HAYNES® 718 alloy

Principal Features

HAYNES® 718 alloy (UNS N07718) is an age-hardenable nickel-iron-chromium-niobium (columbium)-molybdenum-titanium-aluminum alloy designed to combine excellent strength with good fabrication characteristics in the annealed condition. While limited to applications below 1200°F (650°C), it is significantly stronger at these lower temperatures than materials such as Waspaloy alloy, R-41 alloy, or X-750 alloy. It is also much easier to weld than these alloys, and is less susceptible to the strain age cracking problems common for gamma prime strengthened materials. At temperatures greater than 1200°F (650°C), 718 alloy is being replaced by HAYNES® 282® alloy due to the superior strength of 282® alloy at those temperatures as well as its excellent fabricability.

HAYNES® 718 alloy is normally only used for component applications up to 1200°F (650°C); however, its oxidation resistance is comparable to that for other gamma-prime-strengthened superalloys.

Nominal Composition

Weight %

Nickel:	52 Balance
Cobalt:	1 max.
Iron:	19
Chromium:	18
Columbium + Tantalum	5
Molybdenum:	3
Manganese:	0.35 max.
Silicon:	0.35 max.
Titanium:	0.9
Aluminum:	0.5
Carbon:	0.05
Boron:	0.004

Creep and Stress-Rupture Strengths

HAYNES® 718 Sheet, Age-Hardened*

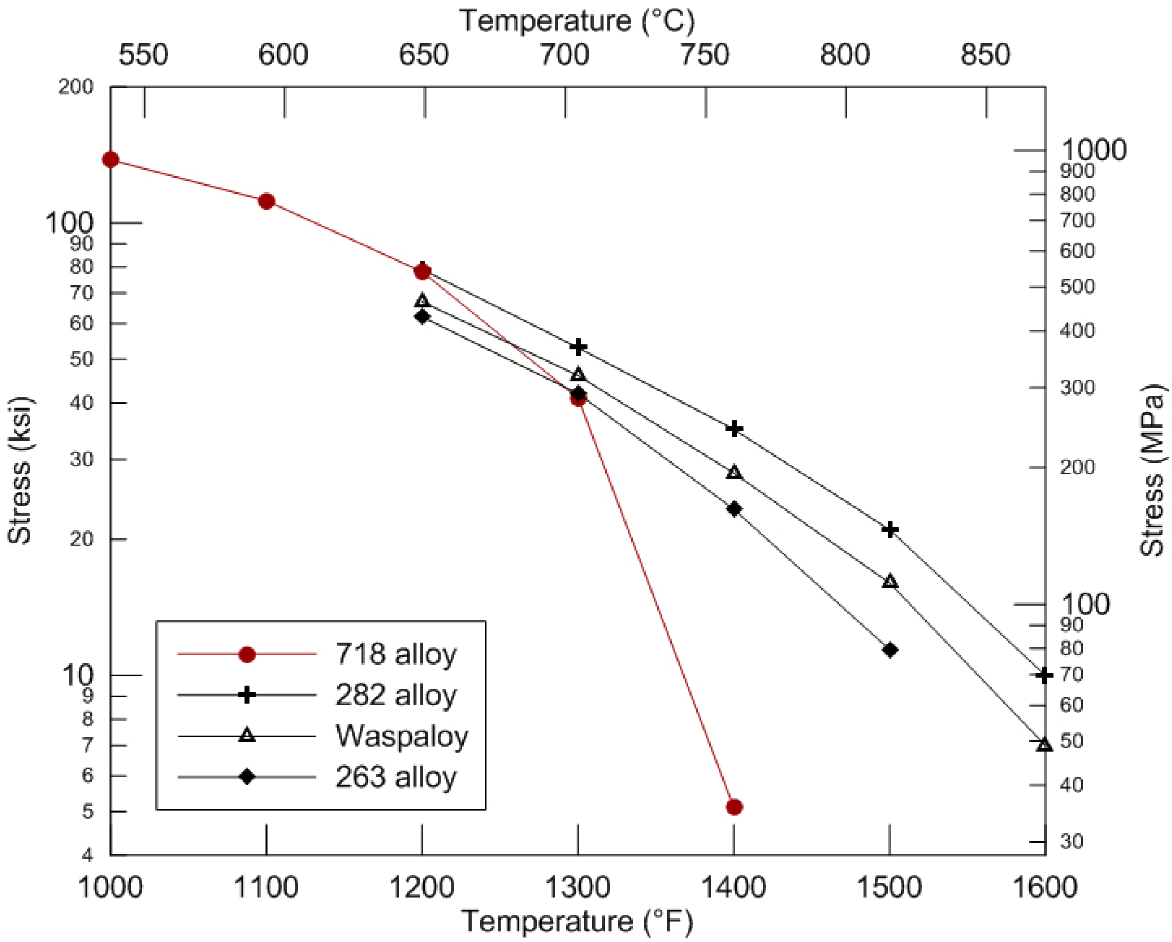
Temperature		Creep	Approximate Initial Stress to Produce Specified Creep in					
			10h		100h		1,000h	
°F	°C	%	ksi	MPa	ksi	MPa	ksi	MPa
1000	538	0.5	157	1083	146	1007	132	910
		1	160	1103	150	1034	138	952
		R	-	-	165	1138	144	993
1100	593	0.5	140	965	126	869	108	745
		1	143	986	130	896	112	772
		R	150	1034	134	924	115	793
1200	649	0.5	121	834	101	696	75	517
		1	124	855	103	710	78	538
		R	130	896	105	724	87	600
1300	704	0.5	95	655	64	441	35	241
		1	98	676	67	462	41	283
		R	106	731	76	524	46	317
1400	760	0.5	54	372	24	165	3.8	26
		1	60	414	28	193	5.1	35
		R	70	483	37	255	17	117

