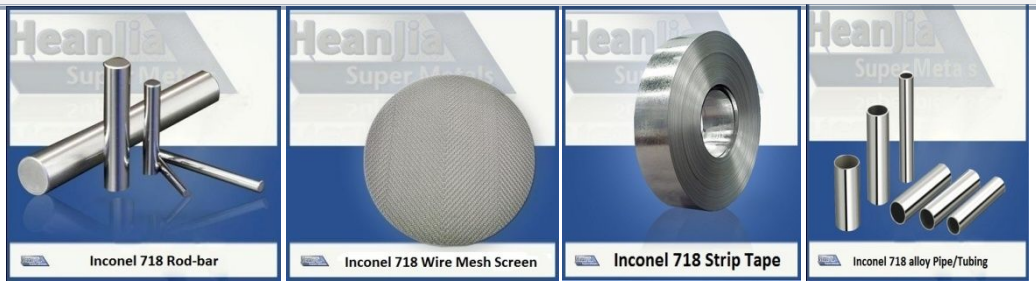
Nickel-Chromium Alloy Inconel Alloy 718 (UNS N07718)



Inconel 718 is a nickel-chromium-molybdenum alloy that is made to offer resistance to the variety of corrosive conditions, pitting and crevice corrosion. It offers high tensile and creeping strength at the elevated temperatures. It is employed in the applications from cryogenic temperatures to 1200oF for prolong service. Nickel 718 super alloy is a preferred material for use in aeronautics and land based gas turbines, marine engineering, pollution control, nuclear power plants, nuclear fuel processing and other industries.

An easy to form and economical alloy 718 offers high tensile strength, fatigue strength, creeping resistance and stress rupturing properties that are widely useful in the different applications.

Chemical Composition

Carbon (C)	0.08 %	Aluminum (Al)	0.35 to 0.80 %
Manganese (Mn)	0.35 %	Molybdenum (Mo)	2.80 % to 3.30 %
Silicon (Si)	0.35 %	Titanium (Ti)	0.65 % to 1.15 %
Phosphorous (P)	0.015 %	Boron (B)	0.001 to 0.006 %
Sulfur (S)	0.015 %	Chromium (Cr)	17 to 21 %
Nickel + Cobalt	50 to 55 %	Cobalt (Co)	1 %
Iron (Fe)	Rem %	Copper (Cu)	0.15 %
Columbium + Tantalum	4.75 to 5.50 %		

Physical Properties

Density of annealed alloy 718	0.296 lb/in3
Density of annealed and aged alloy 718	0.297 lb/in3
Melting Point	2300-2437oF, 1260-1336oC
Specific Heat at 70oF, Btu/lb oF	0.104 (435)
Curie Temperature of annealed welding alloy	<-320 oF , <-196oC
Curie Temperature annealed and aged alloy	-170oF (-112oC)
Permeability at 200 oersted and 70oF of Annealed Material	1.0013

Thermal Properties

Temp, oF	Thermal Conductivity, BTU•in/ft 2 •h•oF		Electrical Resistivity, A ohm circ mil/ft, Ann. 1800oF/1 hr	Mean Linear Expansion, in/in/oF x 10-6
	Ann. 1800°F/1 hr	Ann. + Aged		
70 oF	77	79	753	-
200 oF	86	87	762	7.31
400 oF	98	100	772	7.53
600 oF	111	112	775	7.74
800 oF	123	124	784	7.97
1000 oF	135	136	798	8.09
1200 oF	147	148	805	8.39

