



## METAL STRIP PRODUCTS

# High Purity Nickel Strip

**ISO 9001:2000**

### ADVANTAGES

AMETEK High Purity Nickel 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: Computers, PDA, Cellular Phones, Power Tools, Electric Vehicles, Pagers and Camcorders.**

### CHEMICAL COMPOSITION IN PERCENT Maximum values except where noted otherwise

	899A	899L	899M	899D	899E	899G	ASTM B-162; UNS	
	HIGH PURITY			DISPERSED PHASE			NO2200	NO2233
<b>Nickel-Nominal</b>	99.97 <sup>(a)</sup>	99.8	99.6	99.6	99.5	99.6	-	-
<b>C-Nominal</b>	0.005	0.005	0.005	0.01	0.01	0.01	-	-
<b>C</b>	0.02	0.02	0.02	0.02	0.02	0.02	0.15	0.15
<b>Si</b>	0.001	0.001	0.001	0.002	0.002	0.002	0.35	0.10
<b>Mn</b>	0.001	0.07	0.25	0.25	0.25	0.022-0.042	0.35	0.30
<b>S</b>	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.008
<b>Cu</b>	0.001	0.005	0.005	0.005	0.005	0.01	0.25	0.10
<b>Fe</b>	0.005	0.05	0.05	0.05	0.05	0.05	0.40	0.10
<b>Sn</b>	-	-	-	-	0.07	-	-	-
<b>Mg</b>	-	-	-	0.035	0.0035	0.006-0.014	-	0.10
<b>Equivalent</b>	NO2270	NO2200 NO2201	NO2200 NO2201	NO2233	NO2201	NO2205		

(a) This is a minimum not nominal value.

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# High Purity Nickel Strip

## 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<sup>6</sup>

30.1

#### ELECTRICAL CONDUCTIVITY

22.6% IACS

#### ELECTRICAL RESISTIVITY AT 20° C

microhm, cm: 7.63

ohms/cir. mil./ft.: 45.9

#### THERMAL CONDUCTIVITY

cal./cm.<sup>2</sup>/sec./cm. at 70° C: 0.206

BTU/ft.<sup>2</sup>/hr./°F/ft. at 158° C: 49.9

#### TEMPERATURE COEFFICIENT OF ELECTRICAL RESISTIVITY

20-100° C/°C 0.0058  
20-500° C/°C 0.0074  
20-800° C/°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

#### BOILING POINT

2,730° C; 4,950° 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

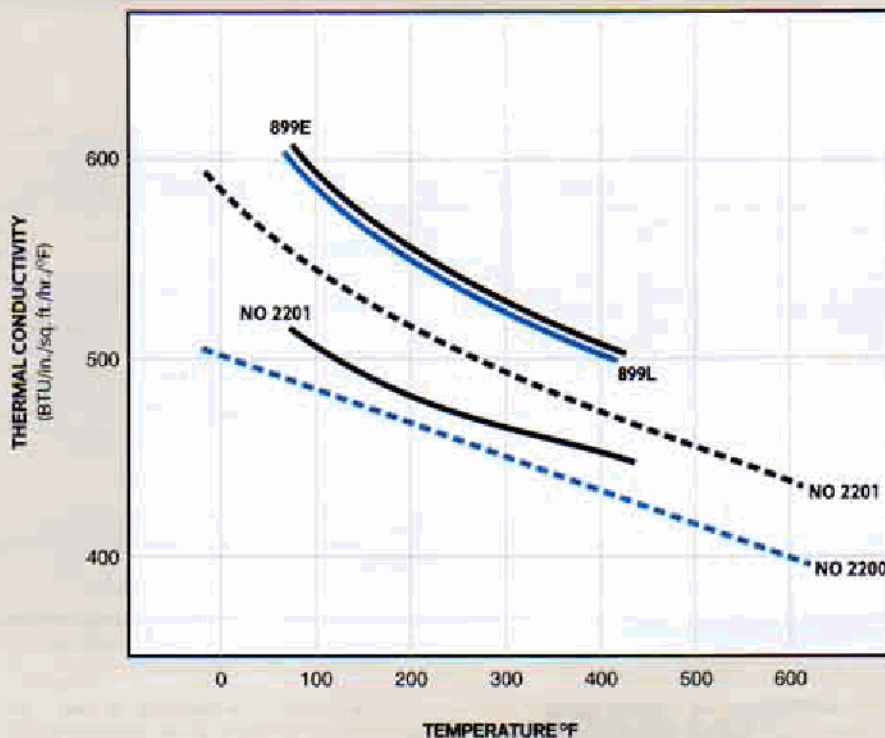
#### REMANENCE, GAUSS (B)

