AMETEK®
SPECIALTY METAL PRODUCTS

HIGH PURITY NICKEL STRIP

FOR HIGH PERFORMANCE BATTERY APPLICATIONS

AMETEK Specialty Metal Products manufactures High Purity Nickel Strip using Wrought Powder Metallurgy. The 99.98% purity of the material achieves high electrical conductivity delivering greater power transmission.

AMETEK
SPECIALTY METAL PRODUCTS
ULTRA POWER
NICKEL STRIP

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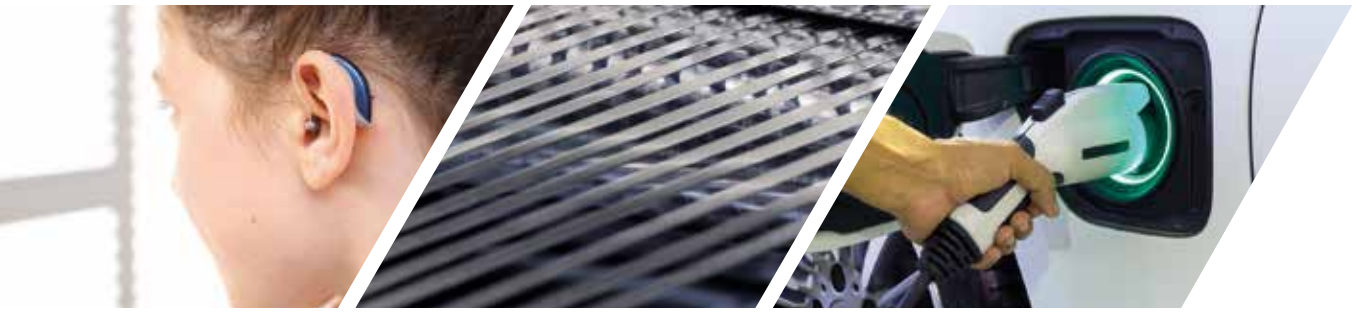


ADVANTAGES

Our High Purity Nickel strip offers major advantages to the rechargeable battery industry:

- Lowest electrical resistivity available in pure nickel strip
- Homogeneity microcleanliness, and close composition control enhances weldability
- Significantly low levels of surface oxides reduces die wear and provides excellent solderability
- Excellent formability

Typical applications for rechargeable batteries include computers, cellular phones, cardiac pacemaker cells, power tools, electric vehicles, aerospace batteries and defense / military.

Chemical Composition In Percent *(Maximum values except where noted otherwise)*

	899A	899L	899M	899D	899E	899G	ASTM B-162; UNS	
	HIGH PURITY			DISPERSED PHASE			N02200	N02233
Nickel-Nominal	99.97[(a)]	99.8	99.6	99.6	99.5	99.6	-	-
C-Nominal	0.005	0.005	0.005	0.01	0.01	0.01	-	-
C	0.02	0.02	0.02	0.02	0.02	0.02	0.15	0.15
Si	0.001	0.001	0.001	0.002	0.002	0.002	0.35	0.10
Mn	0.001	0.07	0.25	0.25	0.25	0.022-0.042	0.35	0.30
S	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.008
Cu	0.001	0.005	0.005	0.005	0.005	0.01	0.25	0.10
Fe	0.005	0.05	0.05	0.05	0.05	0.05	0.40	0.10
Sn	-	-	-	-	0.07	-	-	-
Mg	-	-	-	0.035	0.0035	0.006-0.014	-	0.10
Equivalent	N02270	N02200 N02201	N02200 N02201	N02233	N02201	N02205	-	-

(a) This is a minimum, not nominal value.

