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.

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 9002, 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.

SPECIAL METALS

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

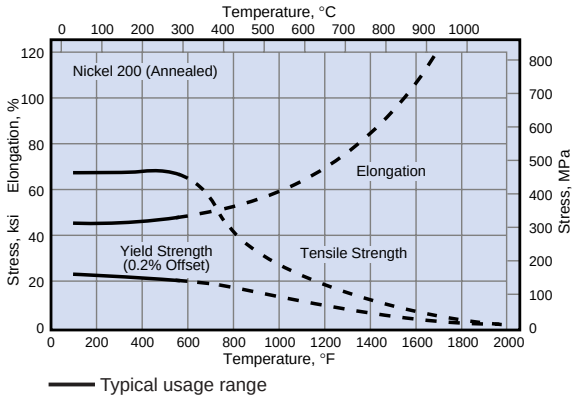
Density, lb/in³	0.321
g/cm³	8.89
Melting Range, °F	2615 – 2635
°C	1435 – 1446
Specific Heat, Btu/lb•°F	0.109
J/kg•°C	456
Curie Temperature, °F	680
°C	360
Permeability	Ferromagnetic
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F	7.4
21 – 93°C, µm/m•°C	13.3
Thermal Conductivity, Btu • in/ft²•h•°F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

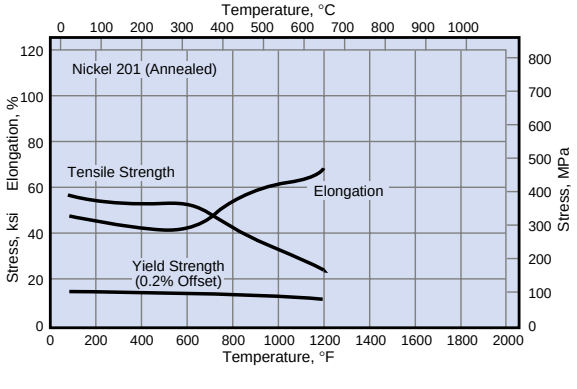
(Annealed)

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

Nickel 205

Wrought nickel similar to Nickel 200 but with compositional adjustments to enhance performance in electrical and electronic applications. Used for the anodes and grids of electronic valves, magnetostrictive transducers, lead wires, transistor housings, and battery cases.

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.

Standard Product Forms

Nickel 205	Nickel 212
Sheet, strip and wire.	Wire.

Major Specifications

Nickel 205	Nickel 212
UNS N02205 SAE AMS 5555 ASTM F 1, F 3	DIN 17741, 17750 – 17753 Werkstoff Nr. 2.4110

Limiting Chemical Composition, %

Nickel 205	Nickel 212
Ni[a] .... 99.0 min. Mg .. 0.01 – 0.08 Ti .... 0.01 – 0.05 Cu ... 0.15 max. Fe .... 0.20 max. C ..... 0.15 max. Si ..... 0.15 max. S .... 0.008 max. Mn ... 0.35 max. [a]Plus Co.	Ni[a] .... 97.0 min. Mn ..... 1.5 – 2.5 Fe .... 0.25 max. C ..... 0.10 max. Cu ... 0.20 max. Si ..... 0.20 max. Mg ... 0.20 max. [a]Plus Co.

Physical Constants and Thermal Properties

Nickel 205	Nickel 212
Density, lb/in^3 ..... 0.321 g/cm^3 ..... 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/ft^2•h•°F ..... 520 W/m•°C ..... 75.0 Electrical Resistivity, ohm•circ mil/ft ..... 57 µΩ•m 0.095	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 µΩ•m 0.109

Typical Mechanical Properties

Nickel 205	Nickel 212
(Annealed) Tensile Strength, ksi ..... 50 MPa ..... 345 Yield Strength (0.2% Offset), ksi ..... 13 MPa ..... 90 Elongation, % 45	

SPECIAL METALS

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.

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.

Standard Product Forms

Strip, round bar and wire.

Round bar and wire.

Major Specifications

UNS N02270
ASTM F 3
Werkstoff Nr. 2.4050

UNS N03301

Limiting Chemical Composition, %

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.

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.

Physical Constants and Thermal Properties

Density, lb/in³ 0.322
g/cm³ 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/ft²•h•°F 595
W/m•°C 86

Electrical Resistivity, ohm•circ mil/ft 45
µΩ•m 0.075

Density, lb/in³ (g/cm³) 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/ft²•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.

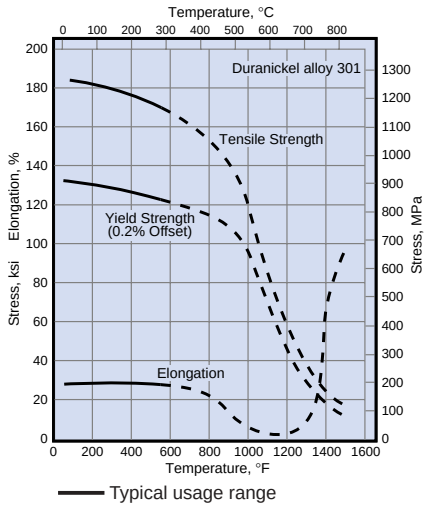
Typical Mechanical Properties

(Annealed)

Tensile Strength, ksi 50
MPa 345

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

Elongation, % 50



SPECIAL METALS

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.

MONEL® alloy 401

A copper-nickel alloy designed for specialized electrical and electronic applications. It has a very low temperature coefficient of resistance and medium-range electrical resistivity. Used for wire-wound precision resistors and bi-metal contacts.

Standard Product Forms

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

Wire.

Major Specifications

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-01-75

UNS N04401

Limiting Chemical Composition, %

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.

Ni ... 40.0 – 45.0	Fe .... 0.75 max.	S .... 0.015 max.
Cu ... Remainder	Si ..... 0.25 max.	Co ... 0.25 max.
Mn ... 2.25 max.	C ..... 0.10 max.	

Physical Constants and Thermal Properties

Density, lb/in³ 0.318
g/cm³ 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/ft²•h•°F 151
W/m•°C 21.8

Electrical Resistivity, ohm•circ mil/ft 329
µΩ•m 0.547

Density, lb/in³ 0.321
g/cm³ 8.89

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

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/ft²•h•°F 133
W/m•°C 19.2

Electrical Resistivity, ohm•circ mil/ft 294
µΩ•m 0.489

Temperature Coefficient of Resistance,
77 – 302 °F, 10^{-6} ohm/ohm•°F .. ±20
25 – 150°C, µΩ/Ω•°C ..... ±36

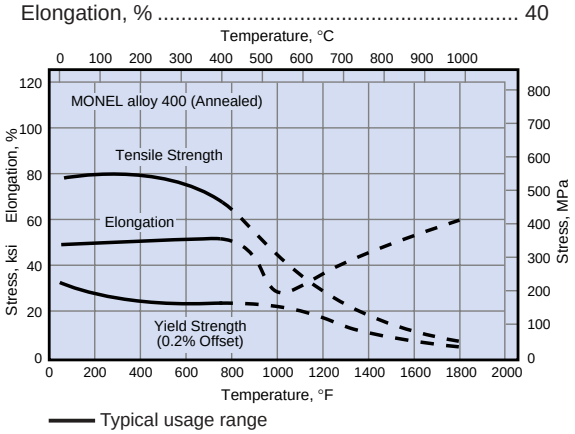
Typical Mechanical Properties

(Annealed)

Tensile Strength, ksi 80
MPa 550

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

Elongation, % 40



(Annealed)

Tensile Strength, ksi 64
MPa 441

Yield Strength (0.2% Offset), ksi 19.5
MPa 134

Elongation, % 51

SPECIAL METALS

MONEL® alloy 404

Composition of this alloy is carefully adjusted to provide low Curie temperature, low permeability, and good brazing characteristics. Because its low permeability is not significantly affected by processing and fabrication, the alloy is particularly suitable for electronic parts. It can be fabricated by the same procedures used for MONEL alloy 400. It can be joined to itself by the gas tungsten-arc welding process without the addition of filler metal.

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.

Standard Product Forms

Sheet and round bar.

Round bar, hexagon and wire.

Major Specifications

Contact Special Metals for further information.

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

Limiting Chemical Composition, %

Ni[a] . 52.0 – 57.0	Fe .... 0.50 max.	S .... 0.024 max.
Cu ..... Balance	C ..... 0.15 max.	Si ..... 0.10 max.
Al ..... 0.05 max.	Mn ... 0.10 max.	

[a]Plus Co.

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

[a]Plus Co.

Physical Constants and Thermal Properties

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

Specific Heat, Btu/lb•°F 0.099
J/kg•°C 414

Thermal Expansion, in/in °F • 10^{-6}
70° – 200°F (21 – 93°C) 7.4
70° – 500°F (21 – 260°C) 8.5
70° – 1000°F (21 – 539°C) 9.2
70° – 1500°F (21 – 816°C) 9.8

Thermal Conductivity, Btu • in/ft^2•h•°F 146
W/m•°C 21.0

Electrical Resistivity, ohm•circ mil/ft 300
µΩ•m 0.498

Curie Temperature, °F ..... -110
°C ..... -79

Permeability at 200 Oersted (15.9 kA/m) 1.002

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

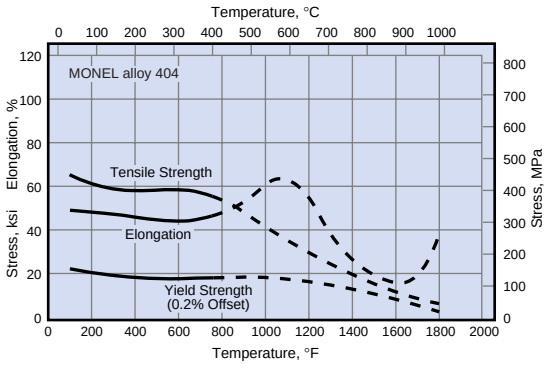
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F ... 7.6
21 – 93°C, µm/m•°C 13.7

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

Typical Mechanical Properties

(Annealed)



(Annealed)

Tensile Strength, ksi 80
MPa 550

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

Elongation, % 40

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

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

Major Specifications

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-01-75
ISO 6208, 9723 – 9725
ASME Code Case 1192

Limiting Chemical Composition, %

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

[a]Plus Co.

