# 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**
cal./cm.$^2$/sec. °C/cm. at 70° C: 0.206
B.T.U./ft.$^2$/hr./°F/ft. at 158° C: 49.9

**TEMPERTURE 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

**LATENT OF HEAT FUSION**
73.8 cal./g.

**SPECIFIC HEAT AT 20° C-B.T.U./lb./°F**
0.105

**ELECTRODE POTENIAL**
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

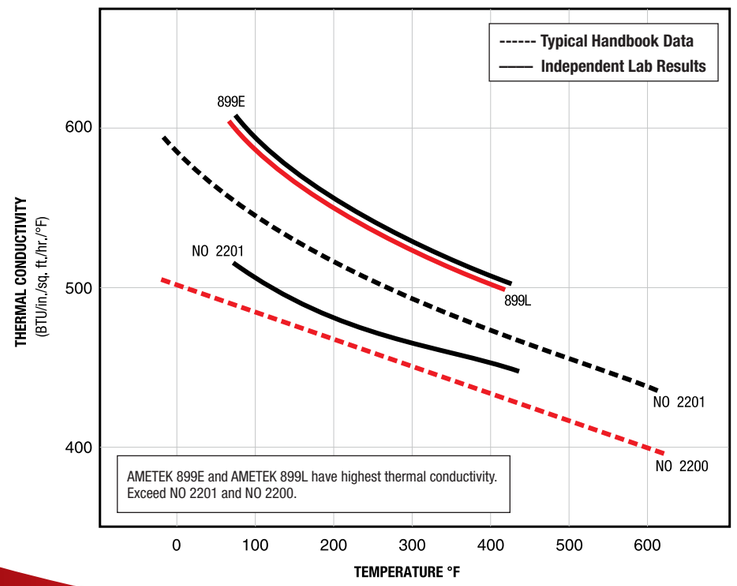
**MAXIMUM PERMEABILITY**
124

**SATURATION INDUCTION, GAUSS (B)**
6050

**REMANENCE, GAUSS (B)**
3250

**COERCIVITY, OERSTEDS (H)**
3.0

## THERMAL CONDUCTIVITY





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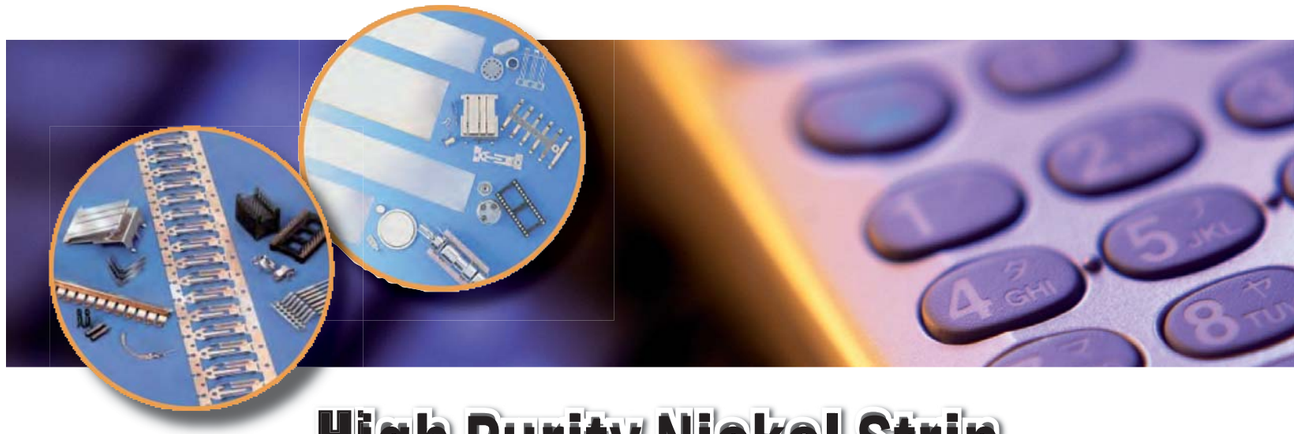
# TECH BRIEFS



