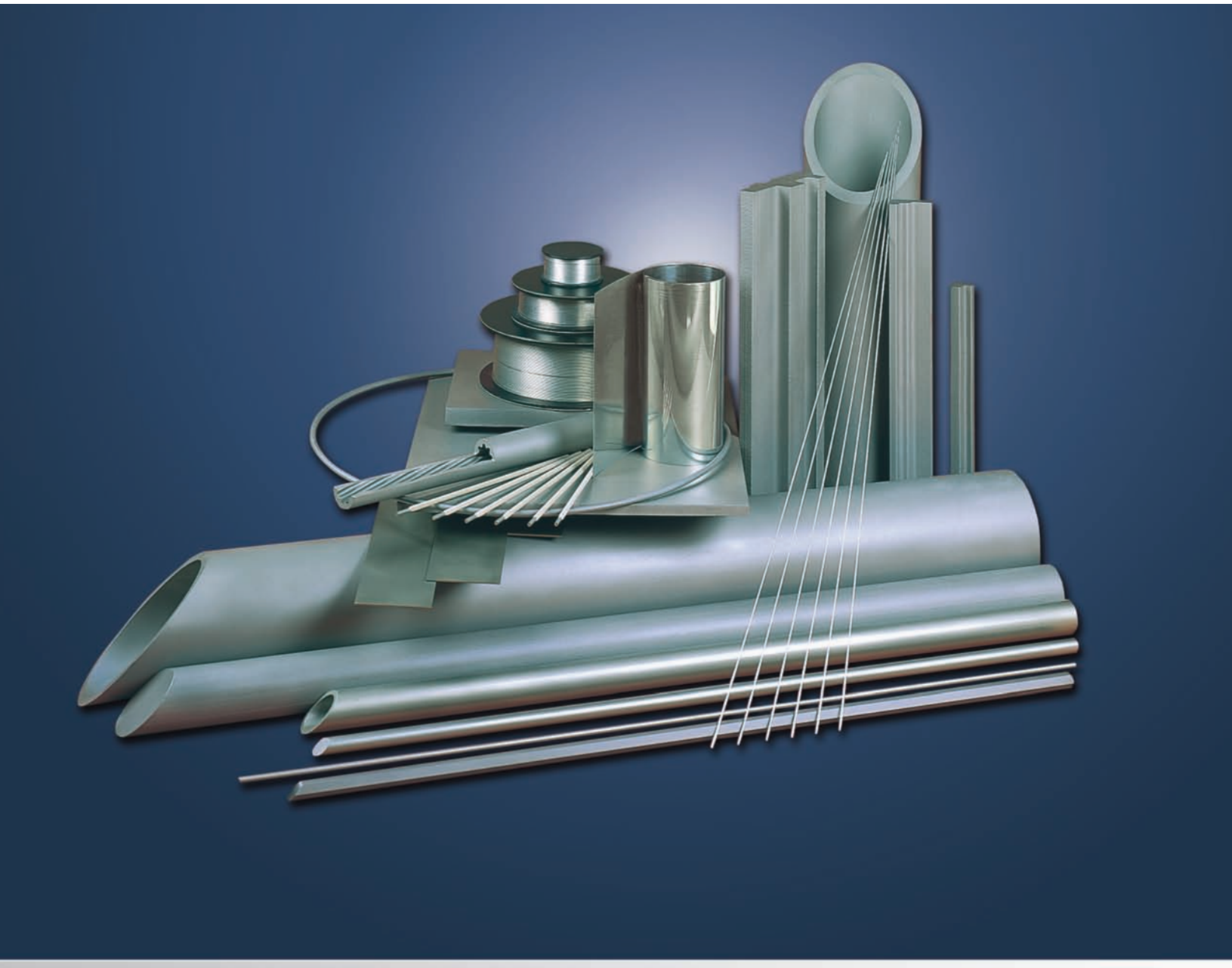
SPECIAL METALS

A PCC Company

Product Handbook

of High-Performance Alloys



THE ALLOY EXPERTS

PRODUCT FAMILIES INCLUDE:
NICKEL, MONEL, INCONEL,
INCOLOY, NIMONIC, BRIGHTRAY,
NILO AND OTHER ALLOYS

Contents

Special Metals Corporation produces high-performance nickel-base alloys at (top to bottom) New Hartford, NY and Huntington, WV, U.S.A., and Hereford, United Kingdom.

SPECIAL METALS
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PRODUCT HANDBOOK
OF HIGH-PERFORMANCE ALLOYS

Notes on Product Handbook Data

Property data contained in this publication are typical of the materials described but are not suitable for specifications unless given as limiting. Values for properties are expressed in both U.S. customary units and the International System of Units (SI). Values may have been measured in either system or may be rounded conversions from those or other systems.

Mechanical properties are for usual product sizes and may not represent large or small sections. Some rupture-strength values were derived from the Larson-Miller parameter and may not be the results of actual tests under stated conditions.

Property data are room-temperature values unless otherwise noted.

Publication No. SMC-035

Special Metals Corporation is the world's leading developer and manufacturer of nickel alloys. We offer the industry's widest range of products, all backed by over 100 years of experience in nickel alloy technology. Most of our products are used for corrosion-resistance or strength at high temperatures. Some are specified for physical properties such as electrical resistance, controlled thermal expansion or magnetic characteristics. This publication outlines the availability of over 90, mostly nickel base, alloy compositions, of which over 80% were created in our own laboratories.

Manufacturing

Alloying processes include electric arc, air induction and vacuum induction melting. A few of our most specialized superalloys are made by the mechanical alloying process. Refining facilities include AOD and vacuum refining, and vacuum arc and electroslag remelting. Hot working includes forging, hot rolling and extrusion. Cold working covers rolling, drawing and pilgering. For technical assistance, please contact any SMC Marketing Department location to review your specific alloy application.

Quality Standards

All of our operations, in the U.S.A. and Great Britain, work to quality management standards audited and certified to ISO 9001, to produce alloy compositions and forms to national and internationally recognized standards, or to customers' own specifications.

Distribution

Available direct from the manufacturer, most of our products are also supplied from distributor stocks in most of the industrialized countries of the world. For a list of SMC worldwide distributors, please contact any SMC location or office.

Additional Information

Comprehensive product data sheets and bulletins on Special Metals High-Performance Alloys are available via phone or fax from the offices listed on the back cover and are also posted on our website **www.specialmetals.com**. Technical and commercial inquiries may be entered on the website as well.

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Nickel 200

Commercially pure (99.6%) wrought nickel with good mechanical properties and resistance to a range of corrosive media. Good thermal, electrical, and magnetostrictive properties. Used for a variety of processing equipment, particularly to maintain product purity in handling foods, synthetic fibers, and alkalies.

Nickel 201

Commercially pure (99.6%) wrought nickel essentially the same as Nickel 200 but with a lower carbon content to prevent embrittlement by intergranular carbon at temperatures over 600°F (315°C). Lower carbon content also reduces hardness, making Nickel 201 particularly suitable for cold-formed items.

Standard Product Forms

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Major Specifications

UNS N02200
BS 3072 – 3076 (NA11)
ASTM B 160 – B 163, B 366, B 564, B 725, B 730, B 751, B 775, B 829
ASME SB-160 – SB-163, SB-366, SB-564, SB-725, SB-730, SB-751, SB-775, SB-829
ASME Code Case 2249
DIN 17740, 17750 – 17754
Werkstoff Nr. 2.4060, 2.4066
ISO 6207, 6208, 9723 – 9725

UNS N02201
BS 3072 – 3074 (NA12)
ASTM B 160 – B 163, B 366, B 725, B 730, B 751, B 775, B 829
ASME SB-160 – SB-163, SB-366, SB-725, SB-730, SB-751, SB-775, SB-829
ASME Code Case 2249
SAE AMS 5553
DIN 17740, 17750 – 17754
Werkstoff Nr. 2.4061, 2.4068
VdTÜV 345
ISO 6207, 6208, 9723 – 9725

Limiting Chemical Composition, %

Ni[a] .....99.0 min.
Cu .....0.25 max.
Fe .....0.40 max.
Mn.....0.35 max.
C .....0.15 max.
Si .....0.35 max.
S .....0.01 max.

[a]Plus Co.

Ni[a] .....99.0 min.
Cu .....0.25 max.
Fe .....0.40 max.
Mn.....0.35 max.
C .....0.02 max.
Si .....0.35 max.
S .....0.01 max.

[a]Plus Co.

Physical Constants and Thermal Properties

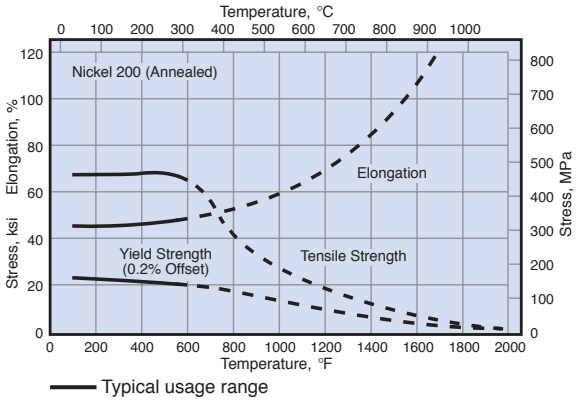
Density, lb/in³	0.321
g/cm³	8.89
Melting Range, °F	2615 – 2635
°C	1435 – 1446
Specific Heat, Btu/lb •°F	0.109
J/kg • °C	456
Curie Temperature, °F	680
°C	360
Permeability	Ferromagnetic
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F	7.4
21 – 93°C, μm/m • °C	13.3
Thermal Conductivity, Btu • in/ft²•h•°F	487
W/m•°C	70.2
Electrical Resistivity, ohm•circ mil/ft	58
μΩ•m	0.096

Density, lb/in³	0.321
g/cm³	8.89
Melting Range, °F	2615 – 2635
°C	1435 – 1446
Specific Heat, Btu/lb •°F	0.109
J/kg • °C	456
Curie Temperature, °F	680
°C	360
Permeability	Ferromagnetic
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F	7.3
21 – 93°C, μm/m • °C	13.1
Thermal Conductivity, Btu • in/ft²•h•°F	550
W/m•°C	79.3
Electrical Resistivity, ohm•circ mil/ft	51
μΩ•m	0.085

Typical Mechanical Properties

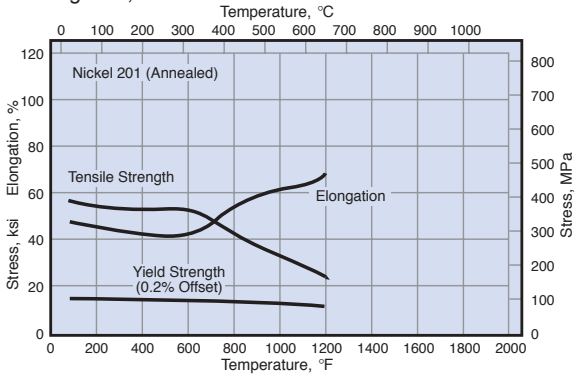
(Annealed)

Tensile Strength, ksi	67
MPa	462
Yield Strength (0.2% Offset), ksi	21.5
MPa	148
Elongation, %	47



(Annealed)

Tensile Strength, ksi	58.5
MPa	403
Yield Strength (0.2% Offset), ksi	15
MPa	103
Elongation, %	50



SPECIAL METALS
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Nickel 212

Wrought nickel strengthened with an addition of manganese. Used for electrical and electronic applications such as lead wires, supporting components in lamps and cathode-ray tubes, and electrodes in glow-discharge lamps.

Nickel 270

A high-purity grade of nickel made by powder metallurgy. It has a low base hardness and high ductility. Its extreme purity is useful for components of hydrogen thyratrons. It is also used for electrical resistance thermometers.

Standard Product Forms

Wire.

Strip, round bar and wire.

Major Specifications

DIN 17741, 17750 – 17753
Werkstoff Nr. 2.4110

UNS N02270 Werkstoff Nr. 2.4050
ASTM F 3

Limiting Chemical Composition, %

Ni[a] .....97.0 min. C.....0.10 max. Mg.....0.20 max.
Mn..... 1.5 – 2.5 Cu.....0.20 max.
Fe .....0.25 max. Si .....0.20 max.

[a]Plus Co.

Ni[a] .....99.9 min. Mn....0.003 max. Ti.....0.005 max.
Cu.....0.01 max. C..... 0.02 max. Mg....0.005 max.
Fe .....0.05 max. S .....0.003 max. Si .....0.005 max.

[a]Plus Co.

Physical Constants and Thermal Properties

Density, lb/in^3 .....0.320
g/cm^3 .....8.86

Melting Range, °F..... 2615 – 2635
°C..... 1435 – 1446

Specific Heat, Btu/lb • °F 0.103
J/kg • °C.....430

Coefficient of Expansion, 68 – 212°F, 10^{-6} in/in • °F ...7.2
20 – 100°C, μm/m • °C 12.9

Thermal Conductivity, Btu • in/ft^2•h•°F 305
W/m•°C.....44.0

Electrical Resistivity, ohm•circ mil/ft.....66
$\mu\Omega$•m 0.109

Density, lb/in^3 .....0.322
g/cm^3 .....8.91

Melting Point, °F 2650
°C.....1454

Specific Heat, Btu/lb •°F.....0.110
J/kg • °C 460

Permeability..... Ferromagnetic

Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F ...7.4
20 – 95°C, μm/m • °C 13.3

Thermal Conductivity, Btu • in/ft^2•h•°F 595
W/m • °C 86

Electrical Resistivity, ohm•circ mil/ft.....45
$\mu\Omega$•m 0.075

Typical Mechanical Properties

(Annealed)

Tensile Strength, ksi 50
MPa.....345

Yield Strength (0.2% Offset), ksi 16
MPa.....110

Elongation, % 50

SPECIAL METALS
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DURANICKEL® alloy 301

An age-hardened alloy that combines the excellent corrosion resistance characteristics of Nickel 200 with the added advantages of greater strength and hardness. The alloy is used for springs requiring high electrical conductivity, parts of equipment requiring good thermal conductivity, and magnetostrictive units which are operated under stress conditions for which the fatigue strength of Nickel 200 is inadequate.

MONEL® alloy 400

A nickel-copper alloy with high strength and excellent corrosion resistance in a range of media including sea water, hydrofluoric acid, sulfuric acid, and alkalies. Used for marine engineering, chemical and hydrocarbon processing equipment, valves, pumps, shafts, fittings, fasteners, and heat exchangers.

Standard Product Forms

Round bar and wire.

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Major Specifications

UNS N03301

UNS N04400
BS 3072 – 3076 (NA13)
ASTM B 127, B 163 – B 165, B 366, B 564, B 725, B 730, B 751, B 775, B 829
ASME SB-127, SB-163 – SB-165, SB-366, SB-564, SB-725, SB-730, SB-751, SB-775, SB-829
AECMA Pr EN 2305
SAE AMS 4544, 4574, 4675, 4730, 4731, 7233
DIN 17743, 17750 – 17754
Werkstoff Nr. 2.4360, 2.4361
VdTÜV 263
QQ-N 281
NACE MR-0175/ISO 15156

Limiting Chemical Composition, %

Ni[a] .....93.0 min.	Cu .....0.25 max.	Si .....1.00 max.
Mn.....0.50 max.	Fe .....0.60 max.	S .....0.01 max.
Ti..... 0.25 – 1.00	C.....0.30 max.	Al ....4.00 – 4.75

[a]Plus Co.

Ni[a] .....63.0 min.	Mn.....2.0 max.	Si .....0.5 max.
Cu ....28.0 – 34.0	C.....0.3 max.	
Fe .....2.5 max.	S .....0.024 max.	

[a]Plus Co.

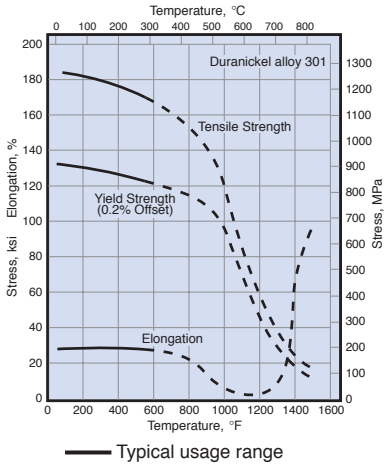
Physical Constants and Thermal Properties

Density, lb/in^3 (g/cm^3) 0.296 (8.19)
Melting Range, °F (°C) .....2550 – 2620 (1400 – 1440)
Specific Heat, Btu/lb • °F (J/kg • °C) 0.104 (435)
Curie Temperature[A], °F (°C) 200 (95)
Permeability at 200 Oersted[A] (15.9 kA/m) 10.58
Coefficient of Expansion[A], 10^{-6} in/in • °F (μm/m • °C)
70-200°F (21–93°C) 7.2 (13.0)
70-500°F (21–260°C) 7.7 (13.9)
70-800°F (21–427°C) 8.0 (14.4)
70-1000°F (21–538°C) 8.2 (14.8)
70-1200°F (21–650°C) 8.5 (15.3)
70-1400°F (21–760°C) 8.8 (15.9)
Thermal Conductivity[A], Btu • in/ft^2•h•°F (W/m•°C) .....165(23.8)
Electrical Resistivity[A], ohm • circ mil/ft (μΩ • m) ...255 (0.424)
Young's Modulus[A] 10^6 psi (GPa).....30.0 (207)
Poisson's Ratio[A] 0.31
Hardness[A], HRC ..... 30 – 42

[A]Room temperature, as aged.

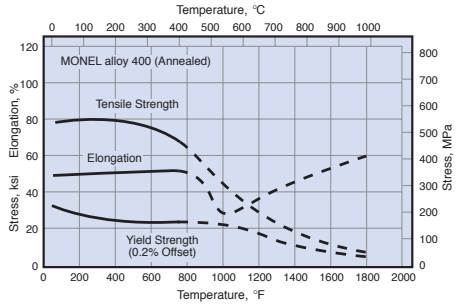
Density, lb/in^3 .....0.318
g/cm^3 .....8.80
Melting Range, °F..... 2370 – 2460
°C..... 1300 – 1350
Specific Heat, Btu/lb • °F.....0.102
J/kg • °C 427
Curie Temperature, °F .....70 – 120
°C .....20 – 50
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F 7.7
21 – 93°C, μm/m • °C 13.9
Thermal Conductivity, Btu • in/ft^2•h•°F 151
W/m•°C.....21.8
Electrical Resistivity, ohm•circ mil/ft.....329
μΩ•m 0.547

Typical Mechanical Properties



Typical usage range

(Annealed)
Tensile Strength, ksi 80
MPa 550
Yield Strength (0.2% Offset), ksi 35
MPa 240
Elongation, % 40



Typical usage range

SPECIAL METALS
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MONEL® alloy R-405

The free-machining version of MONEL alloy 400. A controlled amount of sulfur is added to the alloy to provide sulfide inclusions that act as chip breakers during machining. Other characteristics are essentially the same as those of MONEL alloy 400. Used for meter and valve parts, fasteners, and screw-machine products.

MONEL® alloy K-500

A precipitation-hardenable nickel-copper alloy that combines the corrosion resistance of MONEL alloy 400 with greater strength and hardness. It also has low permeability and is nonmagnetic to temperatures as low as -150°F (-101°C). Used for pump shafts, oil-well tools and instruments, doctor blades and scrapers, springs, valve trim, fasteners, and marine propeller shafts.

Standard Product Forms

Round bar, hexagon and wire.

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Major Specifications

UNS N04405
NACE MR-01-75
ASTM B 164
ASME SB-164
SAE AMS 4674, 7234
QQ-N 281
MIL-N-894

UNS N05500
BS 3072 – 3076 (NA18)
ASTM B 865
SAE AMS 4676
DIN 17743, 17752 –17754
Werkstoff Nr. 2.4375
QQ-N 286
NACE MR-0175/ISO 15156
ISO 6208, 9723 – 9725
ASME Code Case 1192

Limiting Chemical Composition, %

Ni[a] .....63.0 min.
Cu ...28.0 – 34.0
Fe .....2.5 max.
S ....0.025 – 0.060
Mn.....2.0 max.
C.....0.3 max.
Si .....0.5 max.

[a]Plus Co.

Ni[a] .....63.0 min.
Cu ... 27.0 – 33.0
Al .... 2.30 – 3.15
Ti..... 0.35-0.85
Fe .....2.0 max.
C.....0.25 max.
Mn.....1.5 max.
S .....0.01 max.
Si .....0.5 max.

[a]Plus Co.

Physical Constants and Thermal Properties

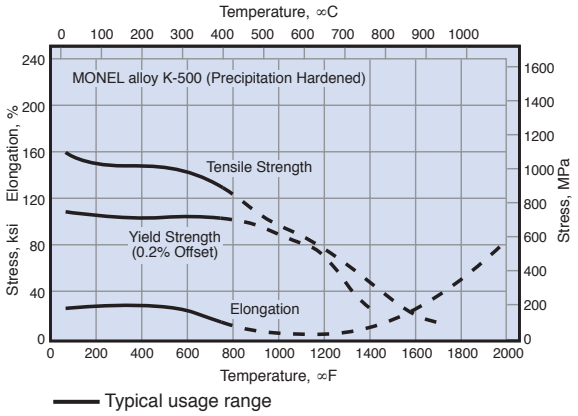
Density, lb/in^3 .....0.318
g/cm^3 .....8.80
Melting Range, °F..... 2370 – 2460
°C..... 1300 – 1350
Specific Heat, Btu/lb •°F.....0.102
J/kg • °C 427
Curie Temperature, °F .....70 – 120
°C .....20 – 50
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F 7.6
21 – 93°C, µm/m • °C 13.7
Thermal Conductivity, Btu • in/ft^2•h•°F 151
W/m•°C.....21.8
Electrical Resistivity, ohm•circ mil/ft.....307
µΩ•m 0.510

Density, lb/in^3 .....0.305
g/cm^3 .....8.44
Melting Range, °F..... 2400 – 2460
°C..... 1315 – 1350
Specific Heat, Btu/lb •°F.....0.100
J/kg • °C.....419
Curie Temperature, °F ..... -150
°C ..... -100
Permeability at 200 Oersted (15.9 kA/m) 1.002
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F 7.6
21 – 93°C, µm/m • °C 13.7
Thermal Conductivity, Btu • in/ft^2•h•°F 121
W/m • °C 17.5
Electrical Resistivity, ohm•circ mil/ft.....370
µΩ•m 0.615
Young's Modulus at RT, 10^3 ksi.....26

Typical Mechanical Properties

(Annealed)
Tensile Strength, ksi 80
MPa.....550
Yield Strength (0.2% Offset), ksi 35
MPa.....240
Elongation, % 40

(Precipitation Hardened)
Tensile Strength, ksi 160
MPa 1100
Yield Strength (0.2% Offset), ksi 115
MPa 790
Elongation, % 20



SPECIAL METALS
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INCONEL® alloy 600

A nickel-chromium alloy with good oxidation resistance at high temperatures and resistance to chloride-ion stress-corrosion cracking, corrosion by high-purity water, and caustic corrosion. Used for furnace components, in chemical and food processing, in nuclear engineering, and for sparking electrodes.

INCONEL® alloy 601

A nickel-chromium alloy with an addition of aluminum for outstanding resistance to oxidation and other forms of high-temperature corrosion. It also has high mechanical properties at elevated temperatures. Used for industrial furnaces; heat-treating equipment such as baskets, muffles, and retorts; petrochemical and other process equipment; and gas-turbine components.

Standard Product Forms

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon, wire and extruded section.

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Major Specifications

UNS N06600
BS 3072 – 3076 (NA14)
ASTM B 163, B 166 – B 168, B 366, B 516, B 517, B 564, B 751, B 775, B 829
ASME SB-163, SB-166 – SB-168, SB-366, SB-516, SB-517, SB-564, SB-751, SB-775, SB-829
ASME Code Cases 1827, N-20, N-253, N-576
SAE AMS 5540, 5580, 5665, 5687
DIN 17742, 17750 – 17754
Werkstoff Nr. 2.4816
VdTÜV 305
NACE MR-01-75
QQ-W 390
EN 10095
ISO 6207, 6208, 9723 –9725, 4955A

UNS N06601
ASTM B 166 – B 168, B 751, B 775, B 829
ASME SB-166 – SB-168, SB-751, SB-775, SB-829
ASME Code Case 1500
DIN 17742, 17750 – 17754
Werkstoff Nr. 2.4851
EN 10095
ISO 6207, 6208, 9723-9725

Limiting Chemical Composition, %

Ni[a] ....72.0 min.	C .....0.15 max.	Si .....0.5 max.
Cr.... 14.0 – 17.0	Mn.....1.0 max.	Cu .....0.5 max.
Fe ..... 6.0 – 10.0	S .....0.015 max.	

[a]Plus Co.

Ni .... 58.0 – 63.0	Fe ... Remainder	Si .....0.50 max.
Cr ... 21.0 – 25.0	C .....0.10 max.	S ....0.015 max.
Al ..... 1.0 – 1.7	Mn.....1.0 max.	Cu .....1.0 max.

Physical Constants and Thermal Properties

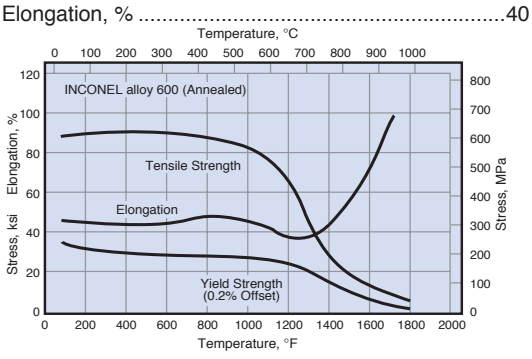
Density, lb/in³ 0.306
g/cm³ 8.47
Melting Range, °F..... 2470 – 2575
°C..... 1354 – 1413
Specific Heat, Btu/lb • °F.....0.106
J/kg • °C 444
Curie Temperature, °F ..... -192
°C ..... -124
Permeability at 200 Oersted (15.9 kA/m) 1.010
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F ...7.4
21 – 93°C, μm/m • °C 13.3
Thermal Conductivity, Btu • in/ft²•h•°F 103
W/m•°C.....14.9
Electrical Resistivity, ohm • circ mil/ft.....620
μΩ•m 1.03

Density, lb/in³ 0.293
g/cm³ 8.11
Melting Range, °F..... 2480 – 2571
°C..... 1360 – 1411
Specific Heat, Btu/lb • °F.....0.107
J/kg • °C 448
Curie Temperature, °F ..... <-320
°C ..... <-196
Permeability at 200 Oersted (15.9 kA/m) 1.003
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F ...7.60
20 – 100°C, μm/m • °C.....13.75
Thermal Conductivity, Btu • in/ft²•h•°F 78
W/m•°C.....11.2
Electrical Resistivity, ohm • circ mil/ft.....717
μΩ•m 1.19

Typical Mechanical Properties

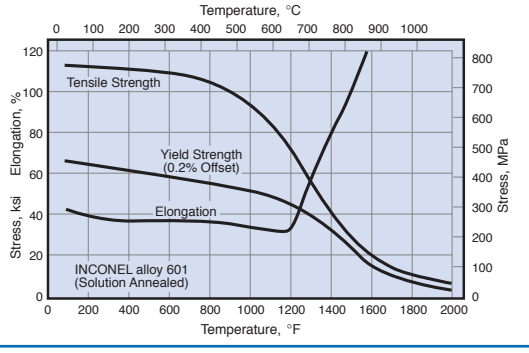
(Annealed)

Tensile Strength, ksi 95
MPa.....655
Yield Strength (0.2% Offset), ksi 45
MPa.....310
Elongation, % 40



(Solution Annealed)

Rupture Strength (1000 h)	ksi	MPa
1200°F / 650°C	28.0	195
1400°F / 760°C	9.1	63
1600°F / 870°C	4.3	30
1800°F / 980°C	2.1	14
2000°F / 1095°C	1.0	7



SPECIAL METALS
A PCC Company

INCONEL® alloy 617

A nickel-chromium-cobalt-molybdenum alloy with an exceptional combination of metallurgical stability, strength, and oxidation resistance at high temperatures. Resistance to oxidation is enhanced by an aluminum addition. The alloy also resists a wide range of corrosive aqueous environments. Used in gas turbines for combustion cans, ducting, and transition liners; for petrochemical processing; for heat-treating equipment; and in nitric acid production.

INCONEL® alloy 625

A nickel-chromium-molybdenum alloy with an addition of niobium that acts with the molybdenum to stiffen the alloy's matrix and thereby provide high strength without a strengthening heat treatment. The alloy resists a wide range of severely corrosive environments and is especially resistant to pitting and crevice corrosion. Used in chemical processing, aerospace and marine engineering, pollution-control equipment, and nuclear reactors.

Standard Product Forms

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon, wire and extruded section.

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon, wire and extruded section.

Major Specifications

UNS N06617
ASTM B 166, B 168, B 546, B 564
ASME SB-166, SB-168, SB-546, SB-564
SAE AMS 5887 – 5889
ASME Code Cases 1956, 1982
Werkstoff Nr. 2.4663a
VdTÜV 485
ISO 6207, 6208, 9724
DIN 17744, 17750-17754

UNS N06625
ASTM B 366, B 443, B 444, B 446, B 564, B 704, B 705, B 751, B 775, B 829
ASME SB-366, SB-443, SB-444, SB-446, SB-564, SB-704, SB-705, SB-751, SB-775, SB-829
ASME Code Case 1935
SAE AMS 5581, 5599, 5666, 5837, 5869, MAM 5599
BS 3072, 3074, 3076 (NA21)
DIN 17744, 17750 – 17754
Werkstoff Nr. 2.4856
NACE MR-0175/ISO 15156
VdTÜV 499, EN 10095
ISO NW6625, ISO 6207, 6208, 9723 – 9725, 4955A

Limiting Chemical Composition, %

Ni .....44.5 min.	C .....0.05 – 0.15	Ti .....0.6 max.
Cr ... 20.0 – 24.0	Fe .....3.0 max.	Cu .....0.5 max.
Co ... 10.0 – 15.0	Mn.....1.0 max.	B ....0.006 max.
Mo .... 8.0 – 10.0	Si .....1.0 max.	
Al ..... 0.8 – 1.5	S ....0.015 max.	