Physical Constants and Thermal Properties

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 ..... -65

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

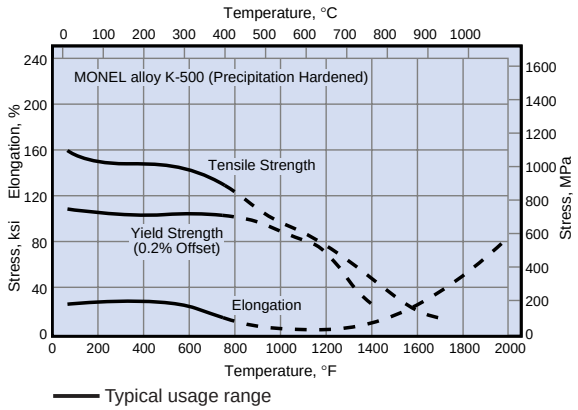
Typical Mechanical Properties

(Precipitation Hardened)

Tensile Strength, ksi 160
MPa 1100

Yield Strength (0.2% Offset), ksi 115
MPa 790

Elongation, % 20



SPECIAL METALS

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, N-580
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.
Cr ... 14.0 – 17.0
Fe ..... 6.0 – 10.0
C ..... 0.15 max.
Mn ..... 1.0 max.
S .... 0.015 max.
Si ..... 0.5 max.
Cu ..... 0.5 max.

[a]Plus Co.

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

Physical Constants and Thermal Properties

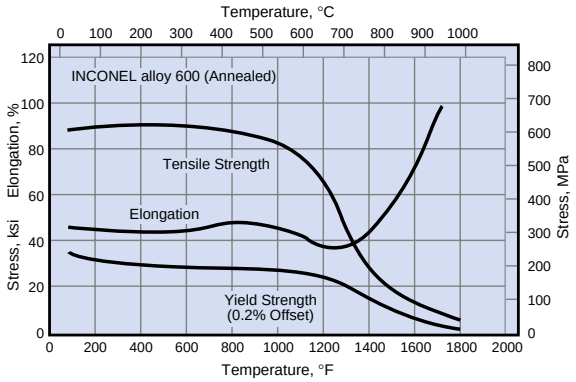
Density, lb/in^3 ..... 0.306
g/cm^3 ..... 8.47
Melting Range, °F ..... 2470 – 2575
°C ..... 1354 – 1413
Specific Heat, Btu/lb•°F 0.106
J/kg•°C 444
Curie Temperature, °F ..... -192
°C ..... -124
Permeability at 200 Oersted (15.9 kA/m) 1.010
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F ... 7.4
21 – 93°C, µm/m•°C 13.3
Thermal Conductivity, Btu • in/ft^2•h•°F 103
W/m•°C 14.9
Electrical Resistivity, ohm•circ mil/ft 620
µΩ•m 1.03

Density, lb/in^3 ..... 0.293
g/cm^3 ..... 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/ft^2•h•°F 78
W/m•°C 11.2
Electrical Resistivity, ohm•circ mil/ft 717
µΩ•m 1.19

Typical Mechanical Properties

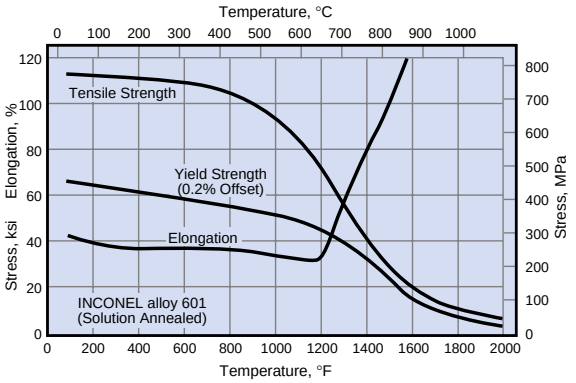
(Annealed)

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

INCONEL® alloy 601GC

This alloy is a grain-controlled version of INCONEL alloy 601 available for special applications such as seam-welded roller tubes in glazed ceramic tiles and strand annealing furnace tubes. Zirconium and nitrogen in INCONEL alloy 601GC act to inhibit grain growth during exposure up to 2130˚F (1165˚C).

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.

Standard Product Forms

Pipe and tube.

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

Major Specifications

Contact Special Metals for further information.

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
Werstoff Nr. 2.4663a
VdTÜV 485
ISO 6207, 6208, 9724

Limiting Chemical Composition, %

Ni[a] .. 58.0 – 63.0
Cr ... 23.0 – 25.0
Al ..... 0.8 – 1.7
C ... 0.03 – 0.08
Fe ... Remainder
Mn ..... 1.0 max.
S .... 0.015 max.
Si ..... 1.0 max.
N ... 0.02 – 0.07
Cu ..... 1.0 max.
Zr ... 0.07 – 0.25

[a]Plus Co.

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

Physical Constants and Thermal Properties

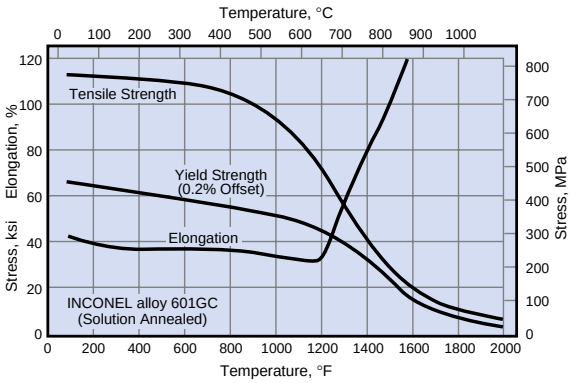
Density, lb/in³ (g/cm³) 0.293 (8.11)
Melting Range, °F (°C) ..... 2374 – 2494 (1301 – 1368)
Specific Heat, Btu/lb•°F (J/kg•°C) 0.107 (448)
Curie Temperature, °F (°C) ..... <-320 (<-196)
Permeability at 200 Oersted (15.9 kA/m) 1.003
Coefficient of Expansion, 10^{-6} in/in•°F (µm/m•˚C)
70 – 200°F (21– 93°C) 7.60 (13.7)
70 – 1000°F (21 – 538°C) 8.50 (15.3)
70 – 1800°F (21 – 982°C) 9.82 (17.7)
Thermal Conductivity, Btu • in/ft²•h•°F 78
W/m•°C 11.2
Electrical Resistivity, ohm•circ mil/ft 710
µΩ•m 1.18
Young's Modulus, 10^6 psi (GPa) 30.0 (207)
Shear Modulus, 10^6 psi (GPa) 11.8 (81.2)
Poission's Ratio 0.27
Hardness, HRB 77

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

Typical Mechanical Properties

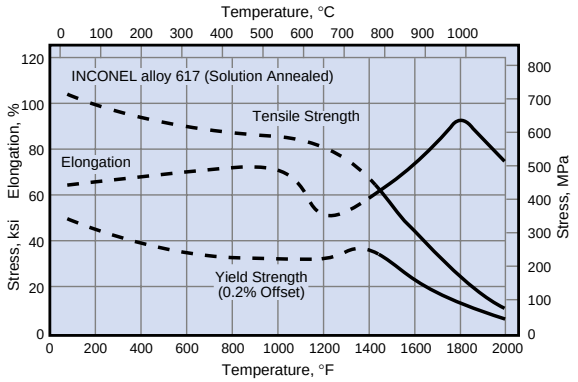
(Solution Annealed)

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



(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



SPECIAL METALS

INCONEL® alloy 622

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.

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

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

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

Major Specifications

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

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 Cases 1409, 1935
SAE AMS 5581, 5599, 5666, 5837, 5869, MAM 5599
BS 3072, 3074, 3076 (NA21)
DIN 17744, 17750 – 17752
Werkstoff Nr. 2.4856
NACE MR-01-75
VdTÜV 499
EN 10095
ISO 6207, 6208, 9723 – 9725

Limiting Chemical Composition, %

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.

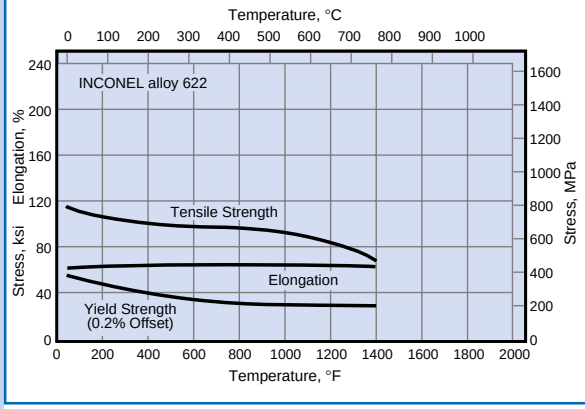
Ni ..... 58.0 min.	Fe ..... 5.0 max.	Al ..... 0.40 max.
Cr ... 20.0 – 23.0	C ..... 0.10 max.	Ti ..... 0.40 max.
Mo .... 8.0 – 10.0	Mn ... 0.50 max.	P .... 0.015 max.
Nb[a] .. 3.15 – 4.15	Si ..... 0.50 max.	Co[b] .... 1.0 max.
[a]Plus Ta.	S .... 0.015 max.	[b]If determined.

Physical Constants and Thermal Properties

Density, lb/in³ (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 (µΩ•cm) 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.