Dynamic Modulus of Elasticity

Temperature		x 10 (6) Psi	MPa x 10(3)
oF	oC		
70 oF	21 oC	29.6 x 10 (6) psi	208 x 10(3) MPa
200 oF	93 oC	29.2 x 10 (6) psi	205 x 10(3) MPa
400 oF	204 oC	28.8 x 10 (6) psi	202 x 10(3) MPa
600 oF	316 oC	27.6 x 10 (6) psi	194 x 10(3) MPa
800 oF	427 oC	26.5 x 10 (6) psi	186 x 10(3) MPa
1000 oF	538 oC	25.5 x 10 (6) psi	179 x 10(3) MPa
1200 oF	649 oC	24.5 x 10 (6) psi	172 x 10(3) MPa
1400 oF	760 oC	23.1 x 10 (6) psi	162 x 10(3) MPa
1600 oF	871 oC	18.1 x 10 (6) psi	127 x 10(3) MPa
1750 oF	954 oC	11.1 x 10 (6) psi	78 x 10(3) MPa

Average coefficient of thermal expansion

Temperature		10 (-6) /oF	10 (-6) /oC
oF	oC		
77oF to 200oF	93 oC	7.1	12.8
77 oF to 400 oF	204 oC	7.5	13.5
77 oF to 600 oF	316 oC	7.7	13.9
77 oF to 800 oF	427 oC	7.9	14.2
77 oF to 1000 oF	538 oC	8	14.4
77 oF to 1200 oF	649 oC	8.4	15.1
77 oF to 1400 oF	760 oC	8.9	16

Mechanical Properties

The mechanical features, modulus of elasticity and other features vary on the base of chemical composition and environments in which the alloy is subjected.

High temperature tensile properties

Temperature		0.2% yield strength		Tensile strength		Elongation % 2 inch
oF	oC	Ksi	Mpa	Ksi	Mpa	
200 oF	93 oC	170 Ksi	1172 Mpa	204 Ksi	1407 Mpa	21 %

400 oF	204 oC	163 Ksi	1124 Mpa	198 Ksi	1365 Mpa	20 %
600 oF	316 oC	159 Ksi	1096 Mpa	195 Ksi	1344 Mpa	20 %
800 oF	427 oC	156 Ksi	1076 Mpa	191 Ksi	1317 Mpa	19 %
1000 oF	538 oC	155 Ksi	1069 Mpa	185 Ksi	1276 Mpa	18 %
1200 oF	649 oC	149 Ksi	1027 Mpa	168 Ksi	1158 Mpa	19 %
1400 oF	760 oC	110 Ksi	758 Mpa	110 Ksi	758 Mpa	27 %

Stress Rupture strength after heat processing at 1800oF for 60 minutes, air cooling up to 1325oF for 8 hours, cooling rate 100oF per hour to 1150oF, hold for 8 hours, air quenching.

Temperature		Stress for Rupture							
oF	oC	100 hours				1000 hours			
		Smooth		Notch		Smooth		Notch	
		Ksi	Mpa	Ksi	Mpa	Ksi	Mpa	Ksi	Mpa
1100 oF	593 oC	170 Ksi	1172 Mpa	220 Ksi	1517 Mpa	130 Ksi	896 Mpa	205 Ksi	1416 Mpa
1200 oF	649 oC	110 Ksi	758 Mpa	195 Ksi	1344 Mpa	85 Ksi	586 Mpa	170 Ksi	1172 Mpa
1300 oF	704 oC	75 Ksi	517 Mpa	130 Ksi	896 Mpa	55 Ksi	379 Mpa	80 Ksi	552 Mpa
1400 oF	760 oC	44 Ksi	303 Mpa	63 Ksi	434 Mpa	25 Ksi	172 Mpa	35 Ksi	241 Mpa

Tensile Characteristics of Inconel 718

Different proprietary heat processes are used for Inconel alloy 718 on the base of needed features. The heating methods are often extended to meet the demand of clients.

