INCOLOY® alloy 907 (UNS N19907) is a nickel-iron-cobalt alloy having high strength along with a low coefficient of thermal expansion. The alloy is strengthened by age-hardening heat treatments. Table 1 lists the chemical composition of the alloy.

The combination of low expansion and high strength makes INCOLOY alloy 907 useful for gas-turbine components. The low expansion enables closer control of clearances and tolerances for greater fuel efficiency. The high strength makes possible higher strength-to-density ratios for lower weight in aircraft engines. For those reasons, INCOLOY alloy 907 is used for gas-turbine seals, shafts, casings, and other structural parts.

The properties of INCOLOY alloy 907 are attractive for other applications including instrumentation, glass-to-metal sealing, ceramic-molding dies, and electricity generation.

Physical Properties

Some physical properties of INCOLOY® alloy 907 are listed in Table 2. The values were determined for age-hardened material. Values for modulus of elasticity were determined dynamically and were used to calculate Poisson's ratio. Values were determined at room temperature unless otherwise noted.

The composition of INCOLOY alloy 907 is designed to provide a low coefficient of thermal expansion that remains constant over a broad temperature range. As shown in Figure 1, coefficient of expansion is typically 4.0 to 4.5 x 10^{-6}/°F (7.2 to 8.1 x 10^{-6}/°C) at temperatures to about 800°F (430°C). The expansion rate is about half that of other alloys of comparable strength. Further, the expansion characteristics of alloy 907 are highly reproducible after both static and cyclic exposure to temperature.

INCOLOY alloy 907 has a nearly constant modulus of elasticity over temperature ranges from the cryogenic region to 1200°F (650°C). Table 3 lists modulus values at various temperatures. Testing was done on age-hardened material using a dynamic method.

The combination of low expansion and constant modulus makes INCOLOY alloy 907 highly resistant to thermal fatigue and thermal shock. The alloy's high-temperature performance is also enhanced by relatively high thermal conductivity.

Table 1 - Limiting Chemical Composition, %

Nickel	35.0-40.0
Cobalt	12.0-16.0
Iron	Balance*
Niobium	4.3-5.2
Titanium	1.3-1.8
Aluminum	0.2 max.
Silicon	0.07-0.35

*Reference to the 'balance' of an alloy's composition does not guarantee this is exclusively of the element mentioned, but that it predominates and others are present only in minimal quantities.

Table 2 - Physical & Thermal Properties

Density, lb/in^3	0.301
Mg/cm^3	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
Thermal Conductivity at 200°F (93°C),	
Btu-in/ft^2-h-°F	108.5
W/m- °C	15.6
Electrical Resistivity, ohm circ mil/ft	419
µΩ-m	0.697
Young's Modulus, 10^3 ksi	23.9
GPa	165
Shear Modulus, 10^3 ksi	8.8
GPa	61
Poisson's Ratio	0.36

Table 3 - Modulus of Elasticity of Age-Hardened[a] INCOLOY alloy 907

Temperature		Young's Modulus		Shear Modulus		Poisson's Ratio
°F	°C	10^3 ksi	GPa	10^3 ksi	GPa	
70	21	23.9	165	8.8	61	0.36
200	93	23.8	164	8.7	60	0.37
400	204	23.8	164	8.7	60	0.37
600	316	24.0	165	8.9	61	0.35
700	371	24.1	166	9.0	62	0.34
800	427	24.3	168	9.1	63	0.34
900	482	24.2	167	9.0	62	0.34
1000	538	23.9	165	8.8	61	0.36
1200	649	23.0	159	8.4	58	0.36
1400	760	21.8	150	8.0	55	0.36
1600	871	20.5	141	7.4	51	0.39

[a]Age hardened for rupture-limited applications

Mechanical Properties

In the age-hardened condition, INCOLOY® alloy 907 has high mechanical properties. For example, when heat treated for optimum tensile properties, INCOLOY alloy 907 has yield and tensile strengths similar to those of INCONEL® alloy 718.

INCOLOY alloy 907 normally receives one of two heat treatments, depending on whether the strength requirements of the application are tensile limited or rupture limited. For tensile-limited applications, the age-hardening treatment is:

1325°F (720°C)/8 h, furnace cool at 100°F (55°C)/h to 1150°F (620°C)/8 h, air cool.