*Samples were age hardened by treating at 1325°F (718°C)/8h/FC to 1150°F (621°C)/8h/AC

Creep and Stress-Rupture Strengths Continued

Comparison of Stress to Produce 1% Creep in 1000 Hours in Sheet

At temperatures below 1200°F (649°C), HAYNES® 718 alloy has creep strength that is superior to most other age-hardenable, wrought nickel-base superalloys. However, starting at temperatures around 1200°F (649°C) and higher, gamma-prime strengthened alloys such as HAYNES® 282® alloy, HAYNES® Waspaloy alloy, and HAYNES® 263 alloy provide higher strength.



Tensile Properties

Tensile Data, Plate

Test Temperature		Ultimate Tensile Strength		0.2% Yield Strength		Elongation
°F	°C	ksi	MPa	ksi	MPa	%
RT	RT	200.5	1382	167.8	1157	20.6
800	427	173.1	1193	149	1027	22.6
1000	538	170.2	1173	145.9	1006	21.8
1200	649	162.5	1120	139.9	965	25.1
1400	760	117.3	809	104.9	723	12.1
1600	871	42.2	291	34.3	236	68
1800	982	14.1	97	9.6	66	129.9

Mill Annealed + 1325°F/8h/Furnace Cool to 1150°F/8h/Air Cool
Total time: 18 hours
RT= Room Temperature

Tensile Data, Sheet

Test Temperature		Ultimate Tensile Strength		0.2% Yield Strength		Elongation
°F	°C	ksi	MPa	ksi	MPa	%
RT	RT	203.6	1404	174.7	1205	18.4
800	427	176.2	1215	155.4	1071	21.3
1000	538	172.3	1188	150.2	1036	20.7
1200	649	164.1	1131	144.3	995	16.3
1400	760	114.8	792	103.8	716	6.9
1600	871	39.9	275	34	234	81.8
1800	982	13.7	94	9.7	67	175.6

