PRODUCT HANDBOOK OF

# HIGH-PERFORMANCE NICKEL ALLOYS

THE ALLOY SPECIALISTS

SPECIAL METALS
A PCC COMPANY

# PRODUCT HANDBOOK OF HIGH-PERFORMANCE NICKEL ALLOYS

Special Metals is a world leader in the invention, production and supply of high-performance nickel alloys; in fact, we have invented over 80 percent of the nickel alloys in the market today. We offer the industry's widest range of nickel alloys, cobalt alloys and product forms—backed by over 100 years of experience in nickel alloy technology. These alloys are highly engineered to offer superior properties to perform in the world's most technically demanding applications. These properties may include heat and corrosion resistance, strength, fabricability, electrical resistance, controlled thermal expansion or magnetic characteristics.

## LEVERAGING A NETWORK OF EXPERTISE

The properties of our specialty metal offerings are unmatched, but as part of Precision Castparts Corporation (PCC), Special Metals can leverage the capabilities of leaders in metal to offer an unparalleled range of alloy components and products to diverse industries worldwide.

To supply the critical needs of the energy industry, Special Metals operates as a member of PCC Energy Group—a collection of the top names in the industry, assembled to push what's possible with metals for energy applications, including oil and gas, processing and refining, and power generation.

## MANUFACTURING

**Alloying processes:** Electric arc, air induction and vacuum induction melting

**Mechanical alloying:** Used for a few of our most specialized alloys

**Refining facilities:** AOD and vacuum refining, vacuum arc and electroslag remelting

**Hot working:** Forging, hot rolling and extrusion

**Cold working:** Rolling, drawing and pilgering

## DISTRIBUTION

Our products are available directly from Special Metals and through a network of distributors that stock our alloys and products in most of the industrialized world.

## QUALITY STANDARDS

All of our operations maintain ISO 9001-certified quality management standards to produce alloy compositions and forms that meet nationally and internationally recognized standards or customers' own specifications.

## MANUFACTURING LOCATIONS

- New Hartford, New York
- Huntington, West Virginia
- Newton, North Carolina
- Hereford, United Kingdom
- Elkhart, Indiana
- Perth, Australia
- Albury, New South Wales

## ADDITIONAL INFORMATION

Comprehensive product data sheets and bulletins on Special Metals High-Performance Alloys are available on our website, **www.specialmetals.com**. Technical and commercial inquiries may be entered on the website as well.

## TRADEMARKS OF THE SPECIAL METALS CORPORATION GROUP OF COMPANIES

- BRIGHTRAY
- DURANICKEL
- FERRY
- INCOFLUX
- INCOLOY
- INCONEL
- INCOTEST
- INCOTHERM
- INCO-WELD
- KOTHERM
- MONEL
- NILO
- NIMONIC
- NI-ROD
- RESISTOHM
- UDIMET
- 27-7MO
- 625LCF
- 718SPF
- 725NDUR
- 740H
- 800HT
- 945
- 945X

## CONTENTS

## 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

**NICKEL 200:** Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

**NICKEL 201:** Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and wire.

### MAJOR SPECIFICATIONS

**NICKEL 200:**
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

**NICKEL 201:**
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, %

**NICKEL 200:**
Ni[a].....99.0 min. Mn.....0.35 max. S.....0.01 max.
Cu.....0.25 max. C.....0.15 max.
Fe.....0.40 max. Si.....0.35 max.
[a]Plus Co.

**NICKEL 201:**
Ni[a].....99.0 min. Mn.....0.35 max. S.....0.01 max.
Cu.....0.25 max. C.....0.02 max.
Fe.....0.40 max. Si.....0.35 max.
[a]Plus Co.

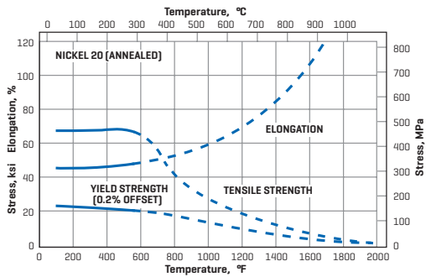
### PHYSICAL CONSTANTS AND THERMAL PROPERTIES

| | NICKEL 200 | NICKEL 201 |
|---|---|---|
| Density, lb/in³ | 0.321 | 0.321 |
| g/cm³ | 8.89 | 8.89 |
| Melting Range, °F | 2615 - 2635 | 2615 - 2635 |
| °C | 1435 - 1446 | 1435 - 1446 |
| Specific Heat, Btu/lb•°F | 0.109 | 0.109 |
| J/kg•°C | 456 | 456 |
| Curie Temperature, °F | 680 | 680 |
| °C | 360 | 360 |
| Permeability | Ferromagnetic | Ferromagnetic |
| Coefficient of Expansion, 70 - 200°F, $10^{-6}$ in/in•°F | 7.4 | 7.3 |
| 21 - 93°C, µm/m•°C | 13.3 | 13.1 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 487 | 550 |
| W/m•°C | 70.2 | 79.3 |
| Electrical Resistivity, ohm•circ mil/ft | 58 | 51 |
| µΩ•m | 0.096 | 0.085 |

### TYPICAL MECHANICAL PROPERTIES

**NICKEL 200 (Annealed)**

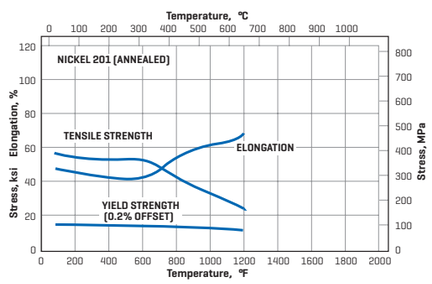
| | |
|---|---|
| Tensile Strength, ksi | 67 |
| MPa | 462 |
| Yield Strength (0.2% Offset), ksi | 21.5 |
| MPa | 148 |
| Elongation, % | 47 |




Typical usage range

**NICKEL 201 (Annealed)**

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








## 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 in which the fatigue strength of Nickel 200 is inadequate.

### STANDARD PRODUCT FORMS

**NICKEL 270:** Strip, round bar and wire.

**DURANICKEL ALLOY 301:** Round bar and wire.

### MAJOR SPECIFICATIONS

**NICKEL 270:**
UNS N02270
ASTM F 3
Werkstoff Nr. 2.4050

**DURANICKEL ALLOY 301:**
UNS N03301

### LIMITING CHEMICAL COMPOSITION, %

**NICKEL 270:**
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.

**DURANICKEL ALLOY 301:**
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

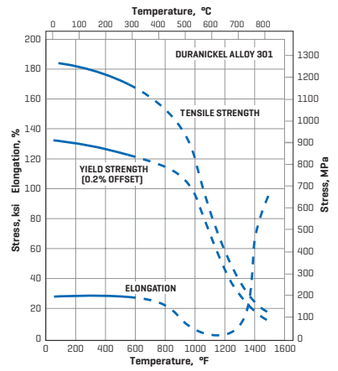
| | NICKEL 270 | DURANICKEL ALLOY 301 |
|---|---|---|
| Density, lb/in³ | 0.322 | 0.296 (8.19) |
| g/cm³ | 8.91 | |
| Melting Range, °F (°C) | 2650 | 2550 – 2620 (1400 – 1440) |
| °C | 1454 | |
| Specific Heat, Btu/lb•°F (J/kg•°C) | 0.110 (460) | 0.104 (435) |
| Permeability | Ferromagnetic | |
| Permeability 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) |
| 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 | |
| Thermal Conductivity[A], Btu•in/ft²•h•°F (W/m•°C) | | 165 (23.8) |
| Electrical Resistivity, ohm • circ mil/ft | 45 | |
| µΩ•m | 0.075 | |
| 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

**NICKEL 270 (Annealed)**

| | |
|---|---|
| Tensile Strength, ksi | 50 |
| MPa | 345 |
| Yield Strength (0.2% Offset), ksi | 16 |
| MPa | 110 |
| Elongation, % | 50 |




Typical usage range

## MONEL ALLOY 400

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

**STANDARD PRODUCT FORMS**

Pipe, tube, sheet, strip, plate, round bar, flat bar, forging stock, hexagon and 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-0175/ISO 15156

**LIMITING CHEMICAL COMPOSITION, %**

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

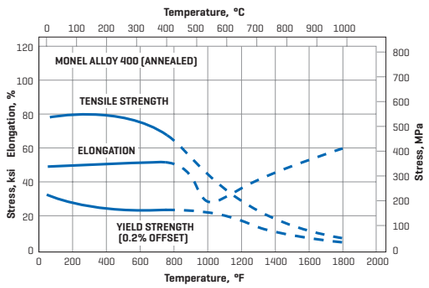
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

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

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

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




Typical usage range

## 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**

Round bar, hexagon and wire.

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in$^3$ | 0.318 |
| g/cm$^3$ | 8.80 |
| Melting Point, °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 |
| 20 – 95°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)**

| | |
|---|---|
| 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-0175/ISO 15156
ISO 6208, 9723 – 9725
ASME Code Case 1192

**LIMITING CHEMICAL COMPOSITION, %**

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

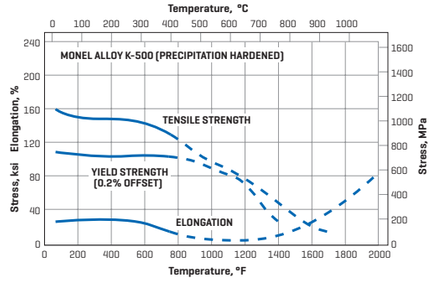
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

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

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

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




Typical usage range

## 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, chemical and food processing, nuclear engineering and sparking electrodes.

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

[a]Plus Co.

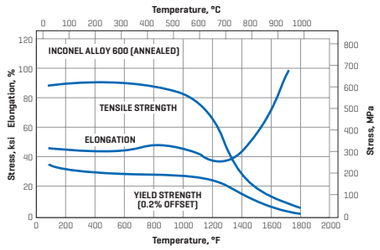
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

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

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

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




Typical usage range

## 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 and wire.

**MAJOR SPECIFICATIONS**

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

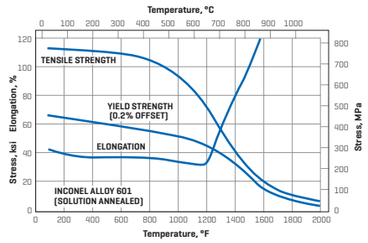
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

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

**TYPICAL MECHANICAL PROPERTIES**

**(Solution Annealed)**

| Rupture Strength (1000h) | 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 |








## 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; petrochemical processing; heat-treating equipment; and in nitric acid production.

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

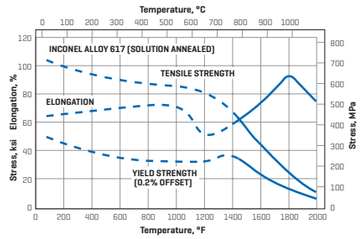
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.302 |
| g/cm³ | 8.36 |
| Melting Range, °F | 2430 - 2510 |
| °C | 1330 - 1380 |
| Specific Heat, Btu/lb•°F | 0.100 |
| J/kg•°C | 419 |
| Coefficient of Expansion, 78 - 200°F, $10^{-6}$ in/in•°F | 6.4 |
| 20 - 100°C, µm/m •°C | 11.6 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 94 |
| W/m•°C | 13.6 |
| Electrical Resistivity, ohm•circ mil/ft | 736 |
| µΩ•m | 1.22 |

**TYPICAL MECHANICAL PROPERTIES**

**(Solution Annealed)**

| Rupture Strength (1000h) | 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 |




Typical usage range

## INCONEL ALLOY 625

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

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

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

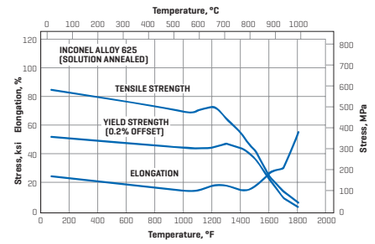
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| 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 |
| 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 (1000h) | 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 |



## 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.

**STANDARD PRODUCT FORMS**

Sheet and strip.

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

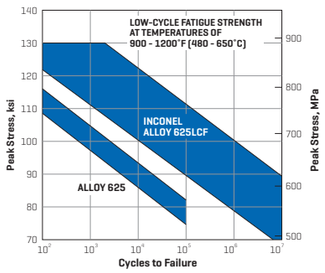
Ni.....58.0 min.
Cr .....20.0 – 23.0
Nb[a]...3.15 – 4.15
Fe.....5.0 max.
C.....0.03 max.
Mn.....0.50 max.
S..... 0.015 max.
Al.....0.40 max.
Si.....0.15 max.
N.....0.02 max.
P..... 0.015 max.
Co..... 1.0 max.
Ti .....0.40 max.
[a]Plus Co.

