HAYNES International

HIGH-TEMPERATURE ALLOYS

HAYNES® 718 alloy

An age-hardenable Ni-Fe-Cr-Cb-Mo-Ti-Al alloy that combines excellent strength to 1200°F (650°C) with good ductility, formability, and weldability.

Contents

H-3055B

PRINCIPAL FEATURES

Excellent High-Temperature Strength Up to 1200°F (650°C), Good Ductility, Formability, and Weldability

HAYNES® 718 alloy is an age-hardenable nickel-iron-chromium-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 such materials 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.

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.

Fabrication

HAYNES 718 alloy has very good forming and welding characteristics. The hot working temperature range for the alloy is approximately 1700 to 2100°F (985-1150°C). The alloy has very good ductility in the annealed condition, and thus may also be formed by cold working. Intermediate annealing in the temperature range from 1700 to 1850°F (925 to 1010°C) may be needed for complex component forming operations. All hot- or cold-worked parts should be annealed and rapidly cooled in order to restore the best balance of properties.

HAYNES 718 alloy can be welded by both manual and automatic welding methods, including gas tungsten arc (TIG), gas metal arc (MIG), electron beam, and resistance welding. Matching composition filler wire is available and is generally used for welding 718 alloy.

Heat Treatment

Wrought HAYNES 718 alloy is furnished in the solution heat-treated condition unless otherwise specified. The alloy is normally solution heat-treated at 1700 to 1850°F (925 to 1010°C) and rapidly cooled or water quenched for optimal properties. Following solution heat treatment, the alloy is normally age-hardened by a two step treatment consisting of 1325°F (720°C) for 8 hours, furnace cooling to 1150°C (620°C), holding for an additional 8 hours, and then air cooling.

Available in Convenient Forms

HAYNES 718 alloy is produced in the form of sheet, strip, plate, bar, billet, wire, and tubular products.

Applications

HAYNES 718 alloy combines properties which make it suitable for a variety of fabricated component applications in both aircraft turbine engines and land-based turbines. These include rings, casings, and many types of formed sheet metal components. It is also used for fasteners and instrumentation parts. The alloy also is used in various applications for oil/gas well down hole and well head components.

Applicable Specifications

HAYNES 718 alloy is covered by the following specifications: AMS 5596/5597 (sheet, strip and plate), AMS 5662/5664 (bar and billet), AMS 5832 (wire), AMS 5589/5590 (seamless tubulars); NACE MR-01-75 (oil field equipment); and ASTM B-626 (welded tubing). The UNS number for this material is N07718.

Nominal Chemical Composition, Weight Percent

Ni	Co	Fe	Cr	Cb+Ta	Mo	Mn	Si	Ti	Al	C	B	Cu
52[a]	1*	19	18	5	3	0.35*	0.35*	0.9	0.5	0.05	0.009	0.1*

[a]As Balance * Maximum

CREEP AND STRESS-RUPTURE STRENGTHS

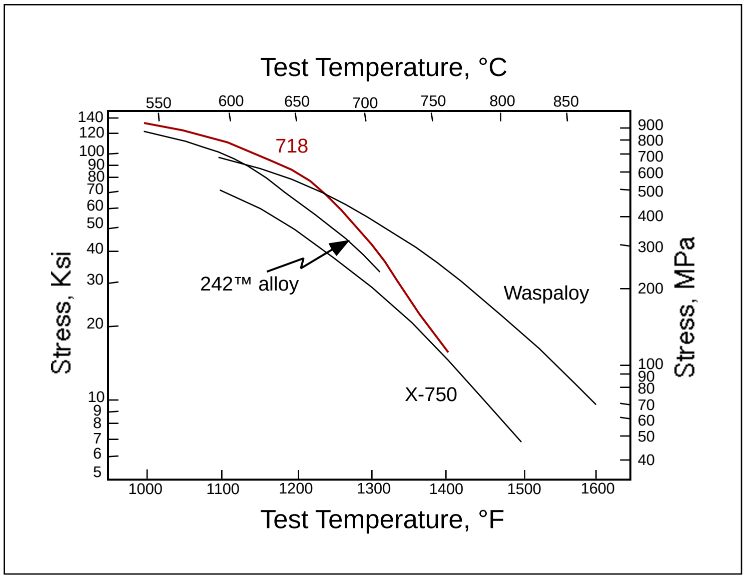
Cold-Rolled, Solution-Treated and Aged* (Sheet)

Test Temperature °F	°C	Creep, Percent	Approximate Initial Stress, Ksi (MPa) to Produce Specified Creep in 10 Hours	100 Hours	1,000 Hours
1000	540	0.5	157 (1080)	146 (1005)	132 (910)
		1.0	160 (1105)	150 (1035)	138 (950)
		Rupture	- -	165 (1140)	144 (995)
1100	595	0.5	140 (965)	126 (870)	108 (745)
		1.0	143 (985)	130 (895)	112 (770)
		Rupture	150 (1035)	134 (925)	115 (795)
1200	650	0.5	121 (835)	101 (695)	75 (515)
		1.0	124 (855)	103 (710)	78 (540)
		Rupture	130 (895)	105 (725)	87 (600)
1300	705	0.5	95 (655)	64 (440)	25 (175)
		1.0	98 (675)	66 (455)	33 (230)
		Rupture	102 (705)	76 (525)	43 (295)
1400	760	0.5	58 (400)	22 (150)	- -
		1.0	60 (415)	26 (180)	- -
		Rupture	70 (485)	36 (250)	14 (97)

*Limited data

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

HAYNES® 718 alloy has stress-rupture strength up to 1200°F (650°C) which is superior to most other age-hardenable, wrought nickel-base superalloys. At temperatures above 1200°F (650°C), materials such as Waspaloy alloy and R-41 alloy provide higher strength.