3250

#### COERCIVITY, OERSTEDS (H)

3.0

## THERMAL CONDUCTIVITY



--- TYPICAL HANDBOOK DATA  
— INDEPENDENT LAB RESULTS

AMETEK 899E and AMETEK 899L have highest thermal conductivity. Exceed NO 2201 and NO 2200.

**ELECTRICAL RESISTIVITY AT 70° F FOR 899 NICKEL** OHM/CMF

NICKEL GRADE	ANNEALED	50% COLD WORK
899A	44.5	45.0
899L	45.1 <sup>(a)</sup>	45.6
899M	46.7	47.2
899D	47.3	47.8
899E	48.1	48.6
899G	45.0	45.5
<b>COMPARATIVE DATA FOR WROUGHT AND CAST NICKEL</b>		
UNS NO 2270	45.0 <sup>(b)</sup>	-
UNS NO 2201	59.6	62.2
UNS NO 2201	52.0 <sup>(b)</sup>	-
UNS NO 2200	57.0	59.2

(a) Wrought powder metallurgy (b) Handbook value (c) Special grade with 44 maximum value available

**SOFTENING TEMPERATURES FOR 899 NICKEL**

TYPE	GRADE	SOFTENING POINT FOR 50% COLD ROLLED TEMPER	
		SOFTENING CURVE <sup>1</sup> KNEE, TEMPERATURE °F	HALF HARD SOFTENING <sup>2</sup> 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

<sup>1</sup> Approximate temperature at which rapid softening occurs. Refer to included softening curves.

<sup>2</sup> 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

TYPE	GRADE	ANNEALED PROPERTIES				50% COLD ROLLED PROPERTIES			
		TENSILE STRENGTH ksi	YIELD STRENGTH ksi	ELONGATION % in 2 INCHES	VICKERS HARDNESS	TENSILE STRENGTH ksi	YIELD STRENGTH ksi	ELONGATION % in 2 INCHES	VICKERS HARDNESS
H. P.	A	53.0	15.0	44	70	93.5	90.5	2	203
H. P.	L	53.5	15.5	44	73	97.0	94.0	2	208
H. P.	M	57.5	16.5	43	78	98.5	95.5	2	210
D. P.	D	59.2	18.5	42	85	101.0	99.0	2	220
D. P.	E	61.0	20.0	42	86	102.0	100.0	2	224
<b>COMPARATIVE DATA FOR WROUGHT AND CAST ALLOYS</b>									
UNS NO 2201		57.7	12.3	42	70	92.5	91.8	2	209