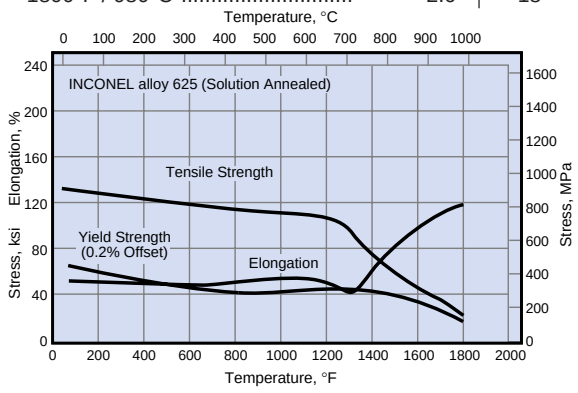
Density, lb/in³ 0.305
g/cm³ 8.44
Melting Range, °F ..... 2350 – 2460
°C ..... 1290 – 1350
Specific Heat, Btu/lb•°F 0.098
J/kg•°C 410
Curie Temperature, °F ..... <-320
°C ..... <-196
Permeability at 200 Oersted (15.9 kA/m) 1.0006
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F 7.1
21 – 93°C, µm/m•°C 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	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

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 366, B 443, B 704, B 705, B 751, B 775
ASME SB-366, SB-443, SB-704, SB-705, SB-751, SB-775
SAE AMS 5879
ASME Code Case 2276

UNS N06686
ASTM B 564, B 574, B 575, B 619, B 622, B 626, B 751, B 775, B 829
DIN 17744, 17750 – 17754
Werkstoff Nr. 2.4606
ASME Code Case 2198
ASME SB-564, SB-574, SB-575, SB-619, SB-622, SB-626, SB-751, SB-775, SB-829
VdTÜV 515
NACE MR-01-75

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

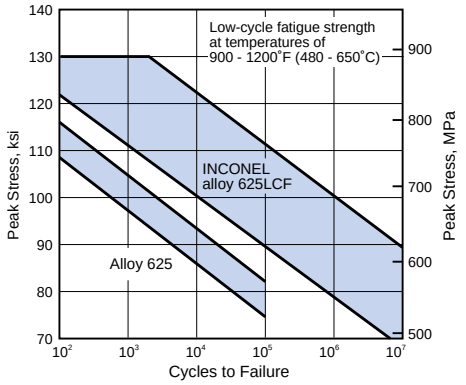
Typical Mechanical Properties

Annealed

Tensile Strength, ksi 130
MPa 894

Yield Strength (0.2% Offset), ksi 68
MPa 469

Elongation, % 50



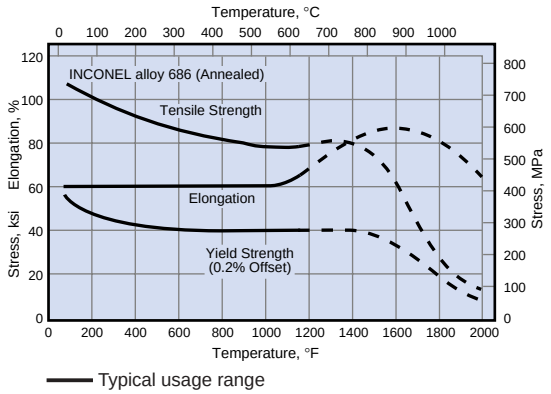
Solution Annealed

Tensile Strength, ksi 110
MPa 758

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

Elongation, % 60

Hardness (HRB) ..... 85 – 95



SPECIAL METALS

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 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 base gas turbine parts and components requiring resistance to creep and stress rupture up to 1300˚F (704˚C), oxidation resistance, and good fabricability.

Standard Product Forms

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

Round bar and forging stock.

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
Werstoff Nr. 2.4642
ISO 6207, 6208, 9723

UNS N09706
SAE AMS 5605, 5606, 5701 – 5703

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[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.

Physical Constants and Thermal Properties

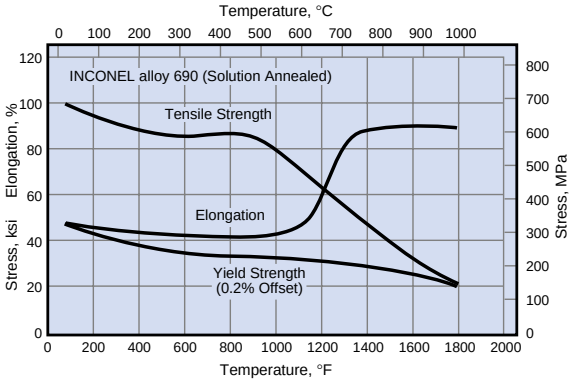
Density, lb/in³ (g/cm³) 0.296 (8.19)
Melting Range, °F (°C) ..... 2450 – 2510 (1343 – 1377)
Specific Heat, Btu/lb•°F (J/kg•°C) 0.107 (450)
Permeability at 200 Oersted (15.9 kA/m) 1.001
Coefficient of Expansion, 10^{-6} in/in•°F (µm/m•°C)
70 – 200°F (21 – 93°C) 7.80 (14.0)
70 – 1000°F (21 – 538°C) 8.53 (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
µΩ•m 1.15
Young's Modulus[A], 10^6 psi (GPa) 30.6 (211)
Poisson's Ratio[A] 0.29
Hardness[A], HRB 85

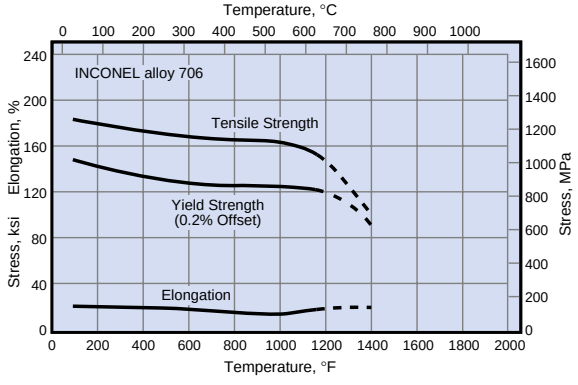
[A]Room temperature, as annealed.

Density, lb/in³ (g/cm³) 0.291 (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
µΩ•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.

Typical Mechanical Properties





SPECIAL METALS

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.

INCONEL® alloy 725

A nickel-chromium-moybdenum-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.

Standard Product Forms

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

Round bar and wire.

Major Specifications

UNS N07718, N07719
ASTM B 637, B 670
ASME SB-637, SB-670
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-01-75
AECMA Pr EN 2404, 2405, 2407, 2408, 2952, 2961, 3219, 3666
ISO 6208, 9723 – 9725

UNS N07725
ASTM B 805
ASME Code Case 2217

Limiting Chemical Composition, %

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.

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

Physical Constants and Thermal Properties

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
µΩ•m 1.25

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

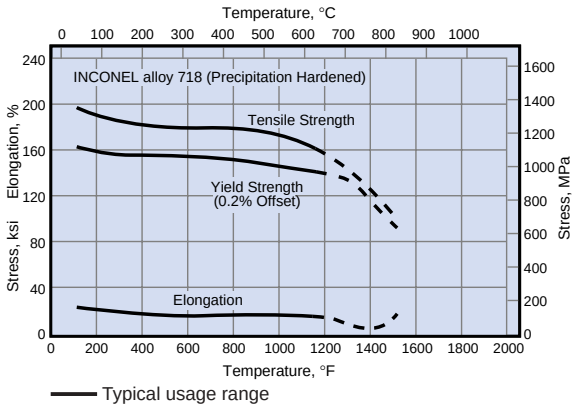
Thermal Conductivity, Btu • in/ft²•h•°F 73.8
W/m•°C 10.6

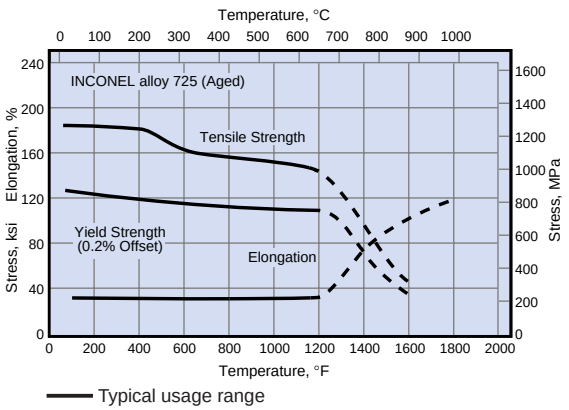
Electrical Resistivity, ohm•circ mil/ft 688
µΩ•m 1.144

Typical Mechanical Properties

(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





SPECIAL METALS

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 and extruded section.

Round bar.

Major Specifications

UNS N07750
BS HR 505
ASTM B 637
ASME SB-637
Werkstoff Nr. 2.4669
NACE MR-01-75
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.
Cr ... 14.0 – 17.0
Fe ..... 5.0 – 9.0
Ti .... 2.25 – 2.75
Al .... 0.40 – 1.00
Nb[b] ... 0.70 – 1.20
C ..... 0.08 max.
Mn ... 1.00 max.
Si ..... 0.50 max.
S ..... 0.01 max.
Cu ... 0.50 max.
Co[c] .. 1.00 max.