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

Density, lb/in$^3$.....0.305
g/cm$^3$.....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/ft$^2$•h•°F .....68
W/m•°C.....9.7
Electrical Resistivity, ohm•circ mil/ft..... 776
µΩ•m ..... 1.29

**TYPICAL MECHANICAL PROPERTIES**

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




## 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 reheaters, fans and housings.

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

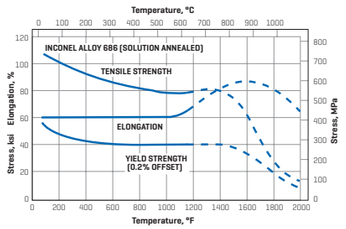
Cr..... 19.0 – 23.0
Mo.... 15.0 – 17.0
W.....3.0 – 4.4
Ti .....0.02 – 0.25
Fe..... 1.0 max.
C.....0.01 max.
S.....0.02 max.
Mn.....0.75 max.
Si.....0.08 max.
P.....0.04 max.
Ni..... Balance

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

Density, lb/in$^3$.....0.315
g/cm$^3$.....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..... 110
MPa..... 758
Yield Strength (0.2% Offset), ksi .....55
MPa ..... 379
Elongation, % .....60
Hardness (HRB) ..... 85 - 95




Typical usage range





## INCONEL ALLOY 690

INCONEL alloy 690 is a high-chromium nickel alloy with 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.

**STANDARD PRODUCT FORMS**

Pipe, tube, plate, 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
Werkstoff Nr. 2.4642
ISO 6207, 6208, 9723
ISO NW6690

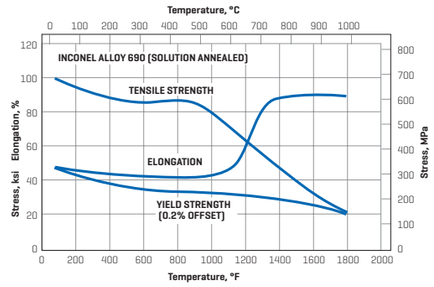
**LIMITING CHEMICAL COMPOSITION, %**

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

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

Density, lb/in$^3$.....0.296
g/cm$^3$..... 8.19
Melting Range, °F.....2450 – 2510
°C.....1343 – 1377
Specific Heat, Btu/lb•°F.....0.107
J/kg•°C..... 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/ft$^2$•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..... 30.6
GPa ..... 211
Poisson's Ratio[A]..... 0.29
Hardness[A], HRB .....85
[A]Room temperature, as aged.

**TYPICAL MECHANICAL PROPERTIES**




## INCONEL ALLOY 693

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

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

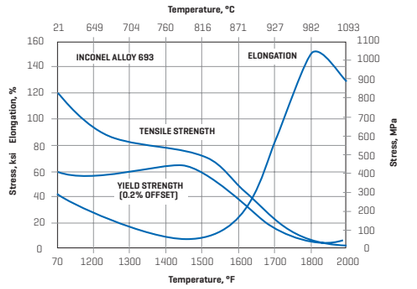
UNS N06693
ASTM B 166, B 167, B 168
ASME SB 166, SB 167, SB 168

**LIMITING CHEMICAL COMPOSITION, %**

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

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

Density, lb/in$^3$.....0.280
g/cm$^3$.....7.77
Melting Range, °F.....2403 – 2493
°C .....1317 – 1367
Specific Heat, Btu/lb•°F.....0.109
J/kg•°C..... 455
Permeability at 200 Oersted..... <1.005
Electrical Resistivity[A], ohm•circ mil/ft ..... 702.7
Thermal Conductivity[A], Btu•in/ft$^2$•h•°F..... 64.3
W/m•°C .....9.1
Coefficient of Expansion, 10$^{-6}$ in/in•°F (µm/m•°C)
70-200°F (21–93°C).....7.22 (13.04)
Young's Modulus[A], 10$^3$ psi..... 28.5
GPa ..... 197
Shear Modulus[A], 10$^3$ psi ..... 11.0
GPa.....76
Poisson's Ratio[A]..... 0.30
[A]Room temperature, as aged.



## INCONEL ALLOY 706

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

**STANDARD PRODUCT FORMS**

Round bar and forging stock.

**MAJOR SPECIFICATIONS**

UNS N09706
SAE AMS 5605, 5606, 5701 – 5703

**LIMITING CHEMICAL COMPOSITION, %**

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

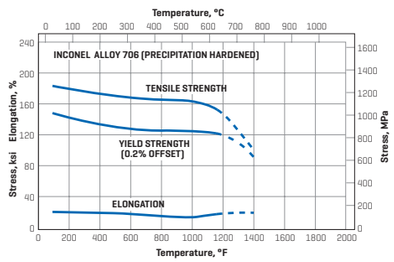
[a]Plus Co. [b]Plus Ta.

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ (g/cm³) | 0.291 (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's 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**




Typical usage range

## INCONEL ALLOY 718 & 718SPF

Inconel alloy 718 is 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 designed for superplastic forming.

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

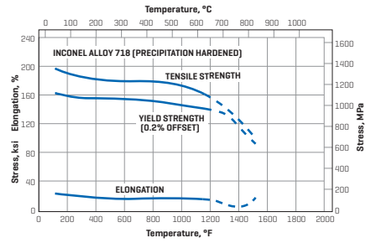
[a]Plus Co. [b]Plus Ta. [c]If determined.

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.296 |
| g/cm³ | 8.19 |
| Melting Point, °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 |

**(Solution Annealed)**

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




Typical usage range





## INCONEL ALLOY 725

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

**STANDARD PRODUCT FORMS**

Round bar and wire.

**MAJOR SPECIFICATIONS**

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

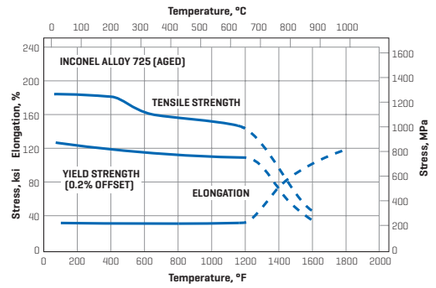
**LIMITING CHEMICAL COMPOSITION, %**

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

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.300 |
| g/cm³ | 8.31 |
| Melting Point, °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**




Typical usage range

## INCONEL ALLOY 740H

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

**STANDARD PRODUCT FORMS**

Bar, seamless tubes.

**MAJOR SPECIFICATIONS**

Contact Special Metals

**LIMITING CHEMICAL COMPOSITION, %**

| Nominal | | | | | |
|---|---|---|---|---|---|
| C | 0.03 | Co | 20.0 | Mn | 0.30 |
| Ni | Balance | Al | 1.0 | Fe | 0.7 |
| Cr | 25.0 | Ti | 1.8 | Si | 0.5 |
| Mo | 0.5 | Nb | 2.0 | | |

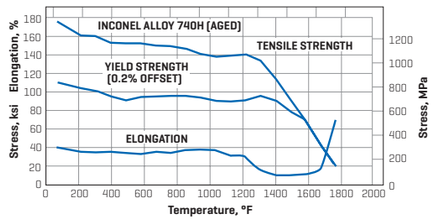
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

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

[A]Room temperature, as aged.

**TYPICAL MECHANICAL PROPERTIES**

| | |
|---|---|
| Yield Strength, Room Temperature, Aged, ksi | 111 |
| Tensile Strength, Room Temperature, Aged, ksi | 170 |
| Elongation, Aged, % | 36 |



## 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.

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

| | | | |
|---|---|---|---|
| Ni[a] | 70.0 min. | Al | 0.40 – 1.00 |
| Cr | 14.0 – 17.0 | Nb[b] | 0.70 – 1.20 |
| Fe | 5.0 – 9.0 | C | 0.08 max. |
| Ti | 2.25 – 3.75 | 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.

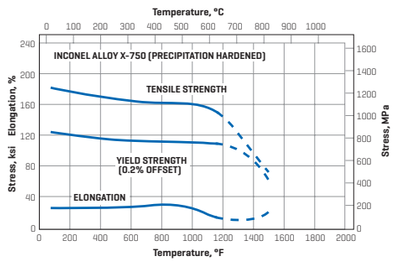
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.299 |
| g/cm³ | 8.28 |
| Melting Point, °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 (1000h) | 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

## 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**

Round bar.

**MAJOR SPECIFICATIONS**

UNS N07751

**LIMITING CHEMICAL COMPOSITION, %**

Limiting

| | | | | | |
|---|---|---|---|---|---|
| Ni[a] | 70.0 min. | Ti | 2.0 – 2.6 | Mn | 1.0 max. |
| Cr | 14.0 – 17.0 | Al | 0.9 – 1.5 | Si | 0.5 max. |
| Fe | 5.0 – 9.0 | Nb[b] | 0.7 – 1.2 | S | 0.01 max. |
| | | C | 0.10 max. | Cu | 0.05 max. |

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

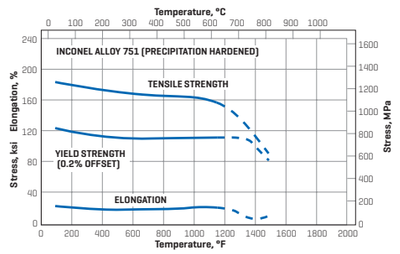
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.297 |
| g/cm³ | 8.22 |
| Melting Point, °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 (1000h) | ksi | MPa |
|---|---|---|
| 1200°F / 650°C | 40 | 280 |
| 1350°F / 730°C | 35 | 240 |
| 1500°F / 815°C | 14 | 97 |




Typical usage range





## 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 temperatures. 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, %**

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

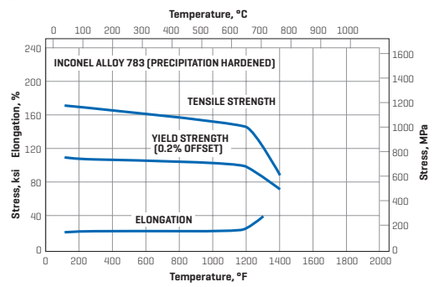
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ [g/cm³] | 0.282 [7.81] |
| Melting Range, °F [°C] | 2437 – 2565 [1336 – 1407] |
| Specific Heat, Btu/lb•°F [J/kg•°C] | 0.109 [455] |
| Coefficient of Expansion, $10^{-6}$ in/in•°F [µm/m•°C] | |
| 70-200°F [21-93°C] | 5.60 [10.08] |
| 70-500°F [21-260°C] | 5.74 [10.94] |
| 70-800°F [21-427°C] | 6.08 [10.67] |
| 70-1000°F [21-538°C] | 6.57 [11.83] |
| 70-1200°F [21-650°C] | 7.15 [12.87] |
| Thermal Conductivity[A], Btu•in/ft²•h•°F [W/m•°C] | 70.9 [10.2] |
| Electrical Resistivity[A], ohm•circ mil/ft [µΩ•m] | 615 [1.021] |
| Young's Modulus[A], $10^6$ psi [GPa] | 26.8 [185] |
| Shear's 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 22

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

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

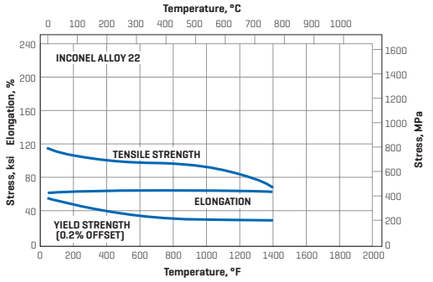
**LIMITING CHEMICAL COMPOSITION, %**

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

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ [g/cm³] | 0.311 [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 [W/m•°C] | 91 [13.2] |
| Electrical Resistivity[A], ohm•circ mil/ft [µΩ•m] | 730.7 [1.215] |
| Young's Modulus[A], $10^6$ psi [GPa] | 30.3 [209] |
| Shear's Modulus[A], $10^6$ psi [GPa] | 11.0 [75.8] |
| Poisson's Ratio[A] | 0.30 |
| Hardness[A], HRB | 86 |

[A]Room temperature, as aged.



INCONEL

## INCONEL ALLOY C-276

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

## INCONEL ALLOY G-3

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

### STANDARD PRODUCT FORMS

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

Pipe and tube.