Ni .....58.0 min.	Fe .....5.0 max.	Al .....0.40 max.
Cr ... 20.0 – 23.0	C.....0.10 max.	Ti .....0.40 max.
Mo..... 8.0 – 10.0	Mn ....0.50 max.	P ....0.015 max.
Nb[a] ...3.15 – 4.15	Si .....0.50 max.	Co[b] .....1.0 max.
[a]Plus Ta.	S .....0.015 max.	[b]If determined.

Physical Constants and Thermal Properties

Density, lb/in³ 0.302
g/cm³ 8.36

Melting Range, °F..... 2430 – 2510
°C ..... 1330 – 1380

Specific Heat, Btu/lb•°F.....0.100
J/kg•°C.....419

Coefficient of Expansion, 78 – 200°F, 10^{-6} in/in•°F 6.4
20 – 100°C, μm/m•°C 11.6

Thermal Conductivity, Btu • in/ft²•h•°F 94
W/m•°C 13.6

Electrical Resistivity, ohm•circ mil/ft.....736
μΩ•m.....1.22

Density, lb/in³ 0.305
g/cm³ 8.44

Melting Range, °F..... 2350 – 2460
°C ..... 1290 – 1350

Specific Heat, Btu/lb•°F.....0.098
J/kg•°C 410

Curie Temperature, °F ..... <-320
°C ..... <-196

Permeability at 200 Oersted (15.9 kA/m) 1.0006

Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F 7.1
21 – 93°C, μm/m•°C 12.8

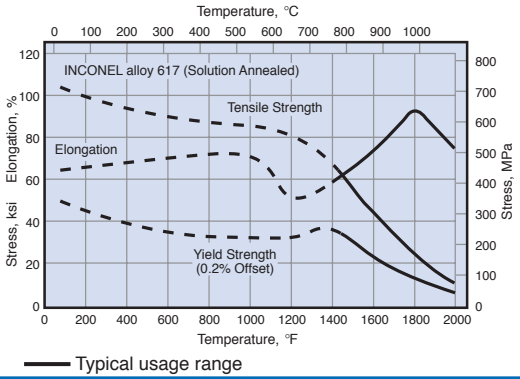
Thermal Conductivity, Btu • in/ft²•h•°F 68
W/m•°C 9.8

Electrical Resistivity, ohm•circ mil/ft.....776
μΩ•m 1.29

Typical Mechanical Properties

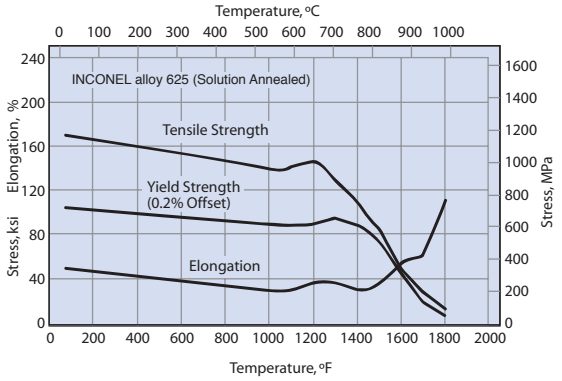
(Solution Annealed)

Rupture Strength (1000 h)	ksi	MPa
1200°F / 650°C	47.0	320
1400°F / 760°C	22.0	150
1600°F / 870°C	8.4	58
1800°F / 980°C	3.6	25
2000°F / 1095°C	1.5	10



(Solution Annealed)

Rupture Strength (1000 h)	ksi	MPa
1200°F / 650°C	52.0	360
1400°F / 760°C	23.0	160
1600°F / 870°C	7.2	50
1800°F / 980°C	2.6	18



SPECIAL METALS
A PCC Company

INCONEL® alloy 625LCF®

A nickel-chromium-molybdenum alloy that was developed as a fatigue-resistant bellows-quality version of INCONEL alloy 625. Alloying, melting and processing of this alloy are specially designed and controlled to provide a sheet product with optimum resistance to low-cycle and thermal fatigue at temperatures up to 1200°F (650°C). Used in aircraft exhaust and automotive flexible coupling bellows, and expansion joints in various types of process or transport piping.

INCONEL® alloy 686

An alloy designed for outstanding corrosion-resistance in a wide range of severe environments. The alloy is used in the most severe environments encountered in chemical processing, pollution control, pulp and paper production, and treatment of industrial and municipal wastes. Chemical processing uses include heat exchangers, reaction vessels, evaporators, and transfer piping. Air pollution control applications are stack liners, ducts, dampers, scrubbers, stack-gas re-heaters, fans, and housings.

Standard Product Forms

Sheet and strip.

Pipe, tube, sheet, strip, plate, round bar, forging stock, hexagon and wire.

Major Specifications

UNS N06625, N06626
ASTM B 443
ASME SB-443
SAE AMS 5879
ASME Code Case 2276
W.Nr. 2.4856
BS 3072 (NA21)

UNS N06686
ASTM B 163, B 462, B 564, B 574, B 575, B 619, B 622, B 626, B 751, B 775, B 829, B 906, F 467, F 467M, F 468, F 468M
DIN 17744, 17750 – 17754
Werkstoff Nr. 2.4606
ASME Code Case 2198
ASME SB-163, SB-564, SB-574, SB-575, SB-619, SB-622, SB-626, SB-751, SB-775, SB-829, SB-906
VdTÜV 515
NACE MR-0175/ISO 15156
SAE/AMS J2295, J2271, J2655, J2280, J2485

Limiting Chemical Composition, %

Ni .....58.0 min.	Fe .....5.0 max.	S .....0.015 max.
Cr.... 20.0 – 23.0	C.....0.03 max.	Al .....0.40 max.
Mo..... 8.0 – 10.0	Si .....0.15 max.	Ti.....0.40 max.
Nb[a] . 3.15 – 4.15	N.....0.02 max.	P .....0.015 max.
	Mn.....0.50 max.	Co.....1.0 max.

[a]Plus Ta.

Cr ... 19.0 – 23.0	Fe .....1.0 max.	Si .....0.08 max.
Mo... 15.0 – 17.0	C .....0.01 max.	P .....0.04 max.
W ..... 3.0 – 4.4	Mn.....0.75 max.	Ni .....Balance
Ti..... 0.02 – 0.25	S .....0.02 max.	

Physical Constants and Thermal Properties

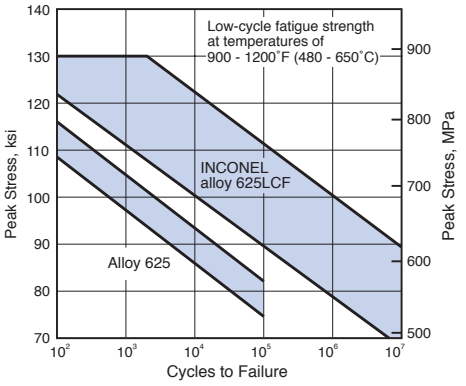
Density, lb/in³ 0.305
g/cm³ 8.44
Melting Range, °F..... 2350 – 2460
°C ..... 1290 – 1350
Specific Heat, Btu/lb •°F.....0.098
J/kg • °C 410
Curie Temperature, °F ..... <-320
°C ..... <-196
Permeability at 200 Oersted (15.9 kA/m) 1.0006
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F ...7.1
20 – 100°C, μm/m • °C 12.8
Thermal Conductivity, Btu • in/ft²•h•°F 68
W/m•°C 9.7
Electrical Resistivity, ohm•circ mil/ft.....776
μΩ•m.....1.29

Density, lb/in³ 0.315
g/cm³ 8.73
Melting Range, °F..... 2440 – 2516
°C ..... 1338 – 1380
Specific Heat, Btu/lb •°F.....0.089
J/kg • °C 373
Permeability at 200 Oersted (15.9 kA/m) 1.001
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F ...6.67
20 – 100°C, μm/m • °C 11.97
Electrical Resistivity, ohm•circ mil/ft.....744.4
μΩ•m.....1.237

Typical Mechanical Properties

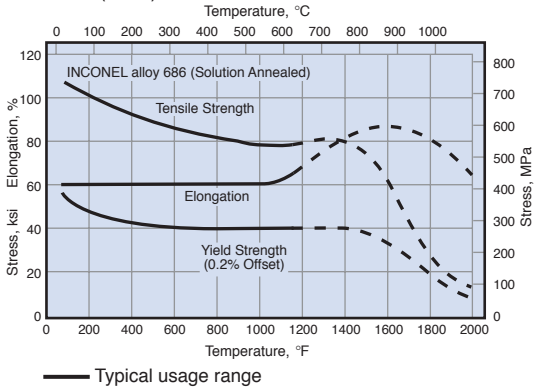
(Annealed)

Tensile Strength, ksi 130
MPa.....894
Yield Strength (0.2% Offset), ksi 68
MPa.....469
Elongation, % 50



(Solution Annealed)

Tensile Strength, ksi 110
MPa.....758
Yield Strength (0.2% Offset), ksi 55
MPa.....379
Elongation, % 60
Hardness (HRB) .....85 – 95



SPECIAL METALS
A PCC Company

INCONEL® alloy 690

INCONEL alloy 690 is a high-chromium nickel alloy having excellent resistance to many corrosive aqueous media and high-temperature atmospheres. The alloy's high chromium content gives it excellent resistance to aqueous corrosion by oxidizing acids (especially nitric acid) and salts, and to sulfidation at high-temperatures. In addition to its corrosion resistance, alloy 690 has high strength, good metallurgical stability, and favorable fabrication characteristics.

INCONEL® alloy 693

A nickel-chromium-aluminum alloy offering the best resistance to metal dusting of any available conventional alloy. Alloy 693 also offers exceptional resistance to oxidation and carburization at temperatures up to 2100°F (1150°C) with excursions to even higher temperatures. The alloy's ability to resist metal dusting is especially useful in systems used to reform hydrogen and generate synthesis gas for various industries including gas to liquid fuel production. Alloy 693 is protected by U.S. Patent Number 4,882,125.

Standard Product Forms

Pipe, tube, plate, round bar and forging stock.

Plate, sheet, strip, bar, seamless tubes and pipes.

Major Specifications

UNS N06690
ASTM B 163, B 166 – B 168, B 564, B 829
ASME Code Cases 2083, N-20, N-525
ASME SB-163, SB-166 – SB-168, SB-564, SB-829
Werkstoff Nr. 2.4642
ISO 6207, 6208, 9723
ISO NW6690

UNS N06693
ASTM B 166, B 167, B 168
ASME SB 166, SB 167, SB 168

Limiting Chemical Composition, %

Ni[a] .....58.0 min.	Mn.....0.50 max.	
Cr.... 27.0 – 31.0	S .....0.015 max.	
Fe ..... 7.0 – 11.0	Si .....0.50 max.	
C .....0.05 max.	Cu .....0.50 max.	

[a]Plus Co.

Ni ... Remainder[a]	Nb 0.5-2.5	Si .....0.50 max.	
Cr.... 27.0 – 31.0	Mn.....1.0 max.	C .....0.15 max.	
Fe 2.5-6.0	Ti.....1.0 max.	S .....0.015 max.	
Al 2.5-4.0	Cu.....0.50 max.		

[a]Element determined arithmetically by difference.

Physical Constants and Thermal Properties

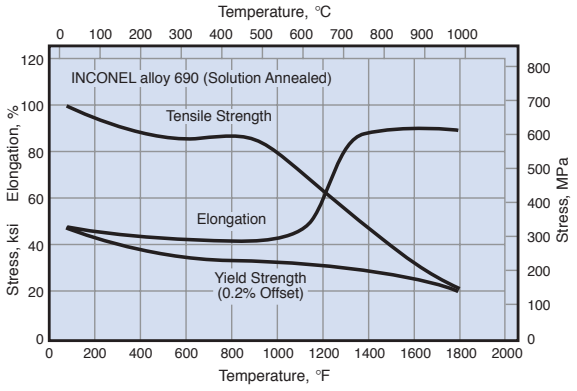
Density, lb/in³ (g/cm³) 0.296 (8.19)
Melting Range, °F (°C) ..... 2450 – 2510 (1343 – 1377)
Specific Heat, Btu/lb•°F (J/kg•°C) 0.107 (450)
Permeability at 200 Oersted (15.9 kA/m) 1.001
Coefficient of Expansion, 10^{-6} in/in•°F (μm/m•°C)
70 – 200°F (21 – 93°C) 7.80 (14.0)
70 – 1000°F (21 – 538°C) 8.53 (15.4)
70 – 1600°F (21 – 970°C) 9.38 (16.9)
Thermal Conductivity[A], Btu • in/ft²•h•°F 84
W/m•°C 12.1
Electrical Resistivity[A], ohm•circ mil/ft 691
$\mu\Omega$•m 1.15
Young's Modulus[A], 10^6 psi (GPa)..... 30.6 (211)
Poisson's Ratio[A] 0.29
Hardness[A], HRB 85

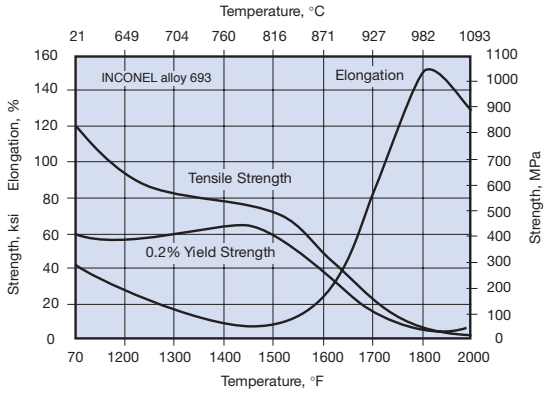
[A]Room temperature, as annealed.

Density, lb/in³ (g/cm³) 0.280 (7.77)
Melting Range, °F (°C) ..... 2403 – 2493 (1317 – 1367)
Specific Heat, Btu/lb•°F (J/kg•°C) 0.109 (455)
Permeability at 200 Oersted .....<1.005
Electrical Resistivity[A], ohm•circ mil/ft 702.7
Thermal Conductivity[A], Btu • in/ft²•h•°F 64.3
W/m•°C 9.1
Coefficient of Expansion, 10^{-6} in/in•°F (μm/m•°C)
70-200°F (21-93°C).... 7.22 (13.04)
Young's Modulus[A], 10^3 ksi (GPa) 28.5 (197)
Shear Modulus[A], 10^3 ksi (GPa)..... 11.0 (76)
Poisson's Ratio[A] 0.30

[A]Room temperature.

Typical Mechanical Properties





SPECIAL METALS
A PCC Company

INCONEL® alloy 706

INCONEL alloy 706 is a precipitation-hardenable nickel-iron-chromium alloy that provides high mechanical strength in combination with good fabricability. The properties of the alloy are similar to those of INCONEL alloy 718 (N07718) except that alloy 706 is more readily fabricated, particularly by machining. Primary uses of the alloy are aerospace and land-based gas turbine parts and components requiring resistance to creep and stress rupture up to 1300˚F (704˚C), oxidation resistance, and good fabricability.

INCONEL® 718 & 718SPF™

A precipitation-hardenable nickel-chromium alloy also containing significant amounts of iron, niobium, and molybdenum along with lesser amounts of aluminum and titanium. It combines corrosion resistance and high strength with outstanding weldability including resistance to post-weld cracking. The alloy has excellent creep-rupture strength at temperatures to 1300°F (700°C). Used in gas turbines, rocket motors, spacecraft, nuclear reactors, pumps, and tooling. INCONEL alloy 718SPF is a special version of INCONEL alloy 718, designed for superplastic forming.

Standard Product Forms

Round bar and forging stock.

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon, wire and extruded section.

Major Specifications

UNS N09706
SAE AMS 5605, 5606, 5701 – 5703

UNS N07718, N07719
ASTM B 637, B 670
ASME SB-637, SB-670
DIN 17744, 17750-17754
SAE AMS 5589, 5590, 5596, 5597, 5662 – 5664, 5832, 5914, 5950, 5962
Werkstoff Nr. 2.4668
ASME Code Cases 1993, 2206, 2222, N-62, N-208, N-253
NACE MR-0175/ISO 15156
AECMA Pr EN 2404, 2405, 2407, 2408, 2952, 2961, 3219, 3666
ISO 6208, 9723 – 9725

Limiting Chemical Composition, %

Ni[a] ..39.0 – 44.0	Ti.....1.5 – 2.0	S .....0.015 max.
Cr.... 14.5 – 17.5	Al .....0.40 max.	Si .....0.35 max.
Fe ... Remainder	C.....0.06 max.	P .....0.020 max.
Nb[b] .....2.5 – 3.3	Cu.....0.30 max.	B .....0.006 max.
	Mn.....0.35 max.	Co .....1.00 max.

[a]Plus Co. [b]Plus Ta.

Ni[a] .. 50.0 – 55.0	Ti..... 0.65 – 1.15	Si .....0.35 max.
Cr ... 17.0 – 21.0	Al ... 0.20 – 0.80	P ....0.015 max.
Fe ....Remainder	Co[c] .....1.0 max.	S ....0.015 max.
Nb[b] .. 4.75 – 5.50	C.....0.08 max.	B ....0.006 max.
Mo ... 2.80 – 3.30	Mn ....0.35 max.	Cu ....0.30 max.

[a]Plus Co. [b]Plus Ta. [c]If determined.

Physical Constants and Thermal Properties

Density, lb/in³ (g/cm³) 0.291 (8.05)
Melting Range, °F (°C) .....2434 – 2499 (1334 – 1371)
Specific Heat, Btu/lb•°F (J/kg•°C) 0.106 (444)
Curie Temperature, °F (°C)..... < -109 (-78)
Permeability at 200 Oersted (15.9 kA/m) 1.011
Coefficient of Expansion, 10^{-6} in/in•°F (μm/m•°C)
70 – 200°F (21 – 93°C) 7.40 (13.3)
70 – 500°F (21 – 260°C) 8.25 (14.9)
70 – 800°F (21 – 427°C) 8.57 (15.4)
70 – 1000°F (21 – 538°C) 8.73 (15.7)
70 – 1200°F (21 – 650°C) 8.97 (16.2)
Thermal Conductivity[A], Btu • in/ft²•h•°F 87
W/m•°C..... 12.5
Electrical Resistivity[A], ohm•circ mil/ft..... 592
$\mu\Omega$•m..... 0.985
Young's Modulus[A], 10^6 psi (GPa).....30.4 (210)
Shear Modulus[A], 10^6 psi (GPa)..... 11.0 (76)
Poisson's Ratio[A] 0.382
Hardness[A], HRC ..... 36 – 42

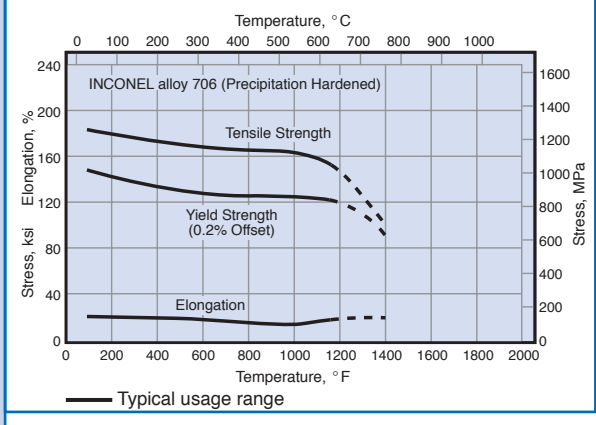
[A]Room temperature, as aged.

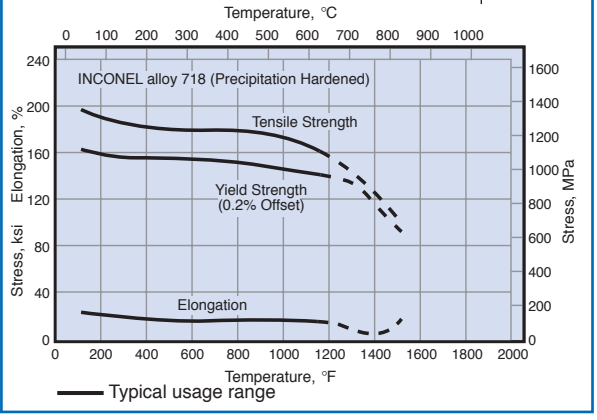
Density, lb/in³ 0.296
g/cm³ 8.19
Melting Range, °F..... 2300 – 2437
°C..... 1260 – 1336
Specific Heat, Btu/lb•°F.....0.104
J/kg•°C 435
Curie Temperature, °F ..... -170
°C .....-112
Permeability at 200 Oersted (15.9 kA/m) 1.0011
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F 7.2
21 – 93°C, μm/m•°C 13.0
Thermal Conductivity, Btu • in/ft²•h•°F.....79
W/m•°C.....11.4
Electrical Resistivity, ohm•circ mil/ft.....751
$\mu\Omega$•m.....1.25

(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1100°F / 595°C	110	760
1200°F / 650°C	86	590
1300°F / 705°C	53	370
1400°F / 760°C	24	170

Typical Mechanical Properties





SPECIAL METALS
A PCC Company

INCONEL® alloy 725

A nickel-chromium-molybdenum-niobium alloy that is highly resistant to corrosion and is age hardenable for extremely high strength. The strength of this alloy is developed by heat treatment to achieve high ductility and toughness. The alloy is resistant to hydrogen embrittlement and stress-corrosion cracking. Used for hangers, landing nipples, side pocket mandrels and polished bore receptacles in sour gas service. Also used for high-strength fasteners in marine applications.

INCONEL® alloy 740

A nickel-chromium-cobalt superalloy age hardened by the precipitation of a gamma prime second phase. Alloy 740 exhibits excellent high temperature strength in the age-hardened condition up to 1500°F (815°C). With its high contents of chromium and cobalt, alloy 740 offers excellent resistance to oxidation, carburization, and sulfidation at elevated temperatures. Alloy 740 is targeted for use as advanced power production boiler tubes.

Standard Product Forms

Round bar and wire.

Bar, seamless tubes.

Major Specifications

UNS N07725 SMC HA91
ASTM B 805
ASME Code Case 2217
NACE MR-0175/ISO 15156

Contact Special Metals

Limiting Chemical Composition, %

Ni ... 55.0 – 59.0	Ti..... 1.0 – 1.7	Si .....0.20 max.
Cr.... 19.0 – 22.5	Al .....0.35 max.	P .....0.015 max.
Mo..... 7.0 – 9.5	C.....0.03 max.	S ....0.010 max.
Nb..... 2.75 – 4.0	Mn ....0.35 max.	Fe .....Balance

Nominal

C.....0.03	Co.....20.0	Mn.....0.30
Ni ..... Bal	Al 1.0	Fe 0.7
Cr.....25.0	Ti.....1.8	Si 0.5
Mo.....0.5	Nb.....2.0	

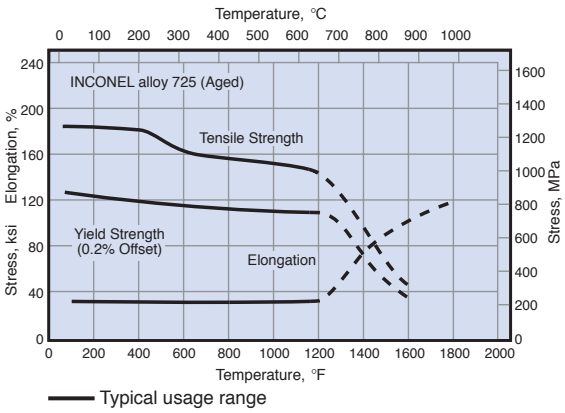
Physical Constants and Thermal Properties

Density, lb/in³ 0.300
g/cm³ 8.31
Melting Range, °F ..... 2320 – 2449
°C ..... 1271 – 1343
Permeability at 200 Oersted (15.9 kA/m) .....<1.001
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F ...7.22
20 – 100°C, μm/m • °C 13.0
Thermal Conductivity, Btu • in/ft²•h•°F 73.8
W/m•°C.....10.6
Electrical Resistivity, ohm•circ mil/ft.....688
μΩ•m.....1.144

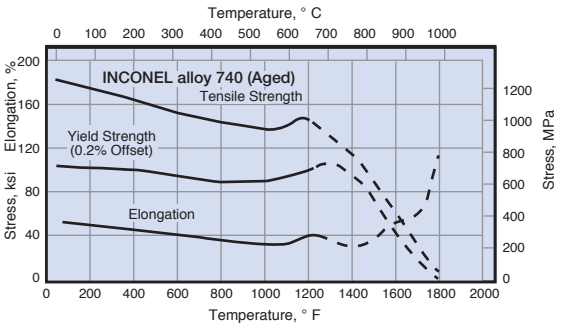
Density, lb/in³ 0.291
g/cm³ 8.05
Melting Range, °F..... 2350 – 2484
°C..... 1288 – 1362
Specific Heat, Btu/lb • °F (J/kg • °C) 0.108 (449)
Electrical Resistivity, ohm • circ mil/ft.....702.7
μΩ•m.....1.168
Thermal Conductivity, Btu • in/ft²•h•°F 72.9
W/m•°C.....10.2
Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)
70-200°F (21-93°C)...6.84 (12.38)
Young's Modulus[A], 10^3 ksi (GPa)..... 32 (221)
Shear Modulus[A], 10^3 ksi (GPa)..... 11.5 (79)
Poisson's Ratio[A] 0.35
Magnetic Permeability .....< 1.005

[A]Room temperature.

Typical Mechanical Properties



Yield Strength, Room Temperature, Aged, ksi 115
Tensile Strength, Room Temperature, Aged, ksi 178
Elongation, Aged, % 33



SPECIAL METALS
A PCC Company

INCONEL® alloy X-750

A nickel-chromium alloy similar to INCONEL alloy 600 but made precipitation hardenable by additions of aluminum and titanium. It has good resistance to corrosion and oxidation along with high tensile and creep-rupture properties at temperatures to 1300°F (700°C). Its excellent relaxation resistance is useful for high-temperature springs and bolts. Used in gas turbines, rocket engines, nuclear reactors, pressure vessels, tooling, and aircraft structures.

INCONEL® alloy 751

A nickel-chromium alloy similar to INCONEL alloy X-750 but with increased aluminum content for greater precipitation hardening. This alloy was designed for use as exhaust valves in internal-combustion engines. In that application, the alloy offers high strength at operating temperatures, high hot hardness for wear resistance, and corrosion resistance in hot exhaust gases containing lead oxide, sulfur, bromine, and chlorine.

Standard Product Forms

Sheet, strip, plate, round bar, flat bar, forging stock, hexagon, wire, tubing and extruded section.

Round bar.

Major Specifications

UNS N07750
BS HR 505
ASTM B 637
ASME SB-637
Werkstoff Nr. 2.4669
NACE MR-0175/ISO 15156
SAE AMS 5542, 5582, 5583, 5598, 5667 – 5671, 5698, 5699, 5747
EN 10269
ISO 6208, 9723 – 9725

UNS N07751

Limiting Chemical Composition, %

Ni[a] ..... 70.0 min.	Al ... 0.40 – 1.00	Si ..... 0.50 max.
Cr ... 14.0 – 17.0	Nb[b] .. 0.70 – 1.20	S ..... 0.01 max.
Fe ..... 5.0 – 9.0	C ..... 0.08 max.	Cu .... 0.50 max.
Ti .... 2.25 – 2.75	Mn..... 1.00 max.	Co[c] ... 1.00 max.

[a]Plus Co. [b]Plus Ta. [c]If determined.

Limiting

Ni[a] ..... 70.0 min.	Ti..... 2.0 – 2.6	Mn..... 1.0 max.
Cr.... 14.0 – 17.0	Al ..... 0.9 – 1.5	Si ..... 0.5 max.
Fe ..... 5.0 – 9.0	Nb[b]..... 0.7 – 1.2	S ..... 0.01 max.
	C..... 0.10 max.	Cu ..... 0.5 max.

[a]Plus Co. [b]Plus Ta.

Physical Constants and Thermal Properties

Density, lb/in³ 0.299
g/cm³ 8.28

Melting Range, °F ..... 2540 – 2600
°C ..... 1390 – 1430

Specific Heat, Btu/lb •°F 0.103
J/kg • °C 431

Curie Temperature, °F ..... -193
°C ..... -125

Permeability at 200 Oersted (15.9 kA/m) 1.0035

Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F 7.0
21 – 93°C, μm/m • °C 12.6

Thermal Conductivity, Btu • in/ft²•h•°F 83
W/m•°C 12.0

Electrical Resistivity, ohm•circ mil/ft 731
μΩ•m 1.22

Density, lb/in³ 0.297
g/cm³ 8.22

Melting Range, °F ..... 2540 – 2600
°C ..... 1390 – 1430

Specific Heat, Btu/lb •°F 0.103
J/kg • °C 431

Curie Temperature, °F ..... -193
°C ..... -125

Permeability at 200 Oersted (15.9 kA/m) 1.0035

Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F ... 7.0
21 – 93°C, μm/m • °C 12.6

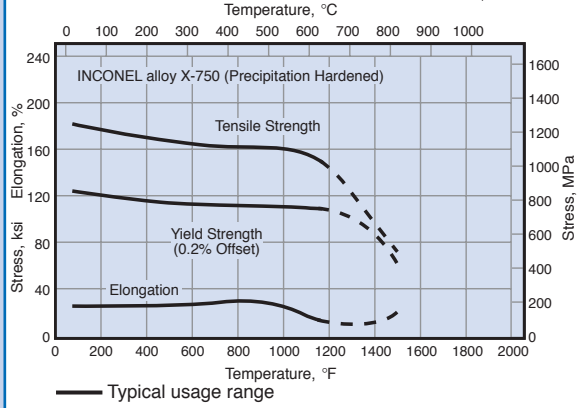
Thermal Conductivity, Btu • in/ft²•h•°F 83
W/m•°C 12.0

Electrical Resistivity, ohm•circ mil/ft 731
μΩ•m 1.22

Typical Mechanical Properties

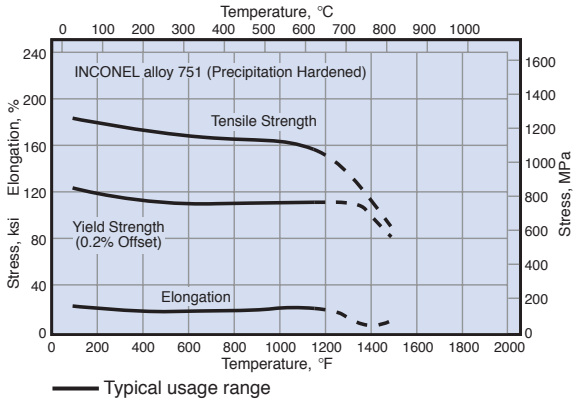
(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1100°F / 595°C	92	630
1200°F / 650°C	68	470
1350°F / 730°C	37	260
1500°F / 815°C	16	110



(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1200°F / 650°C	40	280
1350°F / 730°C	35	240
1500°F / 815°C	14	97



SPECIAL METALS
A PCC Company

INCONEL® alloy 783

An oxidation resistant low coefficient of thermal expansion (low CTE) superalloy developed for gas turbine applications. The alloy is strengthened by a precipitation-hardening heat treatment made possible by additions of niobium and aluminum. In addition, the aluminum content provides excellent resistance to oxidation at high temperature. The alloy's density is 5% less than those of superalloys such as INCONEL alloy 718. The combination of low expansion, high strength and excellent resistance to oxidation makes the alloy especially useful for gas turbine and steam turbine components. The low expansion enables closer control of clearances and tolerances for greater power output and fuel efficiency.