Mill Annealed + 1325°F/8h/Furnace Cool to 1150°F/8h/Air Cool
Total time: 18 hours

Physical Properties

Physical Property	British Units		Metric Units	
Density	RT	0.297 lb/in.^{3}	RT	8.23 g/cm.^{3}
Melting Range	2300-2435°F	-	1260-1335°C	-
Electrical Resistivity	RT	47.5 µohm.in	RT	121 µohm.cm
	200°F	48.0 µohm.in	100°C	122 µohm.cm
	400°F	49.4 µohm.in	200°C	125 µohm.cm
	600°F	50.3 µohm.in	300°C	127 µohm.cm
	800°F	50.7 µohm.in	400°C	129 µohm.cm
	1000°F	51.6 µohm.in	500°C	130 µohm.cm
	1200°F	52.0 µohm.in	600°C	132 µohm.cm
	1400°F	52.2 µohm.in	700°C	132 µohm.cm
	1600°F	52.1 µohm.in	800°C	132 µohm.cm
	1800°F	52.4 µohm.in	900°C	133 µohm.cm
	-	-	1000°C	133 µohm.cm
Thermal Conductivity	RT	79 Btu.in/h.ft^2.°F	RT	11.4 W/m-°C
	200°F	87 Btu.in/h.ft^2.°F	100°C	12.6 W/m-°C
	400°F	100 Btu.in/h.ft^2.°F	200°C	14.3 W/m-°C
	600°F	112 Btu.in/h.ft^2.°F	300°C	15.9 W/m-°C
	800°F	124 Btu.in/h.ft^2.°F	400°C	17.5 W/m-°C
	1000°F	136 Btu.in/h.ft^2.°F	500°C	19.0 W/m-°C
	1200°F	148 Btu.in/h.ft^2.°F	600°C	20.6 W/m-°C
	1400°F	161 Btu.in/h.ft^2.°F	700°C	22.2 W/m-°C
	1600°F	173 Btu.in/h.ft^2.°F	800°C	23.8 W/m-°C
	1800°F	186 Btu.in/h.ft^2.°F	900°C	25.4 W/m-°C
	-	-	1000°C	27.1 W/m-°C
Mean Coefficient of Thermal Expansion	70-200°F	7.1 µin/in-°F	25-100°C	12.8 µm/m-°C
	70-400°F	7.5 µin/in-°F	25-200°C	13.5 µm/m-°C
	70-600°F	7.7 µin/in-°F	25-300°C	13.8 µm/m-°C
	70-800°F	7.9 µin/in-°F	25-400°C	14.1 µm/m-°C
	70-1000°F	8.0 µin/in-°F	25-500°C	14.3 µm/m-°C
	70-1200°F	8.4 µin/in-°F	25-600°C	14.8 µm/m-°C
	70-1400°F	8.9 µin/in-°F	25-700°C	15.5 µm/m-°C
	70-1600°F	9.4 µin/in-°F	25-800°C	16.3 µm/m-°C
	-	-	25-900°C	17.2 µm/m-°C