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

Limiting

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

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

Physical Constants and Thermal Properties

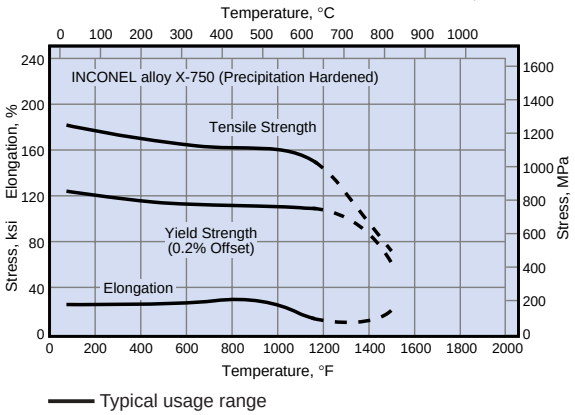
Density, lb/in³	0.299
g/cm³	8.28
Melting Range, °F	2540 – 2600
°C	1390 – 1430
Specific Heat, Btu/lb•°F	0.103
J/kg•°C	431
Curie Temperature, °F	-193
°C	-125
Permeability at 200 Oersted (15.9 kA/m)	1.0035
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F	7.0
21 – 93°C, µm/m•°C	12.6
Thermal Conductivity, 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

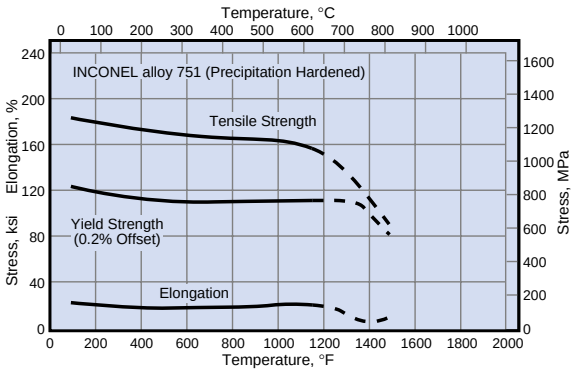


Typical usage range

(Precipitation Hardened[a])

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

[a]Short-time heat treatment of 1350°F (730°C) / 2h.



Typical usage range

SPECIAL METALS

INCONEL® alloy MA754

A mechanically alloyed nickel-chromium alloy with oxide dispersion strengthening. Mechanical alloying, which involves high-energy milling of metal powders, is used to create a uniformly distributed, fine dispersoid of yttrium oxide in the alloy. The dispersoid, which is stable to the alloy's melting point, imparts exceptional high-temperature strength and creep resistance. The alloy's strength, corrosion resistance, and micro-structural stability make it useful for gas-turbine vanes and other extreme-service applications.

INCONEL® alloy MA758

A mechanically alloyed nickel-chromium alloy with oxide dispersion strengthening. Approaches the high temperature strength capabilities of INCONEL alloy MA754. The alloy's 30% chromium content imparts an extra measure of corrosion resistance oxidizing environments and molten glass. The alloy is formed into bowl-shaped spinner components for the production of fiberglass at 2200˚F (1200˚C). It has been used in diesel engine applications, and for furnace skid rail service to transport steel slabs and billets at and above 2300˚F (1260˚C).

Standard Product Forms

Tube, sheet, plate, round bar and flat bar.

Tube, plate, round bar and flat bar.

Major Specifications

UNS N07754

Contact Special Metals for further information.

Chemical Composition, %

Nominal

Ni 78	Fe 1.0	Ti 0.5
Cr 20	C 0.05	Al 0.3
Y_2O_3 ..... 0.6		

Nominal

Ni .... Remainder	Al 0.3	Fe 1.0
Cr 30.0	Ti 0.5	Y_2O_3 ..... 0.6
C 0.05		

Physical Constants and Thermal Properties

Density, lb/in^3 ..... 0.309
g/cm^3 ..... 8.55

Melting Point (Approximate Solidus), °F 2550
°C 1400

Permeability at 200 Oersted (15.9 kA/m) 1.001

Coefficient of Expansion, 78 – 200°F, 10^{-6} in/in •°F .. 6.79
26 – 93°C, µm/m •°C 12.2

Thermal Conductivity, Btu • in/ft^2•h•°F 98.9
W/m•°C 14.26

Electrical Resistivity, ohm•circ mil/ft 646.6
µΩ•m 1.075

Density, lb/in^3 ..... 0.294
g/cm^3 ..... 8.14

Melting Point (Approximate Solidus), °F 2507
°C 1375

Coefficient of Expansion, 10^{-6} in/in •°F (µm/m •°C)
70 – 200°F (21 – 93°C) 6.93 (12.47)
70 – 1000°F (21 – 538°C) 7.91 (14.24)
70 – 1400°F (21 – 760°C) 8.35 (15.03)

Electrical Resistivity[A], ohm•circ mil/ft 685
µΩ•m 1.139

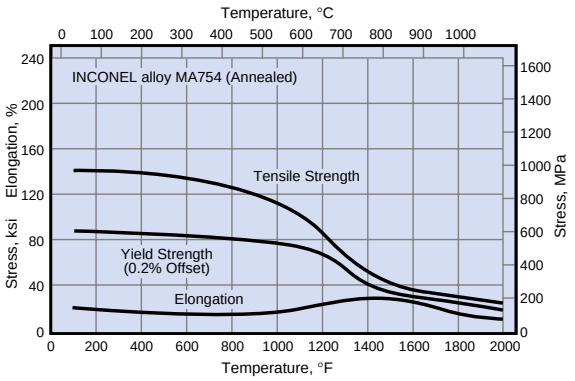
Young's Modulus[A], 10^6 psi 33.0
GPa 228

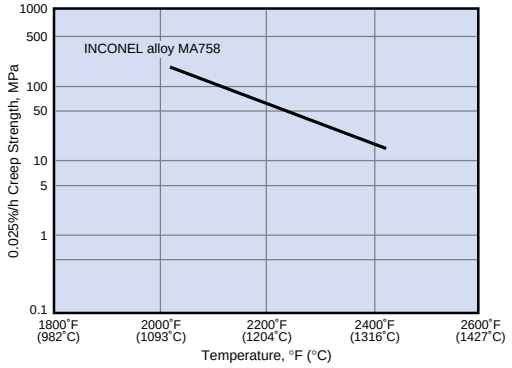
[A]Room temperature, as recrystallized.

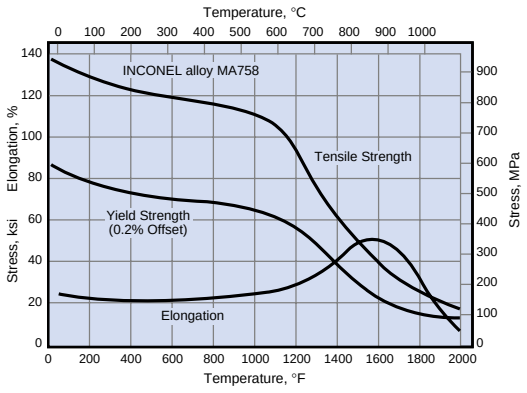
Typical Mechanical Properties

(Annealed)

Longitudinal Rupture Strength (1000 h)	ksi	MPa
1200°F / 650°C	37.2	256
1400°F / 760°C	28.8	199
1600°F / 870°C	22.9	158
1800°F / 980°C	18.7	129
2000°F / 1095°C	13.6	94
2100°F / 1150°C	11.3	78







SPECIAL METALS

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.

Standard Product Forms

Sheet, round bar, wire and extruded section.

Major Specifications

UNS R30783
SAE AMS 5940

Limiting Chemical Composition, %

Nominal

Ni ... 26.0 – 30.0	Cr ..... 2.5 – 3.5	Mn ... 0.50 max.
Fe .. 24.0 – 27.0	Ti ..... 0.1 – 0.3	P .... 0.015 max.
Co .. Remainder	B .. 0.003 – 0.012	S .... 0.005 max.
Al ..... 5.2 – 5.6	C ..... 0.1 max.	Si ..... 0.50 max.
Nb ..... 2.5 – 3.5	Cu ... 0.50 max.	

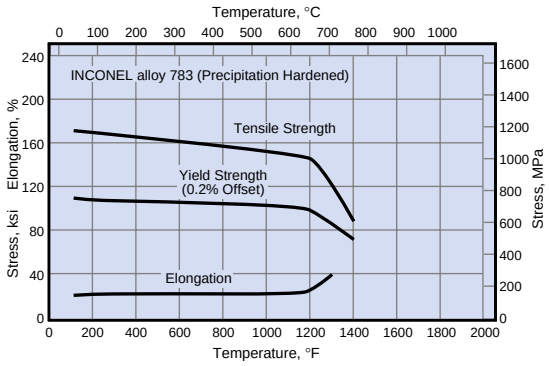
Physical Constants and Thermal Properties

Density, lb/in^3 (g/cm^3) 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/ft^2•h•°F 70.9
W/m•°C 10.2
Electrical Resistivity[A], ohm•circ mil/ft 615
µΩ•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.

Typical Mechanical Properties

(Precipitation Hardened)



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.

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

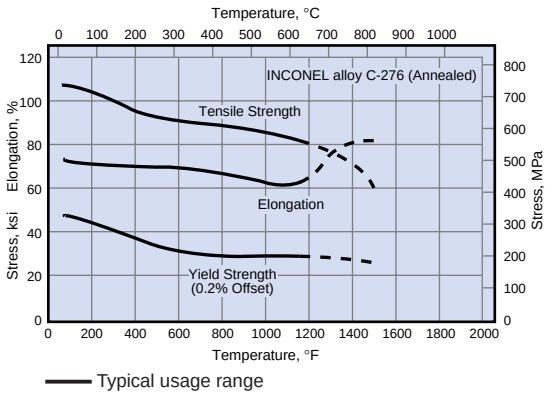
UNS N10276
ASTM B 366, B 564, B 574, B 575, B 619, B 622, B 626, B 751, B 775, B 829
DIN 17744, 17750 – 17752
Werkstoff Nr. 2.4819
VdTÜV 400, 400a
ASME SB-366, SB-564, SB-574, SB-575, SB-619, SB-622, SB-626, SB-751, SB-775, SB-829
ASME Code Case 1924
NACE MR-01-75
ISO 6207, 6208, 9723 – 9725

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.

Density, lb/in^3 ..... 0.321
g/cm^3 ..... 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/ft^2•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

(Annealed)

Tensile Strength, ksi 110
MPa 758
Yield Strength (0.2% Offset), ksi 53
MPa 363
Elongation, % 62



SPECIAL METALS

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.

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.

Standard Product Forms

Pipe and tube.