**RANGE OF TYPICAL MECHANICAL PROPERTIES FOR 899 A-L-M NICKELS**

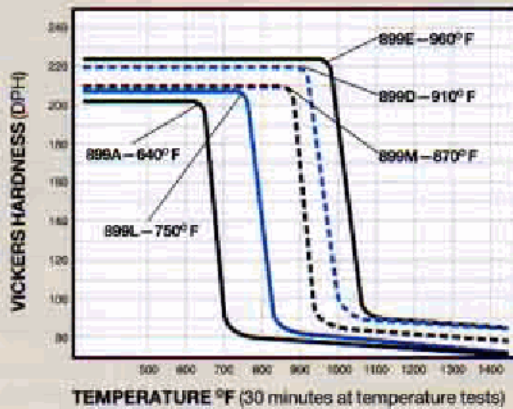
TEMPER	UTS	0.2% YS	ELONGATION	ROCKWELL B	VICKERS HARDNESS
Annealed	50-58	15-20	40-45	46 Max.	64-90
Skin Hard	52-65	20-45	30-40	64-70	110-126
1/4 Hard	55-70	25-55	20-35	70-80	120-151
1/2 Hard	60-80	50-75	15-25	79-86	148-171
3/4 Hard	70-90	65-85	5-10	85-91	168-193
Hard	85-100	80-95	3-6	91 Min.	193-203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

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

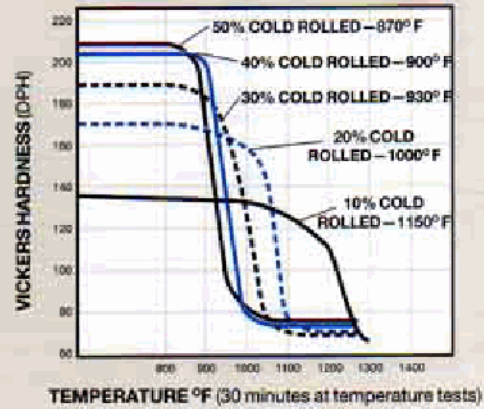
# High Purity Nickel Strip

## TYPICAL SOFTENING CURVES

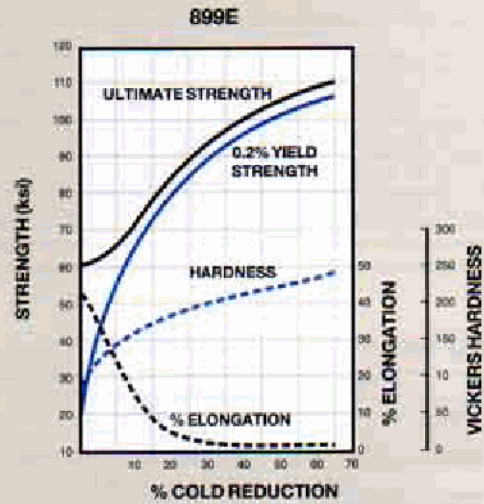
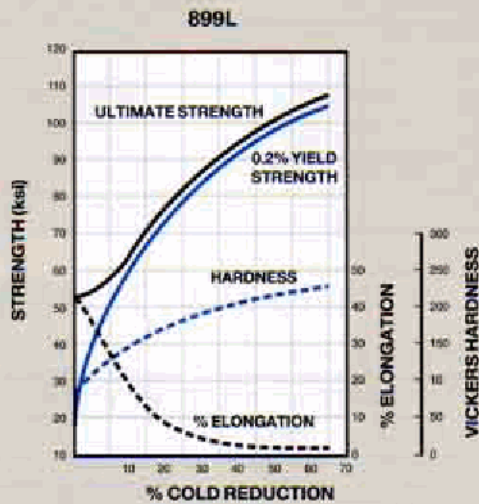
SELECTED 50% COLD ROLLED 899 NICKEL GRADES



899M NICKEL (0.2% MN)



## TYPICAL COLD ROLLED CURVES



RECRYSTALLIZATION GRAIN GROWTH COMPARISON AMETEK wrought powder metallurgy nickel and wrought cast nickel

NI GRADE	ASTM GRAIN SIZE BEFORE 50% COLD ROLLED	ASTM GRAIN SIZE AFTER INDICATED HEAT TREATMENT, °F				
		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
NO2233	8.0	8.0	6.5	4.5	3.5	2.5
NO2201	8.0	8.0	7.5	3.0	2.0	2.0

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

**AMETEK®**

SPECIALTY METAL PRODUCTS

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