### MAJOR SPECIFICATIONS

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

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

### LIMITING CHEMICAL COMPOSITION, %

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

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

### PHYSICAL CONSTANTS AND THERMAL PROPERTIES

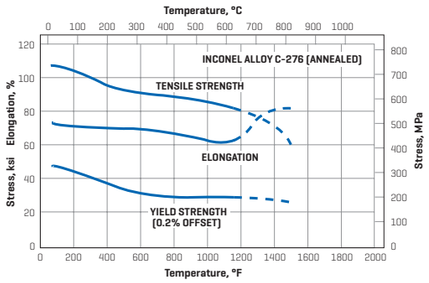
| | |
|---|---|
| Density, lb/in³ | 0.321 |
| g/cm³ | 8.89 |
| Melting Point, °F | 2415 – 2500 |
| °C | 1325 – 1370 |
| Specific Heat, Btu/lb • °F | 0.102 |
| J/kg • °C | 427 |
| Coefficient of Expansion, 70 - 200°F, 10⁻⁶ in/in • °F | 6.8 |
| 24 - 100°C, µm/m • °C | 12.2 |
| Thermal Conductivity, Btu • in/ft² • h • °F | 67.9 |
| W/m • °C | 9.8 |
| Electrical Resistivity, ohm • circ mil/ft | 739.2 |
| µΩ • m | 1.229 |
| Permeability at 200 Oersted (15.9 kA/m) | 1.0002 |

| | |
|---|---|
| Density, lb/in³ | 0.294 |
| g/cm³ | 8.14 |
| Melting Point, °F | 2300 – 2450 |
| °C | 1260 – 1340 |
| Specific Heat, Btu/lb • °F | 0.108 |
| J/kg • °C | 452 |
| Coefficient of Expansion, 70 - 200°F, 10⁻⁶ in/in • °F | 8.1 |
| 24 - 100°C, µm/m • °C | 14.6 |
| Thermal Conductivity, Btu • in/ft² • h • °F | 69 |
| W/m • °C | 10.0 |

### TYPICAL MECHANICAL PROPERTIES

**(Annealed)**

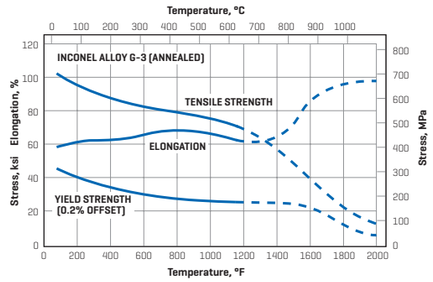
| | |
|---|---|
| Tensile Strength, ksi | 100 |
| MPa | 758 |
| Yield Strength (0.2% Offset), ksi | 53 |
| MPa | 363 |
| Elongation, % | 62 |




Typical usage range

**(Annealed)**

| | |
|---|---|
| Tensile Strength, ksi | 100 |
| MPa | 690 |
| Yield Strength (0.2% Offset), ksi | 47 |
| MPa | 320 |
| Elongation, % | 50 |




Typical usage range



## INCONEL ALLOY HX

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

## INCONEL ALLOY NO6230

A carbide strengthened nickel-chromium-tungsten alloy with an exceptional combination of strength, stability and resistance to corrosion at very high temperatures. Alloy NO6230 offers particularly good resistance to oxidation at temperatures greater than 1800°F (980°C). It also offers good resistance to carburization and nitridation. Potential applications for this alloy include equipment and components for land-based gas turbines, thermal and petrochemical processing, heat treating, and ore refining.

### STANDARD PRODUCT FORMS

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

Contact Special Metals.

### MAJOR SPECIFICATIONS

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

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

### LIMITING CHEMICAL COMPOSITION, %

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

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

### PHYSICAL CONSTANTS AND THERMAL PROPERTIES

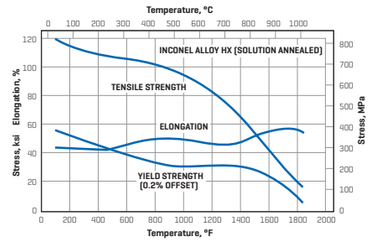
| | |
|---|---|
| Density, lb/in³ | 0.297 |
| g/cm³ | 8.22 |
| Melting Point, °F | 2300 – 2470 |
| °C | 1260 – 1355 |
| Specific Heat, Btu/lb • °F | 0.110 |
| J/kg • °C | 461 |
| Permeability at 200 Oersted (15.9 kA/m) | 1.0110 |
| Coefficient of Expansion, 70 - 200°F, 10⁻⁶ in/in • °F | 7.4 |
| 20 - 100°C, µm/m • °C | 13.3 |
| Thermal Conductivity, Btu • in/ft² • h • °F | 80.4 |
| W/m • °C | 11.6 |
| Electrical Resistivity, ohm • circ mil/ft | 698 |
| µΩ • m | 1.16 |

| | |
|---|---|
| Density, lb/in³ | 0.322 |
| g/cm³ | 8.91 |
| Melting Point, °F | 2480 – 2570 |
| °C | 1360 – 1410 |
| Permeability at 200 Oersted (15.9 kA/m) | 1.002 |
| Coefficient of Expansion, 70 - 600°F, 10⁻⁶ in/in • °F | 6.9 |
| 20 - 316°C, 10⁻⁶ cm/cm • °C | 12.4 |
| Electrical Resistivity, ohm • circ mil/ft | 759 |
| µΩ • m | 126 |
| Young's Modulus, 10³ ksi | 30.7 |
| GPa | 211 |
| Shear Modulus, 10³ ksi | 11.4 |
| GPa | 78.8 |
| Poisson's Ratio | 0.34 |

### TYPICAL MECHANICAL PROPERTIES

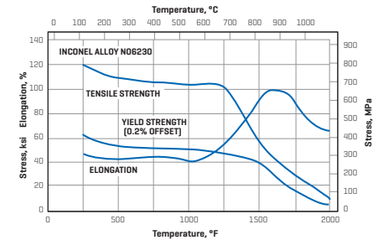
**(Solution Annealed)**

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




**(Annealed)**

| | |
|---|---|
| Tensile Strength, ksi | 117 – 122 |
| MPa | 807 – 841 |
| Yield Strength (0.2% Offset), ksi | 55 – 62 |
| MPa | 379 – 427 |
| Elongation, % | 44 – 48 |




Typical usage range

## 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 ALLOY 800H & 800HT

Nickel-iron-chromium alloys that have 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, power plants for super-heater and reheater tubing, industrial furnaces and heat-treating equipment.

### STANDARD PRODUCT FORMS

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

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

### MAJOR SPECIFICATIONS

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

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

### LIMITING CHEMICAL COMPOSITION, %

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

**800H**

| | | | |
|---|---|---|---|
| Ni | 30.0–35.0 | C | 0.05–0.10 |
| Fe | 39.5 min. | Al | 0.15–0.60 |
| Cr | 19.0–23.0 | Ti | 0.15–0.60 |
| | | Al+Ti | 0.30–1.20 |

**800HT**

| | | | |
|---|---|---|---|
| Ni | 30.0–35.0 | C | 0.06–0.10 |
| Fe | 39.5 min. | Al | 0.25–0.60 |
| Cr | 19.0–23.0 | 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

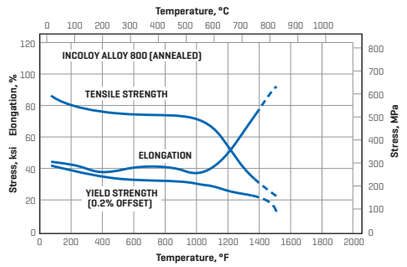
| | |
|---|---|
| Density, lb/in³ (g/cm³) | 0.287 (7.94) |
| Melting Range, °F (°C) | 2475 – 2525 (1357 – 1385) |
| Specific Heat, Btu/lb•°F (J/kg•°C) | 0.11 (460) |
| Curie Temperature, °F (°C) | -175 (-115) |
| Permeability at 200 Oersted (15.9 kA/m) | 1.014 |
| Coefficient of Expansion, $10^{-6}$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

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

### TYPICAL MECHANICAL PROPERTIES

**(Annealed)**

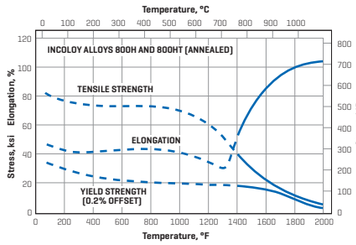
| Rupture Strength (1000h) | ksi | MPa |
|---|---|---|
| 1000°F / 540°C | 48 | 330 |
| 1100°F / 595°C | 32 | 220 |
| 1200°F / 650°C | 21 | 145 |
| 1300°F / 705°C | 11 | 75 |




Typical usage range

**(Annealed)**

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




Typical usage range





## 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, stress-corrosion cracking and localized attack such as pitting and crevice corrosion. The alloy is especially resistant to sulfuric and phosphoric acids. Used for chemical processing, pollution-control equipment, oil and gas well piping, nuclear fuel reprocessing, acid production and pickling equipment.

### STANDARD PRODUCT FORMS

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

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

### MAJOR SPECIFICATIONS

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

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

### LIMITING CHEMICAL COMPOSITION, %

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

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

### PHYSICAL CONSTANTS AND THERMAL PROPERTIES

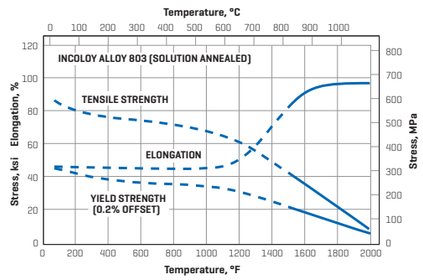
| | |
|---|---|
| Density, lb/in³ (g/cm³) | 0.284 (7.86) |
| Melting Range, °F (°C) | 2490 – 2555 (1365 – 1400) |
| Specific Heat, Btu/lb•°F (J/kg•°C) | 0.114 (479) |
| Permeability at 200 Oersted (15.9 kA/m) | 1.001 |
| Coefficient of Expansion, $10^{-6}$ in/in•°F (µm/m•°C) | |
| 70-200°F (21-93°C) | 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[A], Btu•in/ft²•h•°F (W/m•°C) | 78 (11.3) |
| Electrical Resistivity[A], ohm•circ mil/ft (µΩ•m) | 618 (1.03) |
| Young's Modulus[A], $10^6$ psi (GPa) | 28.3 (195) |
| Shear's 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, $10^{-6}$ in/in•°F (µm/m•°C) | |
| 70-200°F (21-93°C) | 7.8 (14.0) |
| Thermal Conductivity[A], Btu•in/ft²•h•°F | 76.8 |
| W/m•°C | 11.1 |
| Electrical Resistivity[A], ohm•circ mil/ft | 678 |
| µΩ•m | 1.13 |

### TYPICAL MECHANICAL PROPERTIES

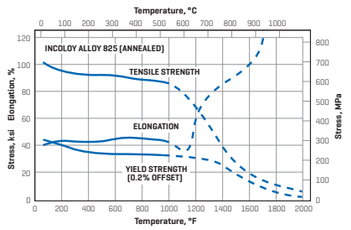
**(Solution Annealed)**




Typical usage range

**(Annealed)**

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




Typical usage range

## INCOLOY ALLOY 864

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

## INCOLOY ALLOY 865

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

**STANDARD PRODUCT FORMS**

Sheet and strip.

Sheet and strip.

**MAJOR SPECIFICATIONS**

UNS S35135
ASTM A 240, A 480

UNS S35115
ASTM A240/A480

**LIMITING CHEMICAL COMPOSITION, %**

| | | | | | | |
|---|---|---|---|---|---|---|
| Ni | 30.0 – 38.0 | Mo | 4.0 – 4.8 | Mn | 0.01 |
| Fe | Remainder | C | 0.08 max. | S | 0.015 max. |
| Cr | 20.0 – 25.0 | Si | 0.6 – 1.0 | Ti | 0.4 – 1.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Ni | 19.0 – 22.0 | N | 0.20 – 0.30 | P | 0.045 max. |
| Cr | 23.0 – 25.0 | Mn | 1.0 max. | S | 0.015 max. |
| Mo | 1.50 – 2.50 | C | 0.020 max. | | |

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

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

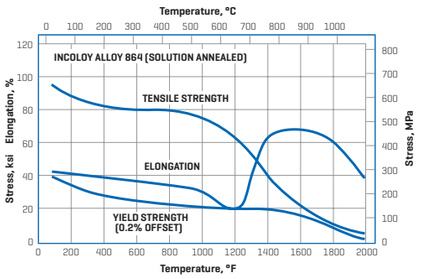
[A]Room temperature, as annealed.

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

**TYPICAL MECHANICAL PROPERTIES**

**(Solution Annealed)**

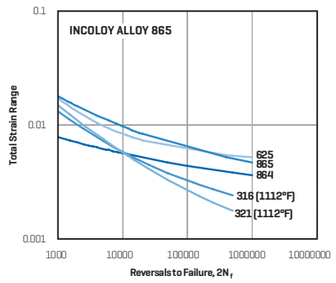
| | |
|---|---|
| Tensile Strength, ksi | 94 |
| MPa | 648 |
| Yield Strength (0.2% Offset), ksi | 40 |
| MPa | 276 |
| Elongation, % | 44 |




**(Annealed)**

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

**FATIGUE PROPERTIES AT 1000°F (538°C)**
**LONGITUDINAL STRAIN CONTROLLED**








## INCOLOY ALLOY 903

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

## INCOLOY ALLOY 907

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

**STANDARD PRODUCT FORMS**

Sheet, plate, rod, bar and forging stock.

Round bar and forging stock.