INCONEL® alloy 22

By virtue of its contents of chromium, molybdenum, and tungsten and controlled iron, this alloy exhibits excellent resistance to both oxidizing and reducing acid environments as well as those containing mixed acids. It is particularly useful for resistance to pitting and crevice corrosion in acid-halide environments. Applications include the chemical processing, pollution control, flue gas desulfurization, waste incineration, and pulp and paper processing industries.

Standard Product Forms

Sheet, round bar, wire and extruded section.

Sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Major Specifications

UNS R30783
SAE AMS 5940

USN N06022
ASTM B 366, B 462, B 564, B 574, B 575, B 619, B 622, B 626, B 751, B 775, B 829, B 906
ASME SB-366, SB-564, SB-574, SB-575, SB-619, SB-622, SB-626, SB-751, SB-775, SB-829, SB-906
ASME Code Cases 2226, N-621
Werkstoff Nr. 2.4602
ISO 6207, 6208, 9723, 9724
DIN 17744, 17750-17754

Limiting Chemical Composition, %

Ni ....26.0 – 30.0	Cr .....2.5 – 3.5	Mn.....0.50 max.
Fe ...24.0 – 27.0	Ti.....0.1 – 0.4	P .....0.015 max.
Co ... Remainder	B ..0.003 – 0.012	S .....0.005 max.
Al ..... 5.0 – 6.0	C .....0.3 max.	Si .....0.50 max.
Nb ..... 2.5 – 3.5	Cu .....0.50 max.	

Ni .... Remainder	W .....2.5 – 3.5	V .....0.35 max.
Cr ... 20.0 – 22.5	Co.....2.5 max.	S .....0.02 max.
Mo... 12.5 – 14.5	C .....0.015 max.	Si .....0.08 max.
Fe .....2.0 – 6.0	Mn ....0.50 max.	P .....0.02 max.

Physical Constants and Thermal Properties

Density, lb/in³ (g/cm³) 0.282 (7.81)
Melting Range, °F (°C) ..... 2437 – 2565 (1336 – 1407)
Specific Heat, Btu/lb • °F (J/kg • °C) 0.109 (455)
Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)
70 – 200°F (21 – 93°C) 5.60 (10.08)
70 – 500°F (21 – 260°C) 5.74 (10.94)
70 – 800°F (21 – 427°C) 6.08 (10.67)
70 – 1000°F (21 – 538°C) 6.57 (11.83)
70 – 1200°F (21 – 650°C) 7.15 (12.87)
Thermal Conductivity[A], Btu • in/ft²•h•°F 70.9
W/m • °C 10.2
Electrical Resistivity[A], ohm•circ mil/ft.....615
$\mu\Omega$ • m 1.021
Young's Modulus[A], 10^6 psi (GPa)..... 26.8 (185)
Shear Modulus[A], 10^6 psi (GPa)..... 9.7 (67)
Poisson's Ratio[A] 0.38
Hardness[A], HRC .....30 – 38

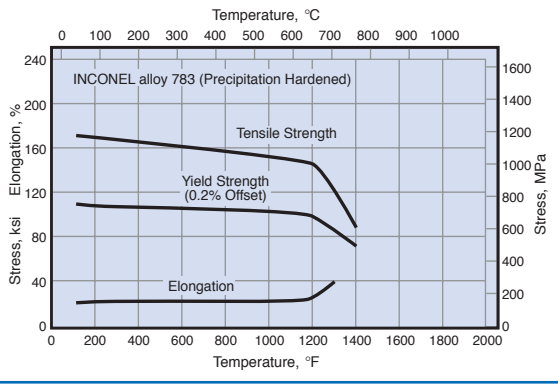
[A]Room temperature, as aged.

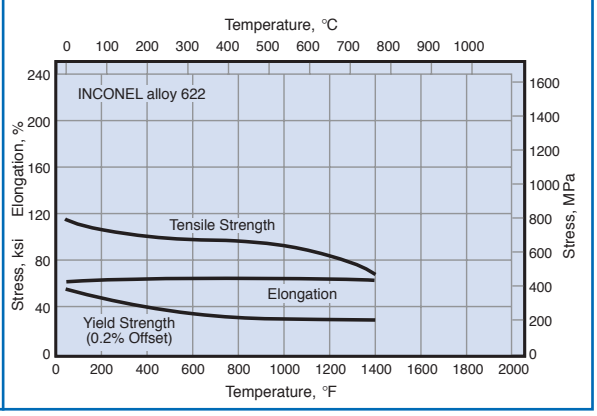
Density, lb/in³ (g/cm³) 0.311 (8.61)
Melting Range, °F (°C) ..... 2464 – 2529 (1351 – 1387)
Specific Heat, Btu/lb • °F (J/kg • °C) 0.091 (381)
Curie Temperature, °F (°C).....<-320 (<-196)
Permeability at 200 oersted (15.9 kA/m) .....<1.001
Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)
70 – 200°F (21 – 93°C) 6.90 (12.42)
70 – 1000°F (21 – 538°C) 7.46 (13.43)
70 – 1800°F (21 – 982°C) 7.84 (14.11)
Thermal Conductivity[A], Btu • in/ft²•h•°F.....91
W/m•°C.....13.2
Electrical Resistivity[A], ohm • circ mil/ft ($\mu\Omega$•m) .730.7 (1.215)
Young's Modulus[A], 10^6 psi (GPa)..... 30.3 (209)
Shear Modulus[A], 10^6 psi (GPa)..... 11.0 (75.8)
Poission's Ratio[A] 0.30
Hardness[A], HRB 86

[A]Room temperature, as annealed.

Typical Mechanical Properties

(Precipitation Hardened)





SPECIAL METALS
A PCC Company

INCONEL® alloy C-276

A nickel-molybdenum-chromium alloy with an addition of tungsten having excellent corrosion resistance in a wide range of severe environments. The high molybdenum content makes the alloy especially resistant to pitting and crevice corrosion. The low carbon content minimizes carbide precipitation during welding to maintain corrosion resistance in as-welded structures. Used in pollution control, chemical processing, pulp and paper production, and waste treatment.

INCONEL® alloy G-3

A nickel-chromium-iron alloy with additions of molybdenum and copper. It has good weldability and resistance to intergranular corrosion in the welded condition. The low carbon content helps prevent sensitization and consequent intergranular corrosion of weld heat-affected zones. Used for flue-gas scrubbers and for handling phosphoric and sulfuric acids.

Standard Product Forms

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Pipe and tube.

Major Specifications

UNS N10276
ASTM B 366, B 462, B 564, B 574, B 575, B 619, B 622, B 626, B 751, B 775, B 829
DIN 17744, 17750 – 17754
Werkstoff Nr. 2.4819
VdTÜV 400
ASME SB-366, SB-564, SB-574, SB-575, SB-619, SB-622, SB-626, SB-751, SB-775, SB-829
ASME Code Case 1924
NACE MR-0175/ISO 15156
ISO 6207, 6208, 9723 – 9725

UNS N06985
ASTM B 366, B 581, B 582, B 619, B 622, B 626, B 751, B 775, B 829
NACE MR-0175/ISO 15156
ASME SB-366, SB-581, SB-582, SB-619, SB-622, SB-626, SB-751, SB-775, SB-829
DIN 17744, 17750 – 17752
Werkstoff Nr. 2.4619
ISO 6207, 6208, 9724

Limiting Chemical Composition, %

Ni ... Remainder	W .....3.0 – 4.5	V .....0.35 max.
Mo.... 15.0 – 17.0	Co .....2.5 max.	P .....0.04 max.
Cr..... 14.5 – 16.5	Mn.....1.0 max.	S .....0.03 max.
Fe .....4.0 – 7.0	C .....0.01 max.	Si .....0.08 max.

Ni ... Remainder	Nb[a]....0.50 max.	Mn.....1.0 max.
Cr....21.0 – 23.5	C.....0.015 max.	P .....0.04 max.
Fe ...18.0 – 21.0	W .....1.5 max.	S .....0.03 max.
Mo .....6.0 – 8.0	Si .....1.0 max.	Co.....5.0 max.
Cu.....1.5 – 2.5	[a]Plus Ta.	

Physical Constants and Thermal Properties

Density, lb/in³ 0.321
g/cm³ 8.89

Melting Range, °F..... 2415 – 2500
°C ..... 1325 – 1370

Specific Heat, Btu/lb •°F.....0.102
J/kg • °C.....427

Coefficient of Expansion, 75 – 200°F, 10^{-6} in/in • °F 6.8
24 – 100°C, μm/m • °C 12.2

Thermal Conductivity, Btu • in/ft²•h•°F.....67.9
W/m•°C 9.8

Electrical Resistivity, ohm•circ mil/ft.....739.2
μΩ•m.....1.229

Permeability at 200 Oersted (15.9 kA/m) 1.0002

Density, lb/in³ 0.294
g/cm³ 8.14

Melting Range, °F..... 2300 – 2450
°C..... 1260 – 1340

Specific Heat, Btu/lb •°F.....0.108
J/kg • °C 452

Coefficient of Expansion, 75 – 212°F, 10^{-6} in/in • °F 8.1
24 – 100°C, μm/m • °C 14.6

Thermal Conductivity, Btu • in/ft²•h•°F 69
W/m•°C.....10.0

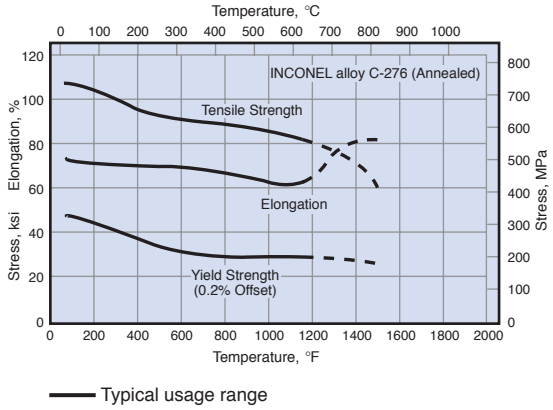
Typical Mechanical Properties

(Annealed)

Tensile Strength, ksi 110
MPa.....758

Yield Strength (0.2% Offset), ksi 53
MPa.....363

Elongation, % 62



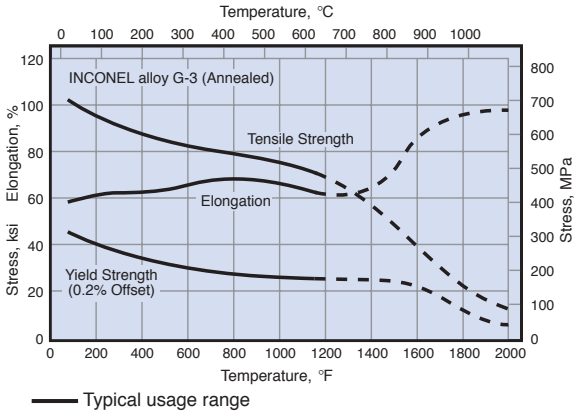
Typical usage range

(Annealed)

Tensile Strength, ksi 100
MPa.....690

Yield Strength (0.2% Offset), ksi 47
MPa.....320

Elongation, % 50



Typical usage range

SPECIAL METALS
A PCC Company

INCONEL® alloy HX

A nickel-chromium-iron-molybdenum alloy with outstanding strength and oxidation resistance at temperatures to 2200°F (1200°C). Matrix stiffening provided by the molybdenum content results in high strength in a solid-solution alloy having good fabrication characteristics. Used in gas turbines, industrial furnaces, heat-treating equipment, and nuclear engineering.

INCONEL® alloy N06230

A carbide strengthened nickel-chromium-tungsten alloy with an exceptional combination of strength, stability, and resistance to corrosion at very high temperatures. Alloy N06230 offers particularly good resistance to oxidation at temperatures greater than 1800°F (980°C). It also offers good resistance to carburization and nitridation. Potential applications for this alloy include equipment and components for land-based gas turbines, thermal and petrochemical processing, heat treating, and ore refining.

Standard Product Forms

Sheet, strip, plate, round bar, flat bar, forging stock, hexagon, wire and extruded section.

Contact Special Metals.

Major Specifications

UNS N06002
ASTM B 366, B 435, B 572, B 619, B 622, B 626, B 751, B 775, B 829
ASME SB-366, SB-435, SB-572, SB-619, SB-622, SB-626, SB-751, SB-775, SB-829
DIN 17744, 17750-17754
SAE AMS 5536, 5587, 5588, 5754, 5798
Werkstoff Nr. 2.4665
NACE MR-0175/ISO 15156
AECMA Pr EN 2182 – 2185
BS HR 6, HR 204
ISO 6207, 6208, 9723 – 9725

UNS N06230
W. Nr. 2.4733
ASTM B 366, B 435, B 564, B 572, B 619, B 622, B 626
ASME SB 435, SB 564, SB 572, SB 619, SB 622, SB 626
SAE/AMS 5839, 5878, 5891

Limiting Chemical Composition, %

Ni .... Remainder	Co .....0.5 – 2.5	Mn.....1.0 max.
Cr....20.5 – 23.0	W .....0.2 – 1.0	P .....0.04 max.
Fe ...17.0 – 20.0	C .....0.05 – 0.15	S .....0.03 max.
Mo.....8.0 – 10.0	Si .....1.0 max.	

Ni ...Remainder	W 13.0-15.0	S ..... 0.015 max.
Fe .....3.0 max.	C 0.05-0.15	Al 0.20- 0.50
Cr..... 20.0-24.0	Si 0.25-0.75	La....0.005-0.050
Co .....5.0 max.	Mn..... 0.30-1.00	B ..... 0.015 max.
Mo..... 1.0-3.0	P ..... 0.030 max.	

Physical Constants and Thermal Properties

Density, lb/in³ 0.297
g/cm³ 8.22

Melting Range, °F.....2300 – 2470
°C.....1260 – 1355

Specific Heat, Btu/lb•°F.....0.110
J/kg • °C.....461

Permeability at 200 Oersted (15.9 kA/m) 1.0110

Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F 7.4
20 – 100°C, μm/m • °C 13.3

Thermal Conductivity, Btu • in/ft²•h•°F 80.4
W/m•°C.....11.6

Electrical Resistivity, ohm•circ mil/ft.....698
μΩ•m 1.16

Density, lb/in³ 0.322
g/cm³ 8.91

Melting Range, °F..... 2480 – 2570
°C..... 1360 – 1410

Permeability at 200 Oersted (15.9 kA/m) 1.002

Coefficient of Expansion, 70 – 600°F, 10^{-6} in/in • °F..... 6.9
20 – 316°C,10^{-6} cm/cm •°C... 12.4

Electrical Resistivity, ohm•circ mil/ft..... 759
μΩ•cm..... 126

Young's Modulus, 10^3 ksi 30.7
GPa 211

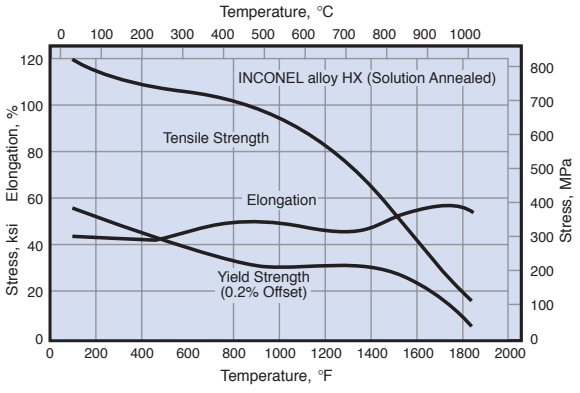
Shear Modulus, 10^3 ksi.....11.4
GPa 78.8

Poisson's Ratio..... 0.34

Typical Mechanical Properties

(Solution Annealed)

Rupture Strength (1000 h)	ksi	MPa
1400°F / 760°C	16.0	110
1500°F / 815°C	10.5	72
1600°F / 870°C	6.5	45
1700°F / 925°C	3.8	26
1800°F / 980°C	2.2	15

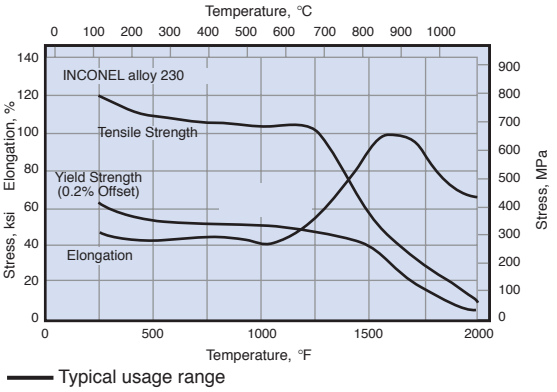


(Annealed)

Tensile Strength, ksi 117-122
MPa 807-841

Yield Strength (0.2% Offset), ksi 55-62
MPa 379-427

Elongation, % 44-48



SPECIAL METALS
A PCC Company

INCOLOY® alloy 800

A nickel-chromium alloy with good strength and excellent resistance to oxidation and carburization in high-temperature atmospheres. It also resists corrosion by many aqueous environments. The alloy maintains a stable, austenitic structure during prolonged exposure to high temperatures. Used for process piping, heat exchangers, carburizing equipment, heating-element sheathing, and nuclear steam-generator tubing.

INCOLOY® alloys 800H & 800HT®

Nickel-iron-chromium alloys having the same basic composition as INCOLOY alloy 800 but with significantly higher creep-rupture strength. The higher strength results from close control of the carbon, aluminum, and titanium contents in conjunction with a high-temperature anneal. Used in chemical and petrochemical processing, in power plants for super-heater and reheater tubing, in industrial furnaces, and for heat-treating equipment.

Standard Product Forms

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Major Specifications

UNS N08800
BS 3072 – 3076 (NA15)
ASTM B 163, A 240, B 366, B 407 – B 409, A 480, B 514, B 515, B 564, B 751, B 775, B 829
DIN 470
Werkstoff Nr. 1.4876
VdTÜV 412
ASME SB-163, SA-240, SB-366, SB-407 – SB-409, SA-480, SB-514, SB-515, SB-564, SB-751, SB-775, SB-829
ASME Code Cases 1325, 1949, 2339, N-20
SAE AMS 5766, 5871
NACE MR-0175/ISO 15156
ISO 9723 – 9725, 6207, 6208

UNS N08810, N08811
BS 3072, 3073, 3074, 3075 , 3076 (NA15)
ASTM A 240, A 480, B 163, B 366, B 407 – 409, B 514, B 515, B 564, B 751, B 775, B 829
ASME SA-240, SA-480, SB-163, SB-366, SB-407 – SB-409, SB-514, SB-515, SB-564, SB-751, SB-775, SB-829
ASME Code Cases 1325, 1949, 1983, 2339, N-201, N-254
DIN 17459, 17460
Werkstoff Nr. 1.4876, 1.4958, 1.4959
VdTÜV 412, 434
EN 10028-7, 10095
ISO 4955A, 6207, 6208, 9723, 9725

Limiting Chemical Composition, %

Ni ...30.0 – 35.0
Fe .....39.5 min.
Cr....19.0 – 23.0
C.....0.10 max.
Mn.....1.50 max.
S .....0.015 max.
Si .....1.0 max.
Cu .....0.75 max.
Al ....0.15 – 0.60
Ti.....0.15 – 0.60

800H	Ni ...30.0 – 35.0 Fe .....39.5 min. Cr....19.0 – 23.0	C.....0.05 – 0.10 Al ....0.15 – 0.60	Ti.....0.15 – 0.60 Al+Ti ....0.30 – 1.20
800HT	Ni ...30.0 – 35.0 Fe .....39.5 min. Cr....19.0 – 23.0	C.....0.06 – 0.10 Al ....0.25 – 0.60	Ti.....0.25 – 0.60 Al+Ti ....0.85 – 1.20

*By special agreement, this product can be supplied with aluminum + titanium limited to 0.4 – 0.7%.

Physical Constants and Thermal Properties

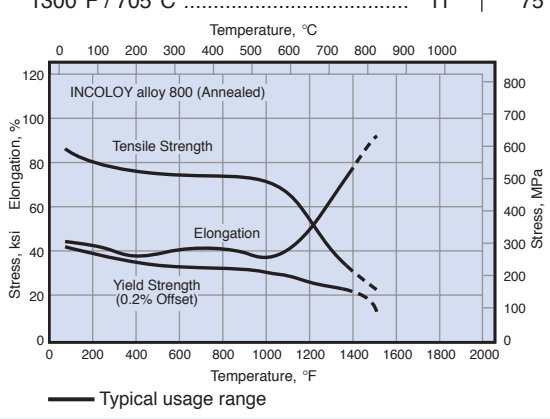
Density, lb/in³	0.287
g/cm³	7.94
Melting Range, °F	2475 – 2525
°C	1357 – 1385
Specific Heat, Btu/lb • °F	0.11
J/kg • °C	460
Curie Temperature, °F	-175
°C	-115
Permeability at 200 Oersted (15.9 kA/m)	1.014
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F	7.9
20 – 100°C, μm/m • °C	14.4
Thermal Conductivity, Btu • in/ft²•h•°F	80
W/m•°C	11.5
Electrical Resistivity, ohm•circ mil/ft	595
μΩ•m	0.989

Density, lb/in³	0.287
g/cm³	7.94
Melting Range, °F	2475 – 2525
°C	1357 – 1385
Specific Heat, Btu/lb • °F	0.11
J/kg • °C	460
Curie Temperature, °F	-175
°C	-115
Permeability at 200 Oersted (15.9 kA/m)	1.014
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F	7.9
20 – 100°C, μm/m • °C	14.4
Thermal Conductivity, Btu • in/ft²•h•°F	80
W/m•°C	11.5
Electrical Resistivity, ohm•circ mil/ft	595
μΩ•m	0.989

Typical Mechanical Properties

(Annealed)

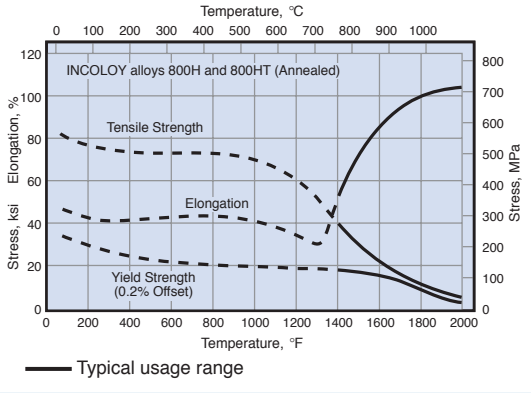
Rupture Strength (1000 h)	ksi	MPa
1000°F / 540°C	48	330
1100°F / 595°C	32	220
1200°F / 650°C	21	145
1300°F / 705°C	11	75



Typical usage range

(Annealed)

Rupture Strength (1000 h)	ksi	MPa
1200°F / 650°C	24.0	165
1300°F / 705°C	15.0	105
1400°F / 760°C	10.0	70
1600°F / 870°C	4.7	32
1800°F / 980°C	2.0	14



Typical usage range

SPECIAL METALS
A PCC Company

INCOLOY® alloy 803

Designed for use in petrochemical, chemical and thermal processing applications, the alloy provides an exceptional level of high-temperature corrosion-resistance in oxidation, sulfidation, carburization and nitridation environments. In addition to thermal stability characteristics required to prevent thermal distortion and embrittlement, it exhibits excellent stress-rupture strengths. These characteristics, along with a high resistance to carburization and cyclic oxidation, make this alloy the material of choice for many severe applications including ID-finned pyrolysis tubing in high-severity ethylene furnaces.

INCOLOY® alloy 825

A nickel-iron-chromium alloy with additions of molybdenum and copper. It has excellent resistance to both reducing and oxidizing acids, to stress-corrosion cracking, and to localized attack such as pitting and crevice corrosion.
The alloy is especially resistant to sulfuric and phosphoric acids. Used for chemical processing, pollution-control equipment, oil and gas well piping, nuclear fuel reprocessing, acid production, and pickling equipment.

Standard Product Forms

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, ID finned tube and wire.

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Major Specifications

UNS S35045
ASTM A 182, A 213, A 240, A 249, A 480
ASME Code Case 2304
ASME SA 182, SA 213, SA 240, SA 249, SA 480

UNS N08825
BS 3072 – BS 3074, 3076 (NA16)
ASTM B 163, B 366, B 423 – B 425, B 564, B 704, B 705, B 751, B 775, B 829
Werkstoff Nr. 2.4858
VdTÜV 432
NACE MR-0175/ISO 15156
ASME SB-163, SB-366, SB-423 – SB-425, SB-564, SB-704, SB-705, SB-751, SB-775, SB-829
ASME Code Cases 1936, N-572
DIN 17744, 17750 – 17754
ISO 6207, 6208, 9723 – 9725

Limiting Chemical Composition, %

Ni ...32.0 – 37.0	Mn.....1.50 max.	Al ....0.15 – 0.60
Fe ... Remainder	S .....0.015 max.	Ti.....0.15 – 0.60
Cr....25.0 – 29.0	Si .....1.0 max.	
C .....0.06 – 0.10	Cu .....0.75 max.	

Ni ...38.0 – 46.0	Cu.....1.5 – 3.0	S .....0.03 max.
Fe .....22.0 min.	Ti.....0.6 – 1.2	Si .....0.5 max.
Cr....19.5 – 23.5	C.....0.05 max.	Al .....0.2 max.
Mo.....2.5 – 3.5	Mn.....1.0 max.	

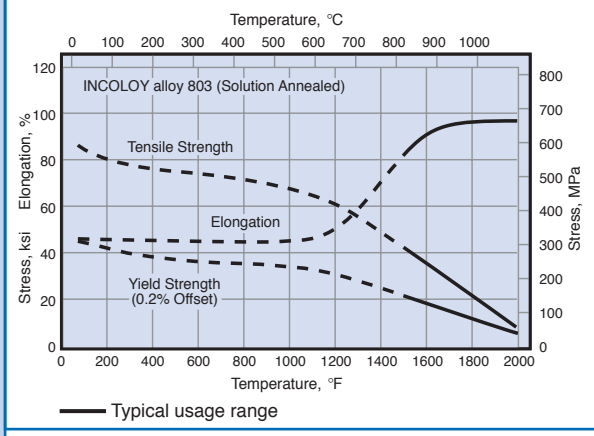
Physical Constants and Thermal Properties

Density, lb/in^3 (g/cm^3) 0.284 (7.86)
Melting Range, °F (°C) ..... 2490 – 2555 (1365 – 1400)
Specific Heat, Btu/lb•°F (J/kg•°C) 0.114 (479)
Permeability at 200 Oersted (15.9 kA/m) 1.001
Coefficient of Expansion, 10^{-6} in/in•°F (μm/m•°C)
70 – 200°F (21 – 93°C) 8.31 (15.0)
70 – 800°F (21 – 427°C) 9.14 (16.5)
70 – 1200°F (21 – 649°C) 9.48 (17.1)
Thermal Conductivity, Btu • in/ft^2•h•°F 78
W/m•°C 11.3
Electrical Resistivity, ohm•circ mil/ft 618
$\mu\Omega$•m 1.03
Young's Modulus[A], 10^6 psi (GPa) 28.3 (195)
Shear Modulus[A], 10^6 psi (GPa) 10.7 (73.8)
Poisson's Ratio[A] 0.32
[A]Room temperature, as solution annealed.

Density, lb/in^3 ..... 0.294
g/cm^3 ..... 8.14
Melting Range, °F ..... 2500 – 2550
°C ..... 1370 – 1400
Specific Heat, Btu/lb•°F 0.105
J/kg•°C 440
Curie Temperature, °F ..... <-320
°C ..... <-196
Permeability at 200 Oersted (15.9 kA/m) 1.005
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F 7.8
21 – 93°C, μm/m•°C 14.0
Thermal Conductivity, Btu • in/ft^2•h•°F 76.8
W/m•°C 11.1
Electrical Resistivity, ohm•circ mil/ft 678
$\mu\Omega$•m 1.13

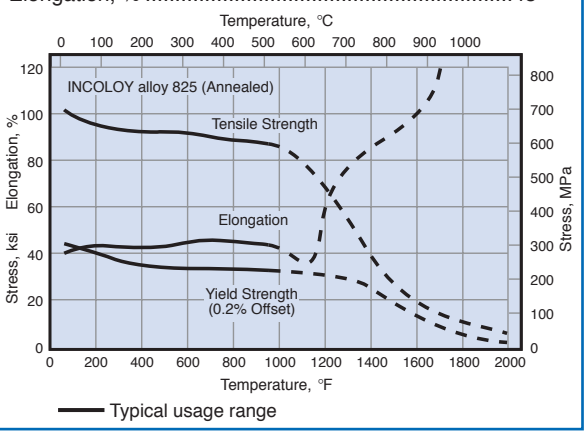
Typical Mechanical Properties

(Solution Annealed)



(Annealed)

Tensile Strength, ksi 100
MPa 690
Yield Strength (0.2% Offset), ksi 45
MPa 310
Elongation, % 45



SPECIAL METALS
A PCC Company

INCOLOY® alloy 864

A new high-performance and cost-effective alloy specifically developed for automotive exhaust system flexible couplings and potentially useful for exhaust gas re-circulation tubes and other fabricated exhaust system components.

INCOLOY® alloy 865

INCOLOY alloy 865 (UNS S35115) is an economical, high performance corrosion resistant alloy. Developed from the technology of INCOLOY alloy 864, it improved strength, ductility and fatigue resistance at a reduced cost. The alloy was designed for automotive applications such as flexible couplings and exhaust gas recirculation (EGR) components. However, with its excellent combination of strength and corrosion resistance, alloy 865 may be evaluated for chemical processing and marine applications.

Standard Product Forms

Sheet, strip and wire.

Sheet and strip.

