Alloy 718

Alloy 718 - Nickel-Base Superalloy

(UNS Designation N07718)

INTRODUCTION

Alloy 718 (N07718) is an austenitic nickel-base superalloy which is used in applications requiring high strength to approximately 1400°F (760°C) and oxidation resistance to approximately 1800°F (982°C). In addition, the alloy exhibits excellent tensile and impact strength even at cryogenic temperatures.

High strength at room and elevated temperatures is developed by a precipitation heat treatment at 1325°F (718°C) with cooling and a hold at 1150°F (621°C). The relatively slow response to precipitation hardening permits repair welding of the Alloy 718 even in the aged condition.

The Alloy 718 is usually produced by a double melt practice using consumable electrode remelt procedures to provide homogeneity and extremely clean structures.

FORMS AND CONDITIONS AVAILABLE

The Alloy 718 is available in plate, sheet and strip and long product forms. The alloy is generally supplied in the solution treated condition.

SPECIFICATIONS

Alloy 718 is covered by the following specifications:

Product Form	AMS	ASTM	ASME
Sheet, Strip and Plate	5596 5597	B670	
Castings	5583		
Seamless Tube	5589 5590		
Bar, Forgings and Rings	5662 5663 5664	B637	SB-637
Welding Wire	5832		SFA-5.14
Bolting		B1014	

JACQUET

Alloy 718

TYPICAL ANALYSIS

Element	Percent
Carbon	0.05
Manganese	0.10
Phosphorus	0.006
Sulfur	0.001
Silicon	0.15
Chromium	18.5
Nickel	53.0
Molybdenum	3.0
Columbium Plus Tantalum	5.1
Titanium	1.0
Aluminum	0.50
Cobalt	0.30
Boron	0.003
Copper	0.05
Iron	Balance

A restricted analysis with maximum contents of 0.10 percent cobalt and 0.10 percent tantalum is available for nuclear and other special applications.

Corrosion and Oxidation Resistance

The Alloy 718 has good resistance to oxidation and corrosion at temperatures in the alloy's useful strength range in atmospheres encountered in jet engines and gas turbine operations.

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PHYSICAL PROPERTIES

Typical Values

Density

Annealed Condition	0.296 lb/in^3	8.19 g/cm^3
Aged Condition	0.297 lb/in^3	8.22 g/cm^3

Specific Gravity

Annealed Condition	8.19
Aged Condition	8.22

Linear Coefficient of Thermal Expansion

Temperature Range		Mean Coefficient of Thermal Expansion (Units of 10^{-6})	
°F	°C	/°F	/°C
70- 200	21- 93	7.1	12.8
70- 400	21-204	7.5	13.5
70- 600	21-316	7.7	13.9
70- 1000	21-538	8.0	14.4
70-1200	21-649	8.4	15.1
70-1400	21-760	8.9	16.0

Thermal Conductivity

Temperature Range		Thermal Conductivity	
F	C	Btu-ft/ft^2 h- F	W/m•K
32-212	0-100	6.5	11.2

Electrical Resistivity at 68 F (20 C)

Annealed	127 microohm-cm
Aged	121 microohm-cm

Elastic Modulus, Modulus of Rigidity and Poisson's Ratio

Temperature		Elastic Modulus (E)		Modulus of Ridigity (G)		Poisson's Ratio (μ)
°F	°C	Units of 10^6 psi	GPa	Units of 10^6 psi	GPa	
70	21	29.0	200	11.2	77	0.294
200	93	28.4	196	11.0	76	0.288
400	204	27.6	190	10.8	74	0.280
600	316	26.7	184	10.5	72	0.272
800	427	25.8	178	10.1	70	0.271
1000	538	24.8	171	9.7	67	0.271
1200	649	23.7	163	9.2	63	0.283
1400	760	22.3	154	8.5	59	0.306

MECHANICAL PROPERTIES

Room Temperature Properties

The room temperature strength of the Alloy 718 is substantially increased by precipitation heat treatment as the following data indicate. These values are properties specified for sheet, strip and plate in AMS 5596 and AMS 5597.