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

Major Specifications

UNS N06985
ASTM B 366, B 581, B 582, B 619, B 622, B 626, B 751, B 775, B 829
NACE MR-01-75
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

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
SAE AMS 5536, 5587, 5588, 5754, 5798
Werkstoff Nr. 2.4665
NACE MR-01-75
AECMA Pr EN 2182 – 2185
BS HR 6, HR 204
ISO 6207, 6208, 9723 – 9725

Chemical Composition, %

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.

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.	

Physical Constants and Thermal Properties

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

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

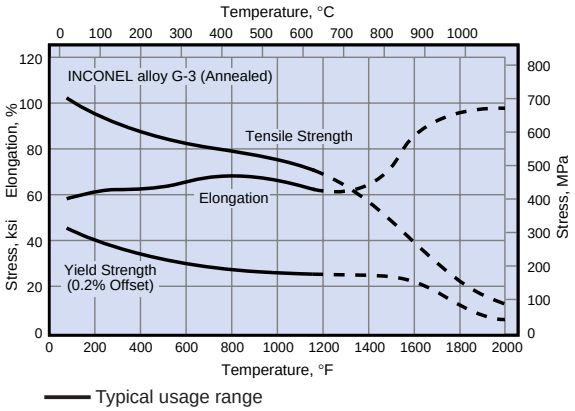
Typical Mechanical Properties

(Annealed)

Tensile Strength, ksi 100
MPa 690

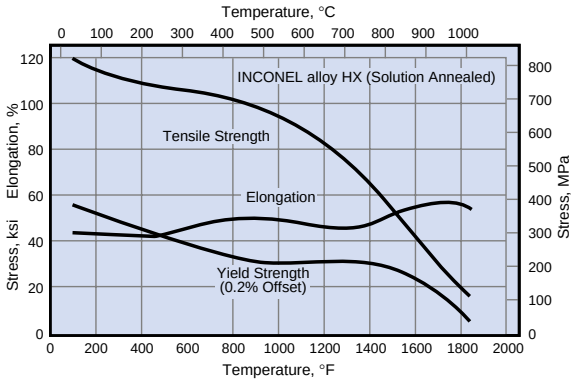
Yield Strength (0.2% Offset), ksi 47
MPa 320

Elongation, % 50



(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



INCONEL® alloy 050

This alloy is supplied as oil country tubular goods for service in severe deep sour gas well environments, especially those high in content of hydrogen sulfide and carbon dioxide. The alloy offers excellent resistance to corrosion and stress cracking and good thermal stability at an economical price. By cold work, tubes are available in a variety of strength levels.

Standard Product Forms

Tube.

Major Specifications

UNS N06950
NACE MR-01-75

Limiting Chemical Composition, %

Ni ..... 50 min.	Co ... 2.50 max.	S .... 0.015 max.
Cr .. 19.0 – 21.0	Cu ... 0.50 max.	Si ..... 1.0 max.
Fe .. 15.0 – 20.0	Al ..... 0.40 max.	Mn ..... 1.0 max.
Mo ... 8.0 – 10.0	W ..... 1.0 max.	P ..... 0.04 max.
Cb ... 0.50 max.	C ..... 0.02 max.	

Physical Constants and Thermal Properties

Density, lb/in^3 ..... 0.303
g/cm^3 ..... 8.38
Specific Heat, Btu/lb•°F 0.107
J/kg•°C 446
Coefficient of Expansion, 10^{-6} in/in•°F (µm/m•°C)
70 – 200°F (21 – 93°C) 7.2 (13.0)
70 – 400°F (21 – 260°C) 7.5 (13.5)
70 – 600°F (21 – 427°C) 7.8 (14.1)
Thermal Conductivity[A], Btu • in/ft^2•h•°F 72.2
W/m•°C 10.4
Young's Modulus[A], 10^6 psi (GPa) 27.9

[A]Room temperature, annealed.

Typical Mechanical Properties

Tensile Strength, ksi 154
MPa 1062
Yield Strength (0.2% Offset), ksi 144
MPa 993
Elongation, % 19
Hardness (HRC) 32

SPECIAL METALS

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-01-75
ISO 9723 – 9725, 6207, 6208

UNS N08810, N08811
BS 3072, 3074, 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, 1987, 2339, N-201, N-254
DIN 17459, 17460
Werkstoff Nr. 1.4876, 1.4958, 1.4959
VdTÜV 412, 434
EN 1028-7, 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%.

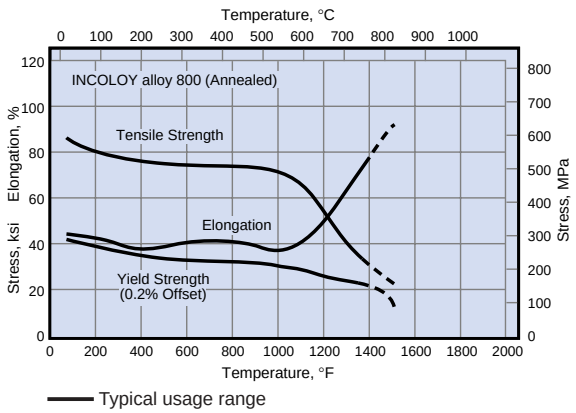
Physical Constants and Thermal Properties

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

Typical Mechanical Properties

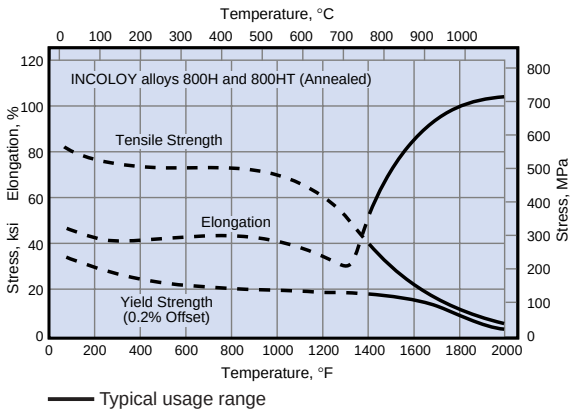
(Annealed)

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



(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



SPECIAL METALS

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 and wire.

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

Major Specifications

UNS S35045
ASTM A 240, A 480
ASME Code Case 2304

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-01-75
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 – 17752, 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.	

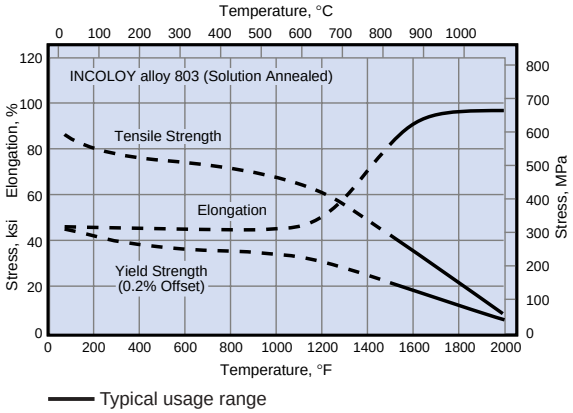
Physical Constants and Thermal Properties

Density, lb/in³ (g/cm³) 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/ft²•h•°F 78
W/m•°C 11.3
Electrical Resistivity, ohm•circ mil/ft 618
µΩ•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.

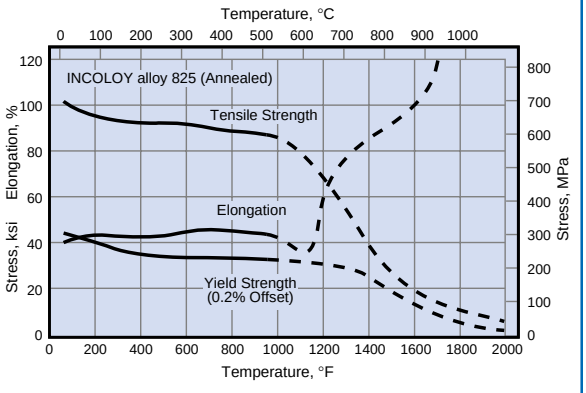
Density, lb/in³ 0.294
g/cm³ 8.14
Melting Range, °F ..... 2500 – 2550
°C ..... 1370 – 1400
Specific Heat, Btu/lb•°F 0.105
J/kg•°C 440
Curie Temperature, °F ..... <-320
°C ..... <-196
Permeability at 200 Oersted (15.9 kA/m) 1.005
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F ... 7.8
21 – 93°C, µm/m•°C 14.0
Thermal Conductivity, Btu • in/ft²•h•°F 76.8
W/m•°C 11.1
Electrical Resistivity, ohm•circ mil/ft 678
µΩ•m 1.13

Typical Mechanical Properties



(Annealed)

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



SPECIAL METALS

INCOLOY® alloy 864

A new high-performance & 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 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.

Standard Product Forms

Sheet, strip and wire.

Round bar and forging stock.

Major Specifications

UNS S35135
ASTM A 240, A 480

UNS N19903

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

Nominal

Ni ... 36.0 – 40.0	Co...13.0 – 17.0	Ti ... 1.20 – 1.85
Fe ... Remainder	Al ... 0.30 – 1.15	Nb... 2.40 – 3.50

Physical Constants and Thermal Properties

Density, lb/in^3 (g/cm^3) 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/ft^2 • h • °F 78.1
W/m • °C 11.3
Electrical Resistivity[A], ohm • circ mil/ft 628
µΩ • m 1.04
Young's Modulus[A], 10^6 psi (GPa) 28.3 (195)

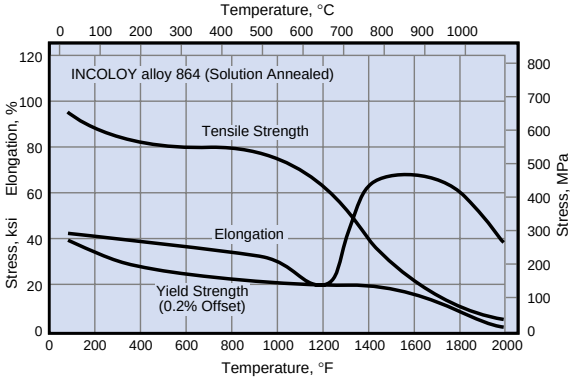
[A]Room temperature, as annealed.

