65-125	15	153-293	A50-65	4	43.1
1/2H	------	130-175	115-170	4	160-383	A51-70	4	43.1
H	------	155-190	150-190	1	180-491	A55-75	4	43.1
AT	2.5 Hr. at 925° F	215 min.	150 min.	12	343-528	15N78-86	6	28.7
1/4HT	2.5 Hr. at 925° F	230 min.	175 min.	10	383-598	15N80-88	6	28.7
1/2HT	1.5 Hr. at 925° F	245 min.	200 min.	9	395-695	15N81-90	6	28.7
HT	1.5 Hr. at 925° F	270 min.	230 min.	8	446-695	15N83-90	6	28.7
MH2	M*	155-180	100-125	14	-----	-----	5	34.5
MH4	M	180-205	120-155	12	-----	-----	5	34.5
MH6	M	200-225	150-175	10	-----	-----	5	34.5
MH8	M	220-245	170-205	9	-----	-----	5	34.5
MH10	M	240-270	200-225	8	-----	-----	5	34.5
MH12	M	260-290	220-245	8	-----	-----	5	34.5

*M - Indicates heat treatment performed at mill.

BERYLLIUM NICKEL STRIP

AGE HARDENING



Beryllium Nickel Aging Curves

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

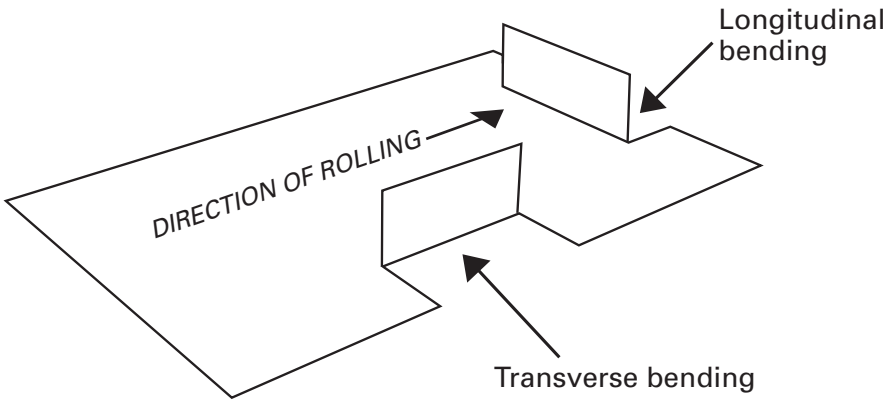
The graph shows typical aging response for ½ hard beryllium nickel strip. If your aged property requirements are different from those shown in the Mechanical and Electrical Properties table, consult your local Brush Wellman Sales Engineer or use beryllium nickel test specimens to establish exact age 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 Brush Wellman. With mill hardened material, heat treatment and associated cleaning steps are unnecessary and shrinkage is eliminated.

FORMABILITY

Both heat treatable and mill hardened beryllium nickel 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 on the following page 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.

BERYLLIUM NICKEL STRIP

RELATIVE FORMABILITY OF BERYLLIUM NICKEL STRIP

Formability Rating	Specific Formability	Rolled Tempers	Heat-Treatable Alloy Ratio (R/t) for 90° Bend Direction of Bend		MH Tempers	Mill-Hardened Alloy Ratio (R/t) for 90° Bend Direction of Bend	
			Longitudinal	Transverse		Longitudinal	Transverse
Excellent	Excellent formability, used for deep-drawn and severely cupped or formed parts; can be bent flat through 180° angle in any direction.	A 1/4H	0 0	0 0	MH2 MH4	0 0.5	0 0.5
Very Good	Very good formability, used for moderately drawn and cupped parts; formable to 90° bend around a radius.	1/2H	0.7	1.2	MH6 MH8	1.0 1.2	1.2 1.6
Good	Slightly reduced formability, formable to 90° bend around a radius.	H	1.2	2.0	MH10 MH12	1.5 2.0	2.2 3.0

*For strip up to 0.050" thick. Strip less than 0.010" thick will exhibit formability somewhat better than shown. This chart should not be used for part design since punch radius and not part dimension is used to calculate formability, and springback is not considered.

STRESS RELAXATION

The stress relaxation characteristic of a material is its resultant loss in spring force with time at constant strain and elevated temperature. Beryllium nickel resists stress relaxation better than most other spring materials.