Solution Treated

Yield Strength (0.2% Offset)	Ultimate Tensile Strength	Elongation (Percent in 2")
Sheet and Strip		
80,000 psi (max)	140,000 psi (max)	30 (min)
550 MPa (max)	965 MPa (max)	
Plate		
105,000 psi (max)	150,000 psi (max)	30 (min)
725 MPa (max)	1,035 MPa (max)	
Solution Treated plus Precipitation Heat Treatment		
Yield Strength (0.2% Offset)	**Ultimate Tensile Strength**	**Elongation (Percent in 2")**
150,000 psi (min)	180,000 psi (min)	12 (min)
1,035 MPa (min)	1,240 MPa (min)	

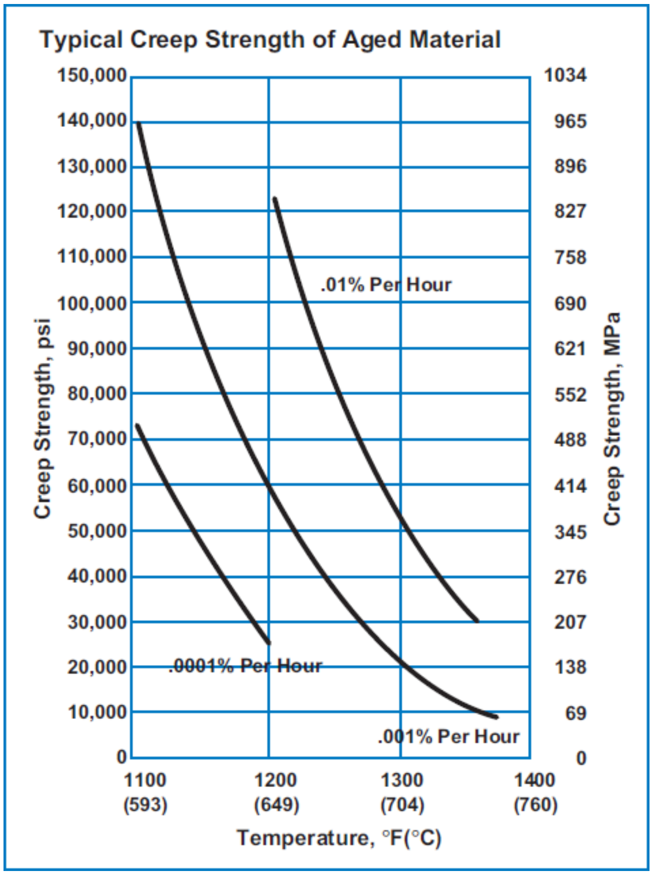
Typical Short Time Tensile Properties as a Function of Temperature

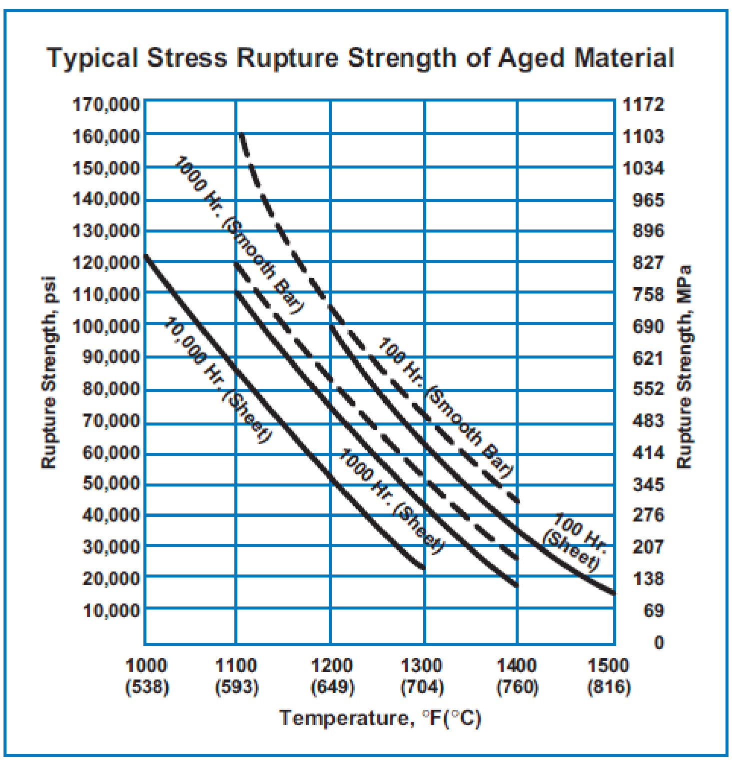
Typical short time tensile properties as a function of temperature are shown here for material solution treated and aged as follows:

Solution Treatment:	1800°F (982°C) 1 hour
Precipitation Treatment:	1325°F (718°C) 8 hours Furnace Cool at 100°F (55°C) per hour to 1150°F (621°C) 1150°F (621°C) 8 hours

Temperature		Yield Strength 0.2% Offset		Ultimate Tensile Strength		Elongation Percent in 2"
°F	°C	psi	MPa	psi	MPa	
70	21	174,000	1200	208,000	1435	21
400	204	163,000	1125	198,000	1365	20
800	427	157,000	1080	192,000	1325	19.5
1000	538	154,500	1065	186,000	1280	19
1200	649	148,000	1020	168,000	1160	19
1300	704	137,000	945	145,500	1005	20

Typical creep and stress rupture strengths are shown in figure form.


Typical Creep Strength of Aged Material
Creep Strength, psi
Creep Strength, MPa
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1034
965
896
827
758
690
621
552
488
414
345
276
207
138
69
0
.01% Per Hour
.0001% Per Hour
.001% Per Hour
1100
(593)
1200
(649)
1300
(704)
1400
(760)
Temperature, °F(°C)


Typical Stress Rupture Strength of Aged Material
Rupture Strength, psi
Rupture Strength, MPa
170,000
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
1172
1103
1034
965
896
827
758
690
621
552
483
414
345
276
207
138
69
0
1000 Hr. (Smooth Bar)
10,000 Hr. (Sheet)
100 Hr. (Smooth Bar)
1000 Hr. (Sheet)
100 Hr. (Sheet)
1000
(538)
1100
(593)
1200
(649)
1300
(704)
1400
(760)
1500
(816)
Temperature, °F(°C)

WELDING

Because of a relatively slow aging reaction rate, welding Alloy 718 does not present the problems associated with most other high-temperature precipitation hardening alloys. Alloy 718 may be welded in either the annealed or precipitation hardened condition. Accordingly, the alloy may be repair welded without difficulty.

Inert gas tungsten arc (TIG) welding is recommended using Alloy 718 weld filler metal or other nickel base superalloy compositions. It does not appear necessary to stress relieve weldments prior to aging.

Alloy 718 is subject to Laves phase (Fe_2Cb) formation during solidification. This phase reduces the strength and toughness of weldments. This phase is dissolved by a 1900-1950°F (1038-1066°C) solution heat treatment.

Heat Treatment

Alloy 718 depends for strength on a precipitation hardening reaction involving nickel, columbium, titanium and aluminum, although some solid solution strengthening is derived from its molybdenum content.

The optimum temperature for annealing or solution treating Alloy 718 is determined by the relative importance of short or long time elevated temperature mechanical properties. If maximum short time yield and tensile strengths are required, the alloy should be solution treated at 1725 to 1825°F (940-995°C) prior to aging; best long time stress rupture or creep properties are obtained by solution treating at 1900 to 1950°F (1038-1066°C) and aging. If excess phases are present in the microstructure, they are more readily dissolved by the higher temperature solution treatment.

The best aging treatment following solution treatment is to hold the alloy at 1325 to 1350°F (718-732°C) for 8 hours, followed by furnace cooling to 1150 to 1200°F (621-649°C), holding for 8 hours and then air cooling. Since cold rolling accelerates the precipitation hardening reaction, cold rolled sheet, if not solution treated after cold reduction, develops optimum strength if aged at 1275°F (691°C) for 16 hours.

APPLICATIONS

Based on its high-temperature resistance up to 700 °C (1,300 °F), its excellent oxidation and corrosion resistance, and its good workability, Alloy 718 is used in many demanding applications. Originally, it was developed and used for static and rotating components in aircraft turbines such as housings, mounting elements and turbine disks, where tough requirements apply for creep resistance and fatigue behavior, in particular for the rotating applications. Due to its properties, its good workability and efficiency, the material is additionally widely used for static and rotating components in stationary gas turbines, rocket drives and spacecraft, motor vehicle turbo chargers, high-strength screws, springs and mounting elements, and for heat-resistant tools in forgeries, extruders and separating shearers.