Density, lb/in^3 ..... 0.298
g/cm^3 ..... 8.25
Melting Range, °F ..... 2405 – 2539
°C ..... 1318 – 1393
Specific Heat, Btu/lb • °F 0.105
J/kg • °C 442
Curie Temperature, °F ..... 780 – 880
°C ..... 415 – 470
Coefficient of Expansion, 77 – 800°F, 10^{-6} in/in • °F 4.0
25 – 427°C, µm/m • °C 7.2
Thermal Conductivity, Btu • in/ft^2 • h • °F 116
W/m • °C 16.7
Electrical Resistivity, ohm • circ mil/ft 379
µΩ • m 0.650

Typical Mechanical Properties

(Solution Annealed)

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



(Precipitation Hardened)

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

SPECIAL METALS

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.

INCOLOY® alloy 908

An age hardenable, Ni-Fe alloy which exhibits a low coefficient of thermal expansion, high tensile strength, high fracture and impact toughness, fatigue crack growth resistance, good ductility, metallurgical stability and weldability plus sufficient resistance to stress accelerated grain boundary oxygen embrittlement (SAGBO) to permit hot fabrication without cracking. This cobalt-free, low CTE alloy was designed to meet sheathing material requirements for internally cooled Nb_3Sn superconductor magnets to be used in prototype fusion reactors at cryogenic operating temperatures of -452˚F (-269˚C / 4˚K). With low temperature properties it is excellent for cryogenic applications.

Standard Product Forms

Round bar and forging stock.

Contact Special Metals for further information.

Major Specifications

UNS N19907

UNS N09908
ASTM B 872

Chemical Composition, %

Ni ... 35.0 – 40.0	Nb ..... 4.3 – 5.2	Al ..... 0.2 max.
Fe ... Remainder	Ti ..... 1.2 – 1.8	Si ... 0.07 – 0.35
Co ...12.0 – 16.0		

Ni ... 47.0 – 51.0	Cu ..... 0.5 max.	Nb ..... 2.7 – 3.3
Fe ... Remainder	Si ..... 0.5 max.	P .... 0.015 max.
Cr .... 3.75 – 4.5	S .... 0.005 max.	B .... 0.012 max.
Mn ..... 1.0 max.	Al ... 0.75 – 1.25	Co ..... 0.5 max.
C ..... 0.03 max.	Ti ... 1.20 – 1.80	

Physical Constants and Thermal Properties

Density, lb/in³ 0.301
g/cm³ 8.33

Melting Range, °F ..... 2440 – 2550
°C ..... 1335 – 1400

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

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/ft²•h•°F 103
W/m•°C 14.8

Electrical Resistivity, ohm•circ mil/ft 419
µΩ•m 0.697

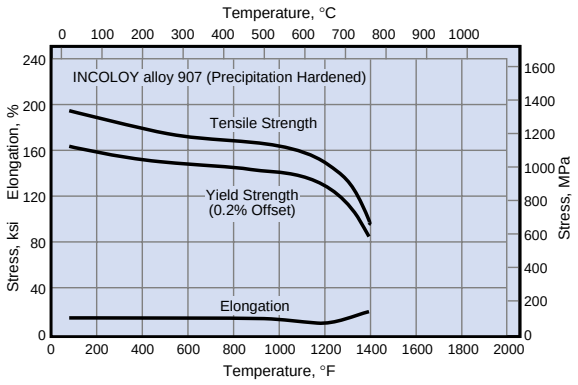
Density, lb/in³ (g/cm³) 0.295 (8.17)
Melting Range, °F (°C) ..... 2482 – 2571 (1361 – 1410)
Specific Heat, Btu/lb•°F (J/kg•°C) 0.104 (439.2)
Curie Temperature, °F (°C) 539 (282)
Coefficient of Expansion, 10^{-6} in/in•°F (µm/m•°C)
70 – 200°F (21 – 93°C) 4.77 (8.59)
70 – 500°F (21 – 260°C) 4.81 (8.66)
70 – 800°F (21 – 427°C) 6.17 (11.11)
70 – 1000°F (21 – 538°C) 6.78 (12.20)
70 – 1200°F (21 – 649°C) 7.32 (13.18)
70 – 1400°F (21 –760°C) 7.84 (14.11)
Thermal Conductivity[A], Btu • in/ft²•h•°F 76.68
W/m•°C 11.05
Young's Modulus[A], 10^6 psi (GPa) 23.7 (163.3)
Shear Modulus[A], 10^6 psi (GPa) 9.37 (64.56)
Poisson's Ratio[A] 0.265
Hardness[A], HRC ..... 38 – 40

[A]Room temperature, as aged.

Typical Mechanical Properties

(Precipitation Hardened)

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



Tensile Strength, ksi 170
MPa 1172

Yield Strength (0.2% Offset), ksi 120
MPa 827

Elongation, % 12

SPECIAL METALS

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 and forging stock.

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

Major Specifications

UNS N19909
SAE AMS 5884, 5892, 5893

UNS N09925
NACE MR-01-75

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
µΩ•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

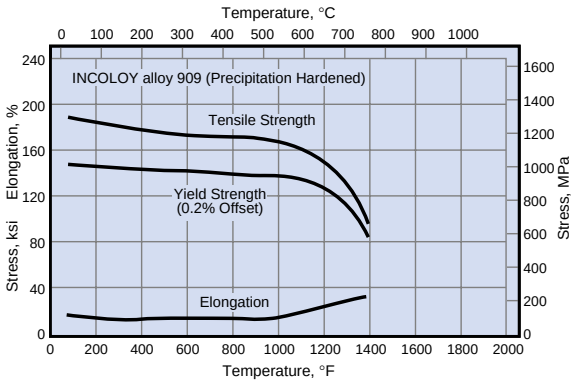
Coefficient of Expansion, 77 – 200°F, 10^{-6} in/in•°F 7.8
25 – 93°C, µm/m•°C 13.2

Electrical Resistivity, ohm•circ mil/ft 701
µΩ•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

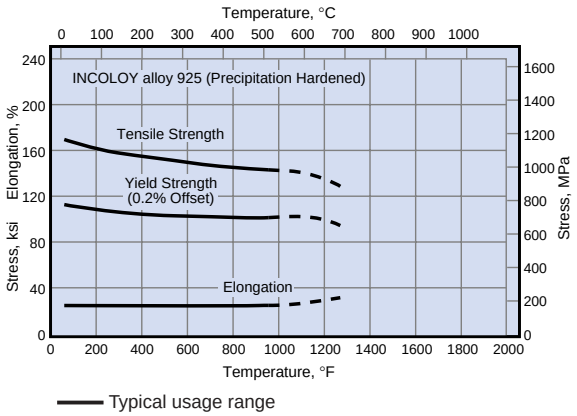


(Precipitation Hardened)

Tensile Strength, ksi 176
MPa 1210

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

Elongation, % 24



SPECIAL METALS

INCOLOY® alloy MA956

An iron-chromium-aluminum alloy that is oxide dispersion strengthened and produced by mechanical alloying. Production involves high-energy milling of metal powders to create an alloy with a strengthening yttrium oxide dispersoid that remains stable to the alloy's melting point.
It has exceptional strength and resistance to oxidation, carburization, and hot corrosion at temperatures to over 2000°F (1100°C). For gas-turbine combustion chambers, energy-conversion systems, and applications with rigorous conditions.

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.

Standard Product Forms

Tube, sheet, plate, round bar and flat bar.

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

Major Specifications

UNS S67956

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

Chemical Composition, %

Nominal

Fe ... Remainder	Al ... 3.75 – 5.75	Ti ..... 0.2 – 0.6
Cr .. 18.5 – 21.5	Y_2O_3 ..... 0.3 – 0.7	C ..... 0.1 max.
Cu ... 0.15 max.	Mn ... 0.30 max.	Co ..... 0.3 max.
Ni ..... 0.50 max.	P ..... 0.02 max.	

Limiting

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.

Physical Constants and Thermal Properties

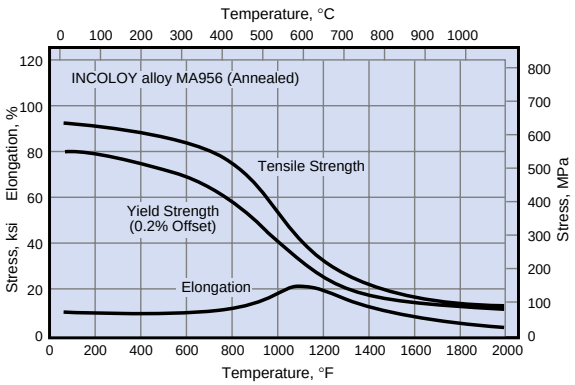
Density, lb/in³	0.262
g/cm³	7.25
Melting Point, (Approximate Solidus), °F	2700
°C	1480
Specific Heat, Btu/lb•°F	0.112
J/kg•°C	469
Coefficient of Expansion, 70 – 200°F, 10^{-6} in/in•°F	6.25
20 – 100°C, µm/m•°C	11.3
Thermal Conductivity, Btu • in/ft²•h•°F	76
W/m•°C	10.9
Electrical Resistivity, ohm•circ mil/ft	788
µΩ•m	1.31

Density, lb/in³	0.284
g/cm³	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/ft²•h•°F	83.2
W/m•°C	12.0
Electrical Resistivity, ohm•circ mil/ft	650
µΩ•m	1.08

Typical Mechanical Properties

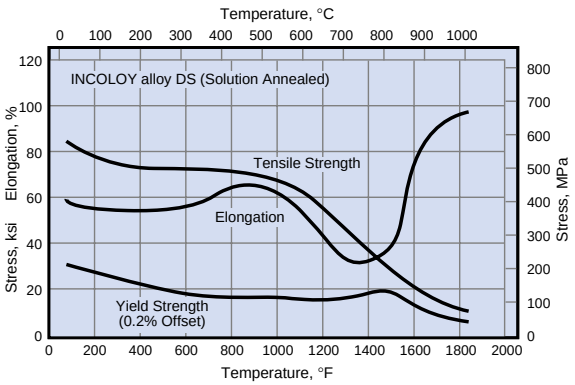
(Annealed)

Rupture Strength (1000 h)	ksi	MPa
1470°F / 800°C	14.2	98
1650°F / 900°C	11.5	79
1800°F / 980°C	9.7	67
2010°F / 1100°C	7.4	51



(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

INCOLOY® alloy 020

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 028

A highly alloyed austenitic stainless steel offering resistance to a variety of corrosive media. By virtue of its contents of chromium and molybdenum, the alloy offers resistance to both oxidizing and reducing acids and salts. The presence of copper increases its resistance to sulfuric acid. Used in the chemical and petrochemical processing industry. Alloy tubes are cold worked to high strength levels for downhole service in moderately corrosive deep sour gas wells.