Major Specifications

UNS S35135
ASTM A 240, A 480

UNS S35115, ASTM A240/A480

Limiting Chemical Composition, %

Ni ..30.0 – 38.0	Mo.....4.0 – 4.8	Mn.....1.0 max.
Fe ... Remainder	C.....0.08 max.	S .....0.015 max.
Cr....20.0 – 25.0	Si .....0.6 – 1.0	Ti.....0.4 – 1.0

Ni 10.0-22.0	N 0.20-0.30	P .....0.045 max.
Cr..... 23.0-25.0	Mn.....1.0 max.	S .....0.015 max.
Mo..... 1.50-2.50	C .....0.020 max.	

Physical Constants and Thermal Properties

Density, lb/in³ (g/cm³) 0.290 (8.02)
Melting Range, °F (°C) .....2467 – 2539 (1353 – 1393)
Permeability at 200 Oersted (15.9 kA/m) 1.004
Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)
70 – 200°F (21 – 93°C) 8.15 (14.7)
70 – 800°F (21 – 427°C) 8.90 (15.9)
70 – 1200°F (21 – 649°C) 9.21 (16.4)
Thermal Conductivity[A], Btu • in/ft²•h•°F 78.1
W/m • °C 11.3
Electrical Resistivity[A], ohm • circ mil/ft 628
$\mu\Omega$ • m..... 1.04
Young's Modulus[A], 10^6 psi (GPa).....28.3 (195)

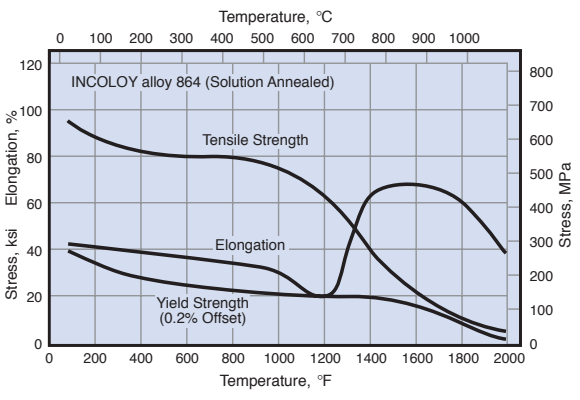
[A]Room temperature, as annealed.

Density, lb/in³ 0.276
g/cm³ 7.64
Melting Range, °F..... 2484 – 2535
°C ..... 1362 – 1390
Permeability at 200 Oersted (15.9 kA/m) 1.002
Electrical Resistivity, ohm•circ mil/ft.....553
Mico-ohm/cm.....92
Young's (Tensile) Modulus..... 28.7 x 10^3 ksi (195 GPa)

Typical Mechanical Properties

(Solution Annealed)

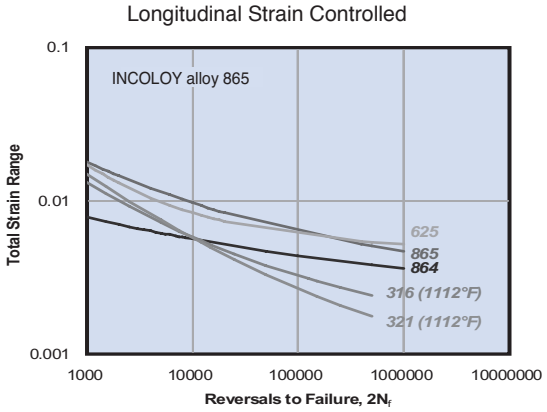
Tensile Strength, ksi 94
MPa 648
Yield Strength (0.2% Offset), ksi 40
MPa 276
Elongation, % 44



(Annealed)

Tensile Strength, ksi 110
MPa.....758
Yield Strength (0.2% Offset), ksi 54
MPa 372
Elongation, % 50
Reduction of Area, %.....44
Hardness .....88 HRB

Fatigue Properties at 1000°F (538°C), Longitudinal Strain Controlled



SPECIAL METALS
A PCC Company

INCOLOY® alloy 903

A nickel-iron-cobalt alloy with additions of niobium, titanium, and aluminum for precipitation hardening. The alloy combines high strength with a low and constant coefficient of thermal expansion at temperatures to about 800°F (430°C). It also has a constant modulus of elasticity and is highly resistant to thermal fatigue and thermal shock. Used in gas turbines for rings and casings.

INCOLOY® alloy 907

A nickel-iron-cobalt alloy with additions of niobium and titanium for precipitation hardening. It has the low coefficient of expansion and high strength of INCOLOY alloy 903 but with improved notch-rupture properties at elevated temperatures. Used for components of gas turbines including seals, shafts, and casings.

Standard Product Forms

INCOLOY alloy 903	INCOLOY alloy 907
Sheet, plate, rod, bar and forging stock.	Round bar and forging stock.

Major Specifications

INCOLOY alloy 903	INCOLOY alloy 907
UNS N19903	UNS N19907

Limiting Chemical Composition, %

INCOLOY alloy 903	INCOLOY alloy 907
Ni ...36.0 – 40.0	Ni ....35.0 – 40.0
Co...13.0 – 17.0	Nb.....4.3 – 5.2
Ti.....1.00 – 1.85	Al .....0.2 max.
Fe ... Remainder	Fe .. Remainder
Al ....0.30 – 1.15	Ti .....1.3 – 1.8
Nb...2.40 – 3.50	Si ....0.07 – 0.35
	Co ...12.0 – 16.0

Physical Constants and Thermal Properties

	INCOLOY alloy 903	INCOLOY alloy 907
Density, lb/in³	0.298	0.301
g/cm³	8.25	8.33
Melting Range, °F	2405 – 2539	2440 – 2550
°C	1318 – 1393	1335 – 1400
Specific Heat, Btu/lb•°F	0.105	0.103
J/kg • °C	442	431
Curie Temperature, °F	780 – 880	750 – 850
°C	415 – 470	400 – 455
Coefficient of Expansion, 77 – 800°F, 10^{-6} in/in • °F	4.0	4.3
25 – 427°C, μm/m • °C	7.2	7.7
Thermal Conductivity, Btu • in/ft²•h•°F	116	103
W/m•°C	16.7	14.8
Electrical Resistivity, ohm•circ mil/ft	379	419
μΩ•m	0.650	0.697

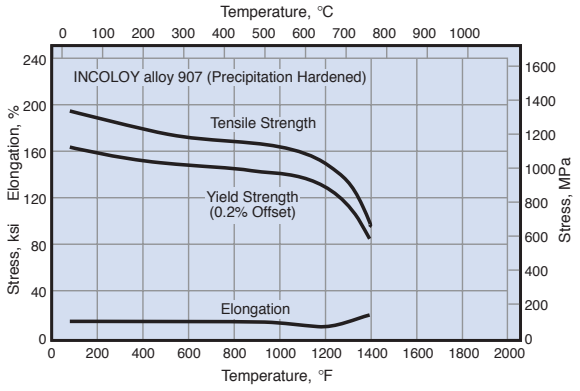
Typical Mechanical Properties

(Precipitation Hardened)

INCOLOY alloy 903	
Tensile Strength, ksi	190
MPa	1310
Yield Strength (0.2% Offset), ksi	160
MPa	1100
Elongation, %	14

(Precipitation Hardened)

INCOLOY alloy 907 Rupture Strength (1000 h)	ksi	MPa
1000°F / 540°C	100	690
1100°F / 595°C	85	590
1200°F / 650°C	50	340



SPECIAL METALS
A PCC Company

INCOLOY® alloy 909

A nickel-iron-cobalt alloy with a silicon addition and containing niobium and titanium for precipitation hardening. It is similar to INCOLOY alloys 903 and 907 in that it has low thermal expansion and high strength. However, the silicon addition results in improved notch-rupture and tensile properties that are achieved with less-restrictive processing and significantly shorter heat treatments. Used for gas-turbine casings, shrouds, vanes, and shafts.

INCOLOY® alloy 925

A precipitation-hardenable nickel-iron-chromium alloy with additions of molybdenum and copper. It combines the high strength of a precipitation-hardenable alloy with the excellent corrosion resistance of INCOLOY alloy 825. The alloy has outstanding resistance to general corrosion, pitting, crevice corrosion, and stress-corrosion cracking in many aqueous environments including those containing sulfides and chlorides. Used for surface and down-hole hardware in sour gas wells and for oil-production equipment.

Standard Product Forms

Round bar, forging stock and hot-rolled profile.

Tube, round bar, flat bar, forging stock and wire.

Major Specifications

UNS N19909
SAE AMS 5884, 5892, 5893

UNS N09925
NACE MR-0175/ISO 15156
ASME Code Case 2218

Limiting Chemical Composition, %

Ni ....35.0 – 40.0	Nb .....4.3 – 5.2	Al .....0.15 max.
Fe .. Remainder	Ti .....1.3 – 1.8	C .....0.06 max.
Co ...12.0 – 16.0	Si ....0.25 – 0.50	

Ni ...42.0 – 46.0	Mo.....2.5 – 3.5	Al .....0.1 – 0.5
Fe ... Remainder	Cu .....1.5 – 3.0	C .....0.03 max.
Cr....19.5 – 22.5	Ti.....1.90 – 2.40	

Physical Constants and Thermal Properties

Density, lb/in^3 .....0.296
g/cm^3 .....8.19

Melting Range, °F..... 2540 – 2610
°C..... 1395 – 1430

Specific Heat, Btu/lb • °F.....0.102
J/kg • °C 427

Curie Temperature, °F .....750 – 850
°C .....400 – 455

Coefficient of Expansion, 77 – 800°F, 10^{-6} in/in • °F ...4.3
25 – 427°C, μm/m • °C 7.7

Thermal Conductivity, Btu • in/ft^2•h•°F 103
W/m•°C.....14.8

Electrical Resistivity, ohm•circ mil/ft.....438
$\mu\Omega$•m 0.728

Density, lb/in^3 .....0.292
g/cm^3 .....8.08

Melting Range, °F..... 2392 – 2490
°C..... 1311 – 1366

Specific Heat, Btu/lb • °F.....0.104
J/kg • °C 435

Permeability at 200 Oersted (15.9 kA/m) 1.001

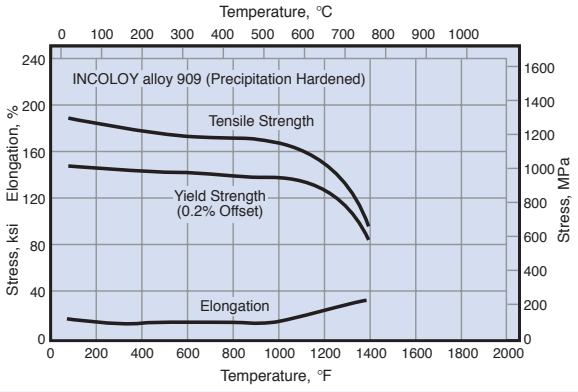
Coefficient of Expansion, 77 – 200°F, 10^{-6} in/in • °F 7.8
25 – 93°C, μm/m • °C.....13.2

Electrical Resistivity, ohm•circ mil/ft.....701
$\mu\Omega$•m 1.17

Typical Mechanical Properties

(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1000°F / 540°C	130	900
1100°F / 595°C	85	590
1200°F / 650°C	45	310

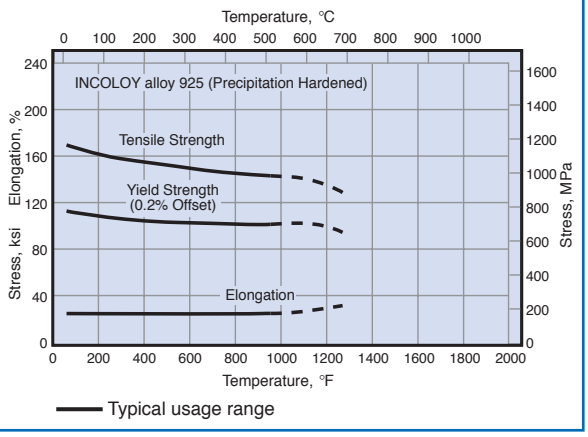


(Precipitation Hardened)

Tensile Strength, ksi 176
MPa.....1210

Yield Strength (0.2% Offset), ksi 118
MPa.....810

Elongation, % 24



INCOLOY® alloy 945

INCOLOY alloy 945 (UNS N09945) is a corrosion-resistant, high strength, age hardenable nickel-iron-chromium alloy. Its nickel content provides resistance stress corrosion cracking. Its combination of nickel, molybdenum and copper gives it outstanding resistance to attack by reducing media while its high chromium content provides resistance to oxidizing environments. Molybdenum and niobium provide resistance to localized attack such as pitting and crevice corrosion. Niobium, titanium and aluminum react upon heat treatment to precipitate gamma prime and gamma double prime phases that give the alloy its high strength. With this highly desirable combination of properties, alloy 945 is suitable for many demanding applications in oil and gas service. With its resistance to sulfide-induced stress corrosion cracking and corrosion in hydrogen sulfide, alloy 945 is ideal for fabrication of down-hole and surface well equipment including tubular products, valves, hangers, landing nipples, tool joints and packers. When cold worked and aged, the alloy provides the properties required for fasteners, pump shafting and high strength piping.

Standard Product Forms

Bar, forging stock, tubes.

Major Specifications

UNS N09945
NACE MR0175 (Approved to Level VI)

Limiting Chemical Composition, %

Ni ...45.0 – 55.0	Nb.....2.5 – 4.5	Mn.....1.0 max.
Cr....19.5 – 23.0	Ti.....0.5 – 2.5	Si .....0.5 max.
Fe .....Balance	Al .....0.01 – 0.7	P .....0.03 max.
Mo.....3.0 – 4.0	C ...0.005 – 0.04	S .....0.030 max.
Cu.....1.5 – 3.0		

Physical Constants and Thermal Properties

Density, lb/in^3 (g/cm^3) 0.281 (7.777)
Melting Range, °F (°C) .....2317 – 2510 (1270 – 1377)
Permeability at 200 Oersted 1.003
Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)
70 – 200°F (21 – 93°C) 7.88 (14.19)
70 – 800°F (21 – 427°C) 8.40 (15.12)
70 – 1200°F (21 – 649°C) 8.85 (15.93)
Young's (Tensile) Modulus..... 28.3 x 10^3 ksi
Shear Modulus ..... 10.8 x 10^3 ksi
Poisson's Ratio..... 0.31

Typical Mechanical Properties

(Annealed + Aged)

Tensile Strength, ksi 172.0
MPa.....1186

Yield Strength (0.2% Offset), ksi 136.5
MPa.....941

Elongation, % 22
Reduction of Area, %.....44
Hardness 41HRC
Impact Strength (CVN @ - 75°F), ft. lbs 64
Joules 87

INCOLOY® alloy DS

A nickel-iron-chromium alloy with an addition of silicon. It has good high-temperature strength and excellent resistance to oxidation and carburization. The silicon content makes the alloy resistant to internal oxidation in high-temperature atmospheres that vary between oxidizing and reducing. Used in industrial furnaces and for heat-treating baskets, trays, and fixtures.

Pipe, tube, sheet, strip, plate, round bar, forging stock, hexagon and wire.

BS 3072 – BS 3076 (NA17)
Werkstoff Nr. 1.4862

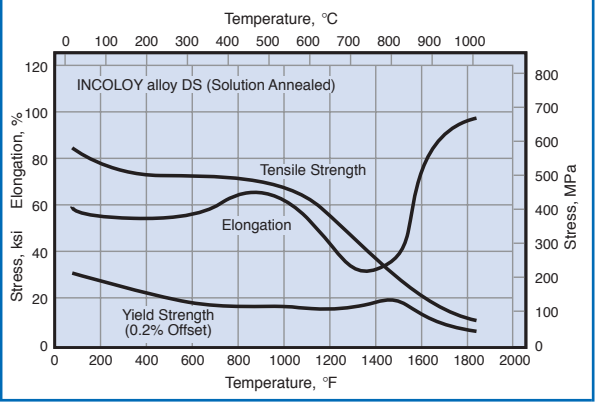
Ni[a] ...34.5 – 41.0	Si .....1.9 – 2.6	Cu.....0.50 max.
Fe ....Remainder	Mn.....0.8 – 1.5	Ti.....0.20 max.
Cr.....17.0 – 19.0	C.....0.10 max.	S .....0.03 max.

[a]Plus Co.

Density, lb/in^3 .....0.284
g/cm^3 .....7.86
Melting Range, °F..... 2430 – 2550
°C..... 1330 – 1400
Specific Heat, Btu/lb •°F.....0.108
J/kg • °C 452
Permeability at 200 Oersted (15.9 kA/m) 1.038
Coefficient of Expansion, 68 – 212°F, 10^{-6} in/in • °F ...8.3
20 – 100°C, μm/m • °C 15.0
Thermal Conductivity, Btu • in/ft^2•h•°F 83.2
W/m•°C.....12.0
Electrical Resistivity, ohm•circ mil/ft.....650
$\mu\Omega$•m 1.08

(Solution Annealed)

Rupture Strength (1000 h)	ksi	MPa
1380°F / 750°C	7.1	49.0
1560°F / 850°C	3.8	26.0
1740°F / 950°C	2.2	15.0
1920°F / 1050°C	0.97	6.7



SPECIAL METALS
A PCC Company

INCOLOY® alloy 20

A nickel-iron-chromium alloy with additions of copper and molybdenum. It also contains niobium for stabilization against sensitization and resultant intergranular corrosion. The alloy has excellent resistance to general corrosion, pitting, and crevice corrosion in chemicals containing chlorides and sulfuric, phosphoric, and nitric acids. Used for tanks, piping, heat exchangers, pumps, valves, and other process equipment.

INCOLOY® alloy 28

INCOLOY alloy 28 (UNS N08028) is a highly corrosion-resistant austenitic alloy offering resistance to a variety of media. The alloy resists attack in reducing media due to its contents of nickel, copper and molybdenum and is resistant to oxidizing species due to its high level of chromium. Alloy 28 offers resistance to general, localized and stress-induced corrosion by chlorides and hydrogen sulfides. Thus, it is widely used in oilfield applications. Tubes are cold worked to high levels of strength for downhole service in deep sour gas wells. With its excellent combination of strength and corrosion resistance, alloy 28 also finds applications in the process industries. It is especially useful for handling phosphoric acid. Due to its resistance to chlorides, alloy 28 tubes may be used in the marine industry for seawater-cooled heat exchangers.

Standard Product Forms

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Tube.

Major Specifications

UNS N08020
ASTM A 240, A 480, B 366, B 462 – 464, B 468, B 471 – B 475, B 729, B 751, B 775, B 829, B 906
DIN 17744, 17750-17754
ASME SA-240, SA-480, SB-366, SB-462 – SB-464, SB-468, SB-471 – SB-475, SB-729, SB-751, SB-775, SB-829, SB-906
ISO 6207, 6208, 9723 – 9725

UNS N08028
ASTM B 668, B 709, B 829
ASME SB-668, SB-709, SB-829
Werkstoff Nr. 1.4563
NACE MR-01-75

Limiting Chemical Composition, %

Ni ...32.0 – 38.0	Nb + Ta .. 8xC-1.0	Mn.....2.0 max.
Fe ... Remainder	Mo.....2.0 – 3.0	P .....0.045 max.
Cr....19.0 – 21.0	Nb ..... 1.0 max.	S .....0.035 max.
Cu .....3.0 – 4.0	C ..... 0.07 max.	Si .....1.0 max.

Ni ...30.0 – 34.0	Fe .....Balance	S .....0.030 max.
Cr....26.0 – 28.0	Mn.....2.50 max.	Si .....1.00 max.
Mo.....3.0 – 4.0	C.....0.030 max.	
Cu .....0.6 – 1.4	P .....0.030 max.	

Physical Constants and Thermal Properties

Density, lb/in^3 .....0.292
g/cm^3 .....8.08

Specific Heat, Btu/lb •°F.....0.12
J/kg • °C 500

Coefficient of Expansion, 77 – 212°F, 10^{-6} in/in • °F 8.2
25 – 100°C, µm/m • °C 14.7

Thermal Conductivity, Btu • in/ft^2•h•°F 85
W/m•°C.....12.3

Electrical Resistivity, ohm•circ mil/ft.....651
µΩ•m 1.08

Density, lb/in^3 .....0.29
g/cm^3 .....8.0

Specific Heat, Btu/lb •°F.....0.105
J/kg • °C ..... (450)

Coefficient of Expansion, 10^{-6} in/in • °F (µm/m • °C)
75 – 200°F (21 – 93°C)..... 8.3 (15.0)
75 – 500°F (21 – 260°C)..... 8.8 (15.9)
75 – 800°F (21 – 427°C)..... 9.3 (16.8)

Thermal Conductivity[A], Btu • in/ft^2•h•°F 66
W/m • °C 11.4

Electrical Resistivity[A], ohm•circ mil/ft.....594
µΩ•m 0.99

Young's Modulus[A], 10^6 psi 29.0
GPa 200

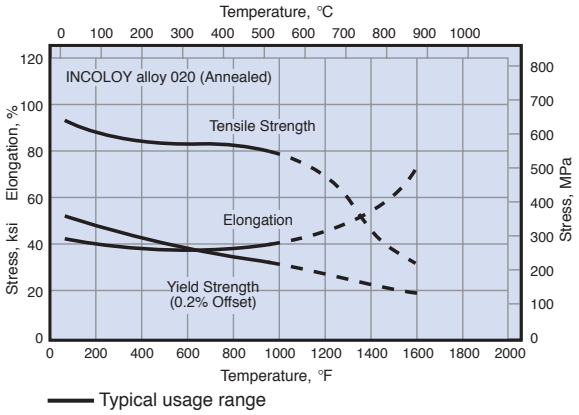
[A]Room temperature, as annealed.

Typical Mechanical Properties

(Annealed)
Tensile Strength, ksi 90
MPa.....620

Yield Strength (0.2% Offset), ksi 45
MPa.....300

Elongation, % 40



(Annealed)
Tensile Strength, ksi 73
MPa.....500

Yield Strength (0.2% Offset), ksi 31
MPa.....214

Elongation, % 40
Hardness (HRB) 70/90

(Cold Worked)
Tensile Strength, ksi 130
MPa.....896

Yield Strength (0.2% Offset), ksi 110
MPa.....758

Elongation, % 15
Hardness (HRC).....33 max.

SPECIAL METALS
A PCC Company

INCOLOY® alloy 330

A nickel-iron-chromium alloy with an addition of silicon for enhanced oxidation resistance. It has good strength at high temperatures and excellent resistance to carburizing and oxidizing atmospheres. The alloy's austenitic microstructure remains stable during long-time exposure to high temperature. Used in industrial heating for furnace muffles, retorts, and conveyor systems and for heat-treating baskets and fixtures.

INCOLOY® alloy 25-6MO

A super-austenitic containing 6% molybdenum and offering excellent corrosion-resistance to neutral and acidic environments containing chlorides or other halides such as are found in air pollution control and flue gas desulfurization systems. The molybdenum and nitrogen content provide resistance to pitting and crevice corrosion, while copper enhances resistance to sulfuric acid. The alloy is especially suited for service in high-chloride environments such as brackish water, seawater, caustic chlorides and pulp mill bleach systems.

Standard Product Forms

Tube, sheet, strip, plate, round bar, forging stock, hexagon, wire, and wire rod.

Pipe, tube, sheet, strip, plate, round bar, forging stock and wire.

Major Specifications

UNS N08330
ASTM B 366, B 511, B 512, B 535, B 536, B 546, B 710, B 739, B 829
SAE AMS 5592, 5716
ASME SB-366, SB-511, SB-512, SB-535, SB-536, SB-546, SB-710, SB-739, SB-829
Werkstoff Nr. 1.4886

UNS N08925, N08926
ASTM A 240, A 480, B 366, B 472, B 625, B 649, B 673, B 674, B 677, B 751, B 775, B 804, B 829
W. Nr. 1.4529
ASME SA-240, SA-480, SB-366, SB-472, SB-625, SB-649, SB-673, SB-674, SB-677, SB-751, SB-775, SB-804, SB-829
ASME Code Cases 2120, N-453, N-454, N-455

Limiting Chemical Composition, %

Ni ...34.0 – 37.0	Si ....0.75 – 1.50	P .....0.030 max.
Fe ... Remainder	C.....0.08 max.	S .....0.030 max.
Cr....17.0 – 20.0	Mn.....2.0 max.	

Ni .... 24.0 – 26.0	Cu ..... 0.5 – 1.5	P .....0.03 max.
Fe ... Remainder	N ..... 0.15 – 0.25	S .....0.01 max.
Cr..... 19.0 – 21.0	C.....0.02 max.	Si .....0.5 max.
Mo..... 6.0 – 7.0	Mn.....2.0 max.	

Physical Constants and Thermal Properties

Density, lb/in³ 0.292
g/cm³ 8.08

Melting Range, °F..... 2520 – 2590
°C..... 1380 – 1420

Specific Heat, Btu/lb•°F.....0.11
J/kg • °C 460

Permeability at 200 Oersted (15.9 kA/m) 1.02

Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)
75 – 200°F (24 – 93°C)..... 8.3 (14.9)

Thermal Conductivity, Btu • in/ft²•h•°F.....86
W/m • °C 12.4

Electrical Resistivity, ohm•circ mil/ft.....612
$\mu\Omega$•m 1.017

Density, lb/in³ 0.290
g/cm³ 8.03

Melting Range, °F..... 2410 – 2550
°C..... 1320 – 1400

Specific Heat, Btu/lb•°F.....0.12
J/kg • °C 500

Permeability at 200 Oersted (15.9 kA/m) 1.005

Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)
70 – 200°F (21 – 93°C) 8.42 (15.2)
70 – 800°F (21 – 427°C) 9.12 (16.4)
70 – 1200°F (21 – 649°C) 9.41 (16.9)

Thermal Conductivity[A], Btu • in/ft²•h•°F 79.8
W/m • °C.....11.5

Electrical Resistivity[A], ohm•circ mil/ft.....480
$\mu\Omega$ • m 0.80

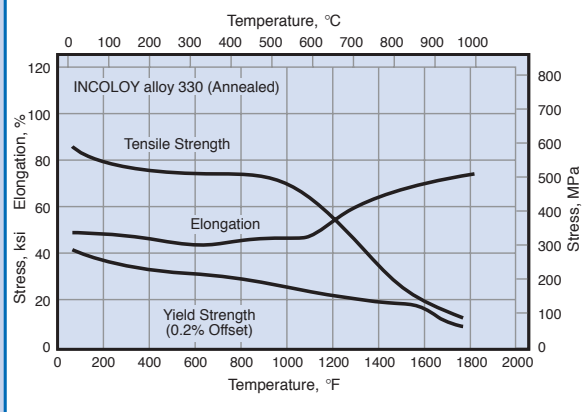
Young's Modulus[A], 10^6 psi (GPa)..... 27.3 (188)

[A]Room temperature, as annealed.

Typical Mechanical Properties

(Annealed)

Rupture Strength (1000 h)	ksi	MPa
1400°F / 760°C	7.0	48
1600°F / 870°C	3.1	21
1800°F / 980°C	1.25	8.6
2000°F / 1095°C	0.78	5.4

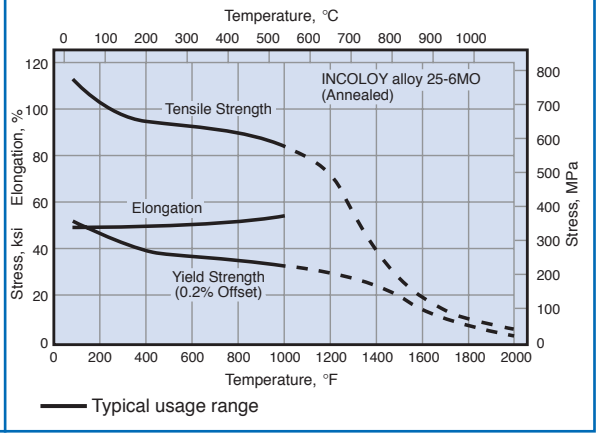


(Annealed)

Tensile Strength, ksi 100
MPa.....690

Yield Strength (0.2% Offset), ksi 48
MPa.....330

Elongation % 42



SPECIAL METALS
A PCC Company

INCOLOY® alloy 25-6HN

INCOLOY alloy 25-6HN is a super-austenitic stainless steel containing 6% molybdenum and with properties enhanced by its content of nitrogen. Its high content of nickel results in thermal stability and resistance to stress corrosion cracking. Designated as UNS N08367, alloy 25-6HN directly competes with alloy AL6XN®[1]. The same ASTM, ASME, and NACE specifications cover the alloys. Alloy 25-6HN offers significantly improved strength and corrosion resistance in most environments over conventional austenitic stainless steels such as AISI 304 or 316L. Typical applications include welded tubes for heat exchangers for chemical processing and marine applications and for desalination systems, flue gas desulfurization equipment for coal-fired power plants, and reaction vessels for pharmaceutical production.

[1]"AL6XN" is a registered trademark of Allegheny Ludlum Corporation.

INCOLOY® alloy 27-7MO

An advanced 7% molybdenum super-austenitic stainless steel offering corrosion resistance in most environments superior to 6% molybdenum super-austenitic stainless steels. In many environments, alloy 27-7MO offers resistance approaching or exceeding that of much more highly alloyed materials such as INCONEL alloys 625, 22 and C-276. Applications for this alloy are found in the pollution control, power, marine, chemical processing, pulp and paper, pharmaceutical, and oil and gas industries.

Standard Product Forms

INCOLOY alloy 25-6HN	INCOLOY alloy 27-7MO
Sheet, strip, plate, round bar, wire rod and forging stock.	Sheet, plate, bar and wire.

Major Specifications

INCOLOY alloy 25-6HN	INCOLOY alloy 27-7MO
UNS N08367	UNS S31277
ASTM B688, A240, B691, B564, B472, B676, B675, B804, B462, B366	ASTM A 182, A 213, A 240, A 249, A 312, A 479
ASME SB688, SA240, SB691, SB564, SB472, SB676, SB675, SB804, SB462, SB366	ASME SA 182, SA 213, SA 240, SA 249, SA 312 SA 479
	ASME Code Case 2458

Limiting Chemical Composition, %

INCOLOY alloy 25-6HN			INCOLOY alloy 27-7MO		
Ni .. 23.50 – 25.50	N .....0.18 – 0.25	Si .....1.00 max.	Ni ...26.0 – 28.0	N 0.3-0.4	S .....0.01 max.
Cr... 20.00 – 22.00	Cu .....0.75 max.	P .....0.040 max.	Cr....20.5 – 23.0	Fe ... Remainder	Si .....0.5 max.
Fe .....Balance	C .....0.03 max.	S .....0.030 max.	Mo.....6.5 – 8.0	Mn.....3.00 max.	C .....0.020 max.
Mo..... 6.00 – 7.00	Mn.....2.00 max.		Cu 0.5-1.5	P .....0.03 max.	