For rupture-limited applications, the treatment is:

1425°F (775°C)/12 h, furnace cool at 100°F (55°C)/h to 1150°F (620°C)/8 h, air cool.

Before either age-hardening treatment, the alloy is given a solution anneal of 1800°F (980°C)/1 h, air cool. Heat treatment of INCOLOY alloy 907 is covered by a U.S. patent.

Table 4 shows tensile properties of INCOLOY alloy 907 at room temperature and various elevated temperatures. The material tested had been given the heat treatment for tensile-limited applications. Tensile properties of material heat treated for rupture-limited applications are listed in Table 5. All tensile testing was in the long-transverse direction using specimens from 5-in × 0.75-in (127-mm × 19-mm) flat bars.

Stress-rupture strength of material given the heat treatment for rupture-limited applications is given in Figure 2. The test orientation of the specimens was transverse to the hot-rolling direction used in production of the bar stock.

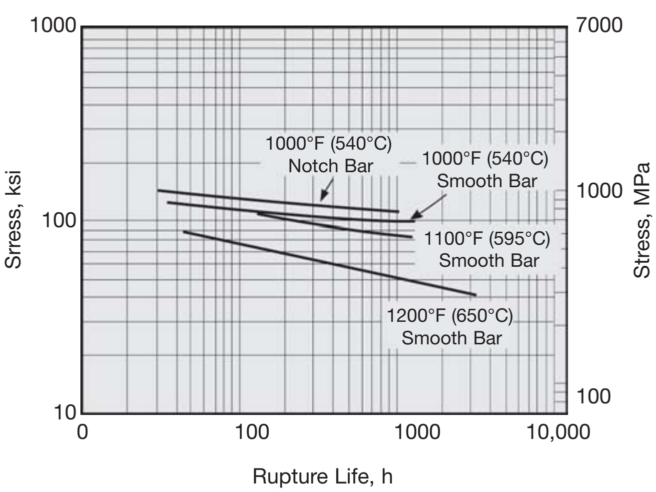

Figure 2. Rupture strength of age-hardened INCOLOY alloy 907. Notch-bar specimens: $K_t = 2.0$. Test material was given the heat treatment for rupture-limited applications.

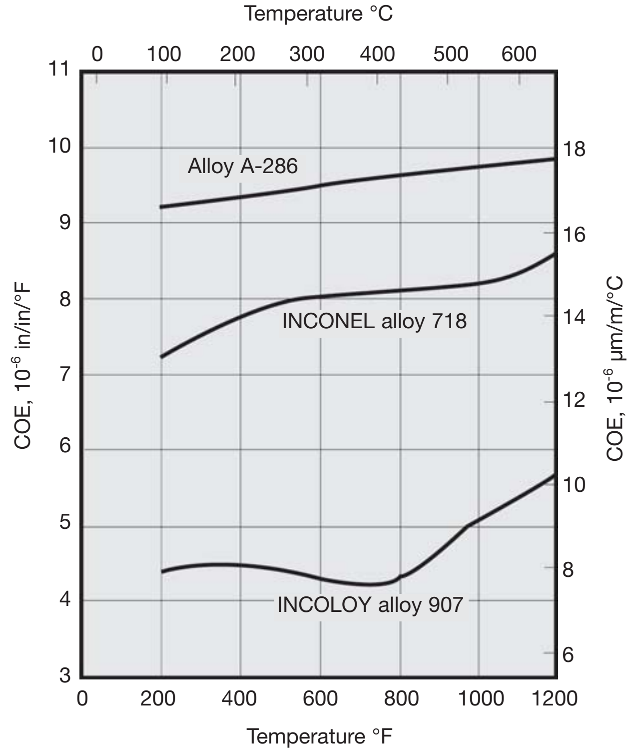

Figure 1. Coefficients of expansion of INCOLOY alloy 907 and other high-strength alloys. Alloy 907 was heat treated for rupture-limited applications.