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
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
ISO 6207, 6208, 9723 – 9725

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

Limiting Chemical Composition, %

Ni ... 32.0 – 38.0	Mo ..... 2.0 – 3.0	P .... 0.045 max.
Fe ... Remainder	Nb ..... 1.0 max.	S .... 0.035 max.
Cr .. 19.0 – 21.0	C ..... 0.07 max.	Si ..... 1.0 max.
Cu ..... 3.0 – 4.0	Mn ..... 2.0 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/m^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)
70 – 200°F (21 – 93°C) 8.3 (15.0)
70 – 500°F (21 – 260°C) 8.8 (15.9)
70 – 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

Hardness[A], HRC ..... 82 – 84

[A]Room temperature, annealed.

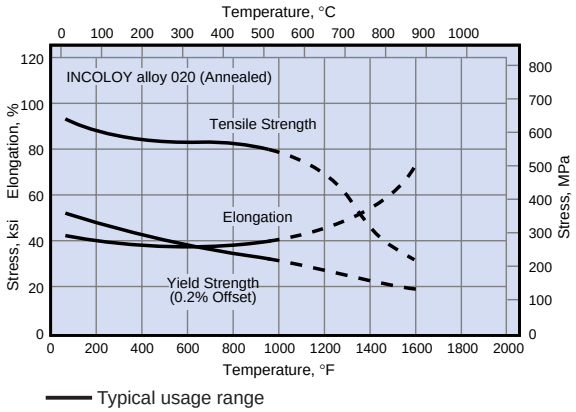
Typical Mechanical Properties

(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 (HRC) ..... 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

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% molybedenum 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

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

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 751, B 775, B 829
SAE AMS 5592, 5716
ASME SB-366, SB-511, SB-512, SB-535, SB-536, SB-546, SB-710, SB-739, SB-751, SB-775, SB-829
Werkstoff Nr. 1.4333

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
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/in^3 ..... 0.292
g/cm^3 ..... 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/ft^2•h•°F 86
W/m•°C 12.4

Electrical Resistivity, ohm•circ mil/ft 612
µΩ•m 1.017

Density, lb/in^3 ..... 0.290
g/cm^3 ..... 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/ft^2•h•°F 79.8
W/m•°C 11.5

Electrical Resistivity[A], ohm•circ mil/ft 480
µΩ•m 0.80

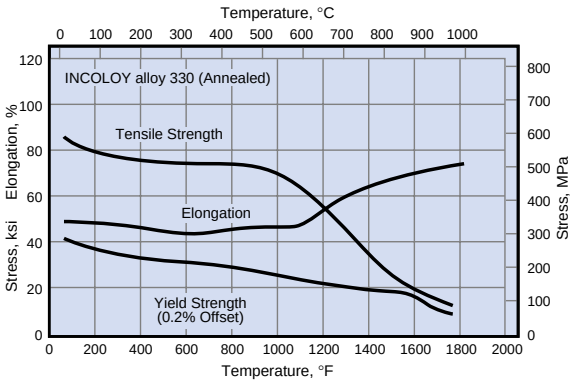
Young's Modulus[A], 10^6 psi (GPa) 27.3 (188)

[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

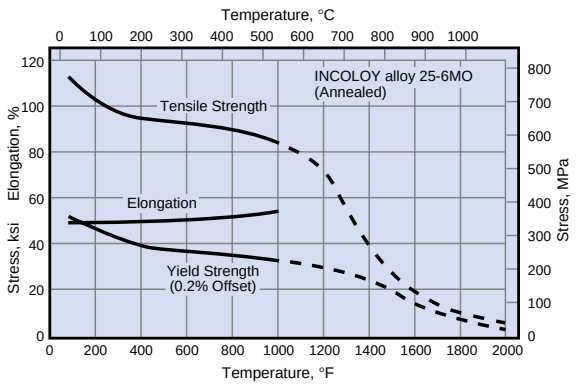


(Annealed)

Tensile Strength, ksi 100
MPa 690

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

Elongation % 42



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.

Standard Product Forms

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

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

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

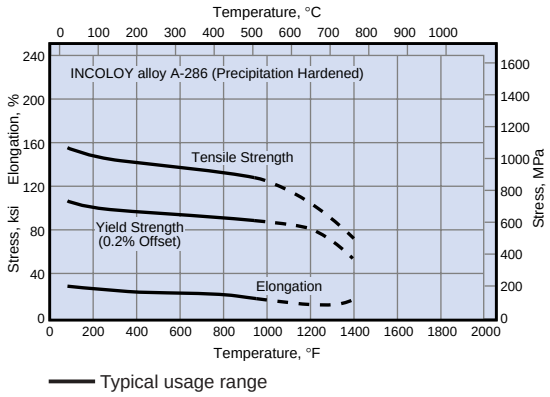
Physical Constants and Thermal Properties

Density, lb/in^3 (g/m^3) 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/ft^2 • °F (W/m • °C) 88 (12.7)
Electrical Resistivity[A], ohm • circ mil/ft 547
µΩ • m 0.910
Young's Modulus[A], 10^6 psi (GPa) 29.1 (201)
Hardness[A], HRC 31

[A]Room temperature, as aged.

Typical Mechanical Properties

(Precipitation Hardened)



SPECIAL METALS

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.

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.

Standard Product Forms

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

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

Major Specifications

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

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

Limiting Chemical Composition, %

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.	

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.	

Physical Constants and Thermal Properties

Density, lb/in^3 ..... 0.302
g/cm^3 ..... 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/ft^2•h•°F 81.1
W/m•°C 11.7

Electrical Resistivity, ohm•circ mil/ft 656
µΩ•m 1.09

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

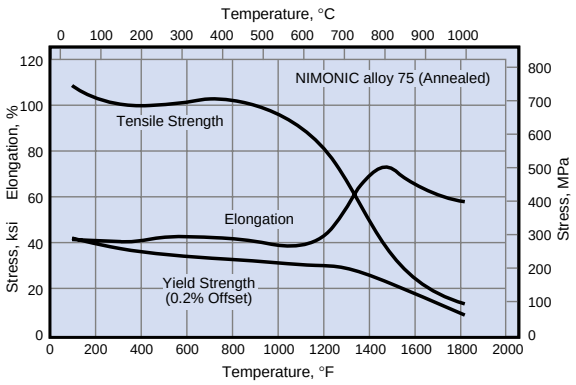
Thermal Conductivity, Btu • in/ft^2•h•°F 77.7
W/m•°C 11.2

Electrical Resistivity, ohm•circ mil/ft 746
µΩ•m 1.24

Typical Mechanical Properties

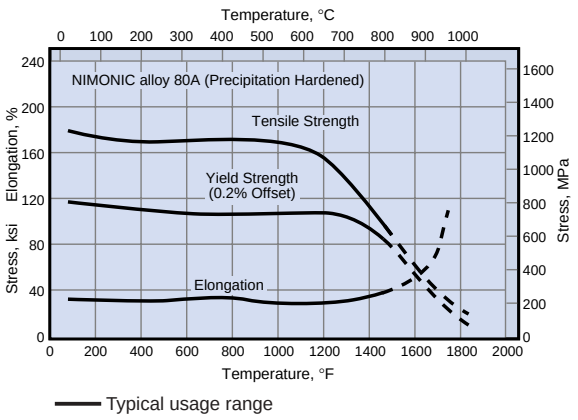
(Annealed)

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



(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



SPECIAL METALS

NIMONIC® alloy 81

A precipitation-hardenable nickel-chromium alloy with enhanced resistance to high-temperature corrosion. The excellent hot-corrosion resistance of the alloy results from its high chromium content of 30%. It has good tensile and rupture strength and creep resistance at elevated temperatures. For gas turbines, piston-engine exhaust valves, and furnace equipment subject to attack by deposits resulting from combustion of impure fuels, particularly those containing alkali metal sulfates and chlorides.

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

Round bar.

Sheet, strip, plate, round bar and forging stock.

Major Specifications

None applicable.

None applicable.

Limiting Chemical Composition, %

Ni .... Remainder	C ..... 0.05 max.	Co ..... 2.0 max.
Cr ..... 30.0[a]	Si ..... 0.50 max.	Mo ... 0.30 max.
Ti ..... 1.80[a]	Cu ... 0.20 max.	B ..... 0.003[a]
Al ..... 0.90[a]	Fe .... 1.00 max.	Zr ..... 0.06[a]
	Mn ... 0.50 max.	S .... 0.015 max.

[a]Nominal value.