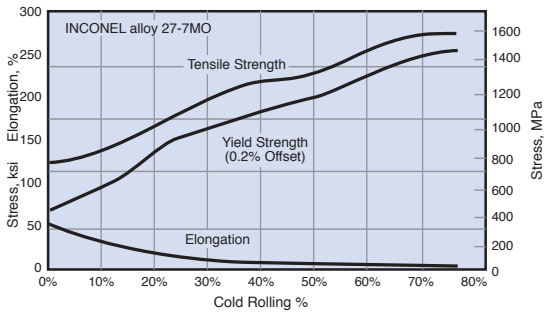
Physical Constants and Thermal Properties

INCOLOY alloy 25-6HN		INCOLOY alloy 27-7MO	
Density, lb/in³	0.291	Density[A], lb/in³ (g/cm³)	0.289 (8.02)
g/cm³	8.06	Specific Heat, Btu/lb • °F (J/kg • °C)	0.109 (454)
Melting Range, °F	2470 – 2550	Permeability[A] at 200 Oersted (15.9 kA/m)	1.004
°C	1320 – 1400	Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)	
Permeability at 200 Oersted	1.003	70 – 200°F (21 – 93°C)	8.33 (15.0)
Coefficient of Expansion, 10^{-6} in/in • °F		Thermal Conductivity[A], Btu • in/ft² h• °F (W/m • K)	69.8 (10.1)
70 – 200°F	8.66	Electrical Resistivity[A], ohm • circ mil/ft	604
70 – 800°F	9.05	$\mu\Omega$ • cm	100
70 – 1200°F	9.53	Young's Modulus[A], 10^6 psi (GPa)	27.7 (191)
		Shear Strength, 10^6 psi (GPa)	10.8 (74)
		Poisson's Ratio	0.29
		Melting Range, °F (°C)	2460-2530 (1350-1390)

Typical Mechanical Properties

INCOLOY alloy 25-6HN		INCOLOY alloy 27-7MO	
(Annealed)		**(Annealed)**	
Tensile Strength, ksi	108	Tensile Strength, ksi	120
MPa	744	MPa	827
Yield Strength (0.2% Offset), ksi	55	Yield Strength (0.2% Offset), ksi	60
MPa	381	MPa	414
Elongation, %	48	Elongation %	50
Hardness	90HRB		

Effect of Cold Work on flat INCOLOY alloy 27-7Mo products



SPECIAL METALS
A PCC Company

INCOLOY® alloy A-286

An alloy that is precipitation hardenable for high mechanical properties. The alloy maintains good strength and oxidation resistance at temperatures up to about 1300˚F (700˚C). The alloy's high strength and excellent fabrication characteristics make it useful for various components of aircraft and industrial gas turbines. Applications include blades, vanes, shafts, tail cones, afterburners, springs, and fasteners. This alloy is also used for automotive applications.

NIMONIC® alloy 75

A nickel-chromium alloy with good mechanical properties and oxidation resistance at high temperatures. Used for sheet-metal fabrications in gas-turbine engines, for components of industrial furnaces, for heat-treating equipment and fixtures, and in nuclear engineering.

Standard Product Forms

Sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

Sheet, strip, plate, round bar, forging stock, wire and extruded section.

Major Specifications

UNS S66286
ASTM A 453, A 638
ASME SA-453, SA-638
SAE AMS 5525, 5726, 5731, 5732, 5734, 5737, 5858, 5895, 7235
BS HR 51, HR 52, HR 650
AECMA Pr EN 2119, 2171 – 2175, 2303, 2304, 2398, 2399, 2417, 3510
NACE MR-0175/ISO 15156
W. NR. 1.4980

UNS N06075
BS HR5, HR203, HR403, HR504
DIN 17742, 17750 – 17752
Werkstoff Nr. 2.4951, 2.4630
ISO 6207, 6208, 9723-9725
AECMA Pr EN 2293, 2294, 2302, 2306 – 2308, 2402, 2411

Limiting Chemical Composition, %

Ni ...24.0 – 27.0	Mo.....1.0 – 1.5	Si .....1.0 max.
Cr....13.5 – 16.0	V .....0.10 – 0.50	Al .....0.35 max.
Fe .....Balance	C.....0.08 max.	S .....0.030 max.
Ti.....1.90 – 2.35	Mn.....2.0 max.	B ...0.001 – 0.01

Ni .... Remainder	C .....0.08 – 0.15	Fe .....5.0 max.
Cr ...18.0 – 21.0	Si .....1.0 max.	Mn .....1.0 max.
Ti .....0.2 – 0.6	Cu.....0.5 max.	

Physical Constants and Thermal Properties

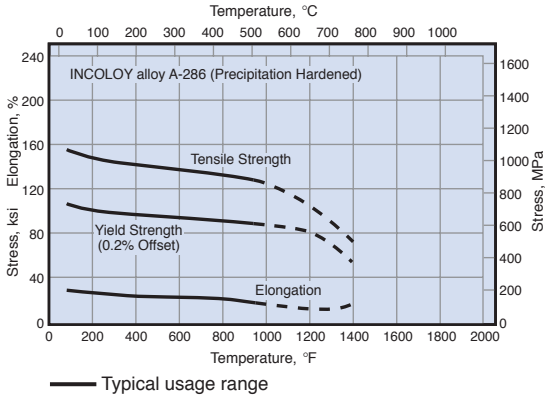
Density, lb/in³ (g/m³) 0.287 (7.94)
Melting Range, °F (°C) ..... 2500 – 2600 (1370 – 1430)
Specific Heat, Btu/lb • °F (J/kg • °C) 0.100 (419)
Permeability at 200 Oersted (15.9 kA/m) 1.007
Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)
70 – 200°F (21 – 93 °C)..... 9.09 (16.4)
70 – 800°F (21 – 427°C) 9.61 (17.3)
70 – 1400°F (21 – 760°C) 9.67 (17.4)
Thermal Conductivity[A], Btu • in/ft² • °F (W/m • °C)..88 (12.7)
Electrical Resistivity[A], ohm • circ mil/ft.....547
$\mu\Omega$ • m 0.910
Young's Modulus[A], 10^6 psi (GPa)..... 29.1 (201)
Hardness[A], HRC.....31

[A]Room temperature, as aged.

Density, lb/in³ 0.302
g/cm³ 8.37
Melting Range, °F..... 2440 – 2520
°C ..... 1340 – 1380
Specific Heat, Btu/lb • °F.....0.110
J/kg • °C 461
Coefficient of Expansion, 68 – 212°F 10^{-6} in/in • °F.....6.1
20 – 100°C μm/m • °C 11.0
Thermal Conductivity, Btu • in/ft²•h•°F.....81.1
W/m • °C 11.7
Electrical Resistivity, ohm•circ mil/ft.....656
$\mu\Omega$•m 1.09

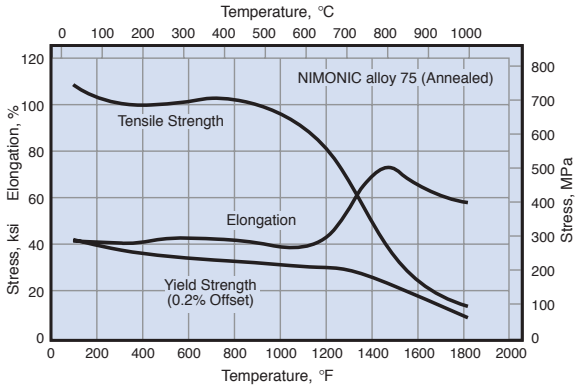
Typical Mechanical Properties

(Precipitation Hardened)



(Annealed)

Rupture Strength (1000 h)	ksi	MPa
1400°F / 760°C	6.0	40
1500°F / 815°C	3.5	24
1600°F / 870°C	2.2	15
1700°F / 925°C	1.5	10
1800°F / 980°C	1.2	8



NIMONIC® alloy 80A

A nickel-chromium alloy similar to NIMONIC alloy 75 but made precipitation hardenable by additions of aluminum and titanium. The alloy has good corrosion and oxidation resistance and high tensile and creep-rupture properties at temperatures to 1500°F (815°C). Used for gas-turbine components (blades, rings, and discs), bolts, tube supports in nuclear steam generators, die-casting inserts and cores, and exhaust valves in internal-combustion engines.

NIMONIC® alloy 86

A nickel-chromium-molybdenum alloy with a rare-earth (cerium) addition. It combines good formability and weldability with exceptional resistance to oxidation and scaling at temperatures to 1920°F (1050°C). Used in gas turbines for sheet-metal fabrications such as combustion chambers and afterburners and in heat-treating furnaces.

Standard Product Forms

Sheet, round bar, flat bar, forging stock, hexagon, wire, extruded section and plate.

Sheet, strip, plate, round bar, forging stock, extruded sections and wire.

Major Specifications

UNS N07080
BS 3076 (NA20), HR1, HR201, HR401, HR601
ASTM B 637
AIR 9165-37
DIN 17742
Werkstoff Nr. 2.4952, 2.4631
AECMA Pr EN 2188 – 2191, 2396, 2397

None applicable.

Limiting Chemical Composition, %

Ni ... Remainder	Si .....1.0 max.	B ....0.008 max.
Cr....18.0 – 21.0	Cu.....0.2 max.	Zr .....0.15 max.
Ti.....1.8 – 2.7	Fe .....3.0 max.	S .....0.015 max.
Al .....1.0 – 1.8	Mn.....1.0 max.	
C.....0.10 max.	Co.....2.0 max.	

Nominal

Ni 65	Mo.....10.0	C.....0.05
Cr.....25.0	Ce 0.03	

Physical Constants and Thermal Properties

Density, lb/in³ 0.296
g/cm³ 8.19

Melting Range, °F..... 2410 – 2490
°C..... 1320 – 1365

Specific Heat, Btu/lb•°F.....0.107
J/kg • °C 448

Permeability at 200 Oersted (15.9 kA/m) 1.0006

Coefficient of Expansion, 68 – 212°F 10^{-6} in/in • °F.....7.1
20 – 100°C μm/m • °C 12.7

Thermal Conductivity, Btu • in/ft²•h•°F.....77.7
W/m • °C 11.2

Electrical Resistivity, ohm • circ mil/ft.....746
$\mu\Omega$•m 1.24

Density, lb/in³ 0.309
g/cm³ 8.54

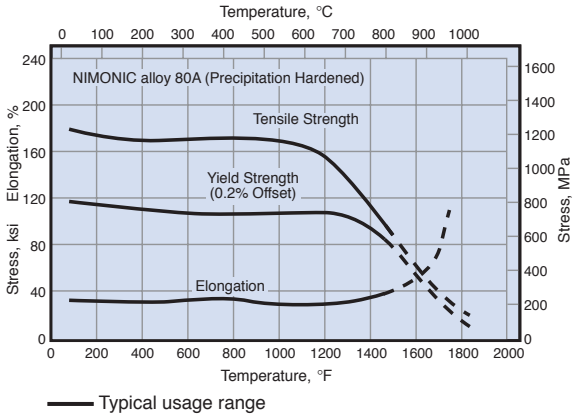
Young's Modulus, 10^6 psi 30.5
GPa 210

Coefficient of Expansion, 68 – 212°F 10^{-6} in/in • °F.....7.1
20 – 100°C μm/m • °C 12.7

Typical Mechanical Properties

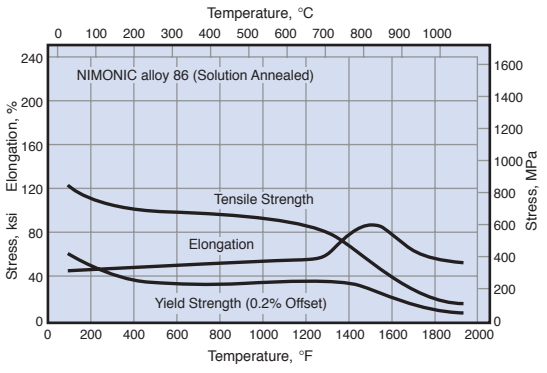
(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1100°F / 595°C	94	650
1200°F / 650°C	73	500
1300°F / 705°C	51	350
1400°F / 760°C	32	220
1500°F / 815°C	16	110



(Solution Annealed)

Rupture Strength (1000 h)	ksi	MPa
1500°F / 815°C	11.6	80
1600°F / 870°C	7.3	50
1700°F / 925°C	4.1	28
1800°F / 980°C	2.6	18



SPECIAL METALS
A PCC Company

NIMONIC® alloy 90

A precipitation-hardenable nickel-chromium-cobalt alloy having high stress-rupture strength and creep resistance at temperatures to about 1700°F (920°C). The alloy also has good resistance to high-temperature corrosion and oxidation. Used for blades and discs in gas turbines, hot-working tools, and springs.

NIMONIC® alloy 105

A precipitation-hardenable nickel-cobalt-chromium alloy with an addition of molybdenum for solid-solution strengthening. The relatively high aluminum content enhances both strength (through greater precipitation hardening) and oxidation resistance. The alloy has high creep-rupture properties at temperatures to about 1740°F (950°C). Used in gas turbines for blades, discs, and shafts.

Standard Product Forms

Sheet, strip, plate, round bar, flat bar, forging stock, wire and extruded section.

Round and extruded section.

Major Specifications

UNS N07090
BS HR2, HR202, HR402, HR501 – HR503
Werkstoff Nr. 2.4632
AECMA Pr EN 2295 – 2299, 2400, 2401, 2669, 2670

BS HR3
Werkstoff Nr. 2.4634
AECMA Pr EN 2179 – 2181

Limiting Chemical Composition, %

Limiting

Ni .... Remainder	C .....0.13 max.	B .....0.02 max.
Cr ... 18.0 – 21.0	Si .....1.0 max.	S ....0.015 max.
Co ...15.0 – 21.0	Cu.....0.2 max.	Zr .....0.15 max.
Ti .....2.0 – 3.0	Fe .....1.5 max.	
Al .....1.0 – 2.0	Mn .....1.0 max.	

Ni .... Remainder	Al .....4.5 – 4.9	Mn .....1.0 max.
Co ...18.0 – 22.0	C .....0.12 max.	S .....0.010 max.
Cr ... 14.0 – 15.7	Si .....1.0 max.	B ..0.003 – 0.010
Mo.....4.5 – 5.5	Cu.....0.2 max.	Zr .....0.15 max.
Ti.....0.9 – 1.5	Fe .....1.0 max.	

Physical Constants and Thermal Properties

Density, lb/in³ 0.296
g/cm³ 8.18

Melting Range, °F..... 2390 – 2500
°C..... 1310 – 1370

Specific Heat, Btu/lb•°F.....0.107
J/kg • °C 446

Permeability at 200 Oersted (15.9 kA/m) 1.0706

Coefficient of Expansion, 68 – 212°F 10^{-6} in/in • °F.....7.1
20 – 100°C μm/m • °C 12.7

Thermal Conductivity, Btu • in/ft²•h•°F.....79.7
W/m•°C.....11.5

Electrical Resistivity, ohm•circ mil/ft.....710
$\mu\Omega$•m 1.18

Density, lb/in³ 0.289
g/cm³ 8.01

Melting Range, °F..... 2350 – 2450
°C..... 1290 – 1345

Specific Heat, Btu/lb•°F.....0.100
J/kg • °C 419

Permeability at 200 Oersted (15.9 kA/m) 1.0007

Coefficient of Expansion, 68 – 212°F 10^{-6} in/in • °F.....6.8
20 – 100°C μm/m • °C 12.2

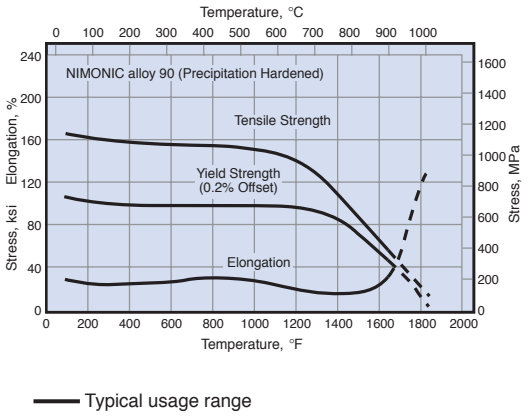
Thermal Conductivity, Btu • in/ft²•h•°F.....75.51
W/m•°C.....10.89

Electrical Resistivity, ohm•circ mil/ft.....788
$\mu\Omega$•m 1.31

Typical Mechanical Properties

(Precipitation Hardened)

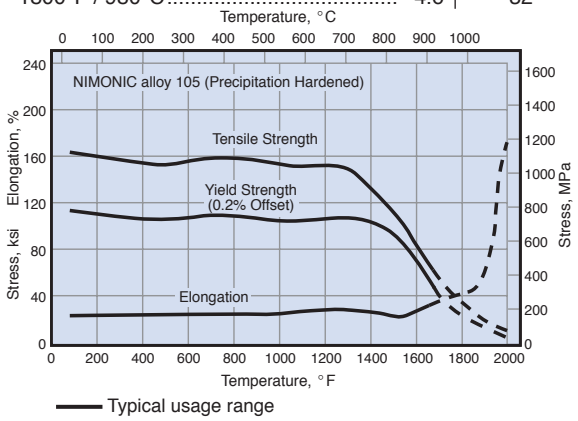
Rupture Strength (1000 h)	ksi	MPa
1300°F / 705°C	52	360
1400°F / 760°C	35	240
1500°F / 815°C	22	150
1600°F / 870°C	11	75



Typical usage range

(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1380°F / 750°C	52.6	363
1500°F / 815°C	32.5	224
1600°F / 870°C	19.4	134
1725°F / 940°C	9.0	62
1800°F / 980°C	4.6	32



Typical usage range

SPECIAL METALS
A PCC Company

NIMONIC® alloy 115

A precipitation-hardenable nickel-chromium-cobalt alloy with an addition of molybdenum for solid-solution strengthening. It is similar to NIMONIC alloy 105 but has higher levels of aluminum and titanium for increased strengthening by precipitation hardening. The alloy has high strength and creep resistance at temperatures to about 1850°F (1010°C). Used for turbine blades in aircraft gas turbines.

NIMONIC® alloy 263

A precipitation-hardenable nickel-chromium-cobalt alloy with an addition of molybdenum for solid-solution strengthening. It has high strength and corrosion resistance along with good formability and high-temperature ductility in welded structures. The alloy is especially suitable for sheet applications. Used in gas turbines for rings, casings, and various sheet fabrications.

Standard Product Forms

Round and extruded section.

Sheet, strip, plate, round bar, flat bar, forging stock, wire and extruded section.

Major Specifications

BS HR4
Werkstoff Nr. 2.4636
AECMA Pr EN 2196, 2197

UNS N07263
BS HR10, HR206, HR404
SAE AMS 5872
DIN 17744, 17750-17754
AECMA Pr EN 2199 – 2203, 2418
Werkstoff Nr. 2.4650

Limiting Chemical Composition, %

Ni .... Remainder	Al .....4.5 – 5.5	Mn .....1.0 max.
Cr ....14.0 – 16.0	C .....0.12 – 0.2	S .....0.015 max.
Co ...13.0 – 15.5	Si .....1.0 max.	B ...0.01 – 0.025
Mo.....3.0 – 5.0	Cu .....0.2 max.	Zr .....0.15 max.
Ti.....3.5 – 4.5	Fe .....1.0 max.	

Ni ... Remainder	Al .....0.60 max.	S .....0.007 max.
Cr.....19.0 – 21.0	Ti+Al ...2.4 – 2.8	B .....0.005 max.
Co....19.0 – 21.0	C .....0.04 – 0.08	Cu.....0.20 max.
Mo.....5.6 – 6.1	Si .....0.40 max.	Fe .....0.7 max.
Ti.....1.9 – 2.4	Mn.....0.60 max.	

Physical Constants and Thermal Properties

Density, lb/in^3 .....0.284
g/cm^3 .....7.85

Melting Range, °F..... 2300 – 2400
°C ..... 1260 – 1315

Specific Heat, Btu/lb•°F.....0.106
J/kg • °C 444

Coefficient of Expansion, 68 – 212°F 10^{-6} in/in • °F 6.7
20 – 100°C μm/m • °C 12.0

Thermal Conductivity, Btu • in/ft^2•h•°F 73.5
W/m•°C.....10.6

Electrical Resistivity, ohm•circ mil/ft.....836
$\mu\Omega$•m 1.39

Density, lb/in^3 .....0.302
g/cm^3 .....8.36

Melting Range, °F..... 2370 – 2470
°C ..... 1300 – 1355

Specific Heat, Btu/lb•°F.....0.110
J/kg • °C 461

Permeability at 200 Oersted (15.9 kA/m) 1.0008

Coefficient of Expansion, 68 – 212°F 10^{-6} in/in • °F.....5.7
20 – 100°C μm/m • °C 10.3

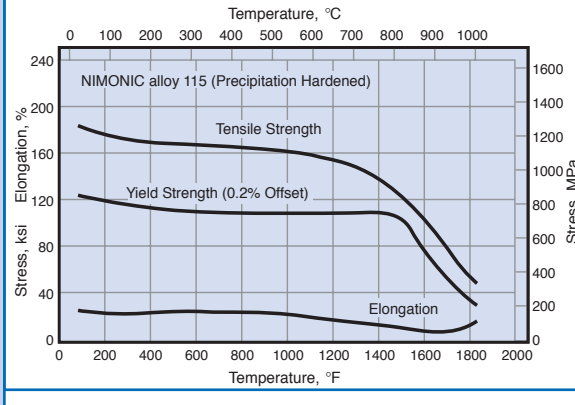
Thermal Conductivity, Btu • in/ft^2•h•°F 81.1
W/m•°C.....11.7

Electrical Resistivity, ohm•circ mil/ft.....692
$\mu\Omega$•m 1.15

Typical Mechanical Properties

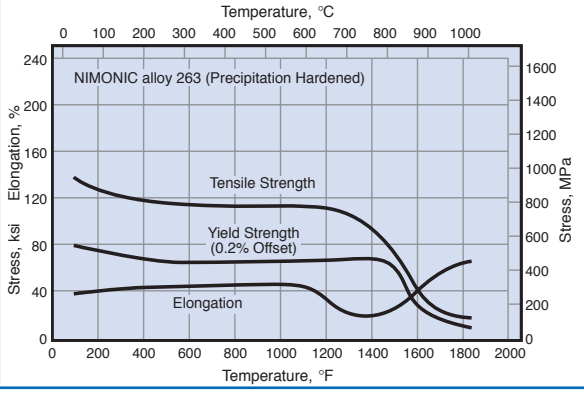
(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1400°F / 760°C	65	450
1500°F / 815°C	45	310
1600°F / 870°C	30	210
1700°F / 925°C	19	130
1800°F / 980°C	12	80



(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1110°F / 600°C	81.8	564
1290°F / 700°C	38.1	263
1470°F / 800°C	16.8	116
1560°F / 850°C	8.7	60
1650°F / 900°C	5.2	36



SPECIAL METALS
A PCC Company

NIMONIC® alloy 901

A nickel-iron-chromium alloy containing titanium and aluminum for precipitation hardening and molybdenum for solid-solution strengthening. The alloy has high yield strength and creep resistance at temperatures to about 1110°F (600°C). A substantial iron content enables the alloy to combine high strength with good forging characteristics. Used in gas turbines for discs and shafts.

NIMONIC® alloy PE11

A nickel-iron-chromium alloy precipitation hardened by titanium and aluminum and solid-solution strengthened by an addition of molybdenum. It was developed as a high-strength sheet alloy for use at temperatures to 1020°F (550°C). The high iron content provides good workability and also relatively high tensile ductility, especially after welding. Used for components of gas turbines.

Standard Product Forms

Flat or round bar, extruded section and forging billet.

Sheet, plate, round bar, flat bar, forging stock and wire.

Major Specifications

UNS N09901
BS HR55
SAE AMS 5660, 5661
AECMA Pr EN 2176 – 2178
Werkstoff Nr. 2.4662
ISO 9723, 9725

None Applicable.

Limiting Chemical Composition, %

Ni[a] ...40.0 – 45.0	Ti .....2.8 – 3.1	Cu.....0.5 max.
Fe ..Remainder	Al .....0.35 max.	Mn.....0.5 max.
Cr.... 11.0 – 14.0	C.....0.1 max.	Co .....1.0 max.
Mo.....5.0 – 6.5	Si .....0.4 max.	S .....0.03 max.

[a]Plus Co.

Ni ...37.0 – 41.0	Al .....0.7 – 1.0	Co.....1.0 max.
Fe ....Remainder	C.....0.03 – 0.08	B.....0.001 max.
Cr.... 17.0 – 19.0	Si .....0.5 max.	Zr ....0.02 – 0.05
Mo....4.75 – 5.75	Cu.....0.5 max.	S .....0.015 max.
Ti.....2.2 – 2.5	Mn.....0.2 max.	

Physical Constants and Thermal Properties

Density, lb/in³ 0.294
g/cm³ 8.14

Melting Range, °F..... 2335 – 2455
°C ..... 1280 – 1345

Specific Heat, Btu/lb • °F.....0.103
J/kg • °C 431

Permeability at 200 Oersted (15.9 kA/m) 1.013

Coefficient of Expansion, 68 – 212°F 10^{-6} in/in • °F.....7.5
20 – 100°C μm/m • °C 13.5

Electrical Resistivity, ohm • circ mil/ft.....674
$\mu\Omega$•m 1.12

Density, lb/in³ 0.290
g/cm³ 8.02

Melting Range, °F..... 2340 – 2460
°C..... 1280 – 1350

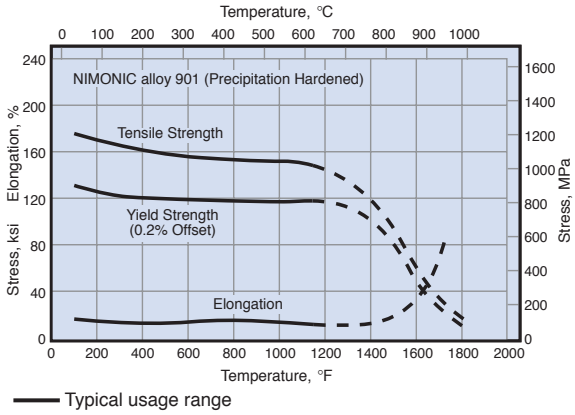
Specific Heat, Btu/lb • °F.....0.104
J/kg • °C 436

Permeability at 300 Oersted (23.9 kA/m) 1.021

Typical Mechanical Properties

(Precipitation Hardened)

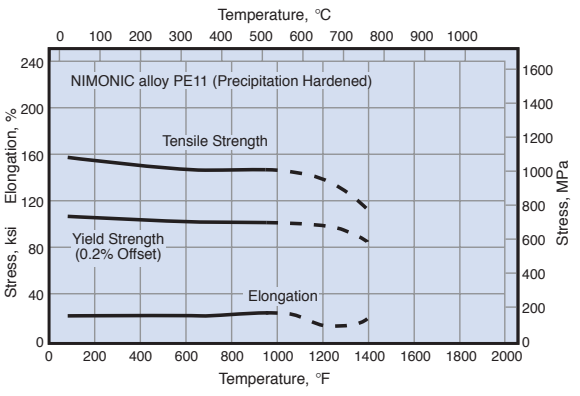
Rupture Strength (1000 h)	ksi	MPa
1000°F / 540°C	116	800
1100°F / 595°C	87	600
1200°F / 650°C	65	450
1300°F / 705°C	44	300
1400°F / 760°C	29	200



Typical usage range

(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1200°F / 650°C	49	340
1300°F / 705°C	36	250
1400°F / 760°C	21	140



Typical usage range

SPECIAL METALS
A PCC Company

NIMONIC® alloy PE16

A precipitation-hardenable nickel-iron-chromium alloy with an addition of molybdenum for solid-solution strengthening. It has good strength and oxidation resistance at temperatures to about 1380°F (750°C). The alloy is designed to provide a precipitation-hardened material having excellent hot-working, cold-working, and welding characteristics. Used for gas-turbine components and in nuclear reactors.

NIMONIC® alloy PK33

A nickel-chromium-cobalt alloy that is precipitation hardenable and also contains a relatively high (7%) level of molybdenum for solid-solution strengthening. It has an exceptional combination of high-temperature strength, creep resistance, and ductility when welded. The alloy is especially suitable for welded sheet structures. Used in gas turbines for flame tubes and other components.

Standard Product Forms

Sheet, plate, round bar, flat bar, forging stock, and extruded section.

Sheet, plate, round bar, flat bar, forging stock, and extruded section.

Major Specifications

BS HR55, HR207

None applicable.

Limiting Chemical Composition, %

Ni[a] ...42.0 – 45.0	Ti .....1.1 – 1.3	Mn.....0.2 max.
Fe ...Remainder	Al .....1.1 – 1.3	Co .....2.0 max.
Cr.....15.5 – 17.5	C.....0.04 – 0.08	B ....0.005 max.
Mo.....2.8 – 3.8	Si .....0.5 max.	Zr .....0.02 – 0.04
[a]Plus Co.	Cu.....0.5 max.	S ....0.015 max.

Ni ...Remainder	Al .....1.7 – 2.5	Mn.....0.5 max.
Cr....16.0 – 20.0	C.....0.07 max.	S .....0.015 max.
Co...12.0 – 16.0	Si .....0.5 max.	B .....0.005 max.
Mo.....5.0 – 9.0	Cu.....0.2 max.	Zr .....0.06 max.
Ti.....1.5 – 3.0	Fe .....1.0 max.	