Table 4 - Tensile Properties of Age-Hardened[a] INCOLOY alloy 907

Temperature		Yield Strength (0.2% Offset)		Tensile Strength		Elonga-tion,	Reduc-tion of Area,
°F	°C	ksi	MPa	ksi	MPa	%	%
70	20	162.5	1120	194.5	1341	15.0	36.5
800	427	142.4	982	168.3	1160	14.9	40.7
1000	538	137.5	948	164.3	1133	13.8	42.2
1200	649	126.2	870	151.2	1043	10.2	26.8
1400	760	82.0	565	93.9	647	20.9	52.0

[a]Age hardened for tensile-limited applications

Table 5 - Tensile Properties of Age-Hardened[a] INCOLOY alloy 907

Temperature		Yield Strength (0.2% Offset)		Tensile Strength		Elonga-tion,	Reduc-tion of Area,
°F	°C	ksi	MPa	ksi	MPa	%	%
70	20	128.5	886	175.5	1210	16.0	25.0
800	427	105.1	725	154.8	1067	16.6	32.6
1000	538	105.5	727	150.2	1036	15.8	38.0
1200	649	98.7	681	136.5	941	19.8	42.2
1400	760	63.5	438	77.4	534	31.5	70.2

[a]Age hardened for rupture-limited applications

Microstructure

The heat treatment given INCOLOY alloy 907 for rupture-limited applications is an over-aging treatment designed to optimize the alloy's notch-bar rupture strength. The heat treatment causes localized precipitation, both intergranular and intragranular, of Ni_3 (Nb, Ti) phase. The acicular, hexagonal phase is referred to as epsilon or epsilon double-prime.

Corrosion Resistance

INCOLOY alloy 907 contains no chromium because the presence of that element would increase thermal expansion. The absence of chromium, however, makes the alloy more susceptible to oxidation in high-temperature atmospheres. In some applications, INCOLOY alloy 907 may require a protective coating to prevent excessive oxidation. Figure 3 compares INCOLOY alloy 907 with INCONEL® alloy 718 (19% chromium) in a cyclic oxidation test at 1200°F (650°C).

A characteristic of INCOLOY alloy 907 is that unlike other alloys of comparable strength, it has good resistance to embrittlement in high-pressure hydrogen.

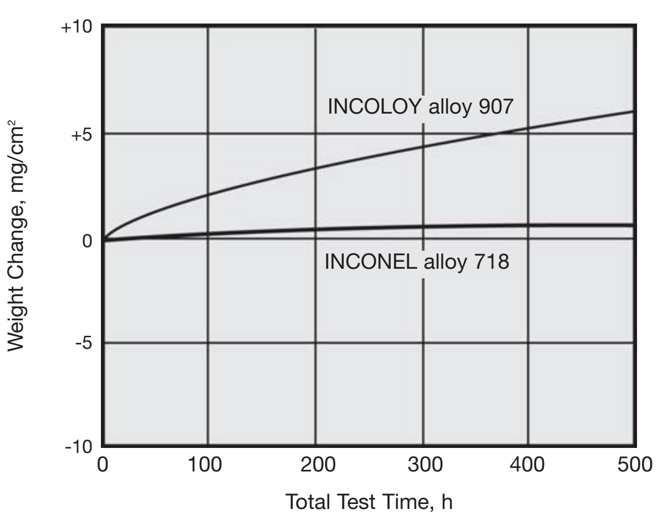

Figure 3 - Resistance to cyclic oxidation at 1200°F (650°C). Cycles consisted of 15 minutes of exposure to temperature and 5 minutes of cooling in air.

Fabrication

HOT WORKING

INCOLOY alloy 907 has hot-working characteristics similar to those of INCONEL alloy 718. The temperature range for hot working is 1650°F to 2100°F (900°C to 1150°C). Some hot working should be done at 1850°F to 1950° (1010°C to 1065°C) to refine the grain structure. A final reduction of at least 20% at a temperature under 1800°F (980°C) is needed for optimum mechanical properties.

MACHINING

INCOLOY alloy 907 is machined by conventional practices for high-strength materials. In machinability tests, INCOLOY alloy 907 is similar to INCONEL alloy 718. Best results are obtained when machining is done on annealed material. Tooling and procedures should be those given for Group D-2 alloys in the publication "Machining" on the website www.specialmetals.com.

WELDING

INCOLOY alloy 907 has good weldability similar to that of INCONEL alloy 718. The alloy has been successfully welded by gas-metal-arc, gas-tungsten-arc, and electron-beam processes. Matching-composition filler metal and INCONEL Filler Metal 718 have been used.

Available Products

INCOLOY alloy 907, designated UNS N19907, is available as round bar and forging stock. Further information on availability may be obtained from the nearest Special Metals office.