Testing of beryllium nickel strip at stress levels of 50% and 100% of the 0.2% offset yield strength and at temperatures of 400° F for more than 10,000 hours has shown a loss in spring force of only 2% and 5% respectively.

PLATING

Brush 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 beryllium nickel.

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 solution of 20 volume percent sulfuric acid plus 2 volume percent hydrogen peroxide followed by water rinsing will remove the copper without harming the beryllium nickel. 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 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 per side.

BERYLLIUM NICKEL STRIP

HEALTH AND SAFETY

Handling beryllium nickel 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 beryllium nickel, contact Brush Wellman Inc. at 800-375-4205.

17876 St. Clair Avenue • Cleveland, OH 44110 USA
TEL: +(1) 216-486-4200 • FAX: +(1) 216-383-6868
www.brushwellman.com

Manufacturing Centers: Lorain, Ohio
Elmore, Ohio
Reading, Pennsylvania

North American Service Centers

Illinois

Brush Wellman Inc.
606 Lamont Road
Elmhurst, IL 60126
TOLL FREE: 800-323-2438
LOCAL: +(1) 630-832-9650
FAX: +(1) 630-832-9657

Michigan

Brush Wellman Inc.
27555 College Park Drive
Warren, MI 48088
TOLL FREE: 800-521-8800
LOCAL: +(1) 586-772-2700
FAX: +(1) 586-772-2472

International Service Centers

United Kingdom & Ireland

Brush Wellman Limited
Units 4/5 Ely Road
Theale Commercial Estate
Theale Reading RG7 4BQ
Berkshire, England
TEL: +(44) 118-930-3733
FAX: +(44) 118-930-3635
CONTACT: Mr. Guy Shapland
EMAIL: Guy_Shapland@brushwellman.com

Germany

Brush Wellman GmbH
Motorstrasse 34
D-70499 Stuttgart
Germany
TEL: +(49) 711-830-930
FAX: +(49) 711-833-822
CONTACT: Mr. Karl Ludwig Rausch
EMAIL: K_L_Rausch@brushwellman.com

Japan

Brush Wellman (Japan), Ltd.
Daichi Marusan Building 9
Kanda Jimbocho, 3-Chome,
Chiyoda-Ku, Tokyo 101-0051,
Japan
TEL: +(81) 33 230 2961
FAX: +(81) 33 230 2908
CONTACT: Mr. Kazuo Hase
EMAIL: Kazuo_Hase@brushwellman.com

Singapore/Asean

Brush Wellman
(Singapore) Pte Ltd.
110 Paya Lebar Road #02-01
Singapore 409009
TEL: +(65) 6842-4456
FAX: +(65) 6842-6646
CONTACT: Mr. Tony Ong
EMAIL: Tony_Ong@brushwellman.com

China/Hong Kong

Brush International, Inc.
Hong Kong Representative Office
Room 604, Blk 1, Enterprise Square
9 Sheung Yuet Road,
Kowloon Bay, Kowloon
Hong Kong
TEL: + (852) 2318-1960 / 1907
FAX: + (852) 2318-1879
CONTACT: Mr. Jeffrey Oei
EMAIL: Jeffrey_Oei@brushwellman.com

China/Shanghai

Brush Wellman (Singapore) Pte Ltd.
Shanghai Representative Office
22B HuaMin Empire Plaza,
No.726 Yan An West Road
Shanghai 200050, P.R.C
TEL: + (86) 21-5237-2328
FAX: + (86) 21-5237-2823
CONTACT: Mr. Levis Jin
EMAIL: Levis_Jin@brushwellman.com

Republic of Korea

Brush Wellman (Japan), Ltd.
Korean Representative Office
Room No. 621, Iriom Bldg, 599-1
Yeonsu-2 Dong
Yeonsu-Ku, Incheion City, Korea
TEL: +(82) 32-811-2171
FAX: +(82) 32-811-2175
CONTACT: Mr. Yun Joo Kim
EMAIL: Yun_Joo_Kim@brushwellman.com

Taiwan, R.O.C.

Brush International, Inc.
Taiwan Representative Office
11th FL-6, No. 188 Section 5,
Nanking East Road,
Taipei, Taiwan, Republic of China
TEL: +(886) 2-2747-8800 x-121
FAX: +(886) 2-2747-1485
CONTACT: Kevin Wang
EMAIL: Kevin_Wang@brushwellman.com

AD0005/0107