Physical Constants and Thermal Properties

Density, lb/in^3 .....0.289
g/cm^3 .....8.00

Melting Range, °F.....2390 – 2470
°C.....1310 – 1355

Specific Heat, Btu/lb•°F.....0.130
J/kg•°C.....544

Permeability at 200 Oersted (15.9 kA/m) 1.4

Coefficient of Expansion, 68 – 212°F 10^{-6} in/in•°F.....7.7
20 – 100°C μm/m•°C 13.8

Thermal Conductivity, Btu • in/ft^2•h•°F.....81.26
W/m•°C.....11.72

Electrical Resistivity, ohm•circ mil/ft.....662
$\mu\Omega$•m 1.10

Density, lb/in^3 .....0.297
g/cm^3 .....8.21

Melting Range, °F.....2340 – 2450
°C.....1300 – 1345

Specific Heat, Btu/lb•°F.....0.100
J/kg•°C 419

Permeability at 200 Oersted (15.9 kA/m) 1.0005

Coefficient of Expansion, 68 – 212°F 10^{-6} in/in•°F.....6.7
20 – 100°C μm/m•°C 12.1

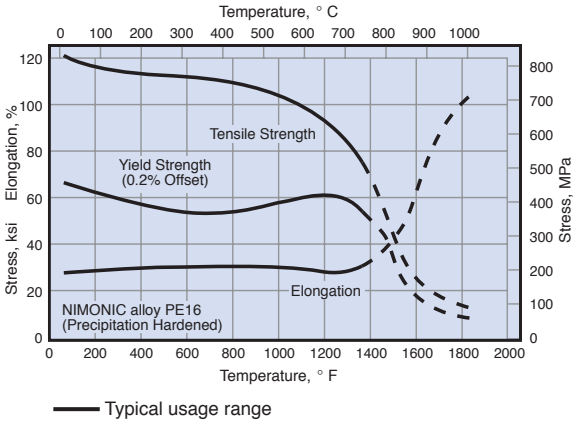
Thermal Conductivity, Btu • in/ft^2•h•°F.....78.3
W/m•°C.....11.3

Electrical Resistivity, ohm•circ mil/ft.....758
$\mu\Omega$•m 1.26

Typical Mechanical Properties

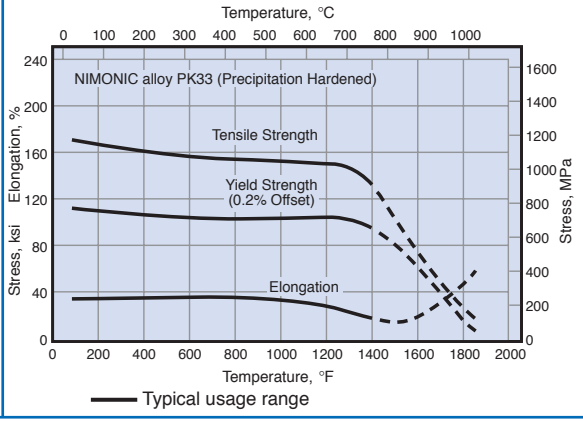
(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1200°F / 650°C	52.6	363
1290°F / 700°C	37.0	255
1380°F / 750°C	22.5	155



(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1200°F / 650°C	87	600
1300°F / 705°C	65	450
1400°F / 760°C	44	300
1500°F / 815°C	26	180
1600°F / 870°C	15	100



SPECIAL METALS
A PCC Company

BRIGHTRAY® alloy B

A nickel-iron-chromium electrical-resistance alloy for use at operating temperatures up to 2010°F (1100°C). It contains rare-earth additions for increased oxidation resistance, especially under conditions of frequent switching or wide temperature fluctuations. The alloy has a relatively high temperature coefficient of resistance. Used for heating elements in domestic appliances and industrial equipment.

BRIGHTRAY® alloy C

A nickel-chromium electrical-resistance alloy for use at operating temperatures up to 2100°F (1150°C). It contains rare-earth additions for increased oxidation resistance, especially under conditions of frequent switching or wide temperature fluctuations. The alloy has a low temperature coefficient of resistance, making it suitable for control resistors. Used for heating elements in domestic appliances and industrial equipment.

Standard Product Forms

Sheet, strip and wire.

Wire.

Major Specifications

UNS N06004
DIN 17742
Werkstoff Nr. 2.4867

UNS N06003
Werkstoff Nr. 2.4869

Limiting Chemical Composition, %

Limiting[a]

Ni[b] .....57.0 min.	Si .....0.75 – 1.6	S .....0.01 max.
Fe ... Remainder	Mn.....1.0 max.	
Cr..... 14 – 18	C.....0.15 max.	

[a]As in UNS N06004. Also contains rare-earth additions. [b]Plus Co.

Limiting[a]

Ni[b]... Remainder	Fe .....1.0 max.	S .....0.01 max.
Cr ..... 19 – 21	Mn .....1.0 max.	
Si .....0.75 – 1.6	C.....0.15 max.	

[a]As in N06003. Also contains rare-earth additions. [b]Plus Co.

Physical Constants and Thermal Properties

Density, lb/in³ 0.302
g/cm³ 8.36

Melting Range, °F..... 2550 – 2590
°C ..... 1400 – 1420

Specific Heat, Btu/lb•°F.....0.110
J/kg•°C 461

Permeability at 200 Oersted (15.9 kA/m) 1.68

Coefficient of Expansion, 68 – 212°F, 10^{-6} in/in•°F ...6.9
20 – 100°C, μm/m•°C 12.5

Electrical Resistivity, ohm•circ mil/ft.....662
μΩ•m.....1.10

Temp. Coefficient of Resistance,
68 – 932°F, 10^{-6} ohm/ohm•°F ...100
20 – 500°C, μΩ/Ω•°C 180

Density, lb/in³ 0.308
g/cm³ 8.53

Melting Range, °F..... 2520 – 2550
°C..... 1380 – 1400

Specific Heat, Btu/lb•°F.....0.100
J/kg•°C 419

Permeability at 200 Oersted (15.9 kA/m) 1.0005

Coefficient of Expansion, 68 – 212°F, 10^{-6} in/in•°F ...6.9
20 – 100°C, μm/m•°C 12.5

Electrical Resistivity, ohm•circ mil/ft.....650
μΩ•m 1.08

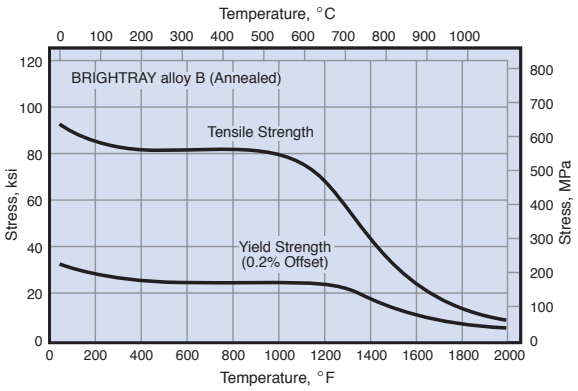
Temp. Coefficient of Resistance,
68 – 932°F, 10^{-6} ohm/ohm•°F 78
20 – 500°C, μΩ/Ω•°C 140

Typical Mechanical Properties

(Annealed)

Tensile Strength, ksi 90
MPa.....620

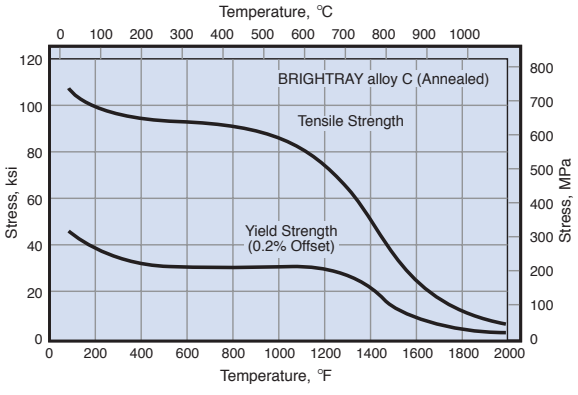
Yield Strength (0.2% Offset), ksi 30
MPa.....210



(Annealed)

Tensile Strength, ksi 110
MPa.....760

Yield Strength (0.2% Offset), ksi 48
MPa.....330



SPECIAL METALS
A PCC Company

BRIGHTRAY® alloy F

A nickel-iron-chromium electrical-resistance alloy for use at temperatures up to 1920°F (1050°C) under continuous operating conditions. Its high iron content and relatively low level of nickel make it particularly resistant to internal oxidation in atmospheres that alternate between oxidizing and reducing or carburizing. The alloy has a high temperature coefficient of resistance. Used for heating elements in industrial furnaces.

BRIGHTRAY® alloy S

A nickel-chromium electrical-resistance alloy for use at temperatures up to 2100°F (1150°C) under continuous operating conditions. It is similar to BRIGHTRAY alloy C but does not contain rare-earth additions. It has good resistance to oxidizing, neutral, and reducing atmospheres. The alloy has a low temperature coefficient of resistance. Used for heating elements in industrial furnaces.

Standard Product Forms

Sheet, strip and wire.

Strip and wire.

Major Specifications

None applicable.

UNS N06003
DIN 17742
Werkstoff Nr. 2.4869

Limiting Chemical Composition, %

Nominal

Ni 37.0	Cr.....18.0	Mn.....1.2
Fe 42.0	Si 2.3	C.....0.05

Limiting

Ni[a] .. Remainder	S .....0.01 max.	C .....0.15 max.
Cr....19.0 – 21.0	Fe .....1.0 max.	
Si ....0.75 – 1.75	Mn.....1.0 max.	

[a]Plus Co.

Physical Constants and Thermal Properties

Density, lb/in^3 .....0.286
g/cm^3 .....7.92

Melting Range, °F..... 2430 – 2550
°C..... 1330 – 1400

Specific Heat, Btu/lb •°F.....0.107
J/kg • °C 450

Permeability at 200 Oersted (15.9 kA/m) 1.038

Coefficient of Expansion, 68 – 212°F, 10^{-6} in/in • °F ...8.3
20 – 100°C, μm/m • °C 15.0

Electrical Resistivity, ohm•circ mil/ft.....650
μΩ•m 1.08

Temp. Coefficient of Resistance,
68 – 932°F, 10^{-6} ohm/ohm • °F ...160
20 – 500°C, μΩ/Ω•°C 290

Density, lb/in^3 .....0.305
g/cm^3 .....8.44

Melting Range, °F..... 2550 – 2590
°C..... 1400 – 1420

Specific Heat, Btu/lb •°F.....0.100
J/kg • °C 419

Coefficient of Expansion, 68 – 212°F, 10^{-6} in/in • °F ...6.9
20 – 100°C, μm/m • °C 12.5

Electrical Resistivity, ohm•circ mil/ft.....662
μΩ•m 1.10

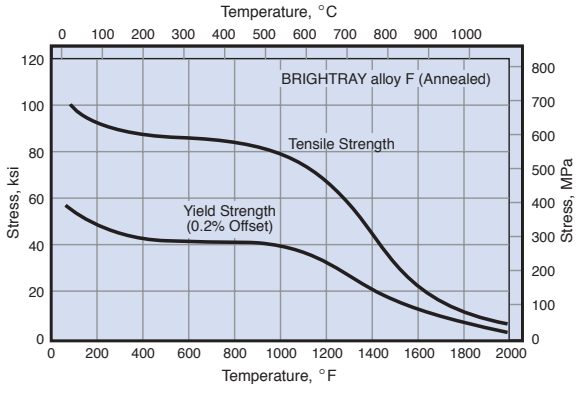
Temp. Coefficient of Resistance,
68 – 932°F, 10^{-6} ohm/ohm • °F 33
20 – 500°C, μΩ/Ω•°C 60

Typical Mechanical Properties

(Annealed)

Tensile Strength, ksi 100
MPa.....690

Yield Strength (0.2% Offset), ksi 54
MPa.....370



(Annealed)

Tensile Strength, 70°F, ksi 106.5
20°C, MPa 734

1110°F, ksi.....72.8
600°C, MPa 502

1470°F, ksi 30.3
800°C, MPa 209

SPECIAL METALS
A PCC Company

BRIGHTRAY® alloy 35

A nickel-iron-chromium electrical-resistance alloy for use at operating temperatures up to 1920°F (1050°C). It is similar to BRIGHTRAY alloy F but with rare-earth additions for greater resistance to oxidation under conditions of frequent switching or wide temperature fluctuations. The alloy has a high temperature coefficient of resistance. Used for heating elements in domestic appliances and industrial equipment.

NILO® alloy 36

A nickel-iron low-expansion alloy containing 36% nickel. It maintains nearly constant dimensions over the range of normal atmospheric temperatures, and has a low coefficient of expansion from cryogenic temperatures to about 500°F (260°C). The alloy also retains good strength and toughness at cryogenic temperatures. Used for standards of length, measuring devices, laser components, bi-metal thermostat strip, thermostat rods, and tanks and piping for storing and transporting liquefied gases.

Standard Product Forms

Wire.

Pipe, tube, sheet, plate, round bar, forging stock and wire.

Major Specifications

None applicable.

UNS K93600, K93601
DIN 385, 1715
Werkstoff Nr. 1.3912

Limiting Chemical Composition, %

Ni[a] .....34 – 37
Fe ..Remainder
Cr .....18 – 21
Si .....1.0 – 3.0
Mn .....1.0 max.
C.....0.15 max.
S .....0.01 max.

[a]Plus Co.

Also contains rare-earth additions.

Ni ...35.0 – 38.0
Fe ... Remainder
C.....0.10 max.
Mn.....0.60 max.
P .....0.025 max.
S .....0.025 max.
Si .....0.35 max.
Cr.....0.50 max.
Mo.....0.50 max.
Co.....1.0 max.

Physical Constants and Thermal Properties

Density, lb/in³ 0.301
g/cm³ 8.33

Melting Range, °F..... 2440 – 2520
°C ..... 1340 – 1380

Specific Heat, Btu/lb •°F.....0.125
J/kg • °C.....523

Permeability at 200 Oersted (15.9 kA/m) 1.026

Coefficient of Expansion, 68 – 212°F, 10^{-6} in/in • °F ...7.2
20 – 100°C, μm/m • °C 12.9

Electrical Resistivity, ohm•circ mil/ft.....614
μΩ•m 1.02

Temp. Coefficient of Resistance,
68 – 932°F, 10^{-6} ohm/ohm • °F ...180
20 – 500°C, μΩ/Ω•°C.....330

Density, lb/in³ 0.293
g/cm³ 8.11

Melting Temperature (Approximate), °F.....2610
°C 1430

Inflection Point, °F 430
°C 220

Thermal Conductivity, Btu • in/ft²•h•°F 69.3
W/m • °C 10.0

Coefficient of Expansion, 68 – 212°F, 10^{-6} in/in • °F 0.83
20 – 100°C, μm/m • °C 1.5

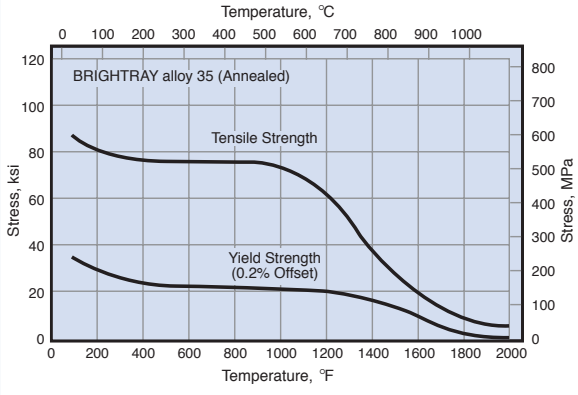
68 – 392°F, 10^{-6} in/in • °F 1.4
20 – 200°C, μm/m • °C 2.6

Electrical Resistivity, ohm•circ mil/ft.....480
μΩ•m 0.800

Typical Mechanical Properties

(Annealed)
Tensile Strength, ksi 88
MPa.....610

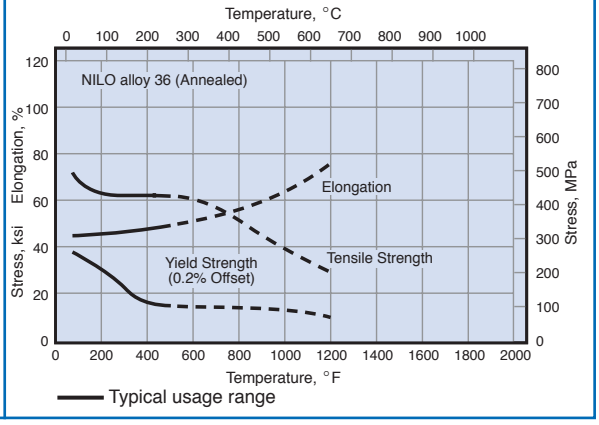
Yield Strength (0.2% Offset), ksi 36
MPa.....250



(Annealed)
Tensile Strength, ksi 71
MPa.....490

Yield Strength (0.2% Offset), ksi 35
MPa.....240

Elongation, % 42



SPECIAL METALS
A PCC Company

NILO® alloy 42

A nickel-iron controlled-expansion alloy containing 42% nickel. It has a low and nominally constant coefficient of thermal expansion from room temperature to about 570°F (300°C). Used for semiconductor lead frames in integrated circuits, bi-metal thermostat strip, thermostat rods, for ceramic-to-metal seals with alumina ceramics, and various glass-to-metal seals such as the core of copper-clad wire for sealing into glass envelopes of electric bulbs, radio valves, television tubes, and fluorescent lights.

NILO® alloy 48

A nickel-iron controlled-expansion alloy containing 48% nickel. Its coefficient of thermal expansion is designed to match that of soft lead and soda-lime glasses. The alloy also has a high inflection point. Used for glass-to-metal seals in radio valves and incandescent electric light bulbs and for industrial thermostats that operate at temperatures up to 840°F (450°C).

Standard Product Forms

Strip, plate and wire.

Wire.

Major Specifications

UNS K94100
ASTM F 29, F 30
DIN 385, 17745
Werkstoff Nr. 1.3917

UNS K94800
ASTM F 30
DIN 17745
Werkstoff Nr. 1.3922, 1.3926, 1.3927

Limiting Chemical Composition, %

Limiting

Ni ..... 42[a]	P .....0.025 max.	Al .....0.15 max.
Fe ....Remainder	S .....0.025 max.	Co .....1.0 max.
C .....0.05 max.	Si .....0.30 max.	
Mn.....0.80 max.	Cr.....0.25 max.	

[a]Nominal value; adjusted to meet expansion requirements.

Ni ..... 48[a]	P .....0.025 max.	Al .....0.10 max.
Fe ... Remainder	S .....0.025 max.	Co .....1.0 max.
C .....0.05 max.	Si .....0.30 max.	
Mn.....0.80 max.	Cr.....0.25 max.	

[a]Nominal value; adjusted to meet expansion requirements.

Physical Constants and Thermal Properties

Density, lb/in^3 .....0.293
g/cm^3 .....8.11

Melting Temperature (Approximate), °F.....2615
°C.....1435

Inflection Point, °F 700
°C 370

Thermal Conductivity, Btu • in/ft^2•h•°F 72.8
W/m • °C 10.5

Coefficient of Expansion, 68 – 212°F, 10^{-6} in/in • °F 2.9
20 – 100°C, μm/m • °C 5.3

68 – 572°F, 10^{-6} in/in • °F ....2.5 – 3.6
20 – 300°C, μm/m • °C .....4.5 – 6.5

Electrical Resistivity, ohm•circ mil/ft.....370
μΩ•m 0.610

Density, lb/in^3 .....0.296
g/cm^3 .....8.20

Melting Temperature (Approximate), °F.....2640
°C.....1450

Inflection Point, °F 860
°C 460

Thermal Conductivity, Btu • in/ft^2•h•°F 116
W/m • °C 16.7

Coefficient of Expansion, 68 – 212°F, 10^{-6} in/in • °F 4.7
20 – 100°C, μm/m • °C 8.5

68 – 752°F, 10^{-6} in/in • °F ....4.6 – 5.2
20 – 400°C, μm/m • °C .....8.3 – 9.3

Electrical Resistivity, ohm•circ mil/ft.....280
μΩ•m 0.470

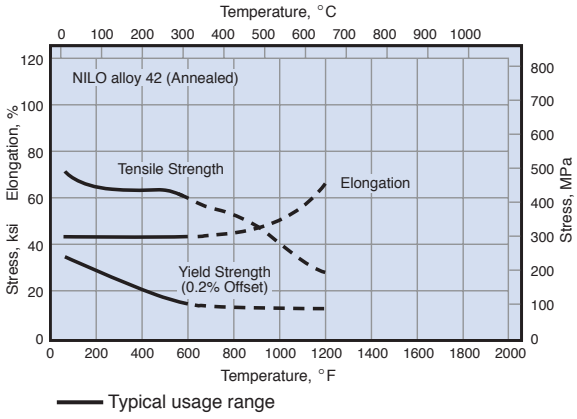
Typical Mechanical Properties

(Annealed)

Tensile Strength, ksi 71
MPa.....490

Yield Strength (0.2% Offset), ksi 36
MPa.....250

Elongation, % 43

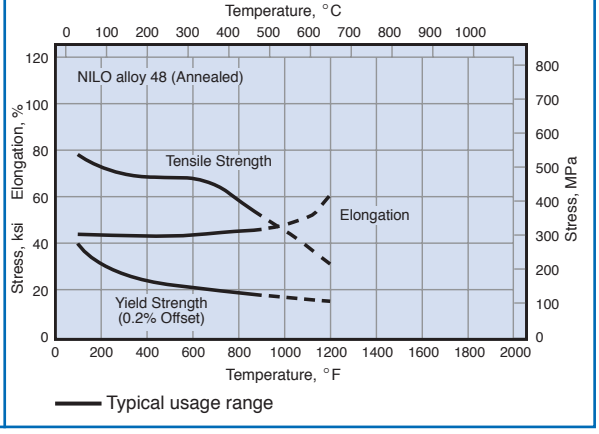


(Annealed)

Tensile Strength, ksi 75
MPa.....520

Yield Strength (0.2% Offset), ksi 38
MPa.....260

Elongation, % 43



SPECIAL METALS
A PCC Company

NILO® alloy K

A nickel-iron-cobalt controlled-expansion alloy containing 29% nickel. Its coefficient of expansion, which decreases with rising temperature to the inflection point, matches the expansion rate of borosilicate glasses and alumina ceramics. Used for glass-to-metal seals in applications requiring high reliability or resistance to thermal shock. Examples are high-power transmitting valves, transistor leads and headers, integrated-circuit lead frames, and photography flash bulbs.

FERRY® alloy

A copper-nickel alloy used mainly for its electrical properties. It has medium-range electrical resistivity and a very low temperature coefficient of resistance (TCR). The low TCR makes the alloy useful for wire-wound precision resistors having operating temperatures up to 750°F (400°C). A reproducible electromotive force against copper makes the alloy suitable for thermocouples and thermocouple compensating leads.

Standard Product Forms

Tube, sheet and round bar.

Strip and wire.

Major Specifications

UNS K94610
ASTM F 15, F 29
SAE AMS 7726 – 7728
DIN 17745
Werkstoff Nr. 1.3981

ASTM B 267
DIN 17644
Werkstoff Nr. 2.0842

Limiting Chemical Composition, %

Ni	29[a]	Si	0.20 max.	Ti	0.10 max.
Fe	53[a]	Al	0.10 max.	Cu	0.20 max.
Co	17[a]	Cr	0.20 max.	Mo	0.20 max.
C	0.04 max.	Mg	0.10 max.		
Mn	0.50 max.	Zr	0.10 max.		

[a]Nominal value; adjusted to meet expansion requirements.

Limiting

Ni	Remainder	Fe	1.0 max.	Mn	1.0 max.
Cu	55.0[a]	C	0.1 max.	Si	0.5 max.

[a]Nominal.

Physical Constants and Thermal Properties

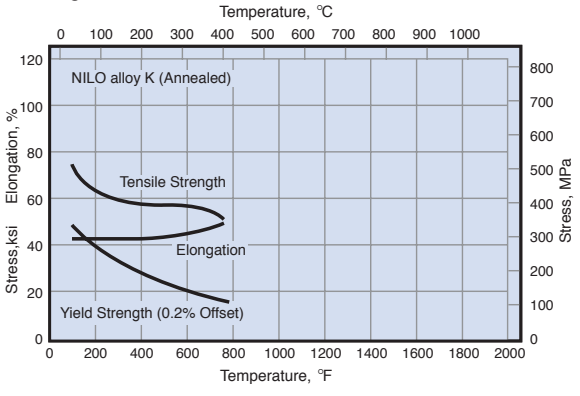
Density, lb/in³	0.295
g/cm³	8.16
Melting Temperature (Approximate), °F	2640
°C	1450
Inflection Point, °F	840
°C	450
Thermal Conductivity, Btu • in/ft²•h•°F	116
W/m • °C	16.7
Coefficient of Expansion, 68 – 212°F, 10⁻⁶ in/in • °F	3.3
20 – 100°C, μm/m • °C	6.0
68 – 752°F, 10⁻⁶ in/in • °F	2.6 – 2.9
20 – 400°C, μm/m • °C	4.6 – 5.2
Electrical Resistivity, ohm•circ mil/ft	260
μΩ•m	0.430

Density, lb/in³	0.321
g/cm³	8.89
Melting Range, °F	2230 – 2320
°C	1220 – 1270
Specific Heat, Btu/lb •°F	0.094
J/kg • °C	394
Temp. Coefficient of Resistance, 68 – 212°F, 10⁻⁶ ohm/ohm • °F	17
20 – 100°C, μΩ/Ω•°C	30
Coefficient of Expansion, 68 – 212°F, 10⁻⁶ in/in • °F	8.17
20 – 100°C, μm/m • °C	14.7
Thermal Conductivity, Btu • in/ft²•h•°F	155
W/m•°C	22.4
Electrical Resistivity, ohm•circ mil/ft	295
μΩ•m	0.490

Typical Mechanical Properties

(Annealed)

Tensile Strength, ksi	75
MPa	520
Yield Strength (0.2% Offset), ksi	49
MPa	340
Elongation, %	42



(Annealed)

Tensile Strength, ksi	60
MPa	415
Yield Strength (0.5% Offset), ksi	21
MPa	145
Elongation, %	32

NILOMAG® alloy 77

A nickel-iron alloy with additions of copper and molybdenum. It is a low-loss, soft-magnetic alloy with a high initial permeability. The alloy is particularly useful for applications in which power requirements must be minimized. Used for transformers, inductors, magnetic amplifiers, switching cores, magnetic shields, tape-recorder heads, and memory storage devices.

NI-SPAN-C® alloy 902

A nickel-iron-chromium alloy made precipitation hardenable by additions of aluminum and titanium. The titanium content also helps provide a controllable thermoelastic coefficient, which is the alloy's outstanding characteristic. The alloy can be processed to have a constant modulus of elasticity at temperatures from –50 to 150˚F (–45 to 65˚C). Used for precision springs, mechanical resonators, and other precision elastic components.

Standard Product Forms

Sheet and strip.

Round bar.

Major Specifications

None applicable.

UNS N09902 SAE AMS 5221, 5223, 5225

Limiting Chemical Composition, %

Nominal

Ni 77	Cu 5.0	C 0.02
Fe 13.5	Mo....4.2	

Limiting

Ni[a] ..41.0 – 43.5	Ti....2.2 – 2.75	Mn....0.80 max.
Fe ... Remainder	Al ....0.30 – 0.80	S ....0.04 max.
Cr....4.9 – 5.75	C....0.06 max.	Si ....1.0 max.
		P ....0.04 max.

[a]Plus Co.

Physical Constants and Thermal Properties

Density, lb/in³	0.317
g/cm³	8.77
Electrical Resistivity, ohm • circ mil/ft	360
μΩ•m	0.600
Curie Temperature, °F	750
°C	400
Initial Permeability	60 000
Maximum Permeability	300 000
Saturation Induction, T	0.63
Remanence, T	0.39
Coercivity, A/m	0.80

Density, lb/in³	0.291
g/cm³	8.05
Melting Range, °F	2650 – 2700
°C	1450 – 1480
Specific Heat, Btu/lb • °F	0.12
J/kg • °C	500
Curie Temperature, °F	380
°C	190
Young's Modulus, 10^6 psi	24 – 29
GPa	165 – 200
Modulus of Rigidity, 10^6 psi	9 – 10
GPa	62 – 69
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F	4.2
20 – 93°C, μm/m • °C	7.6
Thermal Conductivity, Btu • in/ft²•h•°F	84
W/m • °C	12.1
Electrical Resistivity, ohm • circ mil/ft	611
μΩ•m	1.02

Typical Mechanical Properties

(Annealed)

Tensile Strength, ksi	78
MPa	540
Hardness, HV	125

(Precipitation Hardened)

Tensile Strength, ksi	175
MPa	1210
Yield Strength (0.5% Offset), ksi	110
MPa	760
Elongation, %	25

SPECIAL METALS
A PCC Company

Waspaloy

Waspaloy is a nickel-base, age-hardenable superalloy with excellent high-temperature strength and good resistance to corrosion, notably to oxidation. It is used for aerospace and gas turbine engine components at service temperatures up to 1200˚F (650˚C) for critical rotating applications, and up to 1600˚F (870˚C) for other, less demanding, applications. Applications include compressor and rotor discs, shafts, spacers, seals, rings and casings, fasteners and other miscellaneous engine hardware, airframe assemblies and missile systems.

UDIMET® alloy 188

A cobalt-base alloy with excellent high temperature strength and good oxidation resistance to 2000°F (1093°C). The high chromium level coupled with small additions of lanthanum produce an extremely tenacious and protective scale. The alloy also has good sulfidation resistance and excellent metallurgical stability displayed by its good ductility after prolonged exposure to elevated temperatures. Good fabricability and weldability combine to make the alloy useful in typical gas turbine applications such as combustors, flame holders, liners and transition ducts.

Standard Product Forms

Round bar, forging stock, extruded section and wire.

Forging billet, bar, plate, and sheet.

Major Specifications

UNS N07001
ASTM B 637
Werkstoff Nr. 2.4654
ISO 9723 – 9725
SAE AMS 5544, 5704, 5706 – 5709, 5828, MAM 5706
AECMA Pr EN 2193 – 2195, 2406, 2958 – 2960, 3220

UNS R30188
AMS 5608
AMS 5772

Chemical Composition, %

Limiting

Ni ... Remainder	Al ....1.20 – 1.60	Cu..... 0.50 max.
Cr....18.0 – 21.0	Zr ....0.02 – 0.12	S ..... 0.030 max.
Co ...12.0 – 15.0	B ... 0.003 – 0.01	Si .....0.75 max.
Mo...3.50 – 5.00	C ....0.02 – 0.10	Mn.....1.00 max.
Ti.....2.75 – 3.25	Fe .... 2.00 max.	P .....0.030 max.