The following table describes the mechanical features of In 718

Condition	Diameter, in.(mm)	Tensile Strength, ksi (Kg/cm 2)min.	Yield Strength, ksi (Kg/cm2)		Elongation in 2 in. (50.8 mm) or4D% minimum	Reduction of Area, % Min.	Impact Strength, ft•lb (Kg•m) min. average
			Min.	Max.			
Cold worked, solution annealed & aged	0.5 (12.7) to 3 (76.2),	150 (10,545)	120 (8436)	140 (9842)	20	25	40 (5.55)
Hot worked solution annealed & aged	0.5 (12.7) to 8 (203.2),	150 (10,545)	120 (8436)	140 (9842)	20	25	40 (5.55)
Hot worked solution annealed & aged	8 (203.2) to 10 (254)	150 (10,545)	120 (8436)	140 (9842)	20	25	40 (5.55)

Room temperature tensile properties of Inconel 718 bar

Heat Treatment	Tensile Strength, ksi	Yield Strength, ksi	Elongation, %	Reduction of Area %
As-Rolled	140.0 ksi	85.7 ksi	46 %	58 %
1750°F/1 hr	140.0 ksi	83.0 ksi	45 %	49 %

1950°F/1 hr	117.5 ksi	48.5 ksi	58 %	64 %
1750°F/1 hr, Age	208.0 ksi	180.0 ksi	21 %	39 %
1950°F/1 hr, Age	194.0 ksi	157.0 ksi	23 %	34 %

Elevated and low temperature features

Temperature, oF	Tensile strength, ksi	Yield strength, ksi	Elongation %
600 oF	183.5 ksi	163.0 ksi	16 %
1000 oF	173.0 ksi	156.0 ksi	16 %
1200 oF	160.0 ksi	148.0 ksi	15 %
1300 oF	146.0 ksi	140.0 ksi	8 %

Corrosion Resistance

Inconel 718 alloy provides excellent resistance to corrosion in the diverse environments. It offers similar resistance to that of nickel-chromium alloy. Due to presence of nickel it offers significant resistance to the organic and inorganic compounds. Alloy 718 gives excellent resistance to acidity and alkaline media and chloride ion stress corrosion cracking. Due to presence of chromium it is capable to adhere in oxidizing conditions and sulfur compounds. Molybdenum element gives resistance to pitting corrosion in the various conditions.

Fabrication

Inconel 718 alloy can be readily machined however the strength and work toughening features should be considered while choosing and using the precise apparatus alloys and design, processing speed and quenchers. When machining in the age toughened form, the strip offers the enhanced finish, chip performance on the chip breaker tools are enhanced. If annealed alloy is used, it provides more convenient machining and extended tool life.

Hot Forging

The hot forging is done in 1650oF to 2050oF temperature. In the end process of alloy 718, it is processed evenly in the gradually reducing temperature, finishing with low reduction at 1650oF to 1750oF. This temperature range is essential to ensure the high ductility in the stress rupture operations when alloy is annealed and aged. While heating for hot processing, Inconel 718 alloy is recommended to bring at the temperature permitted to absorb the short time to ensure the symmetry. To inhibit the duplex grain configuration Inconel 718 must be provided with the even reductions. The symmetric reductions of minimum 20% are implemented for open die processing and minimum 10% for closed die processing. The components should be air cooled from hot processing point than water cooling.

Precautions are important to inhibit the overheating of alloy through heat formation while processing. Inconel 718 alloy should be reheated when any section is quenched lower to

1650oF. The former heating devices and dies to 500oF is preferred. The cracks observed on the alloy's surface should be removed immediately.

Heating and Pickling

Inconel 718 alloy is heated cautiously to keep the incinerator and alloy getting heated at the specific temperature limits. The fuel that is utilized in the furnace should contain less content of sulfur. The specimen taken must be properly clean and dust free. The furnace conditions should be reducing to conduct forging or annealing. When Inconel 718 is heated in the reducing conditions, it produces green-black oxide layer. When it is heated in the oxidizing conditions, massive black layer is created that is tough to clean. Thus proper care should be taken to get only green black layer created.

Available forms

Wire, mesh, rod, bar, tube, pipe, sheet, plate, foil, strip, flanges