# High Purity Nickel Strip

## Advantages

AMETEK High Purity Nickel offers advantages to the rechargeable battery industry. Typical applications for rechargeable batteries include computers, PDA, cellular phones, power tools, electric vehicles, pagers and camcorders. Other advantages offer:

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

## 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 |
| **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** | NO2270 | NO2200 NO2201 | NO2200 NO2201 | NO2233 | NO2201 | NO2205 | | |

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



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

| NICKEL GRADE | ANNEALED | 50% COLD WORK |
|---|---|---|
| 899A | 44.5 | 45.0 |
| 899L | 45.1[c] | 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 NO 2270 | 45.0[a] | - |
| UNS NO 2201 | 59.6 | 62.2 |
| UNS NO 2201 | 52.0[b] | - |
| UNS NO 2200 | 57.0 | 59.2 |

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

## 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 | 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 | 2 | 220 |
| D.P. | E | 61.0 | 20.0 | 42 | 86 | 102.0 | 100.0 | 2 | 224 |
| **COMPARATIVE DATA FOR WROUGHT AND CAST ALLOYS** | | | | | | | | | |
| UNS NO 2201 | | 57.7 | 122.3 | 42 | 70 | 92.5 | 91.8 | 2 | 209 |

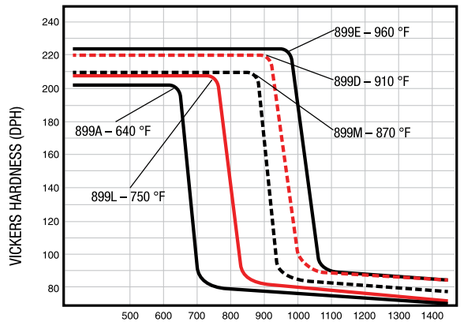
## RANGE OF TYPICAL MECHANICAL PROPERTIES FOR 899 A-L-M NICKELS

| 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 | 12 | 93 min. | >203 |

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

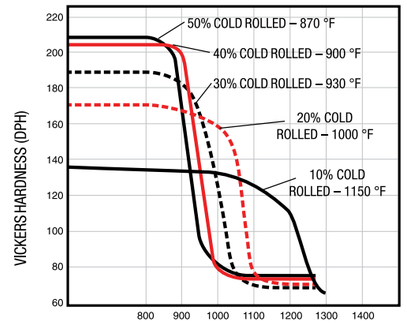
## TYPICAL SOFTENING CURVES

**SELECTED 50% COLD ROLLED 899 NICKEL GRADES**




TEMPERATURE °F (30 minutes at temperature tests)

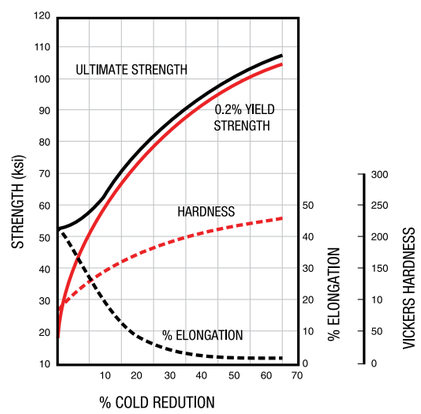
**899M NICKEL (0.2% MN)**



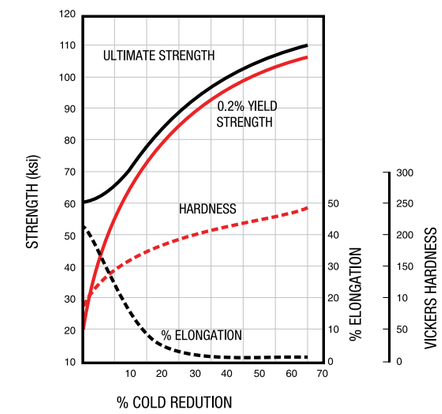

TEMPERATURE °F (30 minutes at temperature tests)

## TYPICAL COLD ROLLED CURVES

**899L**




**899E**




## 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.***