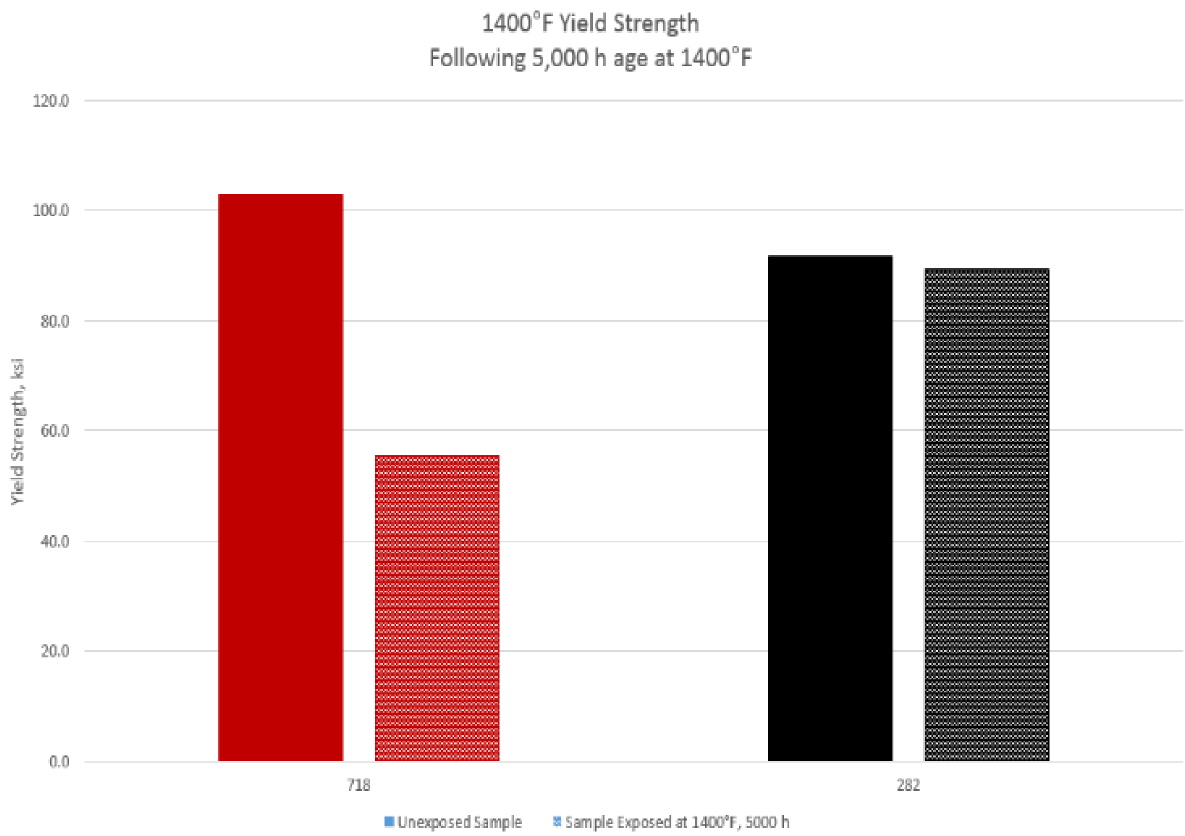
RT= Room Temperature

Physical Properties Continued

Physical Property	British Units		Metric Units	
Dynamic Modulus of Elasticity	RT	29.0×10^6 psi	RT	200 GPa
	200°F	28.4×10^6 psi	100°C	195 GPa
	400°F	27.6×10^6 psi	200°C	191 GPa
	600°F	26.7×10^6 psi	300°C	185 GPa
	800°F	25.8×10^6 psi	400°C	179 GPa
	1000°F	24.8×10^6 psi	500°C	173 GPa
	1200°F	23.7×10^6 psi	600°C	167 GPa
	1400°F	22.3×10^6 psi	700°C	159 GPa
	1600°F	20.2×10^6 psi	800°C	149 GPa
	1800°F	17.4×10^6 psi	900°C	134 GPa

RT= Room Temperature

Thermal Stability



718 data from G.E. Korth, *Mechanical properties test data of Alloy 718 for liquid metal fast breeder reactor applications*, EGG-2229, January 1, 1983.

Fabrication

HAYNES® 718 alloy has very good forming and welding characteristics. It may be hot-worked at temperatures in the range of about 1700-2100°F (925-1150°C) provided the entire piece is soaked for a time sufficient to bring it uniformly to temperature. Initial break-down is normally performed at the higher end of the range, while finishing is usually done at the lower temperatures to afford grain refinement.