**MAJOR SPECIFICATIONS**

UNS N19903

UNS N19907

**LIMITING CHEMICAL COMPOSITION, %**

| | | | | | | |
|---|---|---|---|---|---|---|
| Ni | 36.0 – 40.0 | Co | 13.0 – 17.0 | Ti | 1.00 – 1.85 |
| Fe | Remainder | Al | 0.30 – 1.15 | Nb | 2.40 – 3.50 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Ni | 35.0 – 40.0 | Nb | 4.3 – 5.2 | Al | 0.2 max. |
| Fe | Remainder | Ti | 1.3 – 1.8 | Si | 0.07 – 0.35 |
| Cu | 12.0 – 16.0 | | | | |

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.298 |
| g/cm³ | 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/ft²•h•°F | 116 |
| W/m•°C | 16.7 |
| Electrical Resistivity, ohm•circ mil/ft | 379 |
| µΩ•m | 0.650 |

| | |
|---|---|
| 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 |

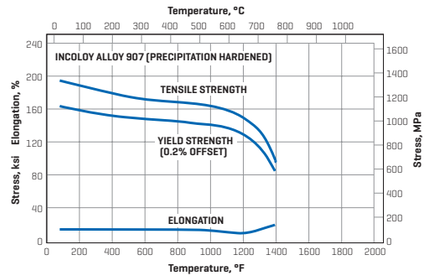
**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

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

**(Precipitation Hardened)**

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



## INCOLOY ALLOY 909

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

## INCOLOY ALLOY 925

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

### STANDARD PRODUCT FORMS

Round bar, forging stock and hot-rolled profile.

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

### MAJOR SPECIFICATIONS

UNS N19909
SAE AMS 5884, 5892, 5893

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

### LIMITING CHEMICAL COMPOSITION, %

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

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

### PHYSICAL CONSTANTS AND THERMAL PROPERTIES

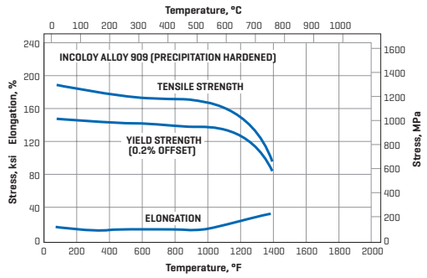
Density, lb/in³ ..... 0.296
g/cm³ ..... 8.19
Melting Range, °F ..... 2540 – 2610
°C ..... 1395 – 1430
Specific Heat, Btu/lb•°F ..... 0.102
J/kg•°C ..... 427
Curie Temperature, °F ..... 750 – 850
°C ..... 400 – 455
Coefficient of Expansion, 77 – 800°F, $10^{-6}$ in/in•°F ..... 4.3
25 – 427°C, µm/m•°C ..... 7.7
Thermal Conductivity, Btu • in/ft²•h•°F ..... 103
W/m•°C ..... 14.8
Electrical Resistivity, ohm•circ mil/ft ..... 438
µΩ•m ..... 0.728

Density, lb/in³ ..... 0.292
g/cm³ ..... 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, 70 – 200°F, $10^{-6}$ in/in•°F ..... 7.8
21 – 93°C, µm/m•°C ..... 13.2
Electrical Resistivity, ohm•circ mil/ft ..... 701
µΩ•m ..... 1.17

### TYPICAL MECHANICAL PROPERTIES

**(Precipitation Hardened)**

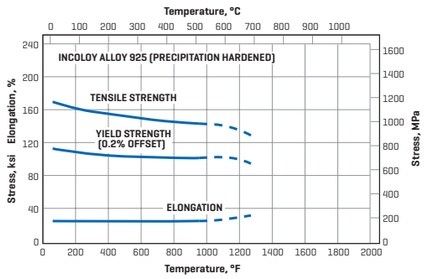
| Rupture Strength (1000h) | ksi | MPa |
|---|---|---|
| 1000°F / 540°C | 130 | 900 |
| 1100°F / 595°C | 85 | 590 |
| 1200°F / 650°C | 45 | 310 |




Typical usage range

**(Precipitation Hardened)**

Tensile Strength, ksi ..... 176
MPa ..... 1210
Yield Strength (0.2% Offset), ksi ..... 118
MPa ..... 810
Elongation, % ..... 24




Typical usage range





## INCOLOY ALLOY 945

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

## INCOLOY ALLOY 945X

INCOLOY alloy 945X (UNS N09945) offers enhanced strength over that of INCOLOY alloy 945. With increased levels of hardeners in the alloy composition, alloy 945X exhibits a minimum yield strength of 140 ksi. With this higher strength, alloy 945X is especially well suited for high strength oilfield equipment as both bar and mechanical tube products.

The corrosion resistance of INCOLOY alloy 945X is comparable to that of INCOLOY alloy 945. Both alloys are approved to NACE MR0175 Level VII and Level VI-450°F. Thus, alloys 945 and 945X find applications in corrosive sour oil and gas environments containing hydrogen sulfide, free-sulfur, carbon dioxide, chlorides and other aggressive corrodents.

### STANDARD PRODUCT FORMS

Bar, forging stock, tubes.

Bar, forging stock, tubes.

### MAJOR SPECIFICATIONS

UNS N09945
NACE MR0175 (Approved to Level VII and Level VI at 450°F)

UNS 09945
NACE MR0175 (Approved to Level VII and Level VI at 450°F)

### LIMITING CHEMICAL COMPOSITION, %

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

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

### PHYSICAL CONSTANTS AND THERMAL PROPERTIES

Density, lb/in³ ..... 0.281
g/cm³ ..... 7.777
Melting Range, °F ..... 2317 – 2510
°C ..... 1270 – 1377
Permeability at 200 Oersted ..... 1.003
Coefficient of Expansion, $10^{-6}$ in/in•°F (µm/m•°C)
70-200°F (21-93°C) ..... 7.88 (14.19)
70-800°F (21-427°C) ..... 8.40 (15.12)
70-1200°F (21-649°C) ..... 8.85 (15.93)
Young's (Tensile) Modulus ..... 28.3 x $10^3$ ksi
Shear Modulus ..... 10.8 x $10^3$ ksi
Poisson's Ratio ..... 0.31

Density, lb/in³ ..... 0.281
g/cm³ ..... 7.777
Melting Range, °F ..... 2317 – 2510
°C ..... 1270 – 1377
Permeability at 200 Oersted ..... 1.003
Coefficient of Expansion, $10^{-6}$ in/in•°F (µm/m•°C)
70-200°F (21-93°C) ..... 7.88 (14.19)
70-800°F (21-427°C) ..... 8.40 (15.12)
70-1200°F (21-649°C) ..... 8.85 (15.93)

### TYPICAL MECHANICAL PROPERTIES

**(Annealed + Aged)**
Minimum Tensile Strength, ksi ..... 150
MPa ..... 1034
Minimum Yield Strength (0.2% Offset), ksi ..... 130
MPa ..... 896
Minimum Elongation, % ..... 18
Minimum Reduction of Area, % ..... 25
Maximum Hardness ..... 42HRC
Minimum Impact Strength (CVN @ - 75°F), ft lbs ..... 35
Joules ..... 47

**(Annealed + Aged)**
Minimum Tensile Strength, ksi ..... 165
MPa ..... 1138
Minimum Yield Strength (0.2% Offset), ksi ..... 140
MPa ..... 965
Minimum Elongation, % ..... 18
Minimum Reduction of Area, % ..... 25
Maximum Hardness ..... 42HRC
Minimum Impact Strength (CVN @ - 75°F), ft lbs ..... 30
Joules ..... 41

## INCOLOY ALLOY 20

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

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

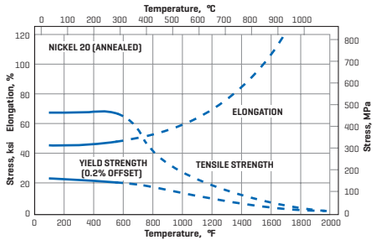
| | | | |
|---|---|---|---|
| Ni | 32.0 – 38.0 | Nb+Ta | 8xC-1.0 |
| Fe | Remainder | Mo | 2.0 – 3.0 |
| Cr | 19.0 – 21.0 | Nb | 1.0 max. |
| Cu | 3.0 – 4.0 | C | 0.07 max. |
| Mn | 2.0 max. | P | 0.045 max. |
| S | 0.035 max. | Si | 1.0 max. |

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

Density, lb/in³ 0.292
g/cm³ 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/ft²•h•°F 85
W/m•°C 12.3
Electrical Resistivity, ohm•circ mil/ft 651
µΩ•m 1.08

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**
Tensile Strength, ksi 90
MPa 620
Yield Strength (0.2% Offset), ksi 45
MPa 300
Elongation, % 40




Typical usage range

## INCOLOY ALLOY 28

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

**STANDARD PRODUCT FORMS**

Tube.

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

Density, lb/in³ (g/cm³) 0.29 (8.0)
Specific Heat, Btu/lb•°F (J/kg•°C) 0.105 (450)
Coefficient of Expansion, 10⁻⁶ in/in•°F (µm/m•°C)
75-200°F (21-93°C) 8.3 (15.0)
75-500°F (21-260°C) 8.8 (15.9)
75-800°F (21-427°C) 9.3 (16.8)
Thermal Conductivity[A], Btu • in/ft²•h•°F 66
W/m•°C 11.4
Electrical Resistivity[A], ohm•circ mil/ft (µΩ•m) 594 (0.99)
Young's Modulus[A], 10⁶ psi (GPa) 29.0 (200)
[A]Room temperature, as annealed.

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**
Tensile Strength, ksi 73
MPa 500
Yield Strength (0.2% Offset), ksi 31
MPa 214
Elongation, % 40
Hardness, (HRB) 70/90

**(Cold Worked)**
Tensile Strength, ksi 130
MPa 896
Yield Strength (0.2% Offset), ksi 110
MPa 758
Elongation, % 15
Hardness, (HRC) 33 max.





## 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, conveyor systems and heat-treating baskets and fixtures.

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

| | | | |
|---|---|---|---|
| Ni | 34.0 – 37.0 | Si | 0.75 – 1.50 |
| Fe | Remainder | C | 0.08 max. |
| Cr | 17.0 – 20.0 | Mn | 2.0 max. |
| P | 0.30 max. | Si | 0.30 max. |

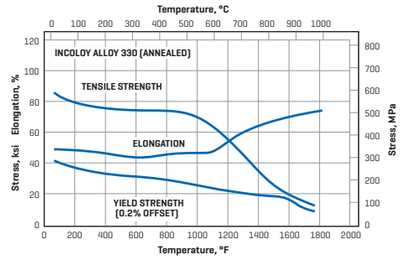
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

Density, lb/in³ 0.292
g/cm³ 8.08
Melting Range, °F 2520 - 2590
°C 1380 - 1420
Specific Heat, Btu/lb•°F 0.11
J/kg•°C 460
Permeability at 200 Oersted (15.9 kA/m) 1.02
Coefficient of Expansion, 10⁻⁶ in/in•°F (µm/m•°C)
75-200°F (24-93°C) 8.3 (14.9)
Thermal Conductivity, Btu • in/ft²•h•°F 86
W/m•°C 12.4
Electrical Resistivity, ohm•circ mil/ft 612
µΩ•m 1.017

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

| Rupture Strength (1000h) | 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 |




Typical usage range

## 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 what is 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, forging stock and wire.

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

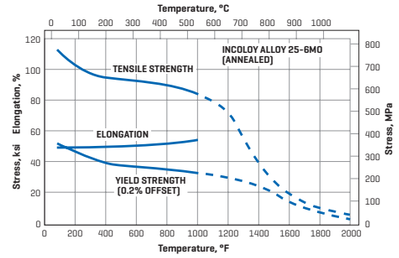
| | | | |
|---|---|---|---|
| Ni | 24.0 – 26.0 | Cu | 0.5 – 1.5 |
| Fe | Remainder | N | 0.15 – 0.25 |
| Mo | 6.0 – 7.0 | Mn | 2.0 max. |
| P | 0.03 max. | S | 0.01 max. |
| C | 0.02 max. | Si | 0.5 max. |

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

Density, lb/in³ (g/cm³) 0.290 (8.03)
Melting Range, °F (°C) 2410 - 2550 (1320 - 1400)
Specific Heat, Btu/lb•°F (J/kg•°C) 0.12 (500)
Permeability at 200 Oersted (15.9 kA/m) 1.005
Coefficient of Expansion, 10⁻⁶ in/in•°F (µm/m•°C)
70-200°F (21-93°C) 8.42 (15.2)
70-800°F (21-427°C) 9.12 (16.4)
70-1200°F (21-649°C) 9.41 (16.9)
Thermal Conductivity[A], Btu • in/ft²•h•°F 79.8
W/m•°C 11.5
Electrical Resistivity[A], ohm•circ mil/ft 480
µΩ•m 0.80
Young's Modulus[A], 10⁶ psi (GPa) 27.3 (188)
[A]Room temperature, as annealed.