Limiting

C .....0.05 – 0.15	Ni ....20.0 – 24.0	Fe .....3.0 max.
Mn.....1.25 max.	W ....13.0 – 16.0	Co.....Balance
Si .....0.2 – 0.5	La....0.02 – 0.12	B .....0.015 max.
Cr....20.0 – 24.0		

Physical Constants and Thermal Properties

Density, lb/in³ 0.296
g/cm³ 8.19

Melting Range, °F..... 2425 – 2475
°C..... 1330 – 1360

Permeability at 200 Oersted (15.9 kA/m) 1.004

Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)
70 – 200°F (21 – 93°C) 6.8 (12.2)
70 – 1000°F (21 – 538°C) 7.7 (13.9)
70 – 2000°F (21 – 1093°C) 10.4 (18.7)

Electrical Resistivity[A], ohm •circ mil/ft.....722
μΩ•m 1.20

Young's Modulus[A], 10^6 psi (GPa)..... 30.6 (211)

Hardness[A], HRC..... 34 – 40

[A]Room temperature, as aged.

Density, lb/in³ 0.330
g/cm³ 9.13

Melting Range, °F..... 2375 – 2425
°C..... 1300 – 1330

Specific Heat, Btu/lb • °F.....0.097
J/kg • °C 405

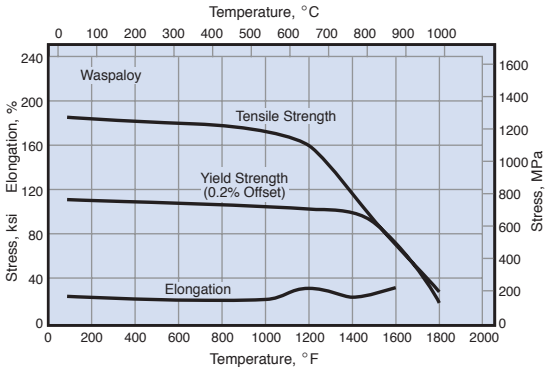
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F 6.6
21 – 93°C, μm/m • °C.....11.9

Thermal Conductivity, Btu • in/ft²•h•°F 84
W/m•°C.....12.1

Typical Mechanical Properties

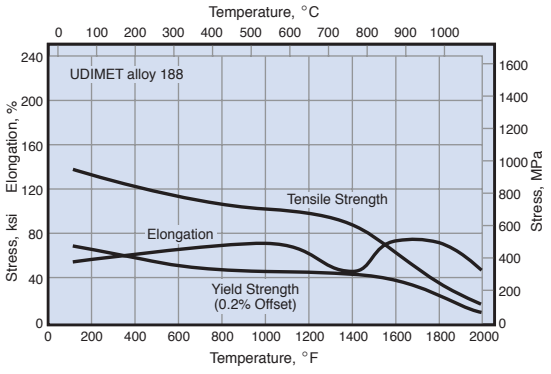
(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1200°F / 649°C	89	615
1300°F / 704°C	65	450
1400°F / 760°C	42	290
1500°F / 816°C	26	180
1600°F / 870°C	16	110



Rupture Strength (1000 hour)

	ksi	MPa
1300°F / 704°C	35	240
1400°F / 760°C	24	165
1500°F / 816°C	16	110
1600°F / 871°C	10	69
1700°F / 927°C	6	41
1800°F / 982°C	3	25
1900°F / 1038°C	2	15
2000°F / 1093°C	1	9



SPECIAL METALS
A PCC Company

UDIMET® alloy L-605

A cobalt-base superalloy with good formability, high strength to 1500°F (816°C), and good oxidation resistance to 2000°F (1093°C). The alloy also has good sulfidation resistance and resistance to wear and galling. The alloy is used in the hot sections of aircraft and land-based gas turbines in combustor liners and other applications requiring moderate strength and good oxidation resistance at high temperatures. The alloy can also be used in industrial furnace applications such as muffles/liners in high temperature kilns.

UDIMET® alloy 520

A precipitation hardenable nickel-base superalloy with an exceptional combination of high temperature mechanical properties, corrosion resistance and forgeability characteristics. Developed for use in the 1400 – 1700°F (760 – 927°C) temperature range, the alloy has excellent structural stability and unusually good fabricability. Primary application is blading for aircraft and land based gas turbines.

Standard Product Forms

Forging billet, bar, sheet, plate and wire.

Forging bar.

Major Specifications

UNS R30605
AMS 5537, 5796, 5797
AMS 5759

PDS 15125A1

Chemical Composition, %

Limiting

Ni .....9.0 – 11.0	Mn.....1.0 – 2.0	S .....0.03 max.
Cr....19.0 – 21.0	Si .....0.40 max.	Co .....Balance
W ....14.0 – 16.0	C .....0.05 – 0.15	
Fe .....3.0 max.		

Limiting

C .....0.02 – 0.06	Mo.....5.5 – 7.0	W .....0.8 – 1.2
Cr....18.0 – 20.0	Ti.....2.9 – 3.25	B .0.004 – 0.010
Co...11.0 – 14.0	Al .....1.8 – 2.3	Ni .....Balance

Physical Constants and Thermal Properties

Density, lb/in³ 0.335
g/cm³ 9.27

Melting Range, °F.....2425 – 2570
°C..... 1330 – 1410

Specific Heat, Btu/lb•°F.....0.092
J/kg • °C 385

Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F ...6.83
20 – 93°C, μm/m • °C.....12.3

Thermal Conductivity, Btu • in/ft²•h•°F 65
W/m•°C.....9.4

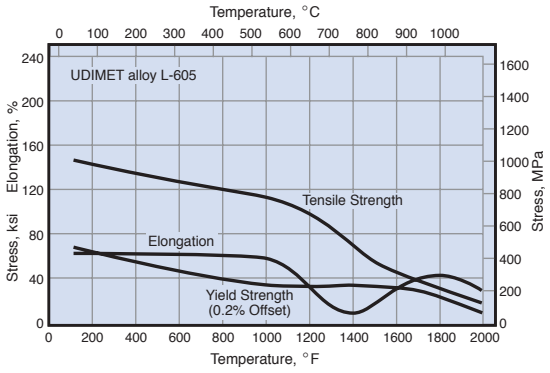
Density, lb/in³ 0.297
g/cm³ 8.21

Melting Range, °F..... 2300 – 2560
°C..... 1260 – 1405

Typical Mechanical Properties

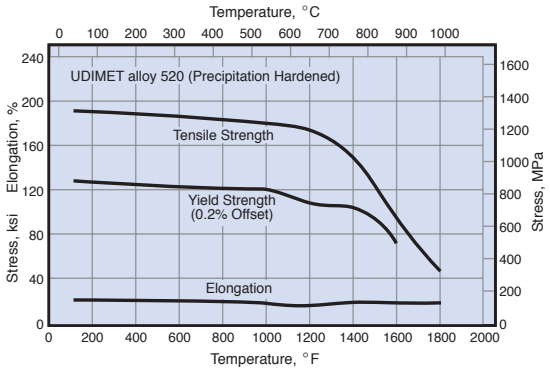
Rupture Strength (1000 hour)

	ksi	MPa
1200°F / 649°C	39	270
1300°F / 704°C	32	220
1400°F / 760°C	24	165
1500°F / 816°C	17	120
1600°F / 871°C	10	72
1700°F / 927°C	6	44
1800°F / 982°C	4	25



(Precipitation Hardened)
Rupture Strength (1000 hour)

	ksi	MPa
1200°F / 649°C	85	585
1300°F / 704°C	69	475
1400°F / 760°C	50	345
1500°F / 816°C	33	230
1600°F / 871°C	22	150



SPECIAL METALS
A PCC Company

UDIMET® alloy 720

A nickel-base alloy solid solution strengthened with tungsten and molybdenum and precipitation hardened with titanium and aluminum. The alloy combines high strength with metallurgical stability as demonstrated by excellent impact strength retention after long exposures at elevated temperatures. Good oxidation and corrosion resistance combined with high strength make the alloy useful in gas turbine blade and disc applications.

UDIMET® alloy D-979

An iron-nickel alloy designed for turbine disc applications at temperatures up to 1200 – 1400°F (649 – 760°C). Hardened by a complex precipitation of intermetallic phases, the alloy combines corrosion resistance with excellent tensile and stress rupture strength.

Standard Product Forms

Forging billet and bar.

Forging billet and bar.

Major Specifications

EMS 55477 MSRR 7252 MTS 5013
EMS 73105 C50TF105

UNS N09979 AMS 5746

Chemical Composition, %

Limiting

Ni .....Balance	W ....1.00 – 1.50	C .....0.01 – 0.02
Cr....15.5 – 16.5	Ti.....4.75 – 5.25	Zr ..0.025 – 0.05
Co ...14.0 – 15.5	Al ....2.25 – 2.75	B ....0.01 – 0.02
Mo...2.75 – 3.25		

Limiting

Cr..... 14.0 – 16.0	W ..... 3.0 – 4.5	C .....0.08 max.
Fe ..... Balance	Ti..... 2.7 – 3.3	Si .....0.75 max.
Mo..... 3.0 – 4.5	Al ..... 0.75 – 1.3	Mn.....0.75 max.
	Ni ..... 42.0 – 48.0	B .. 0.008 – 0.016

Physical Constants and Thermal Properties

Density, lb/in³ 0.292
g/cm³ 8.08

Melting Range, °F..... 2180 – 2440
°C..... 1194 – 1338

Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F 6.8
21 – 93°C, µm/m • °C.....12.24

Density, lb/in³ 0.296
g/cm³ 8.19

Melting Range, °F .....2225 – 2530
°C .....1220 – 1390

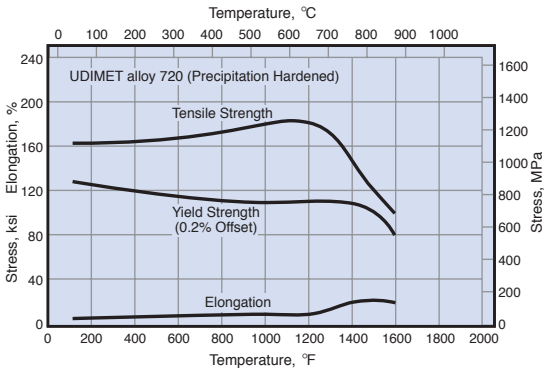
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F 7.60
21 – 93°C, µm/m • °C.....13.7

Thermal Conductivity, Btu • in/ft²•h•°F 87
W/m • °C 12.6

Typical Mechanical Properties

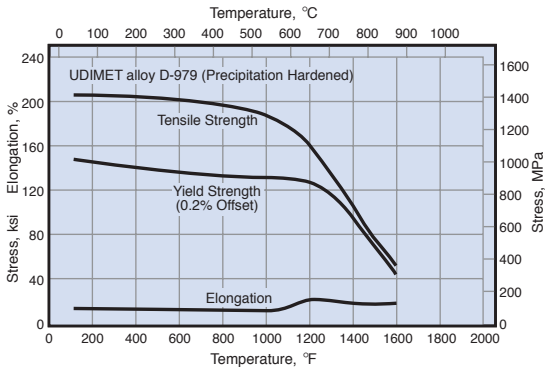
(Precipitation Hardened)
Rupture Strength (1000 hour)

	ksi	MPa
1200°F / 649°C	102	700
1300°F / 704°C	73	500
1400°F / 760°C	70	480
1600°F / 871°C	32	219
1800°F / 982°C	10	68



(Precipitation Hardened)
Rupture Strength (1000 hour)

	ksi	MPa
1200°F / 649°C	75	515
1300°F / 704°C	55	380
1400°F / 760°C	36	250
1500°F / 816°C	21	145
1600°F / 871°C	10	69



SPECIAL METALS
A PCC Company

UDIMET® alloy R41

A precipitation hardenable nickel-chromium alloy containing significant amounts of cobalt and molybdenum along with lesser amounts of aluminum and titanium that exhibits extremely high room and elevated temperature mechanical properties. Excellent corrosion resistance and fabricability have led to wide usage in critical aircraft engine components such as nozzle partitions, turbine blades and wheels, combustion chamber liners and structural hardware.

UDIMAR® alloy 250

An age hardenable (maraging) iron-nickel steel combining ultra-high strength, toughness and resistance to crack propagation. The alloy is well suited to applications where heat treatment distortion and dimensional changes must be minimized and where high fracture toughness is required such as rocket motor casings, light aircraft landing gear, power shafts and low temperature tooling.

Standard Product Forms

Forging billet, bar, sheet and plate.

Forging billet and bar.

Major Specifications

UNS N 07041
AMS 5545
AMS 5712
AMS 5713

UNS K92890
UNS K92940
AMS 6512

Chemical Composition, %

Limiting

Ni .....Balance	Mo.....9.0 – 10.5	Fe ..... 5.0 max.
Cr.....18.0 – 20.0	Al .....1.40 – 1.80	B ... 0.003 – 0.010
Co.....10.0 – 12.0	Ti.....3.0 – 3.3	C.....0.12 max.

Limiting

C.....0.03 max.	S .....0.010 max.	Mo.....4.6 – 5.1
Si .....0.10 max.	P .....0.010 max.	Ti.....0.30 – 0.50
Mn.....0.10 max.	Co.....7.0 – 8.5	Al ....0.05 – 0.15
	Ni ....17.0 – 19.0	Fe .....Balance

Physical Constants and Thermal Properties

Density, lb/in^3 .....0.298
g/cm^3 .....8.25

Melting Range, °F.....2250 – 2535
°C.....1232 – 1391

Specific Heat, Btu/lb • °F 0.104
J/kg • K.....435

Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F 6.63
21 – 93°C, µm/m•°C.....11.9

Thermal Conductivity, Btu • in/ft^2•h•°F 62
W/m•°C 9.0

Density, lb/in^3 .....0.290
g/cm^3 .....8.0

Melting Range, °F .....2600 – 2650
°C .....1427 – 1454

Specific Heat, Btu/lb • °F 0.07
J/kg • K.....293

Permeability at 200 Oersted (15.9 kA/m) 77.5

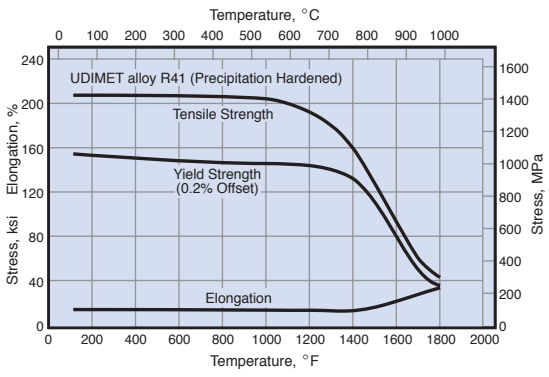
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F 5.4
21 – 93°C, µm/m•°C.....9.72

Thermal Conductivity, Btu • in/ft^2•h•°F 136
W/m•°C 19.6

Typical Mechanical Properties

(Precipitation Hardened)
Rupture Strength (1000 hour)

	ksi	MPa
1200°F / 649°C	102	705
1300°F / 704°C	80	550
1400°F / 760°C	50	345
1500°F / 816°C	29	200
1600°F / 871°C	17	117
1700°F / 927°C	11	76



	Solution Annealed 1500˚F (816˚C) 1 hr, AC	Solution Annealed plus aged 900˚F (482˚C) 3 hrs, AC
0.2% Yld, ksi	115	260
UTS, ksi	145	270
El, %	20	10
RA, %	70	60
Hardness, Rc	30	50

The 18% nickel maraging steels offer a unique combination of properties not available from conventional low alloy ultra high strength steels. They offer high strength, high ductility and toughness, and resistance to crack propagation. Hardening is accomplished by a simple aging cycle of 3 hours at 900°F (482°C) followed by air cooling. UDIMAR alloy 250 provides through hardening without quenching, freedom from decarburization, minimal distortion during aging, good formability, machinability, and weldability and a low coefficient of thermal expansion.

UDIMAR® alloy 300

An age hardenable (maraging) iron-nickel steel combining ultra-high strength and resistance to crack propagation. The alloy is well suited to applications where heat treatment distortion and dimensional changes must be minimized and where high fracture toughness is required such as rocket motor casings, light aircraft landing gear, power shafts and low temperature tooling.

Standard Product Forms

Forging billet and bar.

Major Specifications

UNS K93120 AMS 6514

Chemical Composition, %

Limiting

C .....0.03 max.	S .....0.010 max.	Mo.....4.6 – 5.2
Si .....0.10 max.	P .....0.010 max.	Ti.....0.55 – 0.80
Mn.....0.10 max.	Co.....8.0 – 9.5	Al ....0.05 – 0.15
	Ni ....18.0 – 19.0	Fe .....Balance

Physical Constants and Thermal Properties

Density, lb/in^3 .....0.290
g/cm^3 .....8.0

Melting Range, °F..... 2600 – 2650
°C..... 1427 – 1454

Specific Heat, Btu/lb • °F 0.08
J/kg • K.....335

Permeability at 200 Oersted (15.9 kA/m) 77.5

Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in • °F 4.8
21 – 93°C, μm/m • °C 8.64

Thermal Conductivity, Btu • in/ft^2 • h • °F 136
W/m • °C 19.6

Typical Mechanical Properties

	Solution Annealed 1500˚F (816˚C) 1 hr, AC	Solution Annealed plus aged 900˚F (482˚C) 3 hrs, AC
0.2% Yld, ksi	120	280
UTS, ksi	150	290
El, %	16	8
RA, %	70	40
Hardness, Rc	30	52

The 18% nickel maraging steels offer a unique combination of properties not available from conventional low alloy ultra high strength steels. They offer high strength, high ductility and toughness, and resistance to crack propagation. Hardening is accomplished by a simple aging cycle of 3 hours at 900°F (482°C) followed by air cooling. UDIMAR alloy 300 provides through hardening without quenching, freedom from decarburization, minimal distortion during aging, good formability, machinability, and weldability and a low coefficient of thermal expansion.

INCOTHERM® alloy TD

A nickel-chromium alloy that was originally developed for thermocouple sheathing where high temperature corrosion resistance and strength are required without the use of elements that may cause thermocouple degradation over time, the alloy has now been identified for uses in other high temperature and heat-treating applications. This product has been tailored to provide improved oxidation resistance over stainless steels and higher nickel alloys at temperatures up to 2282˚F (1250˚C) and possibly beyond. The alloying additions improve oxide scale adherence and reduce the rate of mass change, allowing the alloy to show significant improvements over alloys currently being used in heat treating applications. INCOTHERM alloy TD has excellent resistance to nitridation up to 2151˚F (1177˚C). Lacking the alloying elements that form internal nitrides such as Nb or Al, the product exhibits freedom from microstructural degradation in nitrogen-based atmospheres. Because of this excellent resistance to nitridation, the alloy is being evaluated for use in powder metallurgy sintering furnace belts and other thermal processing applications as well as thermocouple sheathing.

Contact Special Metals

Nominal

Cr 22	Fe .....1.0 max.	C.....0.05 max.
Ni .....Balance	Mn.....0.10 max.	Rare earth elements.....0.05
Mo.....3	Al .....0.10 max.	
Si 1.4		

Density, lb/in^3 (g/cm^3) 0.308 (8.54)

Melting Range, °F (°C) ..... 2516 – 2552 (1380 – 1400)

Coefficient of Expansion, 10^{-6} in/in • °F (μm/m • °C)
70 – 932°F (21 – 500°C) 8.09 (14.56)
70 – 1112°F (21 – 600°C)..... 8.32 (14.98)
70 – 1292°F (21 – 700°C) 8.66 (15.59)
70 – 1472°F (21 – 800°C) 8.97 (16.15)
70 – 1652°F (21 – 900°C) 9.34 (16.81)
70 – 1832°F (21 – 1000°C) 9.61 (17.30)

Electrical Resistivity, ohm • circ mil/ft.....698
μΩ•m.....1.16

Mechanical Properties INCOTHERM alloy TD

Temp. (°C)	0.2% YS (MPa)	UTS (MPa)	Elon (%)
22	405	799	51
800	177	279	82
900	75	131	80
1000	39	88	83
1100	20	59	156
1200	10	37	79
1250	8	29	95

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BRIGHTRAY

CORRONEL

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DURANICKEL

FERRY

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INCOFLUX

INCOLOY

INCONEL

INCOTEST

INCOTHERM

INCO-WELD

KOTHERM

MAXORB

MONEL

NILO

NILOMAG

NIMONIC

NIOTHERM

NI-ROD

NI-SPAN-C

RESISTOHM

UDIMAR

UDIMET

625LCF

686CPT

718SPF

725NDUR

800HT

Appendix

This Product Handbook gives brief descriptions of products in the broad line of high-performance alloys manufactured by Special Metals Corporation. Detailed technical literature is also available. The publications contain data on physical and mechanical properties, metallurgy, corrosion resistance, and fabrication procedures including welding, machining, forging, and cold forming. Additional publications are available on use of the alloys in major areas of application such as aerospace, chemical processing, marine engineering, thermal processing, power generation, and pollution control. The literature is available on our website, www.specialmetals.com.

Contents

Welding Products

Special Metals Welding Products Company manufactures companion welding products for the full range of its wrought alloys. The covered electrodes and bare filler wires are designed to match the high level of performance delivered by the alloys and to ensure single-source reliability in welded fabrications. The line of welding products also includes high-quality consumables for welding cast irons and for joining dissimilar metals.

Coated Electrodes	Major Uses	AWS Class	MIL-E-22200 Type
Nickel Welding Electrode 141	Nickel 200 and Nickel 201; the clad side of nickel-clad steel; joining steels to nickel alloys.	ENi-1	4N11
MONEL Welding Electrode 190	MONEL alloy 400 to itself, to low-alloy and carbon steels, to copper and copper-nickel alloys; surfacing of steels.	ENiCu-7	9N10
MONEL Welding Electrode 187	MONEL alloy 450, weldable grades of cast and wrought 70/30, 80/20, and 90/10 copper-nickel alloys.	ECuNi	CuNi
INCONEL Welding Electrode 182	INCONEL alloys 600 and 601; surfacing of steel; dissimilar combinations of steels and nickel alloys.	ENiCrFe-3	8N12
INCONEL Welding Electrode 112	INCONEL alloys 625 and 601; pit-resistant alloys; dissimilar combinations of steels and nickel alloys; surfacing of steels.	ENiCrMo-3	1N12
INCONEL Welding Electrode 117	INCONEL alloy 617; INCOLOY alloy 800HT; dissimilar combinations of high-temperature alloys.	ENiCrCoMo-1	—
INCO-WELD Welding Electrode C-276	INCONEL alloy C-276; other pit-resistant alloys; surfacing of steels.	ENiCrMo-4	—
INCO-WELD A Electrode	INCOLOY alloys 800 and 800HT; dissimilar combinations of steels and nickel alloys; 9% nickel steel; surfacing of steels.	ENiCrFe-2	—
NI-ROD Welding Electrode	Cast irons, especially for thin sections and machinability.	ENi-CI	—
NI-ROD 55 Welding Electrode	Cast irons, especially thick sections and high-phosphorus irons.	ENiFe-CI	—
NI-ROD 55X Welding Electrode	Cast irons, especially for out-of-position welding and high-phosphorus irons.	—	—
NI-ROD 99X Welding Electrode	Cast irons, especially for out-of-position welding, thin sections, and machinability.	—	—
INCONEL Welding Electrode 152	30% Cr for SMAW of INCONEL alloy 690 and other 30% Cr alloys; specifically designed for nuclear applications.	ENiCrFe-7	
INCONEL Welding Electrode 122	For SMAW of alloys 622, C-22 and other NiCrMo alloys; excellent pitting and crevice corrosion resistance & resistance to mixed acids. Also for low NO_x boiler tube overlay.	ENiCrMo-10	
INCO-WELD 686CPT Welding Electrode	Maximum resistance to pitting, crevice corrosion & mixed acids; excellent for overlay, welding of clad steels and providing overmatching corrosion-resistant welds for all types of NiCrMo alloys and super duplex stainless steels.	ENiCrMo-14	
Filler Metals	**Major Uses**	**AWS Class**	**MIL-E-21562 Type**
Nickel Filler Metal 61	Nickel 200 and Nickel 201; dissimilar combinations of nickel alloys and steels; surfacing of steels.	ERNi-1	RN61 EN61
MONEL Filler Metal 60	MONEL alloys 400, R-405, and K-500; surfacing of steel.	ERNiCu-7	RN60 EN60
MONEL Filler Metal 67	MONEL alloy 450; weldable grades of 70/30, 80/20 and 90/10 copper-nickel alloys.	ERCuNi	RN67 EN67
INCONEL Filler Metal 82	INCONEL alloys 600 and 601; INCOLOY alloys 800 and 800HT; INCO alloy 330; dissimilar combinations of steels and nickel alloys; surfacing of steels.	ERNiCr-3	RN82 EN82
INCONEL Filler Metal 92	Dissimilar combinations of steels and nickel alloys.	ERNiCrFe-6	RN6A EN6A
INCONEL Filler Metal 601	INCONEL alloy 601.	ERNiCrFe-11	—
INCONEL Filler Metal 617	INCONEL alloy 617; INCOLOY alloy 800HT; dissimilar combinations of high-temperature alloys.	ERNiCrCoMo-1	—
INCONEL Filler Metal 625	INCONEL alloys 625 and 601; pit-resistant alloys; dissimilar combinations of steels and nickel alloys; surfacing of steels.	ERNiCrMo-3	RN625 EN625
INCONEL Filler Metal 718	INCONEL alloys 718 and X-750.	ERNiFeCr-2	—
INCO-WELD Filler Metal C-276	INCONEL alloy C-276; other pit-resistant alloys; surfacing of steels.	ERNiCrMo-4	—
INCO-WELD Filler Metal HX	INCONEL alloy HX.	ERNiCrMo-2	—
NC 80/20 Filler Metal	BRIGHTRAY electrical-resistant alloys; INCOLOY alloy DS.	—	—
NI-ROD Filler Metal 44	Cast irons, especially robotic and automatic welding.	ERNiFeMn-CI	—

Filler Metals	Major Uses	AWS Class	MIL-E-00000 Type
INCONEL Filler Metal 52	30% Cr for GMAW & GTAW welding of 690 and for overlays on steel; specifically designed for nuclear applications.	ERNiCrFe-7	
INCONEL Filler Metal 622	For GMAW, GTAW, and SAW of alloys 622, C-22 and other NiCroMo alloys; excellent pitting and crevice corrosion-resistance and resistance to mixed acids; also for low NO_x boiler tube overlay.	ERNiCrMo-10	
INCO-WELD 725NDUR Filler Metal	Age hardenable 625 version; capable of heat treated ultimate tensile of 180 KSI and Rc 34 hardness.		ERNiCrMo-15
INCO-WELD 686CPT Filler Metal	For GTAW, GMAW, & SAW; maximum resistance to pitting, crevice corrosion, mixed acids; excellent for overlay, welding of clad steels, and for providing overmatching corrosion resistant welds for all types of NiCrMo alloys and super duplex stainless steels.		ERNiCrMo-14
INCONEL Filler Metal 72	Highest %Cr (43%) with good cracking resistance in GMAW & GTAW; excellent sulfidation and oxidation resistance.	ERNiCr-4	
INCONEL Filler Metal 625BC	Designed for hot and cold wire GTAW applications for valve body overlay and internal bore cladding operations.	ERNiCrMo-3	
NI-ROD Filler Metal 99	For GMAW, GTAW & SAW of all types of cast irons; best machinability in first layer or two layer overlays; not recommended for more than two layers.		
NILO CF36 Filler Metal	For GMAW, GTAW & SAW of INVAR and similar low expansion alloys; deposits crack-free welds that are closely matching in CTE to INVAR.		
NILO CF42 Filler Metal	Similar to NILO CF36, but is intended for 42% nickel low-expansion alloys.		
NI-ROD 44HT Filler Metal	For GMAW & GTAW of high temperature ductile irons to each other and to stainless steels.		
NI-ROD FC44 Cored Wire	For FCAW of all types of cast iron with 75A-25 CO_2; especially suited to ductile iron welding for maximum strength and ductility of welds.		
INCO-CORED 82DH Cored Wire	For flat position (1G) FCAW welding of INCONEL 600 and similar alloys and dissimilar combinations.		
INCO-CORED 82AP Cored Wire	For all position FCAW welding of INCONEL 600 and similar alloys; also for dissimilar joints involving stainless steels, CrMo steels and carbon steels.		
INCO-CORED 625DH Cored Wire	For flat position (1G) FCAW welding of 625 and lower alloyed NiCrMo materials such as super austenitics, and 4% and 6% Mo containing stainless steels.		
INCO-CORED 625AP Cored Wire	For all position FCAW welding of 625 and lower alloyed NiCrMo materials such as super austenitics, and 4% and 6% Mo containing stainless steels.		
Thermal Sprays	**Major Uses**		
DURANICKEL Thermal Spray 301TSW	For highest bond strength arc-spray build ups and bond coats; for bonding and protective coatings.		
INCONEL Thermal Spray 625TSW	Corrosion-resistant arc-spray coatings used for pulp and paper and other industry applications.		
INCONEL Thermal Spray 72TSW	Most sulfidation-resistant arc-spray product; used extensively in black liquor recovery boilers.		
INCOFLUX	**Major Uses**		
INCOFLUX 5	For SAW butt welding with MONEL FM 60 and butt welding and overlaying of cast iron with NI-ROD FC 55.		
INCOFLUX 6	For SAW with FM 82, 625, 61, CF36, CF42, NI-ROD FM 99 and 44; for limited thickness butt welds and overlays.		
INCOFLUX NT100	Neutral SAW flux for overlays with FM 82, 625, 61 and NI-ROD FM 44 and 99; also used with FM CF36 and CF42.		
INCOFLUX NT110	Neutral SAW flux for overlaying with MONEL FM 60 and 67.		
INCOFLUX NT120	SAW flux for butt welding and overlaying with FMs C-276, 622, and 686CPT.		
INCOFLUX ESS1	High-deposition rate flux for strip overlays with INCONEL weldstrips 82, 625, and INCO-WELD weldstrip 686CPT with ESS processes.		
INCOFLUX ESS2	For electroslag strip welding overlay (ESSW) with INCONEL 52 and 52M Weldstrips.		
INCOFLUX ESS3	For electroslag strip welding overlay (ESSW) with INCONEL 82, 622 and 625 Weldstrips, and INCO-WELD C-276.		
INCOFLUX ESS4	For electroslag strip welding overlay (ESSW) with INCONEL 625 Weldstrips, and INCO-WELD C-276 and 86CPT.		
INCOFLUX SAS1	High deposition rate flux for strip overlays with INCONEL weldstrips 82 and 625.		
INCOFLUX SAS2	For submerged arc strip welding overlay (SASW) with INCONEL 52 and 52M Weldstrips.		
Weldstrip	**Major Uses**		
MONEL Weldstrip 60	Weldstrip for producing MONEL 400 type overlays at high-deposition rates with the electroslag surfacing (ESS) and submerged arc strip (SAS) processes.		
Nickel Weldstrip 61	Weldstrip for producing nickel overlays at high-deposition rates with ESS and SAS processes.		
INCONEL Weldstrip 82	Weldstrip for high-deposition rate overlays of 20% Cr INCONEL alloy using ESS and SAS processes.		
INCONEL Weldstrip 625	Weldstrip for high-deposition rate overlays of INCONEL alloy 625 type using ESS and SAS processes.		