Electrical Resistivity At 70°F For 899 Nickel *(OHM/CMF)*

NICKEL GRADE	ANNEALED	50% COLD WORK
899A	44.5	45.0
899L	45.1 [a]	45.6
899M	46.7	47.2
899D	47.3	47.8
899E	48.1	48.6
899G	45.0	45.5
COMPARATIVE DATA FOR WROUGHT AND CAST NICKEL		
UNS N02270	45.0 [b]	-
UNS N02201	59.6	62.2
UNS N02201	52.0 [b]	-
UNS N02200	57.0	59.2

(a) Wrought powder metallurgy (b) Handbook value

Softening Temperature For 899 Nickel

TYPE	GRADE	SOFTENING POINT FOR 50% COLD ROLLED TEMPER	
		SOFTENING CURVE[1] KNEE, TEMPERATURE °F	HALF HARD SOFTENING[2] TEMPERATURE °F
H.P.	A	640	680
H.P.	L	750	800
H.P.	M	870	910
D.P.	D	910	970
D.P.	E	960	1010
D.P.	G	710	750

[1] *Approximate temperature at which rapid softening occurs. Refer to included softening curves.*
[2] *Defined as that temperature at which one half of the hardness imparted by cold rolling is lost during 30 minutes time at temperature softening test.*

Mechanical Property Comparisons *(899 Nickels in the 50% Cold Rolled and Annealed (30 min. at 1450°F) Condition)*

ANNEALED PROPERTIES						50% COLD ROLLED PROPERTIES			
TYPE	GRADE	TENSILE STRENGTH KSI	YIELD STRENGTH KSI	ELONGATION % IN 2 INCHES	VICKER HARDNESS	TENSILE STRENGTH Ksi	YIELD STRENGTH Ksi	ELONGATION % IN 2 INCHES	VICKER HARDNESS
H.P.	A	53.0	15.0	44	70	93.5	90.5	2-10	203
H.P.	L	53.5	15.5	44	73	97.0	94.0	2-8	208
H.P.	M	57.5	16.5	43	78	98.5	95.5	2-5	210
D.P.	D	59.2	18.5	42	85	101.0	99.0	2-5	220
D.P.	E	61.0	20.0	42	86	102.0	100.0	2-5	224
COMPARATIVE DATA FOR WROUGHT AND CAST ALLOYS									
UNS N02201		57.7	17.3	42	95	98.5	96.5	1-4	209

Range Of Typical Mechanical Properties For 899 A-L-M Nickels

TEMPER	UTS	0.2% YS	ELONGATION	ROCKWELL B	VICKERS HARDNESS
Annealed	50-58	15-20	40-45	46 max.	64-90
Skin Hard	52-65	20-45	30-40	64-70	110-126
1/4 Hard	55-70	25-55	20-35	70-80	120-151
1/2 Hard	60-80	50-75	15-25	79-86	148-171
3/4 Hard	70-90	65-85	5-10	85-91	168-193
Hard	85-100	80-95	3-6	91 min.	193-203
Full Hard	94-103	90-100	12	93 min.	>203

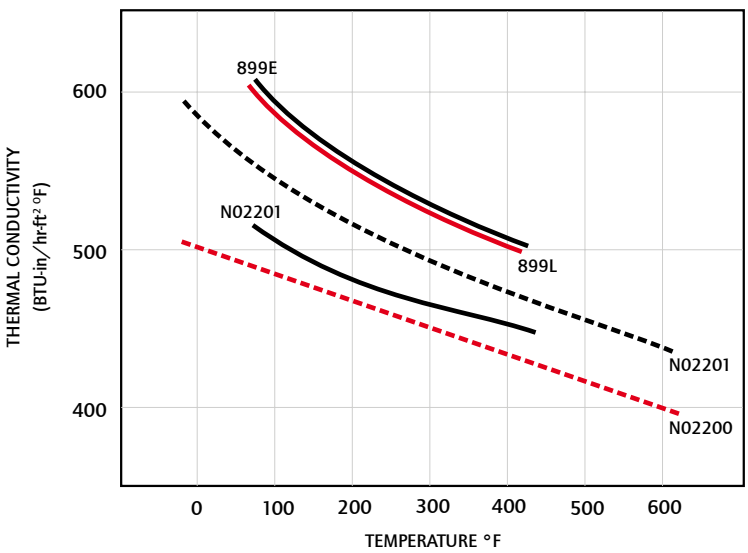
899 Nickel Strip meets ASTM B-162, ASTM F-3, ASTM F-239, MIL-N-19153 and MIL-N-46025

Recrystallization Grain Growth Comparison *(AMETEK Wrought Powder Metallurgy Nickel and Wrought Cast Nickel)*