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**
Tensile Strength, ksi 100
MPa 690
Yield Strength (0.2% Offset), ksi 48
MPa 330
Elongation, % 42




Typical usage range

## INCOLOY ALLOY 25-6HN

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

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

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

UNS N08367
ASTM B688, A240, B691, B564, B472, B676, B675, B804, B462, B366
ASME SB688, SA240, SB691, SB564, SB472, SB676, SB675, SB804, SB462, SB366

**LIMITING CHEMICAL COMPOSITION, %**

| | | | |
|---|---|---|---|
| Ni | 23.50–25.50 | N | 0.18–0.25 |
| Cr | 20.00–22.00 | Cu | 0.75 max. |
| Fe | Balance | C | 0.03 max. |
| Mo | 6.00–7.00 | Mn | 2.00 max |
| Si | 1.00 max. | | |
| P | 0.040 max. | | |
| S | 0.030 max. | | |

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.291 |
| g/cm³ | 8.06 |
| Melting Range, °F | 2470 – 2550 |
| °C | 1320 – 1400 |
| Permeability at 200 Oersted | 1.003 |
| Coefficient of Expansion, $10^{-6}$ in/in•°F | |
| 70 – 200°F | 8.66 |
| 70 – 800°F | 9.05 |
| 70 – 1200°F | 9.53 |

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

| | |
|---|---|
| Tensile Strength, ksi | 108 |
| MPa | 744 |
| Yield Strength (0.2% Offset), ksi | 55 |
| MPa | 381 |
| Elongation, % | 48 |
| Hardness | 90HRB |

## INCOLOY ALLOY 27-7MO

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

**STANDARD PRODUCT FORMS**

Sheet, plate, bar and wire.

**MAJOR SPECIFICATIONS**

UNS S31277
ASTM A 182, A 213, A 240, A 249, A 312, A 479
ASME SA 182, SA 213, SA 240 SA 249, SA 312, SA 479
ASME Code Case 2458

**LIMITING CHEMICAL COMPOSITION, %**

| | | | |
|---|---|---|---|
| Ni | 26.0 – 28.0 | N | 0.3-0.4 |
| Cr | 20.5 – 23.0 | Fe | Remainder |
| Mo | 6.5 – 8.0 | Mn | 3.00 max. |
| Cu | 0.5-1.5 | P | 0.03 max. |
| S | 0.01 max. | | |
| Si | 0.5 max. | | |
| C | 0.020 max. | | |

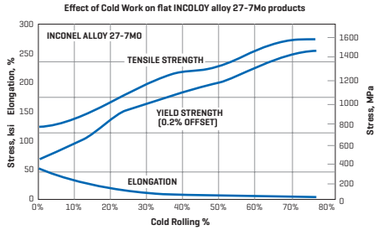
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ (g/cm³) | 0.289 (8.02) |
| Specific Heat, Btu/lb • °F (J/kg • °C) | 0.109 (454) |
| 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) | 8.33 (15.0) |
| Thermal Conductivity, Btu•in/ft²•h•°F (W/m•°C) | 69.8 (10.1) |
| Electrical Resistivity, ohm•circ mil/ft (µΩ•cm) | 604 (100) |
| Young's Modulus, $10^6$ psi (GPa) | 27.7 (191) |
| Shear Strength, $10^6$ psi (GPa) | 10.8 (74) |
| Poisson's Ratio | 0.29 |
| Melting Range, °F (°C) | 2460 – 2530 (1350 – 1390) |

**(Annealed)**

| | |
|---|---|
| Tensile Strength, ksi | 120 |
| MPa | 827 |
| Yield Strength (0.2% Offset), ksi | 60 |
| MPa | 414 |
| Elongation, % | 50 |

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








## 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
NACE MR-0175/ISO 15156
W. NR. 1.4980

**LIMITING CHEMICAL COMPOSITION, %**

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

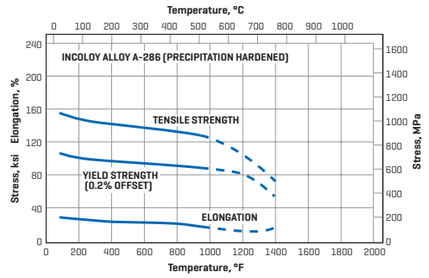
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.287 |
| g/cm³ | 7.94 |
| Melting Range, °F | 2500 – 2600 |
| °C | 1370 – 1430 |
| Specific Heat, Btu/lb•°F | 0.100 |
| J/kg•°C | 419 |
| Permeability at 200 Oersted (15.9 kA/m) | 1.007 |
| Coefficient of Expansion, $10^{-6}$ in/in•°F (µm/m•°C) | |
| 70 - 200°F (21- 93°C) | 9.09 (16.4) |
| 70 - 800°F (21- 427°C) | 9.61 (17.3) |
| 70 -1400°F (21-760°C) | 9.67 (17.4) |
| Thermal Conductivity[A], Btu • in/ft²•h•°F | 88 |
| W/m•°C | 12.7 |
| Electrical Resistivity[A], ohm•circ mil/ft | 547 |
| µΩ•m | 0.910 |
| Young's Modulus[A], $10^6$ psi | 29.1 |
| GPa | 201 |
| Hardness[A], HRC | 31 |

[A]Room temperature, as annealed.

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**




Typical usage range

## INCOLOY ALLOY 890

INCOLOY® alloy 890 (UNS N08890) is the latest addition to the INCOLOY alloy family of heat-resistant alloys. Alloy 890 joins existing INCOLOY products in offering high strength along with excellent resistance to oxidation, carburization and sulfidation at temperatures up to 2200°F (1200°C). Alloy 890 offers the high chromium content of alloy 803 along with enhanced properties from additions of molybdenum, silicon and niobium. The primary application for alloy 890 is tubes for ethylene pyrolysis furnaces.

**STANDARD PRODUCT FORMS**

Smooth bore tubes; Internally finned tubes

**MAJOR SPECIFICATIONS**

UNS N08890
ASTM B407, 408, 409

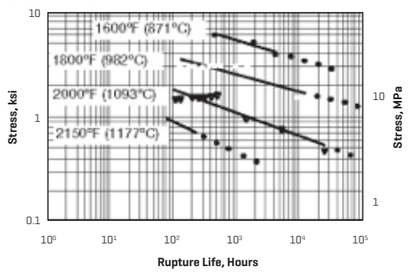
**LIMITING CHEMICAL COMPOSITION, %**

| | | | |
|---|---|---|---|
| Ni | 40.0 - 45.0 | Nb | 0.2 - 1.0 |
| Cr | 23.5 – 28.5 | Ta | 0.10 – 0.60 |
| Fe | Balance | Ti | 0.15 - 0.60 |
| Mo | 1.0 - 2.0 | Al | 0.05 – 0.60 |
| Si | 1.0 - 2.0 | C | 0.06 – 0.14 |
| Mn | 1.5 max. | | |
| Cu | 0.75 max. | | |
| P | 0.03 max. | | |
| S | 0.015 max. | | |

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.287 |
| g/cm³ | 7.94 |
| Coefficient of Expansion, $10^{-6}$ in/in•°F (µm/m•°C) | |
| 70-200°F (21- 100°C) | 8.02 (14.47) |
| 70-600°F (21- 300°C) | 8.43 (15.11) |
| 70-1000°F (21- 600°C) | 8.94 (16.40) |
| Thermal Conductivity, Btu • in/ ft²•h•°F | 550 |
| W/m • °C | 10.98 |
| Electrical Resistivity, ohm • circ mil/ft | 212.47 |
| µΩ•cm | 1033 |
| Modulus of Elasticity*, $10^6$ psi (GPa) | 28.3 (195.1) |
| Shear Modulus*, $10^6$ psi (GPa) | 10.7 (73.8) |
| Poisson's Ratio* | 0.322 |
| Melting Range, °F (°C) | 2388 – 2522 (1309 – 1383) |

**(Annealed)**



## 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, components of industrial furnaces, heat-treating equipment and fixtures, and nuclear engineering.

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

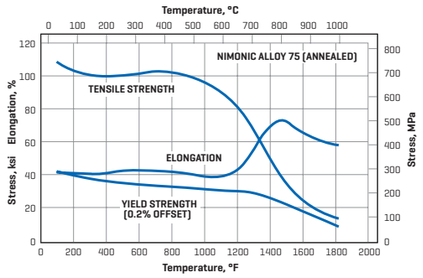
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

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

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

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




## NIMONIC ALLOY 80A

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

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

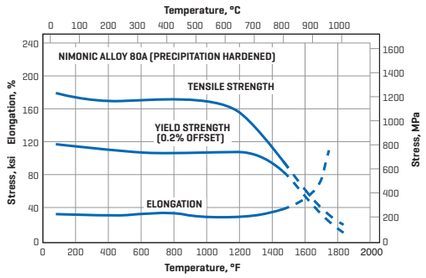
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.296 |
| g/cm³ | 8.19 |
| Melting Range, °F | 2410 – 2490 |
| °C | 1320 – 1365 |
| Specific Heat, Btu/lb•°F | 0.107 |
| J/kg•°C | 448 |
| Permeability at 200 Oersted (15.9 kA/m) | 1.0006 |
| Coefficient of Expansion, 68 - 212°F, 10⁻⁶ in/in•°F | 7.1 |
| 20 - 100°C, µm/m•°C | 12.7 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 77.7 |
| W/m•°C | 11.2 |
| Electrical Resistivity, ohm•circ mil/ft | 746 |
| µΩ•m | 1.24 |

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

| Rupture Strength (1000h) | 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 |








## NIMONIC ALLOY 86

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

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

None applicable.

**LIMITING CHEMICAL COMPOSITION, %**

**Nominal**

| | | | | | |
|---|---|---|---|---|---|
| Ni | 65 | Mo | 10.0 | C | 0.05 |
| Cr | 25.0 | Ce | 0.03 | | |

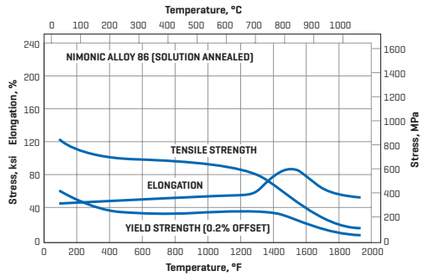
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.309 |
| g/cm³ | 8.54 |
| Melting Range, °F | 2350 – 2460 |
| °C | 1290 – 1350 |
| Specific Heat, Btu/lb•°F | 0.107 |
| J/kg•°C | 448 |
| Permeability at 200 Oersted (15.9 kA/m) | 1.0006 |
| Young's Modulus, 10⁶ 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**

**(Solution Annealed)**

| Rupture Strength (1000h) | 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 |




## 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.

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

**Limiting**

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

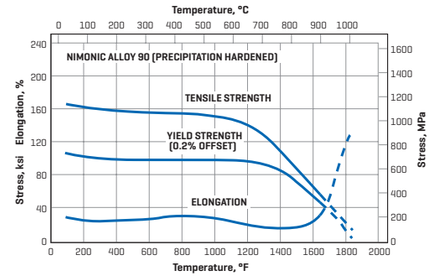
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.296 |
| g/cm³ | 8.18 |
| Melting Range, °F | 2390 - 2500 |
| °C | 1310 - 1370 |
| Specific Heat, Btu/lb•°F | 0.107 |
| J/kg•°C | 446 |
| Permeability at 200 Oersted (15.9 kA/m) | 1.0706 |
| Coefficient of Expansion, 68 - 212°F, 10⁻⁶ in/in•°F | 7.1 |
| 20 - 100°C, µm/m•°C | 12.7 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 79.7 |
| W/m•°C | 11.5 |
| Electrical Resistivity, ohm•circ mil/ft | 710 |
| µΩ•m | 1.18 |

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

| Rupture Strength (1000h) | 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

## 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**

Round and extruded section.

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

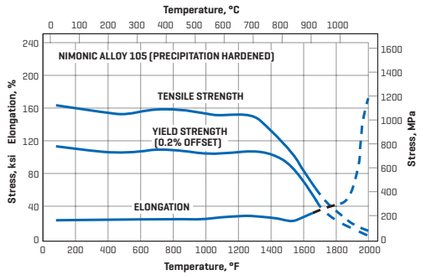
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.289 |
| g/cm³ | 8.01 |
| Melting Range, °F | 2350 - 2450 |
| °C | 1290 - 1345 |
| Specific Heat, Btu/lb•°F | 0.100 |
| J/kg•°C | 419 |
| Permeability at 200 Oersted (15.9 kA/m) | 1.0007 |
| Coefficient of Expansion, 68 - 212°F, $10^{-6}$ in/in•°F | 6.8 |
| 20 - 100°C, µm/m•°C | 12.2 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 75.51 |
| W/m•°C | 10.89 |
| Electrical Resistivity, ohm•circ mil/ft | 788 |
| µΩ•m | 1.31 |

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

| Rupture Strength (1000h) | 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

## 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.

**STANDARD PRODUCT FORMS**

Round and extruded section.

**MAJOR SPECIFICATIONS**

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

**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. | |

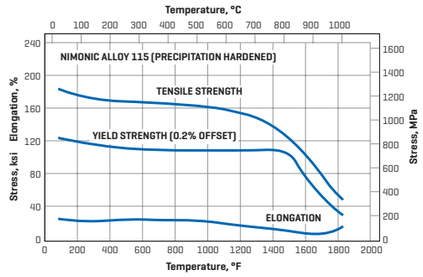
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.284 |
| g/cm³ | 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/ft²•h•°F | 73.5 |
| W/m•°C | 10.6 |
| Electrical Resistivity, ohm•circ mil/ft | 836 |
| µΩ•m | 1.39 |

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

| Rupture Strength (1000h) | 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 |








## 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**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

| | | |
|---|---|---|
| Ni.....Remainder | Al.....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. | |

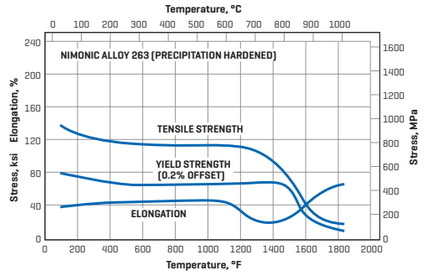
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.302 |
| g/cm³ | 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/ft²•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 (1000h) | ksi | MPa |
|---|---|---|
| 1100°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 |




## 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.

**STANDARD PRODUCT FORMS**

Flat or round bar, extruded section and forging billet.