Publication Number SMC-098

SPECIAL METALS

www.specialmetals.com

U.S.A.
Special Metals Corporation

Billet, rod & bar, flat & tubular products
3200 Riverside Drive
Huntington, WV 25705-1771
Phone +1 (304) 526-5100
+1 (800) 334-4626
Fax +1 (304) 526-5643

Billet & bar products
4317 Middle Settlement Road
New Hartford, NY 13413-5392
Phone +1 (315) 798-2900
+1 (800) 334-8351
Fax +1 (315)798-2016

Atomized powder products
100 Industry Lane
Princeton, KY 42445
Phone +1 (270) 365-9551
Fax +1 (270) 365-5910

Shape Memory Alloys
4317 Middle Settlement Road
New Hartford, NY 13413-5392
Phone +1 (315) 798-2939
Fax +1 (315) 798-6860

United Kingdom

Special Metals Wiggin Ltd.
Holmer Road
Hereford HR4 9SL
Phone +44 (0) 1432 382200
Fax +44 (0) 1432 264030

Special Metals Wire Products
Holmer Road
Hereford HR4 9SL
Phone +44 (0) 1432 382556
Fax +44 (0) 1432 352984

China

Special Metals Pacific Pte. Ltd.
Room 1802, Plaza 66
1266 West Nanjing Road
Shanghai 200040
Phone +86 21 3229 0011
Fax +86 21 6288 1811

Special Metals Pacific Pte. Ltd.
Room 910, Ke Lun Mansion
12A Guanghua Road
Chaoyang District
Beijing 100020
Phone +86 10 6581 8396
Fax +86 10 6581 8381

France

Special Metals Services SA
17 Rue des Frères Lumière
69680 Chassieu (Lyon)
Phone +33 (0) 4 72 47 46 46
Fax +33 (0) 4 72 47 46 59

Germany

Special Metals Deutschland Ltd.
Postfach 20 04 09
40102 Düsseldorf
Phone +49 (0) 211 38 63 40
Fax +49 (0) 211 37 98 64

Hong Kong

Special Metals Pacific Pte. Ltd.
Unit A, 17th Floor, On Hing Bldg
1 On Hing Terrace
Central, Hong Kong
Phone +852 2439 9336
Fax +852 2530 4511

India

Special Metals Services Ltd.
No. 60, First Main Road, First Block
Vasantha Vallabha Nagar
Subramanyapura Post
Bangalore 560 061
Phone +91 (0) 80 2666 9159
Fax +91 (0) 80 2666 8918

Italy

Special Metals Services SpA
Via Assunta 59
20054 Nova Milanese (MI)
Phone +390 362 4941
Fax +390 362 494224

The Netherlands

Special Metals Service BV
Postbus 8681
3009 AR Rotterdam
Phone +31 (0) 10 451 44 55
Fax +31 (0) 10 450 05 39

Singapore

Special Metals Pacific Pte. Ltd.
24 Raffles Place
#27-04 Clifford Centre
Singapore 048621
Phone +65 6532 3823
Fax +65 6532 3621

Affiliated Companies

Special Metals Welding Products
1401 Burris Road
Newton, NC 28658, U.S.A.
Phone +1 (828) 465-0352
+1 (800) 624-3411
Fax +1 (828) 464-8993

Canada House
Bidavon Industrial Estate
Waterloo Road
Bidford-On-Avon
Warwickshire B50 4JN, U.K.
Phone +44 (0) 1789 491780
Fax +44 (0) 1789 491781

Controlled Products Group
590 Seaman Street, Stoney Creek
Ontario L8E 4H1, Canada
Phone +1 (905) 643-6555
Fax +1 (905) 643-6614

A-1 Wire Tech, Inc.
A Special Metals Company
4550 Kishwaukee Street
Rockford, IL 61109, U.S.A.
Phone +1 (815) 226-0477
+1 (800) 426-6380
Fax +1 (815) 226-0537

Rescal SA
A Special Metals Company
200 Rue de la Couronne des Prés
78681 Epône Cédex, France
Phone +33 (0) 1 30 90 04 00
Fax +33 (0) 1 30 90 02 11

DAIDO-*SPECIAL METALS* Ltd.
A Joint Venture Company
Daido Shinagawa Building
6-35, Kohnan 1-chome
Minato-ku, Tokyo 108-0057, Japan
Phone +81 (0) 3 5495 7237
Fax +81 (0) 3 5495 1853