As a consequence of its good ductility, 718 alloy is also readily formed by cold-working. All hot- or cold-worked parts should normally be annealed at 1700 to 1850°F (925 to 1010°C) and cooled by air cool or faster rate before aging in order to develop the best balance of properties.

Tensile Properties of Solution-annealed 718 at Room Temperature

Form	Ultimate Tensile Strength		Yield Strength		Elongation
	ksi	MPa	ksi	MPa	%
Sheet	126.3	871	60.7	419	46.7
Plate	124.3	857	57.3	395	49

Cold-work Hardness

% Cold-work	Average Hardness HRB/ C
0	92.4 HRB
10	27.2 HRC
20	33.6 HRC
30	36.9 HRC
40	38.3 HRC
50	39.2 HRC

HRB= Hardness Rockwell "B"
HRC= Hardness Rockwell "C"

Hardness and Grain Size

Form	Hardness, HRB	Typical ASTM Grain Size
Sheet	94	6-8
Plate	93	5-8

All samples tested in solution-annealed condition

Welding

HAYNES® 718 alloy is readily welded by Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), Shielded Metal Arc Welding (SMAW), Electron Beam (EB) and resistance welding techniques. Its welding characteristics are similar to those for HASTELLOY® X alloy. Submerged Arc Welding (SAW) and oxyacetylene are not recommended as these processes are characterized by high heat input to the base metal and slow cooling of the weld. These factors can increase weld restraint and promote cracking.

Base Metal Preparation

The welding surface and adjacent regions should be thoroughly cleaned with an appropriate solvent prior to any welding operation. All greases, oils, cutting oils, crayon marks, machining solutions, corrosion products, paint, scale, dye penetrant solutions, and other foreign matter should be completely removed.

Filler Metal Selection

HAYNES® 718 alloy should be joined using matching filler metal (AWS A5.14 ERNiFeCr-2, AMS5832). For welding 718 alloy to other alloys, HASTELLOY® S (AMS 5838) or W (AWS A5.14 ERNiMo-3, AMS 5786) filler wires are suggested. Please see the “Welding and Fabrication” brochure or the Haynes Welding SmartGuide for more information.

Preheating and Interpass Temperatures

Preheat is not required. Preheat is generally specified as room temperature (typical shop conditions). Interpass temperature should be maintained below 200°F (93°C). Auxiliary cooling methods may be used between weld passes, as needed, providing that such methods do not introduce contaminants. For further information, please refer to the “Welding and Joining” subsection of the “Welding and Fabrication” brochure.

Post-Weld Heat-treatment

HAYNES® 718 alloy is normally used in the fully-aged condition. Following forming and welding, a full solution anneal prior to aging is often employed in order to develop the best joint and overall fabrication properties. The best practice is dependent upon the specific condition of the fabrication prior to aging. Contact Haynes International, Inc. for further information.

Nominal Welding Parameters

Details for GTAW, GMAW and SMAW welding are given in the “Welding and Fabrication” brochure. Nominal welding parameters are provided as a guide for performing typical operations and are based upon welding conditions used in our laboratories.

Specifications and Codes

Specifications

HAYNES® 718 alloy (N07718)	
Sheet, Plate & Strip	AMS 5596 AMS 5597
Billet, Rod & Bar	AMS 5662 AMS 5663 AMS 5664 SB 637/B 637
Coated Electrodes	-
Bare Welding Rods & Wire	A 5.14 (ERNiFeCr-2) AMS 5832
Seamless Pipe & Tube	AMS 5589 AMS 5590 B 983
Welded Pipe & Tube	-
Fittings	-
Forgings	AMS 5662 AMS 5663 AMS 5664 SB 637/B 637
DIN	17742 No. 2.4668 NiCr19Fe19NbMo3
Others	ASME Code Case No. 1993-6 Case No. 2221-1 NACE MR0175 ISO 15156

Codes

HAYNES® 718 alloy (N07718)	
MMPDS	6.3.5