**MAJOR SPECIFICATIONS**

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

**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. |

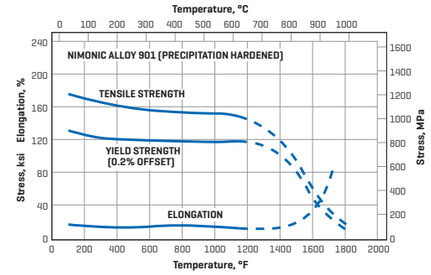
[a]Plus Co.

**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 |

**(Precipitation Hardened)**

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




Typical usage range

## 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**

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

**MAJOR SPECIFICATIONS**

None Applicable.

**LIMITING CHEMICAL COMPOSITION, %**

| | | |
|---|---|---|
| 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. | |

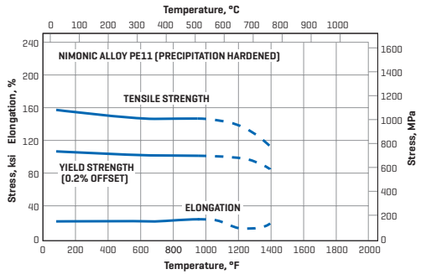
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.290 |
| 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 (1000h) | ksi | MPa |
|---|---|---|
| 1200°F / 650°C | 49 | 340 |
| 1300°F / 705°C | 36 | 250 |
| 1400°F / 760°C | 21 | 140 |




Typical usage range

## 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 nuclear reactors.

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

BS HR55, HR207

**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. |

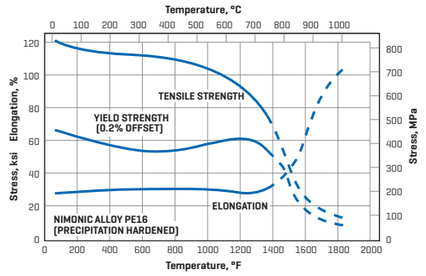
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| 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 |

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

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




Typical usage range

W





## 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.

**MAJOR SPECIFICATIONS**

None applicable.

**LIMITING CHEMICAL COMPOSITION, %**

| | | |
|---|---|---|
| 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. | |

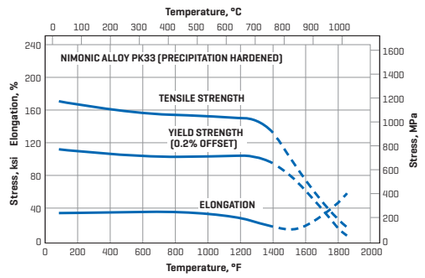
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.297 |
| 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 (1000h) | 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 |




Typical usage range

## NIMONIC ALLOY MP35N

NIMONIC alloy MP35N is a multi-phase, cobalt-base alloy offering a unique combination of ultra-high strength, toughness and corrosion resistance. Common applications are fasteners, springs and high strength components for marine, oil and gas, and chemical processing service.

**STANDARD PRODUCT FORMS**

Cold drawn tube

**MAJOR SPECIFICATIONS**

UNS R30035
BS 3072 – 3074 (NA12)
SAE AMS 5758, 5844, 5845, 7468
ASTM F1636, F2005, F2068, F366, F688, F961

**LIMITING CHEMICAL COMPOSITION, %**

| | | |
|---|---|---|
| Ni..... 33.0 – 37.0 | Fe..... 1.0 max. | Mn..... 0.15 max. |
| Cr .... 19.0 – 21.0. | Si..... 0.15 max. | P..... 0.015 max. |
| Co..... Balance | Ti ..... 1.0 max. | S..... 0.010 max. |
| Mo..... 9.0 – 10.5 | C..... 0.025 max. | |

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.304 |
| g/cm³ | 8.43 |
| Coefficient of Expansion, $10^{-6}$ in/in•°F (µm/m•°C) | |
| 70-200°F (21-93°C) | 7.1 (12.8) |
| 70-600°F (21-316°C) | 8.2 (14.8) |
| 70-1000°F (21-538°C) | 8.7 (15.7) |
| Thermal Conductivity, Btu • in/ft²•h•°F | 78 |
| W/m•°C | 11.2 |
| Electrical Resistivity, µΩ•in | 40.7 |
| µΩ•mm | 1033 |
| Modulus of Elasticity[A], $10^6$ psi (GPa) | 33.8 (233) |
| Modulus of Rigidity[A], $10^6$ psi (GPa) | 11.7 (81) |
| Shear Modulus[A], $10^6$ psi (GPa) | 12.1 (84) |
| Magnetic Permeability[A] | 1.001 |
| Melting Range, °F | 2340 - 2450 |
| °C | 1300 - 1345 |

[A]Room temperature, as annealed

**(Annealed)**

| | |
|---|---|
| Tensile Strength, ksi | 120 - 140 |
| MPa | 827 - 965 |
| Yield Strength (0.2% Offset), ksi | 40 - 60 |
| MPa | 276 - 414 |
| Elongation, % | 40 – 60 |

**(Cold Worked)**

| | |
|---|---|
| Tensile Strength, ksi | 160 – 260 |
| MPa | 1103 – 1792 |
| Yield Strength (0.2% Offset), ksi | 120 - 240 |
| MPa | 827 – 1655 |
| Elongation, % | 10 – 30 |

**(Cold Worked + Aged)**

| | |
|---|---|
| Tensile Strength, ksi | 180 – 280 |
| MPa | 1241 – 1930 |
| Yield Strength (0.2% Offset), ksi | 170 – 270 |
| MPa | 1172 - 1861 |
| Elongation, % | 10 – 20 |

## NILO ALLOY 36

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

**STANDARD PRODUCT FORMS**

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

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

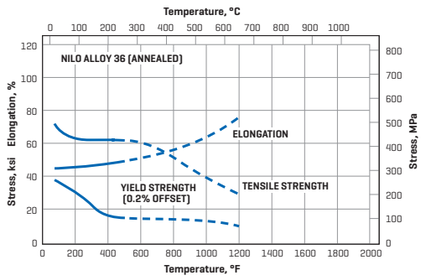
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.293 |
| g/cm³ | 8.11 |
| Melting Temperature (Approximate), °F | 2610 |
| °C | 1430 |
| Inflection Point, °F | 430 |
| °C | 220 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 69.3 |
| W/m • °C | 10.0 |
| Coefficient of Expansion, 68 – 212°F, $10^{-6}$ in/in • °F | 0.83 |
| 20 – 100°C, µm/m • °C | 1.5 |
| 68 – 392°F, $10^{-6}$ in/in • °F | 1.4 |
| 20 – 200°C, µm/m • °C | 2.6 |
| Electrical Resistivity, ohm • circ mil/ft | 480 |
| µΩ • m | 0.800 |

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

| | |
|---|---|
| Tensile Strength, ksi | 71 |
| MPa | 490 |
| Yield Strength (0.2% Offset), ksi | 35 |
| MPa | 240 |
| Elongation, % | 42 |




Typical usage range

## NILO ALLOY 42

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

**STANDARD PRODUCT FORMS**

Strip, plate and wire.

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

**Limiting**

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

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

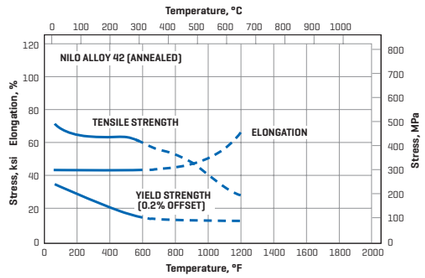
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.293 |
| g/cm³ | 8.11 |
| Melting Temperature (Approximate), °F | 2615 |
| °C | 1435 |
| Inflection Point, °F | 700 |
| °C | 370 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 72.8 |
| W/m • °C | 10.5 |
| Coefficient of Expansion, 68 – 212°F, $10^{-6}$ in/in • °F | 2.9 |
| 20 – 100°C, µm/m • °C | 5.3 |
| 68 – 572°F, $10^{-6}$ in/in • °F | 2.5 – 3.6 |
| 20 – 300°C, µm/m • °C | 4.5 – 6.5 |
| Electrical Resistivity, ohm • circ mil/ft | 370 |
| µΩ • m | 0.610 |

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

| | |
|---|---|
| Tensile Strength, ksi | 71 |
| MPa | 490 |
| Yield Strength (0.2% Offset), ksi | 36 |
| MPa | 250 |
| Elongation, % | 43 |




Typical usage range

## NILO ALLOY 48

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

**STANDARD PRODUCT FORMS**

Wire.

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

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

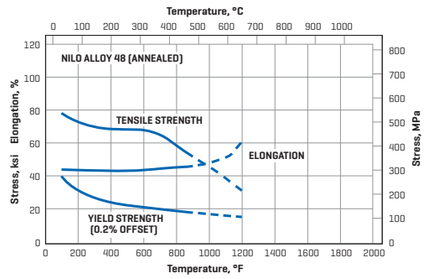
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.296 |
| g/cm³ | 8.20 |
| Melting Temperature (Approximate), °F | 2640 |
| °C | 1450 |
| Inflection Point, °F | 860 |
| °C | 460 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 116 |
| W/m • °C | 16.7 |
| Coefficient of Expansion, 68 – 212°F, $10^{-6}$ in/in • °F | 4.7 |
| 20 – 100°C, µm/m • °C | 8.5 |
| 68 – 752°F, $10^{-6}$ in/in • °F | 4.6 – 5.2 |
| 20 – 400°C, µm/m • °C | 8.3 – 9.3 |
| Electrical Resistivity, ohm • circ mil/ft | 280 |
| µΩ • m | 0.470 |

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

| | |
|---|---|
| Tensile Strength, ksi | 75 |
| MPa | 520 |
| Yield Strength (0.2% Offset), ksi | 38 |
| MPa | 260 |
| Elongation, % | 43 |




Typical usage range

## NILO ALLOY K

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

**STANDARD PRODUCT FORMS**

Tube, sheet and round bar.

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

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

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

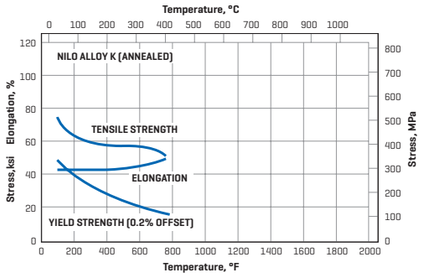
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

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

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

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




Typical usage range

## FERRY ALLOY

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

**STANDARD PRODUCT FORMS**

Strip and wire.

**MAJOR SPECIFICATIONS**

ASTM B 267
DIN 17644
Werkstoff Nr. 2.0842

**LIMITING CHEMICAL COMPOSITION, %**

Limiting

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

[a]Nominal

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

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

**TYPICAL MECHANICAL PROPERTIES**

**(Annealed)**

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

## NI-SPAN-C ALLOY 902

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

**STANDARD PRODUCT FORMS**

Round bar.

**MAJOR SPECIFICATIONS**

UNS N09902
SAE AMS 5221, 5223, 5225

**LIMITING CHEMICAL COMPOSITION, %**

Limiting

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

[a]Plus Co.

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

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

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

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





## WASPALOY

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

**STANDARD PRODUCT FORMS**

Round bar, forging stock, extruded section and wire.

**MAJOR SPECIFICATIONS**

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

**LIMITING CHEMICAL COMPOSITION, %**

Limiting

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

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

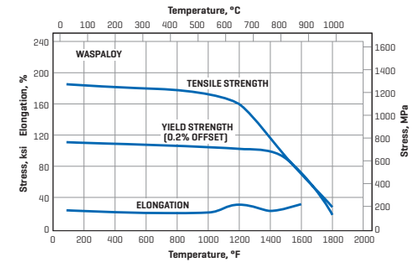
| | |
|---|---|
| Density, lb/in³ (g/cm³) | 0.296 (8.19) |
| Melting Range, °F (°C) | 2425 - 2475 (1330 - 1360) |
| Permeability at 200 Oersted (15.9 kA/m) | 1.004 |
| Coefficient of Expansion, $10^{-6}$ in/in•°F (μm/m•°C) | |
| 70-200°F (21-93°C) | 6.8 (12.2) |
| 70-1000°F (21-538°C) | 7.7 (13.9) |
| 70-2000°F (21-1093°C) | 10.4 (18.7) |
| Electrical Resistivity[A], ohm•circ mil/ft (μΩ•m) | 722 (1.20) |
| Young's Modulus[A], $10^6$ psi (GPa) | 30.6 (211) |
| Hardness[A], HRC | 34 – 40 |

[A]Room temperature, as aged.