Nominal

Ni 65	Mo 10.0	C 0.05
Cr 25.0	Ce 0.03	

Physical Constants and Thermal Properties

Density, lb/in^3 ..... 0.291
g/cm^3 ..... 8.06

Melting Range, °F ..... 2380 – 2510
°C ..... 1305 – 1375

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

Permeability at 200 Oersted (15.9 kA/m) 1.0004

Coefficient of Expansion, 68 – 212°F 10^{-6} in/in•°F ... 6.2
20 – 100°C µm/m•°C 11.1

Thermal Conductivity, Btu • in/ft^2•h•°F 75.6
W/m•°C 10.9

Electrical Resistivity, ohm•circ mil/ft 764
µΩ•m 1.27

Density, lb/in^3 ..... 0.309
g/cm^3 ..... 8.54

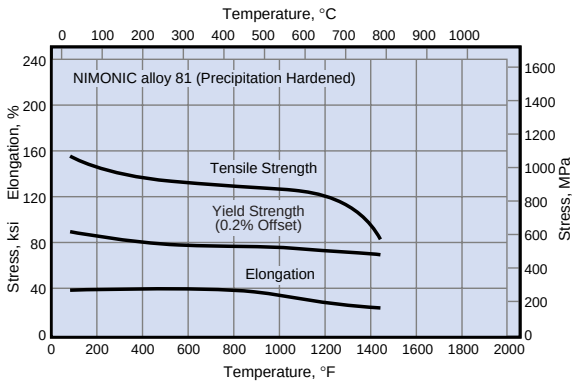
Young's Modulus, 10^6 psi 30.5
GPa 210

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

Typical Mechanical Properties

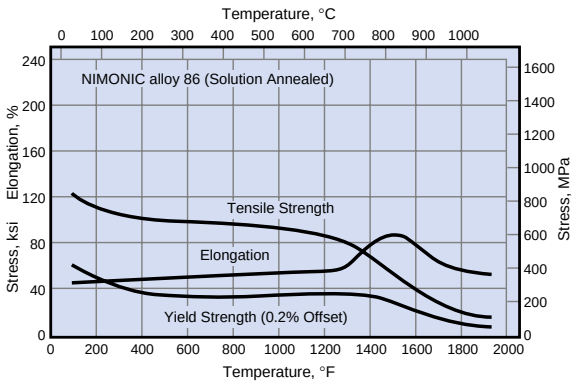
(Precipitation Hardened)

Rupture Strength (1000 h)	ksi	MPa
1100°F / 600°C	72.5	500
1290°F / 700°C	36.0	250
1470°F / 800°C	14.5	100



(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

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
SAE AMS 5829
AECMA Pr EN 2295 – 2299, 2400, 2401, 2412, 2669, 2670

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

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/in^3 ..... 0.296
g/cm^3 ..... 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/ft^2•h•°F 79.7
W/m•°C 11.5

Electrical Resistivity, ohm•circ mil/ft 710
µΩ•m 1.18

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

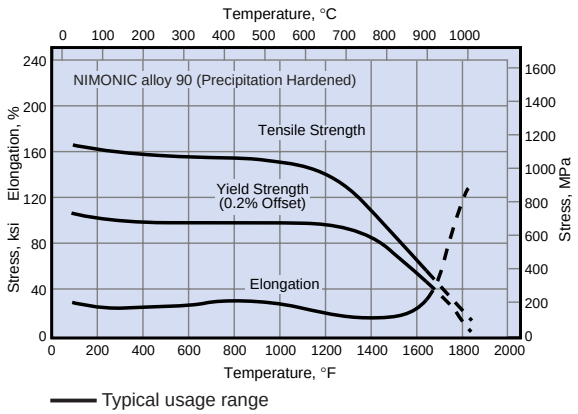
Thermal Conductivity, Btu • in/ft^2•h•°F 75.51
W/m•°C 10.89

Electrical Resistivity, ohm•circ mil/ft 788
µΩ•m 1.31

Typical Mechanical Properties

(Precipitation Hardened)

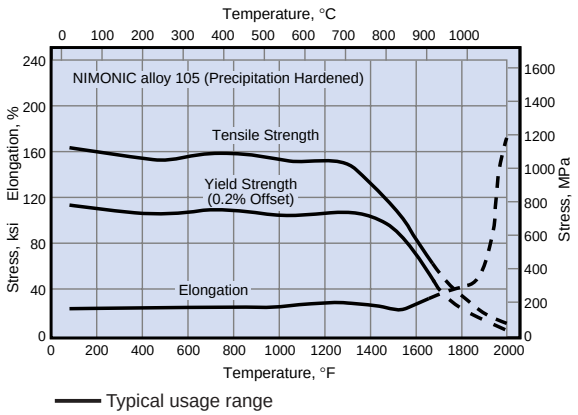
Rupture Strength (1000 h)	ksi	MPa
1300°F / 705°C	52	360
1400°F / 760°C	35	240
1500°F / 815°C	22	150
1600°F / 870°C	11	75



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

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
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
µΩ•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

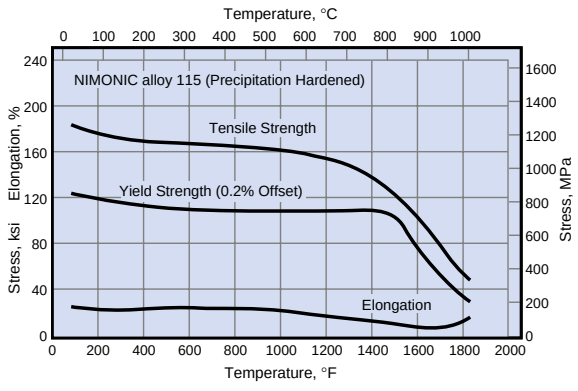
Thermal Conductivity, Btu • in/ft^2•h•°F 81.1
W/m•°C 11.7

Electrical Resistivity, ohm•circ mil/ft 692
µΩ•m 1.15

Typical Mechanical Properties

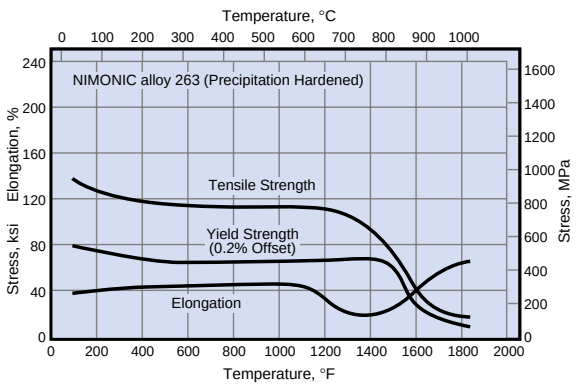
(Precipitation Hardened)

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

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 bar and extruded section.

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

Major Specifications

UNS N09901
BS HR53
SAE AMS 5660, 5661
AECMA Pr EN 2176 – 2178
Werkstoff Nr. 2.4662

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
µΩ•m 1.12

Density, lb/in³ 0.290
g/cm³ 8.02

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

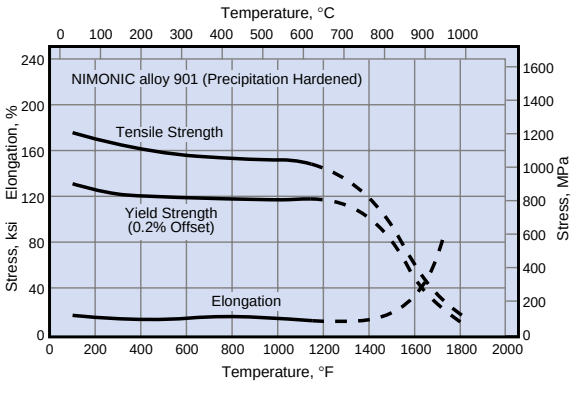
Specific Heat, Btu/lb•°F 0.104
J/kg•°C 436

Permeability at 300 Oersted (23.9 kA/m) 1.021

Typical Mechanical Properties

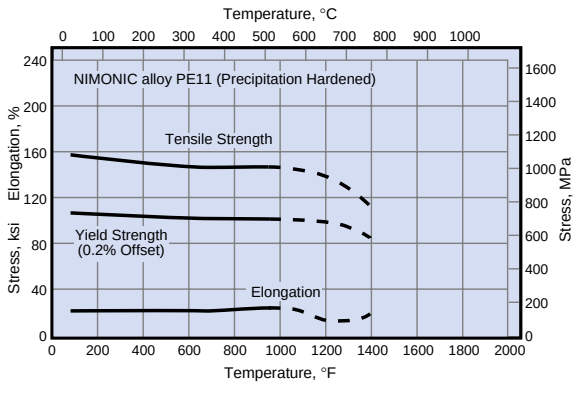
(Precipitation Hardened)

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



(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



SPECIAL METALS

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/in³ 0.289
g/cm³ 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/ft²•h•°F 81.26
W/m•°C 11.72

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

Density, lb/in³ 0.297
g/cm³ 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

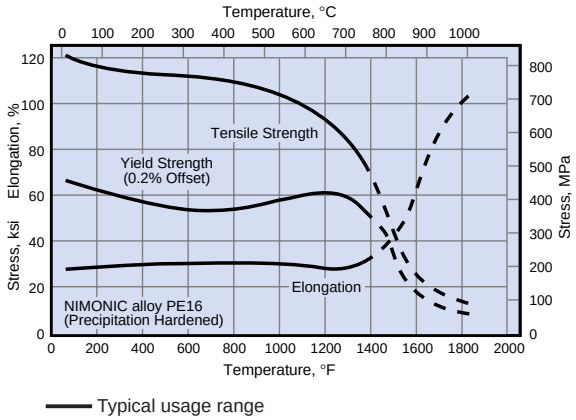
Thermal Conductivity, Btu • in/ft²•h•°F 78.3
W/m•°C 11.3

Electrical Resistivity, ohm•circ mil/ft 758
µΩ•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