TYPICAL TENSILE PROPERTIES

Cold-Rolled, Solution-Treated and Aged* (Sheet)

Test Temperature		Ultimate Tensile Strength		Yield Strength at 0.2% Offset		Elongation in 2 in. (50.8 mm)
°F	°C	Ksi	MPa	Ksi	MPa	%
Room	Room	202.3	1395	170.4	1175	22.3
1000	540	164.1	1130	144.0	995	24.4
1200	650	167.6	1155	144.8	1000	19.9
1400	760	124.1	855	108.6	750	10.2
1600	870	43.9	305	60.6	420	27.7
1800	980	20.9	145	13.0	90	37.0
2000	1095	11.2	77	5.8	40	38.5

*Limited data

DYNAMIC MODULUS OF ELASTICITY

Temperature, °F	British Units	Temperature, °C	Metric Units
Room	29.0×10^6 psi	Room	200 GPa
200	28.4×10^6 psi	100	195 GPa
400	27.6×10^6 psi	200	191 GPa
600	26.7×10^6 psi	300	185 GPa
800	25.8×10^6 psi	400	179 GPa
1000	24.8×10^6 psi	500	173 GPa
1200	23.7×10^6 psi	600	167 GPa
1400	22.3×10^6 psi	700	159 GPa
1600	20.2×10^6 psi	800	149 GPa
1800	17.4×10^6 psi	900	134 GPa
		1000	117 GPa

TYPICAL PHYSICAL PROPERTIES

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

FABRICATION AND WELDING

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 breakdown 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.

The alloy can be welded by a variety of processes, including gas tungsten arc, gas metal arc, electron beam and resistance welding. High heat input processes such as submerged arc and oxyacetalyne welding are not recommended.

Welding Procedures

Welding procedures common to most high-temperature, nickel-base alloys are recommended. These include use of stringer beads and an interpass temperature less than 200°F (95°C). Preheat is not required. Cleanliness is critical, and careful attention should be given to the removal of grease, oil, crayon marks, shop dirt, etc. prior to welding. Because of the alloy's high nickel content, the weld puddle will be somewhat "sluggish" relative to steels. To avoid lack of fusion and incomplete penetration defects, the root opening and bevel should be sufficiently open.

Filler Metals

HAYNES 718 alloy should be joined using matching filler metal. For welding 718 alloy to other alloys, HASTELLOY® alloys S or W filler wires are suggested.

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.

HEALTH AND SAFETY INFORMATION

Welding can be a safe occupation. Those in the welding industry, however, should be aware of the potential hazards associated with welding fumes, gases, radiation, electric shock, heat, eye injuries, burns, etc. Also, local, municipal, state, and federal regulations (such as those issued by OSHA) relative to welding and cutting processes should be considered.

Nickel-, cobalt-, and iron-base alloy products may contain, in varying concentrations, the following elemental constituents: aluminum, cobalt, chromium, copper, iron, manganese, molybdenum, nickel and tungsten. For specific concentrations of these and other elements present, refer to the Materials Safety Data Sheets (MSDS), H3095 and H1072 for the product.

Inhalation of metal dust or fumes generated from welding, cutting, grinding, melting, or dross handling of these alloys may cause adverse health effects such as reduced lung function, nasal and mucous membrane irritation. Exposure to dust or fumes which may be generated in working with these alloys may also cause eye irritation, skin rash and effects on other organ systems.

The operation and maintenance of welding and cutting equipment should conform to the provisions of American National Standard ANSI/AWS Z49.1, "Safety in Welding and Cutting". Attention is especially called to Section 7 (Protection of Personnel) and 8 (Health Protection and Ventilation) of ANSI/AWS Z49.1. Mechanical ventilation is advisable and, under certain conditions such as a very confined space, is necessary during welding or cutting operations, or both, to prevent possible exposure to hazardous fumes, gases, or dust that may occur.

STANDARD PRODUCTS

By Brand or Alloy Designation:

HAYNES International

HASTELLOY ® Family of Corrosion-Resistant Alloys

B-2, B-3®, C-4, C-22®, C-276, C-2000®, D-205™, G-3, G-30®, G-50® and N

HASTELLOY Family of Heat-Resistant Alloys

S, W, and X

HAYNES ® Family of Heat-Resistant Alloys

25, R-41, 75, HR-120®, 150, HR-160®, 188, 214™, 230®, 230-W™, 242™, 263, 556™, 625, 718, X-750, MULTIMET® and WASPALOY

Corrosion-Wear Resistant Alloy

ULTIMET®

Wear-Resistant Alloy

6B

HAYNES Titanium Alloy Tubular

Ti-3Al-2.5V

Standard Forms:

Bar, Billet, Plate, Sheet, Strip, Coils, Seamless or Welded Pipe & Tubing, Pipe Fittings, Flanges, Fittings, Welding Wire and Coated Electrodes

Properties Data:

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