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

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




Typical usage range

## UDIMET ALLOY 188

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

**STANDARD PRODUCT FORMS**

Forging billet, bar, plate, and sheet.

**MAJOR SPECIFICATIONS**

UNS R30188
AMS 5608
AMS 5772

**LIMITING CHEMICAL COMPOSITION, %**

Limiting

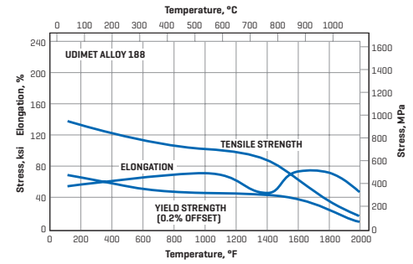
| | | |
|---|---|---|
| C.....0.05 – 0.15 | Ni.....20.0 – 24.0 | Fe..... 3.0 max. |
| Mn.....1.25 max. | W.....13.0 – 16.0 | Co..... Balance |
| Si.....0.2 – 0.5 | La.....0.02 – 0.12 | B..... 0.015 max. |
| Cr.....20.0 – 24.0 | | |

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.330 |
| g/cm³ | 9.13 |
| Melting Range, °F | 2375 - 2425 |
| °C | 1300 - 1330 |
| Specific Heat, Btu/lb•°F | 0.097 |
| J/kg•°C | 405 |
| Coefficient of Expansion, 70 - 200°F, $10^{-6}$ in/in•°F | 6.6 |
| 21 - 93°C, μm/m•°C | 11.9 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 84 |
| W/m•°C | 12.1 |

**TYPICAL MECHANICAL PROPERTIES**

| Rupture Strength (1000h) | ksi | MPa |
|---|---|---|
| 1300°F / 704°C | 35 | 240 |
| 1400°F / 760°C | 24 | 165 |
| 1500°F / 816°C | 16 | 110 |
| 1600°F / 871°C | 10 | 69 |
| 1700°F / 927°C | 6 | 41 |
| 1800°F / 982°C | 3 | 25 |
| 1900°F / 1038°C | 2 | 15 |
| 2000°F / 1093°C | 1 | 9 |




Typical usage range

## UDIMET ALLOY L-605

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

**STANDARD PRODUCT FORMS**

Forging billet, bar, sheet, plate and wire.

**MAJOR SPECIFICATIONS**

UNS R30605
AMS 5759
AMS 5537, 5796, 5797

**LIMITING CHEMICAL COMPOSITION, %**

Limiting

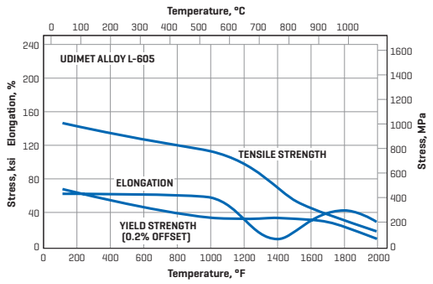
| | | |
|---|---|---|
| Ni ..... 9.0 – 11.0 | Mn..... 1.0 – 2.0 | S.....0.03 max. |
| Cr..... 19.0 – 21.0 | Si.....0.40 max. | Co..... Balance |
| W..... 14.0 – 16.0 | C..... 0.05 – 0.15 | |
| Fe..... 3.0 max. | | |

**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.335 |
| g/cm³ | 9.27 |
| Melting Range, °F | 2425 - 2570 |
| °C | 1330 - 1410 |
| Specific Heat, Btu/lb•°F | 0.092 |
| J/kg•°C | 385 |
| Coefficient of Expansion, 70 - 200°F, $10^{-6}$ in/in•°F | 6.83 |
| 21 - 93°C, µm/m •°C | 12.3 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 65 |
| W/m•°C | 9.4 |

**TYPICAL MECHANICAL PROPERTIES**

| Rupture Strength (1000h) | ksi | MPa |
|---|---|---|
| 1200°F / 649°C | 39 | 270 |
| 1300°F / 704°C | 32 | 220 |
| 1400°F / 760°C | 24 | 165 |
| 1500°F / 816°C | 17 | 120 |
| 1600°F / 871°C | 10 | 72 |
| 1700°F / 927°C | 6 | 44 |
| 1800°F / 982°C | 4 | 25 |




Typical usage range

## UDIMET ALLOY 520

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

**STANDARD PRODUCT FORMS**

Forging bar.

**MAJOR SPECIFICATIONS**

PDS 15125A1

**LIMITING CHEMICAL COMPOSITION, %**

Limiting

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

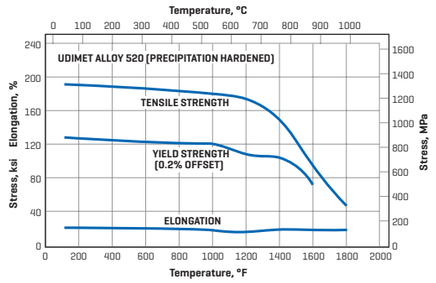
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.297 |
| g/cm³ | 8.21 |
| Melting Range, °F | 2300 - 2560 |
| °C | 1260 - 1405 |

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

| Rupture Strength (1000h) | ksi | MPa |
|---|---|---|
| 1200°F / 649°C | 85 | 585 |
| 1300°F / 704°C | 69 | 475 |
| 1400°F / 760°C | 50 | 345 |
| 1500°F / 816°C | 33 | 230 |
| 1600°F / 871°C | 22 | 150 |




Typical usage range





## UDIMET ALLOY 720

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

**STANDARD PRODUCT FORMS**

Forging billet and bar.

**MAJOR SPECIFICATIONS**

EMS 55477
MSRR 7252
MTS 5013
EMS 73105
C50TF105

**LIMITING CHEMICAL COMPOSITION, %**

Limiting

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

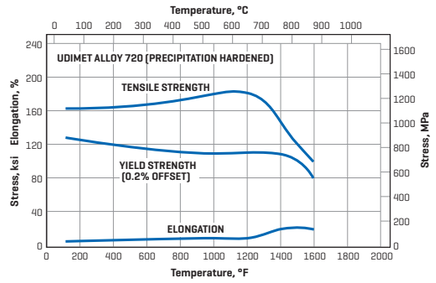
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.292 |
| g/cm³ | 8.08 |
| Melting Range, °F | 2180 - 2440 |
| °C | 1194 - 1338 |
| Coefficient of Expansion, 70 - 200°F, $10^{-6}$ in/in•°F | 6.8 |
| 21 - 93°C, µm/m •°C | 12.24 |

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

| Rupture Strength (1000h) | ksi | MPa |
|---|---|---|
| 1200°F / 649°C | 102 | 700 |
| 1300°F / 704°C | 73 | 500 |
| 1400°F / 760°C | 70 | 480 |
| 1600°F / 871°C | 32 | 219 |
| 1800°F / 982°C | 10 | 68 |




Typical usage range

## UDIMET ALLOY D-979

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

**STANDARD PRODUCT FORMS**

Forging billet and bar.

**MAJOR SPECIFICATIONS**

UNS N09979
AMS 5746

**LIMITING CHEMICAL COMPOSITION, %**

Limiting

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

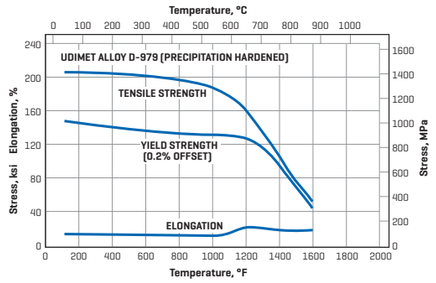
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

| | |
|---|---|
| Density, lb/in³ | 0.296 |
| g/cm³ | 8.19 |
| Melting Range, °F | 2225 - 2530 |
| °C | 1220 - 1390 |
| Coefficient of Expansion, 70 - 200°F, $10^{-6}$ in/in•°F | 7.60 |
| 21 - 93°C, µm/m •°C | 13.7 |
| Thermal Conductivity, Btu • in/ft²•h•°F | 87 |
| W/m•°C | 12.6 |

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

| Rupture Strength (1000h) | ksi | MPa |
|---|---|---|
| 1200°F / 649°C | 75 | 515 |
| 1300°F / 704°C | 55 | 380 |
| 1400°F / 760°C | 36 | 250 |
| 1500°F / 816°C | 21 | 145 |
| 1600°F / 871°C | 10 | 69 |




Typical usage range

## UDIMET ALLOY R41

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

**STANDARD PRODUCT FORMS**

Forging billet, bar, sheet and plate.

**MAJOR SPECIFICATIONS**

UNS N 07041
AMS 5545
AMS 5712
AMS 5713

**LIMITING CHEMICAL COMPOSITION, %**

Limiting

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

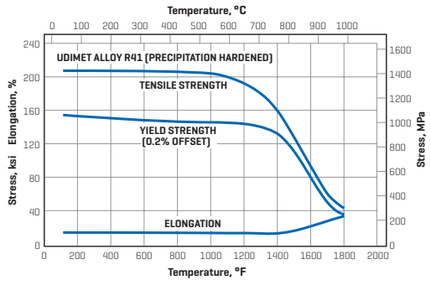
**PHYSICAL CONSTANTS AND THERMAL PROPERTIES**

Density, lb/in³ ..... 0.298
g/cm³ ..... 8.25
Melting Range, °F ..... 2250 - 2535
°C ..... 1232 - 1391
Specific Heat, Btu/lb•°F ..... 0.104
J/kg•°C ..... 435
Coefficient of Expansion, 70 - 200°F, $10^{-6}$ in/in•°F ..... 6.63
21 - 93°C, µm/m •°C ..... 11.9
Thermal Conductivity, Btu • in/ft²•h•°F ..... 62
W/m•°C ..... 9.0

**TYPICAL MECHANICAL PROPERTIES**

**(Precipitation Hardened)**

| Rupture Strength (1000h) | ksi | MPa |
|---|---|---|
| 1200°F / 649°C | 102 | 705 |
| 1300°F / 704°C | 80 | 550 |
| 1400°F / 760°C | 50 | 345 |
| 1500°F / 816°C | 29 | 200 |
| 1600°F / 871°C | 17 | 117 |
| 1700°F / 927°C | 11 | 76 |




Typical usage range

## INCOTHERM ALLOY TD

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

Contact Special Metals

**Nominal**

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

Density, lb/in³ (g/cm³) ..... 0.308 (8.54)
Melting Range, °F (°C)..... 2516 - 2552 (1380 - 1400)
Coefficient of Expansion, $10^{-6}$ in/in•°F (µm/m•°C)
70-932°F (21-500°C)..... 8.09 (14.56)
70-1112°F (21-600°C)..... 8.32 (14.98)
70-1292°F (21-700°C)..... 8.66 (15.59)
70-1472°F (21-800°C)..... 8.97 (16.15)
70-1652°F (21-900°C)..... 9.34 (16.81)
70-1832°F (21-1000°C)..... 9.61 (17.30)
Electrical Resistivity, ohm•circ mil/ft (µΩ•m) ..... 698 (1.16)

**Mechanical Properties INCOTHERM alloy TD**

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





### SELECTED CONVERSION FACTORS FOR U.S. CUSTOMARY TO SI METRIC UNITS

| To convert from | to | multiply by |
|---|---|---|
| atmosphere (760 mm Hg) | pascal (Pa) | $1.013\ 25 \times 10^{5}$ |
| Btu (International Table) | joule (J) | $1.055\ 056 \times 10^{3}$ |
| Btu/h | watt (W) | $2.930\ 711 \times 10^{-1}$ |
| Btu/lb•°F | J/kg•°C | $4.186\ 8 \times 10^{3}$ |
| Btu•in/ft²•h•°F | W/m•°C | $1.442\ 279 \times 10^{-1}$ |
| calorie | joule (J) | 4.186 8 |
| circular mil | square metre (m²) | $5.067\ 075 \times 10^{-10}$ |
| foot | metre (m) | $3.048\ 000 \times 10^{-1}$ |
| ft² | square metre (m²) | $9.290\ 304 \times 10^{-2}$ |
| ft³ | cubic metre (m³) | $2.831\ 685 \times 10^{-2}$ |
| ft•lbf | joule (J) | 1.355 818 |
| ft•lbf/min | watt (W) | $2.259\ 697 \times 20^{-2}$ |
| ft/s² | m/s² | $3.048\ 000 \times 10^{-1}$ |
| gallon (U.S. liquid) | cubic metre (m³) | $3.785\ 412 \times 10^{-3}$ |
| horsepower (electric) | watt (W) | $7.460\ 000 \times 10^{2}$ |
| inch | metre (m) | $2.540\ 000 \times 10^{-2}$ |
| in² | square metre (m²) | $6.451\ 600 \times 10^{-4}$ |
| in³ | cubic metre (m³) | $1.638\ 706 \times 10^{-5}$ |
| inch of mercury (60°F) | pascal (Pa) | $3.375\ 85 \times 10^{3}$ |
| inch of water (60°F) | pascal (Pa) | $2.488\ 4 \times 10^{2}$ |
| kgf/cm² | pascal (Pa) | $9.806\ 650 \times 10^{4}$ |
| kip (1000 lbf) | newton (N) | $4.448\ 222 \times 10^{3}$ |
| kip/in² (ksi) | pascal (Pa) | $6.894\ 757 \times 10^{8}$ |
| oersted | A/m | 7.957 75 x 10 |
| ohm•circ mil/ft | Ω•m | $1.662\ 426 \times 10^{-9}$ |
| ounce (U.S. fluid) | cubic metre (m³) | $2.957\ 353 \times 10^{-5}$ |
| ounch-force | newton (N) | $2.780\ 139 \times 10^{-1}$ |
| ounce (avoirdupois) | kilogram (kg) | $2.834\ 952 \times 10^{-2}$ |
| pint (U.S. liquid) | cubic metre (m³) | $4.731\ 765 \times 10^{-4}$ |
| pound-force (lbf) | newton (N) | 4.448 222 |
| pound (lb avoirdupois) | kilogram (kg) | $4.535\ 924 \times 10^{-1}$ |
| lbf/in² (psi) | pascal (Pa) | $6.894\ 757 \times 10^{3}$ |
| lb/in³ | kg/m³ | $2.767\ 990 \times 10^{4}$ |
| lb/ft³ | kg/m³ | 1.601 846 x 10 |
| quart (U.S. liquid) | cubic metre (m³) | $9.463\ 529 \times 10^{-4}$ |
| ton (short, 2000 lb) | kilogram (kg) | $9.071\ 847 \times 10^{2}$ |
| torr (mm Hg, 0°C) | pascal (Pa) | $1.333\ 22 \times 10^{2}$ |
| W•h | joule (J) | $3.600\ 000 \times 10^{3}$ |
| yard | metre (m) | $9.144\ 000 \times 10^{-1}$ |
| yd² | square metre (m²) | $8.361\ 274 \times 10^{-1}$ |
| yd³ | cubic metre (m³) | $7.645\ 549 \times 10^{-1}$ |