	ASTM GRAIN SIZE AFTER INDICATED HEAT TREATMENT, °F					
NI GRADE	ASTM GRAIN SIZE BEFORE 50% COLD ROLLED	30 MIN./ 1200°F	30 MIN./ 1450°F	1 HR./ 1800°F	1 HR./ 2000°F	1 HR./ 2200°F
899A	7.5	7.0	7.0	7.0	2.0	2.0
899L	8.5	8.5	8.0	7.5	7.0	5.0
899M	8.0	8.0	7.5	7.5	7.0	5.5
899D	10.0	10.0	9.0	9.0	9.0	8.5
899E	10.0	10.0	9.0	9.0	9.0	8.5
899G	9.0	9.0	8.5	8.0	7.5	7.0
N02233	8.0	8.0	6.5	4.5	3.5	2.5
N02201	8.0	8.0	7.5	3.0	2.0	2.0

Specifications Subject to Change Without Notice.

THERMAL CONDUCTIVITY



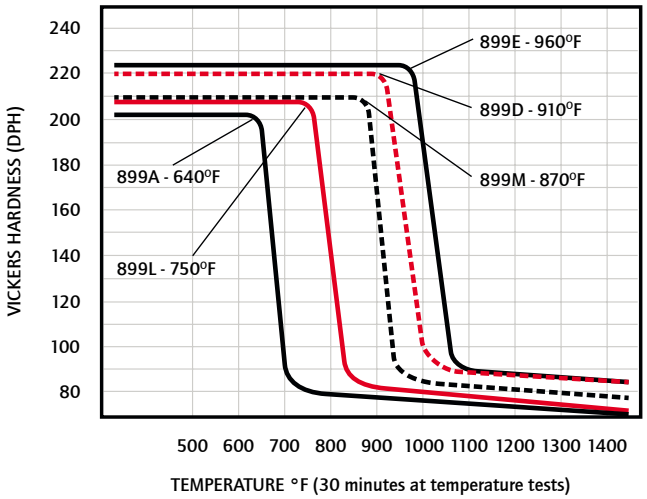
Typical Handbook Data

Independent Lab Results

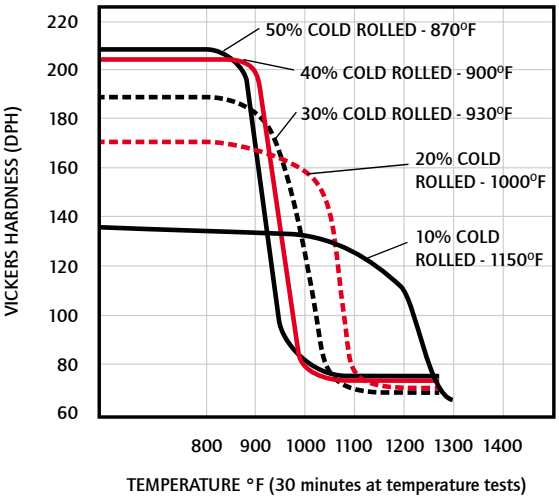
AMETEK 899E and 899L have highest thermal conductivity. Exceed N02201 and N02200.

TYPICAL SOFTENING CURVES

Selected 50% cold rolled 899 Nickel grades

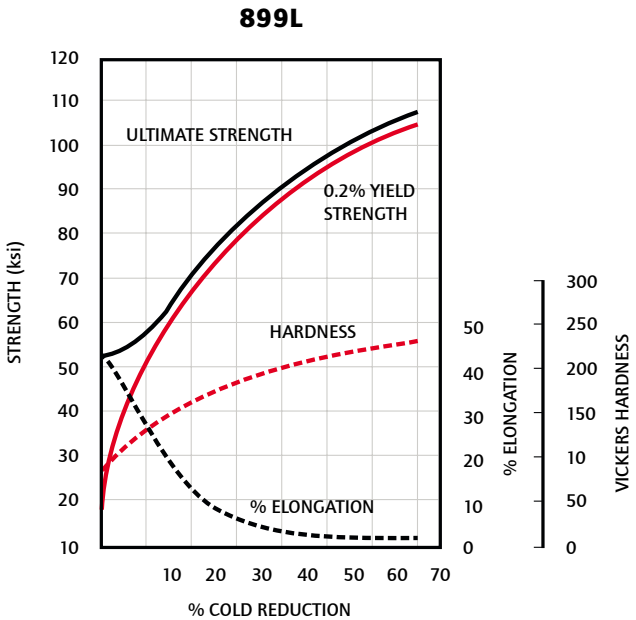


899M Nickel (0.2% Mn)