Conversion Factors for Units of Measure

Selected Conversion Factors for U.S. Customary to SI Metric Units

To convert from	to	multiply by
atmosphere (760 mm Hg)	pascal (Pa)	$1.013\ 25 \times 10^{5}$
Btu (International Table)	joule (J)	$1.055\ 056 \times 10^{3}$
Btu/h	watt (W)	$2.930\ 711 \times 10^{-1}$
Btu/lb·°F	J/kg·°C	$4.186\ 8 \times 10^{3}$
Btu·in/ft²·h·°F	W/m·°C	$1.442\ 279 \times 10^{-1}$
calorie	joule (J)	4.186 8
circular mil	square metre (m^2)	$5.067\ 075 \times 10^{-10}$
foot	metre (m)	$3.048\ 000 \times 10^{-1}$
ft^2	square metre (m^2)	$9.290\ 304 \times 10^{-2}$
ft^3	cubic metre (m^3)	$2.831\ 685 \times 10^{-2}$
ft·lbf	joule (J)	1.355 818
ft·lbf/min	watt (W)	$2.259\ 697 \times 10^{-2}$
ft/s^2	m/s^2	$3.048\ 000 \times 10^{-1}$
gallon (U.S. liquid)	cubic metre (m^3)	$3.785\ 412 \times 10^{-3}$
horsepower (electric)	watt (W)	$7.460\ 000 \times 10^{2}$
inch	metre (m)	$2.540\ 000 \times 10^{-2}$
in^2	square metre (m^2)	$6.451\ 600 \times 10^{-4}$
in^3	cubic metre (m^3)	$1.638\ 706 \times 10^{-5}$
inch of mercury (60°F)	pascal (Pa)	$3.376\ 85 \times 10^{3}$
inch of water (60°F)	pascal (Pa)	$2.488\ 4 \times 10^{2}$
kgf/cm^2	pascal (Pa)	$9.806\ 650 \times 10^{4}$
kip (1000 lbf)	newton (N)	$4.448\ 222 \times 10^{3}$
kip/in^2 (ksi)	pascal (Pa)	$6.894\ 757 \times 10^{6}$
oersted	A/m	$7.957\ 75 \times 10$
ohm·circ mil/ft	Ω·m	$1.662\ 426 \times 10^{-9}$
ounce (U.S. fluid)	cubic metre (m^3)	$2.957\ 353 \times 10^{-5}$
ounce-force	newton (N)	$2.780\ 139 \times 10^{-1}$
ounce (avoirdupois)	kilogram (kg)	$2.834\ 952 \times 10^{-2}$
pint (U.S. liquid)	cubic metre (m^3)	$4.731\ 765 \times 10^{-4}$
pound-force (lbf)	newton (N)	4.448 222
pound (lb avoirdupois)	kilogram (kg)	$4.535\ 924 \times 10^{-1}$
lbf/in^2 (psi)	pascal (Pa)	$6.894\ 757 \times 10^{3}$
lb/in^3	kg/m^3	$2.767\ 990 \times 10^{4}$
lb/ft^3	kg/m^3	$1.601\ 846 \times 10$
quart (U.S. liquid)	cubic metre (m^3)	$9.463\ 529 \times 10^{-4}$
ton (short, 2000 lb)	kilogram (kg)	$9.071\ 847 \times 10^{2}$
torr (mm Hg, 0°C)	pascal (Pa)	$1.333\ 22 \times 10^{2}$
W· h	joule (J)	$3.600\ 000 \times 10^{3}$
yard	metre (m)	$9.144\ 000 \times 10^{-1}$
yd^2	square metre (m^2)	$8.361\ 274 \times 10^{-1}$
yd^3	cubic metre (m^3)	$7.645\ 549 \times 10^{-1}$

Grain-Size Equivalents

ASTM Number	Average Grain Diameter	
	in.	mm
00	0.020	0.508
0	0.0141	0.359
1	0.010	0.254
2	0.007	0.180
3	0.005	0.127
4	0.0035	0.089
5	0.0025	0.064
6	0.0018	0.045
7	0.0012	0.032
8	0.0009	0.022
9	0.0006	0.016
10	0.0004	0.011

Millimetre — Inch Equivalents

mm	in.	mm	in.
1	0.039	14	0.551
2	0.079	15	0.590
3	0.118	16	0.630
4	0.157	17	0.669
5	0.197	18	0.709
6	0.236	19	0.748
7	0.276	20	0.787
8	0.315	21	0.827
9	0.354	22	0.866
10	0.394	23	0.906
11	0.433	24	0.945
12	0.472	25	0.984
13	0.512	26	1.024

Decimal and Metric Equivalents of Fractions of an Inch

in.	in.	mm	in.	in.	mm
1/32	0.03125	0.794	17/32	0.53125	13.494
1/16	0.0625	1.588	9/16	0.5625	14.287
3/32	0.09375	2.381	19/32	0.59375	15.081
1/8	0.125	3.175	5/8	0.625	15.875
5/32	0.15625	3.969	21/32	0.65625	16.669
3/16	0.1875	4.762	11/16	0.6875	17.462
7/32	0.21875	5.556	23/32	0.71875	18.256
1/4	0.25	6.350	3/4	0.75	19.050
9/32	0.28125	7.144	25/32	0.78125	19.844
5/16	0.3125	7.937	13/16	0.8125	20.637
11/32	0.34375	8.731	27/32	0.84375	21.431
3/8	0.375	9.525	7/8	0.875	22.225
13/32	0.40625	10.319	29/32	0.90625	23.018
7/16	0.4375	11.112	15/16	0.9375	23.812
15/32	0.46875	11.906	31/32	0.96875	24.606
1/2	0.5	12.700	1	1.0	25.4

Multiple and Submultiple Units

Unit Prefix	Symbol	Magnitude
micro	μ	0.000 001 (10^{-6})
milli	m	0.001 (10^{-3})
centi	c	0.01 (10^{-2})
deci	d	0.1 (10^{-1})
deka	da	10 (10^{1})
hecto	h	100 (10^{2})
kilo	k	1000 (10^{3})
mega	M	1 000 000 (10^{6})
giga	G	1 000 000 000 (10^{9})
tera	T	1 000 000 000 000 (10^{12})

Hardness Correlations for Nickel Alloys

Approximate Relationships Between Hardness Values, Nickel and High-Nickel Alloys[a]

Diamond Pyramid Hardness Number, DPH	Brinell Hardness Number, BHN	Rockwell Hardness Number								Rockwell Superficial Hardness Number						Knoop Hardness Number[b] KHN
		A Scale	B Scale	C Scale	D Scale	E Scale	F Scale	G Scale	K Scale	15-N Scale	30-N Scale	45-N Scale	15-T Scale	30-T Scale	45-T Scale	
Diamond Pyramid Indenter—1, 5, 10, 30 Kgf Load	10 mm Standard Ball, 3000 Kgf Load	60 Kgf Load Diamond Penetrator	100 Kgf Load, 1/16" (1.588 mm) Ball	150 Kgf Load Diamond Penetrator	100 Kgf Load Diamond Penetrator	100 Kgf Load, 1/8" (3.175 mm) Ball	60 Kgf Load, 1/16" (1.588 mm) Ball	150 Kgf Load, 1/16" (1.588 mm) Ball	150 Kgf Load, 1/8" (3.175 mm) Ball	15 Kgf Load, Superficial Diamond Penetrator	30 Kgf Load, Superficial Diamond Penetrator	45 Kgf Load, Superficial Diamond Penetrator	15 Kgf Load, 1/16" (1.588 mm) Ball	30 Kgf Load, 1/16" (1.588 mm) Ball	45 Kgf Load, 1/16" (1.588 mm) Ball	Knoop Indenter 500 and 1000 gf Load
513	479	75.5	—	50.0	63.0	—	—	—	—	85.5	68.0	54.5	—	—	—	—
481	450	74.5	—	48.0	61.5	—	—	—	—	84.5	66.5	52.5	—	—	—	—
452	425	73.5	—	46.0	60.0	—	—	—	—	83.5	64.5	50.0	—	—	—	—
427	403	72.5	—	44.0	58.5	—	—	—	—	82.5	63.0	47.5	—	—	—	—
404	382	71.5	—	42.0	57.0	—	—	—	—	81.5	61.0	45.5	—	—	—	—
382	363	70.5	—	40.0	55.5	—	—	—	—	80.5	59.5	43.0	—	—	—	436
362	346	69.5	—	38.0	54.0	—	—	—	—	79.5	58.0	41.0	—	—	—	413
344	329	68.5	—	36.0	52.5	—	—	—	—	78.5	56.0	38.5	—	—	—	392
326	313	67.5	—	34.0	50.5	—	—	—	—	77.5	54.5	36.0	—	—	—	372
309	298	66.5	**106**	32.0	49.5	—	**116.5**	94.0	—	76.5	52.5	34.0	94.5	85.5	77.0	352
285	275	64.5	**104**	28.5	46.5	—	**115.5**	91.0	—	75.0	49.5	30.0	94.0	84.5	75.0	325
266	258	63.0	**102**	25.5	44.5	—	**114.5**	87.5	—	73.5	47.0	26.5	93.0	83.0	73.0	304
248	241	61.5	100	22.5	42.0	—	**113.0**	84.5	—	72.0	44.5	23.0	92.5	81.5	71.0	283
234	228	60.5	98	20.0	40.0	—	**112.0**	81.5	—	70.5	42.0	20.0	92.0	80.5	69.0	267
220	215	59.0	96	**17.0**	38.0	—	**111.0**	78.5	100.0	69.0	39.5	17.0	91.0	79.0	67.0	251
209	204	57.5	94	**14.5**	36.0	—	**110.0**	75.5	98.0	68.0	37.5	14.0	90.5	77.5	65.0	239
198	194	56.5	92	**12.0**	34.0	—	**108.5**	72.0	96.5	66.5	35.5	11.0	89.5	76.0	63.0	226
188	184	55.0	90	**9.0**	32.0	**108.5**	**107.5**	69.0	94.5	65.0	32.5	7.5	89.0	75.0	61.0	215
179	176	53.5	88	**6.5**	30.0	**107.0**	**106.5**	65.5	93.0	64.0	30.5	5.0	88.0	73.5	59.5	204
171	168	52.5	86	**4.0**	28.0	**106.0**	**105.0**	62.5	91.0	62.5	28.5	2.0	87.5	72.0	57.5	195
164	161	51.5	84	**2.0**	26.5	**104.5**	**104.0**	59.5	89.0	61.5	26.5	**–0.5**	87.0	70.5	55.5	187
157	155	50.0	82	—	24.5	**103.0**	**103.0**	56.5	87.5	—	—	—	86.0	69.5	53.5	179
151	149	49.0	80	—	22.5	**102.0**	**101.5**	53.0	85.5	—	—	—	85.5	68.0	51.5	173
145	144	47.5	78	—	21.0	**100.5**	**100.5**	50.0	83.5	—	—	—	84.5	66.5	49.5	166
140	139	46.5	76	—	**19.0**	99.5	99.5	47.0	82.0	—	—	—	84.0	65.5	47.5	160
135	134	45.5	74	—	**17.5**	98.0	98.5	43.5	80.0	—	—	—	83.0	64.0	45.5	154
130	129	44.0	72	—	**16.0**	97.0	97.0	40.5	78.0	—	—	—	82.5	62.5	43.5	149
126	125	43.0	70	—	**14.5**	95.5	96.0	37.5	76.5	—	—	—	82.0	61.0	41.5	144
122	121	42.0	68	—	**13.0**	94.5	95.0	34.5	74.5	—	—	—	81.0	60.0	39.5	140
119	118	41.0	66	—	**11.5**	93.0	93.5	31.0	72.5	—	—	—	80.5	58.5	37.5	136
115	114	40.0	64	—	**10.0**	91.5	92.5	—	71.0	—	—	—	79.5	57.0	35.5	—
112	111	39.0	62	—	**8.0**	90.5	91.5	—	69.0	—	—	—	79.0	56.0	33.5	—
108	108	—	60	—	—	89.0	90.0	—	67.5	—	—	—	78.5	54.5	31.5	—
106	106	—	58	—	—	88.0	89.0	—	65.5	—	—	—	77.5	53.0	29.5	—
103	103	—	56	—	—	86.5	88.0	—	63.5	—	—	—	77.0	51.5	27.5	—
100	100	—	54	—	—	85.5	87.0	—	62.0	—	—	—	76.0	50.5	25.5	—
98	98	—	52	—	—	84.0	85.5	—	60.0	—	—	—	75.5	49.0	23.5	—
95	95	—	50	—	—	83.0	84.5	—	58.0	—	—	—	74.5	47.5	21.5	—
93	93	—	48	—	—	81.5	83.5	—	56.5	—	—	—	74.0	46.5	19.5	—
91	91	—	46	—	—	80.5	82.0	—	54.5	—	—	—	73.5	45.0	17.0	—
89	89	—	44	—	—	79.0	81.0	—	52.5	—	—	—	72.5	43.5	14.5	—
87	87	—	42	—	—	78.0	80.0	—	51.0	—	—	—	72.0	42.0	12.5	—
85	85	—	40	—	—	76.5	79.0	—	49.0	—	—	—	71.0	41.0	10.0	—
83	83	—	38	—	—	75.0	77.5	—	47.0	—	—	—	70.5	39.5	7.5	—
81	81	—	36	—	—	74.0	76.5	—	45.5	—	—	—	70.0	38.0	5.5	—
79	79	—	34	—	—	72.5	75.5	—	43.5	—	—	—	69.0	36.5	3.0	—
78	78	—	32	—	—	71.5	74.0	—	42.0	—	—	—	68.5	35.5	1.0	—
77	77	—	30	—	—	70.0	73.0	—	40.0	—	—	—	67.5	34.0	**–1.5**	—

[a] Hardness Conversion Chart for Nickel and High-Nickel Alloys. A.S.T.M., E140-84.

The use of hardness scales for hardness values shown above in **bold** are not recommended by the manufacturers of hardness testing machines since they are beyond the ranges recommended for accuracy. Such values are shown for comparative purposes, only, where comparisons may be desired and the recommended machine and scale are not available.

[b] For Knoop hardness determinations the specimen must be polished, etched, and repolished until a final light etch shows a clearly defined microstructure free from disturbed metal. Care must be exercised to insure that the top and bottom of the mounted specimen are parallel. In no case shall the departure from symmetry in the longitudinal direction of the indentation be greater than 5 filar microscope units.

Comparisons of Gauges / Standard Pipe Sizes

Approximate Comparison of Gauges

Gauge No.	INCHES						MILLIMETRES	
	American or Brown & Sharpe's	Birmingham or Stubs'	Washburn & Moen's	Imperial S.W.G.	London or Old English	United States Standard	United States Standard	Stubs'
7/0	—	—	0.4900	0.500	—	0.5000	12.700	—
6/0	0.5800	—	0.4615	0.464	—	0.4687	11.906	—
5/0	0.5165	—	0.4305	0.432	—	0.4375	11.113	—
4/0	0.4600	0.454	0.3938	0.400	0.454	0.4062	10.319	11.532
3/0	0.4096	0.425	0.3625	0.372	0.425	0.3750	9.525	10.795
2/0	0.3648	0.380	0.3310	0.348	0.380	0.3437	8.731	9.652
1/0	0.3249	0.340	0.3065	0.324	0.340	0.3125	7.938	8.636
1	0.2893	0.300	0.2830	0.300	0.300	0.2812	7.144	7.620
2	0.2576	0.284	0.2625	0.276	0.284	0.2656	6.747	7.214
3	0.2294	0.259	0.2437	0.252	0.259	0.2500	6.350	6.579
4	0.2043	0.238	0.2253	0.232	0.238	0.2343	5.953	6.045
5	0.1819	0.220	0.2070	0.212	0.220	0.2187	5.556	5.588
6	0.1620	0.203	0.1920	0.192	0.203	0.2031	5.159	5.156
7	0.1443	0.180	0.1770	0.176	0.180	0.1875	4.763	4.572
8	0.1285	0.165	0.1620	0.160	0.165	0.1718	4.366	4.191
9	0.11440	0.148	0.1483	0.144	0.148	0.1562	3.969	3.759
10	0.10190	0.134	0.1350	0.128	0.134	0.1406	3.572	3.404
11	0.09074	0.120	0.1205	0.116	0.120	0.1250	3.175	3.048
12	0.08081	0.109	0.1055	0.104	0.109	0.10930	2.778	2.769
13	0.07196	0.095	0.0915	0.092	0.095	0.09375	2.381	2.413
14	0.06408	0.083	0.0800	0.080	0.083	0.07812	1.984	2.108
15	0.05707	0.072	0.0720	0.072	0.072	0.07031	1.786	1.829
16	0.05082	0.065	0.0625	0.064	0.065	0.06250	1.588	1.651
17	0.04526	0.058	0.0540	0.056	0.058	0.05625	1.429	1.473
18	0.04030	0.049	0.0475	0.048	0.049	0.05000	1.270	1.245
19	0.03589	0.042	0.0410	0.040	0.040	0.04375	1.111	1.067
20	0.03196	0.035	0.0348	0.036	0.035	0.03750	0.953	0.889
21	0.02846	0.032	0.0317	0.032	0.0315	0.03437	0.873	0.813
22	0.02535	0.028	0.0286	0.028	0.0295	0.03125	0.794	0.711
23	0.02257	0.025	0.0258	0.024	0.0270	0.02812	0.714	0.635
24	0.02010	0.022	0.0230	0.022	0.0250	0.02500	0.635	0.559
25	0.01790	0.020	0.0204	0.020	0.0230	0.02187	0.556	0.508
26	0.01594	0.018	0.0181	0.018	0.0205	0.01875	0.476	0.457

Nominal Pipe Size, in.	Outside Diameter		Nominal Wall Thickness For									
			Schedule 5		Schedule 10		Schedule 40		Schedule 80		Schedule 160	
	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.
1/8	0.405	10.29	—	—	0.049	1.24	0.068	1.73	0.095	2.41	—	—
1/4	0.540	13.72	—	—	0.065	1.65	0.088	2.24	0.119	3.02	—	—
3/8	0.675	17.14	—	—	0.065	1.65	0.091	2.31	0.126	3.20	—	—
1/2	0.840	21.34	0.065	1.65	0.083	2.11	0.109	2.77	0.147	3.73	0.187	4.75
3/4	1.050	26.67	0.065	1.65	0.083	2.11	0.113	2.87	0.154	3.91	0.218	5.54
1	1.315	33.40	0.065	1.65	0.109	2.77	0.133	3.38	0.179	4.55	0.250	6.35
1 1/4	1.660	42.16	0.065	1.65	0.109	2.77	0.140	3.56	0.191	4.85	0.250	6.35
1 1/2	1.900	48.26	0.065	1.65	0.109	2.77	0.145	3.68	0.200	5.08	0.281	7.14
2	2.375	60.32	0.065	1.65	0.109	2.77	0.154	3.91	0.218	5.54	0.343	8.71
2 1/2	2.875	73.02	0.083	2.11	0.120	3.05	0.203	5.16	0.276	7.01	0.375	9.52
3	3.500	88.90	0.083	2.11	0.120	3.05	0.216	5.49	0.300	7.62	0.438	11.10
3 1/2	4.000	101.60	0.083	2.11	0.120	3.05	0.226	5.74	0.318	8.08	—	—
4	4.500	114.30	0.083	2.11	0.120	3.05	0.237	6.02	0.337	8.56	0.531	13.50
5	5.563	141.30	0.109	2.77	0.134	3.40	0.258	6.55	0.375	9.52	0.625	15.90
6	6.625	168.30	0.109	2.77	0.134	3.40	0.280	7.11	0.432	11.00	0.718	18.20
8	8.625	219.10	0.109	2.77	0.148	3.76	0.322	8.18	0.500	12.70	0.906	23.00
10	10.750	273.00	0.134	3.40	0.165	4.19	0.365	9.27	0.593	15.10	—	—
12	12.750	323.80	0.165	4.19	0.180	4.57	0.406	10.30	0.687	17.40	—	—

Albert Sauveur type of table. Look up reading in middle column; if in degrees Celsius, read Fahrenheit equivalent in right hand column; if in degrees Fahrenheit, read Celsius equivalent in left hand column.

−459.4 to 0			0 to 100						100 to 1000						1000 to 2000						2000 to 3000					
°C		°F	°C		°F	°C		°F	°C		°F	°C		°F	°C		°F	°C		°F	°C		°F	°C		°F
−273	−459.4		−17.8	0	32	10.0	50	122.0	38	100	212	260	500	932	538	1000	1832	816	1500	2732	1093	2000	3632	1371	2500	4532
−268	−450		−17.2	1	33.8	10.6	51	123.8	43	110	230	266	510	950	543	1010	1850	821	1510	2750	1099	2010	3650	1377	2510	4550
−262	−440		−16.7	2	35.6	11.1	52	125.6	49	120	248	271	520	968	549	1020	1868	827	1520	2768	1104	2020	3668	1382	2520	4568
−257	−430		−16.1	3	37.4	11.7	53	127.4	54	130	266	277	530	986	554	1030	1886	832	1530	2786	1110	2030	3686	1388	2530	4586
−251	−420		−15.6	4	39.2	12.2	54	129.2	60	140	284	282	540	1004	560	1040	1904	838	1540	2804	1116	2040	3704	1393	2540	4604
−246	−410		−15.0	5	41.0	12.8	55	131.0	66	150	302	288	550	1022	566	1050	1922	843	1550	2822	1121	2050	3722	1399	2550	4622
−240	−400		−14.4	6	42.8	13.3	56	132.8	71	160	320	293	560	1040	571	1060	1940	849	1560	2840	1127	2060	3740	1404	2560	4640
−234	−390		−13.9	7	44.6	13.9	57	134.6	77	170	338	299	570	1058	577	1070	1958	854	1570	2858	1132	2070	3758	1410	2570	4658
−229	−380		−13.3	8	46.4	14.4	58	136.4	82	180	356	304	580	1076	582	1080	1976	860	1580	2876	1138	2080	3776	1416	2580	4676
−223	−370		−12.8	9	48.2	15.0	59	138.2	88	190	374	310	590	1094	588	1090	1994	866	1590	2894	1143	2090	3794	1421	2590	4694
−218	−360		−12.2	10	50.0	15.6	60	140.0	93	200	392	316	600	1112	593	1100	2012	871	1600	2912	1149	2100	3812	1427	2600	4712
−212	−350		−11.7	11	51.8	16.1	61	141.8	99	210	410	321	610	1130	599	1110	2030	877	1610	2930	1154	2110	3830	1432	2610	4730
−207	−340		−11.1	12	53.6	16.7	62	143.6	100	212	413.6	327	620	1148	604	1120	2048	882	1620	2948	1160	2120	3848	1438	2620	4748
−201	−330		−10.6	13	55.4	17.2	63	145.4	104	220	428	332	630	1166	610	1130	2066	888	1630	2966	1166	2130	3866	1443	2630	4766
−196	−320		−10.0	14	57.2	17.8	64	147.2	110	230	446	338	640	1184	616	1140	2084	893	1640	2984	1171	2140	3884	1449	2640	4784
−190	−310		− 9.4	15	59.0	18.3	65	149.0	116	240	464	343	650	1202	621	1150	2102	899	1650	3002	1177	2150	3902	1454	2650	4802
−184	−300		− 8.9	16	60.8	18.9	66	150.8	121	250	482	349	660	1220	627	1160	2120	904	1660	3020	1182	2160	3920	1460	2660	4820
−179	−290		− 8.3	17	62.6	19.4	67	152.6	127	260	500	354	670	1238	632	1170	2138	910	1670	3038	1188	2170	3938	1466	2670	4838
−173	−280		− 7.8	18	64.4	20.0	68	154.4	132	270	518	360	680	1256	638	1180	2156	916	1680	3056	1193	2180	3956	1471	2680	4856
−169	−273	−459.4	− 7.2	19	66.2	20.6	69	156.2	138	280	536	366	690	1274	643	1190	2174	921	1690	3074	1199	2190	3974	1477	2690	4874
−168	−270	−454	− 6.7	20	68.0	21.1	70	158.0	143	290	554	371	700	1292	649	1200	2192	927	1700	3092	1204	2200	3992	1482	2700	4892
−162	−260	−436	− 6.1	21	69.8	21.7	71	159.8	149	300	572	377	710	1310	654	1210	2210	932	1710	3110	1210	2210	4010	1488	2710	4910
−157	−250	−418	− 5.6	22	71.6	22.2	72	161.6	154	310	590	382	720	1328	660	1220	2228	938	1720	3128	1216	2220	4028	1493	2720	4928
−151	−240	−400	− 5.0	23	73.4	22.8	73	163.4	160	320	608	388	730	1346	666	1230	2246	943	1730	3146	1221	2230	4046	1499	2730	4946
−146	−230	−382	− 4.4	24	75.2	23.3	74	165.2	166	330	626	393	740	1364	671	1240	2264	949	1740	3164	1227	2240	4064	1504	2740	4964
−140	−220	−364	− 3.9	25	77.0	23.9	75	167.0	171	340	644	399	750	1382	677	1250	2282	954	1750	3182	1232	2250	4082	1510	2750	4982
−134	−210	−346	− 3.3	26	78.8	24.4	76	168.8	177	350	662	404	760	1400	682	1260	2300	960	1760	3200	1238	2260	4100	1516	2760	5000
−129	−200	−328	− 2.8	27	80.6	25.0	77	170.6	182	360	680	410	770	1418	688	1270	2318	966	1770	3218	1243	2270	4118	1521	2770	5018
−123	−190	−310	− 2.2	28	82.4	25.6	78	172.4	188	370	698	416	780	1436	693	1280	2336	971	1780	3236	1249	2280	4136	1527	2780	5036
−118	−180	−292	− 1.7	29	84.2	26.1	79	174.2	193	380	716	421	790	1454	699	1290	2354	977	1790	3254	1254	2290	4154	1532	2790	5054
−112	−170	−274	− 1.1	30	86.0	26.7	80	176.0	199	390	734	427	800	1472	704	1300	2372	982	1800	3272	1260	2300	4172	1538	2800	5072
−107	−160	−256	− 0.6	31	87.8	27.2	81	177.8	204	400	752	432	810	1490	710	1310	2390	988	1810	3290	1266	2310	4190	1543	2810	5090
−101	−150	−238	0.0	32	89.6	27.8	82	179.6	210	410	770	438	820	1508	716	1320	2408	993	1820	3308	1271	2320	4208	1549	2820	5108
− 96	−140	−220	0.6	33	91.4	28.3	83	181.4	216	420	788	443	830	1526	721	1330	2426	999	1830	3326	1277	2330	4226	1554	2830	5126
− 90	−130	−202	1.1	34	93.2	28.9	84	183.2	221	430	806	449	840	1544	727	1340	2444	1004	1840	3344	1282	2340	4244	1560	2840	5144
− 84	−120	−184	1.7	35	95.0	29.4	85	185.0	227	440	824	454	850	1562	732	1350	2462	1010	1850	3362	1288	2350	4262	1566	2850	5162
− 79	−110	−166	2.2	36	96.8	30.0	86	186.8	232	450	842	460	860	1580	738	1360	2480	1016	1860	3380	1293	2360	4280	1571	2860	5180
− 73	−100	−148	2.8	37	98.6	30.6	87	188.6	238	460	860	466	870	1598	743	1370	2498	1021	1870	3398	1299	2370	4298	1577	2870	5198
− 68	− 90	−130	3.3	38	100.4	31.1	88	190.4	243	470	878	471	880	1616	749	1380	2516	1027	1880	3416	1304	2380	4316	1582	2880	5216
− 62	− 80	−112	3.9	39	102.2	31.7	89	192.2	249	480	896	477	890	1634	754	1390	2534	1032	1890	3434	1310	2390	4334	1588	2890	5234
− 57	− 70	− 94	4.4	40	104.0	32.2	90	194.0	254	490	914	482	900	1652	760	1400	2552	1038	1900	3452	1316	2400	4352	1593	2900	5252
− 51	− 60	− 76	5.0	41	105.8	32.8	91	195.8				488	910	1670	766	1410	2570	1043	1910	3470	1321	2410	4370	1599	2910	5270
− 46	− 50	− 58	5.6	42	107.6	33.3	92	197.6				493	920	1688	771	1420	2588	1049	1920	3488	1327	2420	4388	1604	2920	5288
− 40	− 40	− 40	6.1	43	109.4	33.9	93	199.4				499	930	1706	777	1430	2606	1054	1930	3506	1332	2430	4406	1610	2930	5306
− 34	− 30	− 22	6.7	44	111.2	34.4	94	201.2				504	940	1724	782	1440	2624	1060	1940	3524	1338	2440	4424	1616	2940	5324
− 29	− 20	− 4	7.2	45	113.0	35.0	95	203.0				510	950	1742	788	1450	2642	1066	1950	3542	1343	2450	4442	1621	2950	5342
− 23	− 10	14	7.8	46	114.8	35.6	96	204.8				516	960	1760	793	1460	2660	1071	1960	3560	1349	2460	4460	1627	2960	5360
− 17.8	0	32	8.3	47	116.6	36.1	97	206.6				521	970	1778	799	1470	2678	1077	1970	3578	1354	2470	4478	1632	2970	5378
			8.9	48	118.4	36.7	98	208.4				527	980	1796	804	1480	2696	1082	1980	3596	1360	2480	4496	1638	2980	5396
			9.4	49	120.2	37.2	99	210.2				532	990	1814	810	1490	2714	1088	1990	3614	1366	2490	4514	1643	2990	5414
						37.8	100	212.0				538	1000	1832				1093	2000	3632				1649	3000	5432

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