### GRAIN-SIZE EQUIVALENTS

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

### MILLIMETRE—INCH EQUIVALENTS

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

### DECIMAL AND METRIC EQUIVALENTS OF FRACTIONS OF AN INCH

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

### MULTIPLE AND SUBMULTIPLE UNITS

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

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

| COATED ELECTRODES | MAJOR USES | AWS CLASS | MIL-E-22200 TYPE |
|---|---|---|---|
| Nickel Welding Electrode 141 | Nickel 200 and Nickel 201; the clad side of nickel-clad steel; joining steels to nickel alloys. | ENi-1 | 4N11 |
| MONEL Welding Electrode 190 | MONEL alloy 400 to itself, to low-alloy and carbon steels, to copper and copper-nickel alloys; surfacing of steels. | ENiCu-7 | 9N10 |
| MONEL Welding Electrode 187 | MONEL alloy 450, weldable grades of cast and wrought 70/30, 80/20, and 90/10 copper-nickel alloys. | ECuNi | CuNi |
| INCONEL Welding Electrode 182 | INCONEL alloys 600 and 601; surfacing of steel; dissimilar combinations of steels and nickel alloys. | ENiCrFe-3 | 8N12 |
| INCONEL Welding Electrode 112 | INCONEL alloys 625 and 601; pit-resistant alloys; dissimilar combinations of steels and nickel alloys; surfacing of steels. | ENiCrMo-3 | 1N12 |
| INCONEL Welding Electrode 117 | INCONEL alloy 617; INCOLOY alloy 800HT; dissimilar combinations of high-temperature alloys. | ENiCrCoMo-1 | — |
| INCO-WELD Welding Electrode C-276 | INCONEL alloy C-276; other pit-resistant alloys; surfacing of steels. | ENiCrMo-4 | — |
| INCO-WELD A Electrode | INCOLOY alloys 800 and 800HT; dissimilar combinations of steels and nickel alloys; 9% nickel steel; surfacing of steels. | ENiCrFe-2 | — |
| NI-ROD Welding Electrode | Cast irons, especially for thin sections and machinability. | ENi-CI | — |
| NI-ROD 55 Welding Electrode | Cast irons, especially thick sections and high-phosphorus irons. | ENiFe-CI | — |
| NI-ROD 55X Welding Electrode | Cast irons, especially for out-of-position welding and high-phosphorus irons. | — | — |
| NI-ROD 99X Welding Electrode | Cast irons, especially for out-of-position welding, thin sections, and machinability. | — | — |
| INCONEL Welding Electrode 152 | 30% Cr for SMAW of INCONEL alloy 690 and other 30% Cr alloys; specifically designed for nuclear applications. | ENiCrFe-7 | — |
| INCONEL Welding Electrode 122 | For SMAW of alloys 622, C-22 and other NiCrMo alloys; excellent pitting and crevice corrosion resistance & resistance to mixed acids. Also for low NOx boiler tube overlay. | ENiCrMo-10 | — |
| INCO-WELD 686CPT Welding Electrode | Maximum resistance to pitting, crevice corrosion & mixed acids; excellent for overlay, welding of clad steels and providing overmatching corrosion-resistant welds for all types of NiCrMo alloys and super duplex stainless steels. | ENiCrMo-14 | — |

| FILLER METALS | MAJOR USES | AWS CLASS | MIL-E-21562 TYPE |
|---|---|---|---|
| Nickel Filler Metal 61 | Nickel 200 and Nickel 201; dissimilar combinations of nickel alloys and steels; surfacing of steels. | ERNi-1 | RN61<br>EN61 |
| MONEL Filler Metal 60 | MONEL alloys 400, R-405, and K-500; surfacing of steel. | ERNiCu-7 | RN60<br>EN61 |
| MONEL Filler Metal 67 | MONEL alloy 450; weldable grades of 70/30, 80/20 and 90/10 copper-nickel alloys. | ERCuNi | RN67<br>EN67 |
| INCONEL Filler Metal 82 | INCONEL alloys 600 and 601; INCOLOY alloys 800 and 800HT; INCO alloy 330; dissimilar combinations of steels and nickel alloys; surfacing of steels. | ERNiCr-3 | RN82<br>EN82 |
| INCONEL Filler Metal 92 | Dissimilar combinations of steels and nickel alloys. | ERNiCrFe-6 | RN6A<br>EN6A |
| INCONEL Filler Metal 601 | INCONEL alloy 601. | ERNiCrFe-11 | — |
| INCONEL Filler Metal 617 | INCONEL alloy 617; INCOLOY alloy 800HT; dissimilar combinations of high-temperature alloys. | ERNiCrCoMo-1 | — |
| INCONEL Filler Metal 625 | INCONEL alloys 625 and 601; pit-resistant alloys; dissimilar combinations of steels and nickel alloys; surfacing of steels. | ERNiCrMo-3 | RN625<br>EN625 |
| INCONEL Filler Metal 718 | INCONEL alloys 718 and X-750. | ERNiFeCr-2 | — |
| INCO-WELD Filler Metal C-276 | INCONEL alloy C-276; other pit-resistant alloys; surfacing of steels. | ERNiCrMo-4 | — |
| INCO-WELD Filler Metal HX | INCONEL alloy HX. | ERNiCrMo-2 | — |
| NC 80/20 Filler Metal | BRIGHTRAY electrical-resistant alloys; INCOLOY alloy DS. | — | — |
| NI-ROD Filler Metal 44 | Cast irons, especially robotic and automatic welding. | ERNiFeMn-CI | — |
| INCONEL Filler Metal 52 | 30% Cr for GMAW & GTAW welding of 690 and for overlays on steel; specifically designed for | ERNiCrFe-7 | — |



APPENDIX—WELDING PRODUCTS

| FILLER METALS | MAJOR USES | AWS CLASS | MIL-E-00000 TYPE |
|---|---|---|---|
| INCONEL Filler Metal 622 | For GMAW, GTAW, and SAW of alloys 622, C-22 and other NiCroMo alloys; excellent pitting and crevice corrosion-resistance and resistance to mixed acids; also for low NOx boiler tube overlay. | ERNiCrMo-10 | — |
| INCO-WELD 725NDUR Filler Metal | Age hardenable 625 version; capable of heat treated ultimate tensile of 180 KSI and Rc 34 hardness. | ERNiCrMo-15 | — |
| INCONEL Filler Metal 625BC | Designed for hot and cold wire GTAW applications for valve body overlay and internal bore cladding operations. | ERNiCrMo-3 | — |
| NI-ROD Filler Metal 99 | For GMAW, GTAW & SAW of all types of cast irons; best machinability in first layer or two layer overlays; not recommended for more than two layers. | | |
| NILO CF36 Filler Metal | For GMAW, GTAW & SAW of INVAR and similar low expansion alloys; deposits crack-free welds that are closely matching in CTE to INVAR. | | |
| NILO CF42 Filler Metal | Similar to NILO CF36, but is intended for 42% nickel low-expansion alloys. | | |
| NI-ROD 44HT Filler Metal | For GMAW & GTAW of high temperature ductile irons to each other and to stainless steels. | | |
| NI-ROD FC44 Cored Wire | For FCAW of all types of cast iron with 75A-25 CO2; especially suited to ductile iron welding for maximum strength and ductility of welds. | | |
| INCO-CORED 82DH Cored Wire | For flat position (1G) FCAW welding of INCONEL 600 and similar alloys and dissimilar combinations. | | |
| INCO-CORED 82AP Cored Wire | For all position FCAW welding of INCONEL 600 and similar alloys; also for dissimilar joints involving stainless steels, CrMo steels and carbon steels. | | |
| INCO-CORED 625DH Cored Wire | For flat position (1G) FCAW welding of 625 and lower alloyed NiCrMo materials such as super austenitics, and 4% and 6% Mo containing stainless steels. | | |
| INCO-CORED 625AP Cored Wire | For all position FCAW welding of 625 and lower alloyed NiCrMo materials such as super austenitics, and 4% and 6% Mo containing stainless steels. | | |

| THERMAL SPRAYS | MAJOR USES |
|---|---|
| DURANICKEL Thermal Spray 301TSW | For highest bond strength arc-spray build ups and bond coats; for bonding and protective coatings. |
| INCONEL Thermal Spray 625TSW | Corrosion-resistant arc-spray coatings used for pulp and paper and other industry applications. |
| INCONEL Thermal Spray 72TSW | Most sulfidation-resistant arc-spray product; used extensively in black liquor recovery boilers. |

| INCOFLUX | MAJOR USES |
|---|---|
| INCOFLUX 5 | For SAW butt welding with MONEL FM 60 and butt welding and overlaying of cast iron with NI-ROD FC 55. |
| INCOFLUX 6 | For SAW with FM 82, 625, 61, CF36, CF42, NI-ROD FM 99 and 44; for limited thickness butt welds and overlays. |
| INCOFLUX NT100 | Neutral SAW flux for overlays with FM 82, 625, 61 and NI-ROD FM 44 and 99; also used with FM CF36 and CF42. |
| INCOFLUX NT110 | Neutral SAW flux for overlaying with MONEL FM 60 and 67. |
| INCOFLUX NT120 | SAW flux for butt welding and overlaying with FMs C-276, 622, and 686CPT. |
| INCOFLUX ESS1 | High-deposition rate flux for strip overlays with INCONEL weldstrips 82, 625, and INCO-WELD weldstrip 686CPT with ESS processes. |
| INCOFLUX ESS2 | For electroslag strip welding overlay (ESSW) with INCONEL 52 and 52M Weldstrips. |
| INCOFLUX ESS3 | For electroslag strip welding overlay (ESSW) with INCONEL 82, 622 and 625 Weldstrips, and INCO-WELD C-276. |
| INCOFLUX ESS4 | For electroslag strip welding overlay (ESSW) with INCONEL 625 Weldstrips, and INCO-WELD C-276 and 86CPT. |
| INCOFLUX SAS1 | High deposition rate flux for strip overlays with INCONEL weldstrips 82 and 625. |
| INCOFLUX SAS2 | For submerged arc strip welding overlay (SASW) with INCONEL 52 and 52M Weldstrips. |

| WELDSTRIP | MAJOR USES |
|---|---|
| MONEL Weldstrip 60 | Weldstrip for producing MONEL 400 type overlays at high-deposition rates with the electroslag surfacing (ESS) and submerged arc strip (SAS) processes. |
| Nickel Weldstrip 61 | Weldstrip for producing nickel overlays at high-deposition rates with ESS and SAS processes. |
| INCONEL Weldstrip 82 | Weldstrip for high-deposition rate overlays of 20% Cr INCONEL alloy using ESS and SAS processes. |
| INCONEL Weldstrip 625 | Weldstrip for high-deposition rate overlays of INCONEL alloy 625 type using ESS and SAS processes. |

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## A CENTURY OF ALLOY INNOVATION

For over 100 years, Special Metals has been a world leader in the invention and production of highly engineered nickel alloys for demanding applications. In fact, Special Metals has invented over 80 percent of the nickel alloys in the market today—offering the industry's widest range of nickel alloys, cobalt alloys and product forms. As part of Precision Castparts Corporation (PCC), Special Metals can leverage the capabilities of other leaders in metal to offer an unmatched range of alloy components and products.