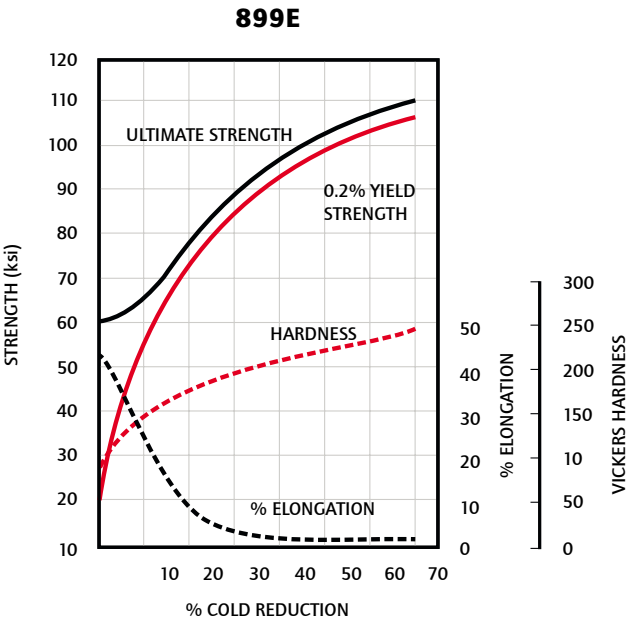


TYPICAL COLD ROLLED CURVES

899L



899E



HIGH PURITY NICKEL STRIP FOR BATTERY APPLICATIONS

SPECIFICATIONS

PHYSICAL PROPERTIES
(Typical handbook values for pure nickel)

DENSITY AT 70°F
8.90 g/cc; 0.322 lb./cu. in.

COEFFICIENT OF LINEAR EXPANSION
(IN./IN.-°C)
20-100°C 0.000014
20-200°C 0.000014
20-500°C 0.000015
20-700°C 0.000016

YOUNG'S MODULUS, E, PSI X 10^{-6}
30.1

ELECTRICAL CONDUCTIVITY
22.6% IACS

ELECTRICAL RESISTIVITY AT 20°C
microhm, cm: 7.63
ohms/cir. mil./ft.: 45.9

THERMAL CONDUCTIVITY
70 W/m-K
487 BTU-in/hr-ft^2 °F

TEMPERATURE COEFFICIENT OF ELECTRICAL RESISTIVITY
20-100°C 0.0058
20-500°C 0.0074
20-800°C 0.0060

ATOMIC NUMBER
28

ATOMIC WEIGHT
58.1

ATOMIC RADIUS (A)
1.25

CRYSTAL STRUCTURE
f.c.c.

LATTICE CONSTANT "a" (A)
3.52

MELTING POINT
1,453° C; 2,647°F

LATENT OF HEAT FUSION
73.8 cal./g.

SPECIFIC HEAT AT 20°C-BTU/lb./°F
0.105

ELECTRODE POTENTIAL
0.25 volts

VELOCITY OF SOUND
16,300 ft./sec.; 4,973 m/sec.

POISSON'S RATIO
0.31

THERMAL NEUTRON CROSS SECTION (BARNS)
Absorption: 4.6
Scattering: 17.5

CURIE TEMPERATURE
353° C; 665°F

MAGNETIC PROPERTIES
(Typical handbook values for pure nickel)

CURIE TEMPERATURE
353°C; 665°F

INITIAL PERMEABILITY
130

MAXIMUM PERMEABILITY
124

SATURATION INDUCTION, GAUSS (B)
6050

REMANENCE, GAUSS (B)
3250

COERCIVITY, OERSTEDS (H)
3.0

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