HAYNES® 617 alloy

Principal Features

HAYNES® 617 alloy (UNS N06617) is a nickel-chromium-cobalt-molybdenum alloy with a good combination of metallurgical stability, strength, and oxidation resistance at high temperatures. The alloy is readily formed and welded by conventional techniques. HAYNES® 617 alloy is use in applications such as gas turbines for combustion cans, ducting, and transition lines. For modern application, HAYNES® 230® alloy should be considered as a replacement.

Nominal Composition

Weight %

Nickel:	Balance
Cobalt:	12.5
Chromium:	22
Molybdenum:	9
Manganese:	0.2 max.
Silicon:	0.2 max.
Iron:	1
Titanium:	0.3
Aluminum:	1.2
Carbon:	0.07
Boron:	0.006 max.

Creep-Rupture Strength

Solution annealed Sheet

Temperature		Creep	Approximate Initial Stress to Produce Specified Creep in					
			10 Hours		100 Hours		1,000 Hours	
°F	°C	%	ksi	MPa	ksi	MPa	ksi	MPa
1400	760	0.5	18.7	129	14.5	100	11	76
		1	20.5	141	15.5	107	12	83
		R	33*	228*	26	179	20	138
1500	816	0.5	13.2*	91*	10.2	70	7.7	53
		1	14.0*	97*	10.8	74	8.5	59
		R	23.5	162	17.0	117	12.2	84
1600	871	0.5	9.5	66	7.3	50	5.0*	34*
		1	10.0	69	7.7	53	5.3*	37*
		R	16.5	114	11.4	79	7.3	50
1700	927	0.5	6.5	45	4.3	30	2.9*	20*
		1	7.4	51	4.8	33	3.2*	22*
		R	11.7	81	7.4	51	4.5	31
1800	982	0.5	-	-	2.9	20	1.7	12
		1	-	-	3.3	23	1.9	13
		R	-	-	5.2	36	2.3	16

*Significant extrapolation

Oxidation Resistance

Comparative Oxidation Resistance in Flowing Air, 1008 Hours*

Material	1800°F (982°C)				2000°F (1093°C)				2100°F (1149°C)				2200°F (1204°C)			
	Average Metal Loss		Average Metal Affected		Average Metal Loss		Average Metal Affected		Average Metal Loss		Average Metal Affected		Average Metal Loss		Average Metal Affected	
	Mils	µm	Mils	µm	Mils	µm	Mils	µm	Mils	µm	Mils	µm	Mils	µm	Mils	µm
214®	0.1	3	0.3	8	0.1	3	0.2	5	0.1	3	0.5	13	0.1	3	0.7	18
230®	0.2	5	1.5	38	0.5	13	3.3	84	1.2	30	4.4	112	4.7	119	8.3	211
X	0.2	5	1.5	38	1.3	33	4.4	112	3.6	91	6.1	115	-	-	-	-
601	0.4	10	1.7	43	1.3	33	3.8	97	2.8	71	6.5	165	4.4	112	7.5	191
625	0.4	10	1.9	48	3.5	89	7.8	198	18.3	465	20.2	513	-	-	-	-
617	**0.3**	**8**	**2.0**	**51**	**0.6**	**15**	**3.8**	**97**	**1**	**25**	**5.2**	**132**	**10.7**	**272**	**12.6**	**320**
HR-120®	0.4	10	2.1	53	1	25	4.4	112	7.9	201	10.1	257	21.7	551	25.4	645
556®	0.4	10	2.3	58	1.5	38	6.9	175	10.4	264	17.5	445	-	-	-	-
600	0.3	8	2.4	61	0.9	23	3.3	84	2.8	71	4.8	122	5.1	130	8.4	213

*Flowing air at a velocity of 7.0 ft/min (213.4 cm/min) past the samples. Samples cycled to room temperature once per week.

Oxidation Resistance Continued

Amount of metal affected for high-temperature sheet (0.060 - 0.125") alloys exposed in still air.

Alloy	1800°F (982°C), 8640 h				2100°F (1149°C), 8640 h			
	Metal Loss		Average Metal Affected		Metal Loss		Average Metal Affected	
	mils	µm	mils	µm	mils	µm	mils	µm
214®	0.1	3	0.2	5	-	-	-	-
188	0.4	10	3	76	-	-	-	-
230®	0.5	13	3.4	86	11.1	282	34	864
617	**0.7**	**18**	**3.7**	**94**	**21.3**	**541**	**37.2**	**945**
X	3	76	5.1	130	-	-	-	-
556®	7.6	193	11.9	302	>247.5	>6287	>247.5	>6287
HR-120®	9.2	234	14.4	366	43.7	1110	53	1346
HR-160®	2.6	66	17.7	450	7.6	193	58.7	1491

Samples cycled to room temperature once per month.

Oxidation Resistance Continued

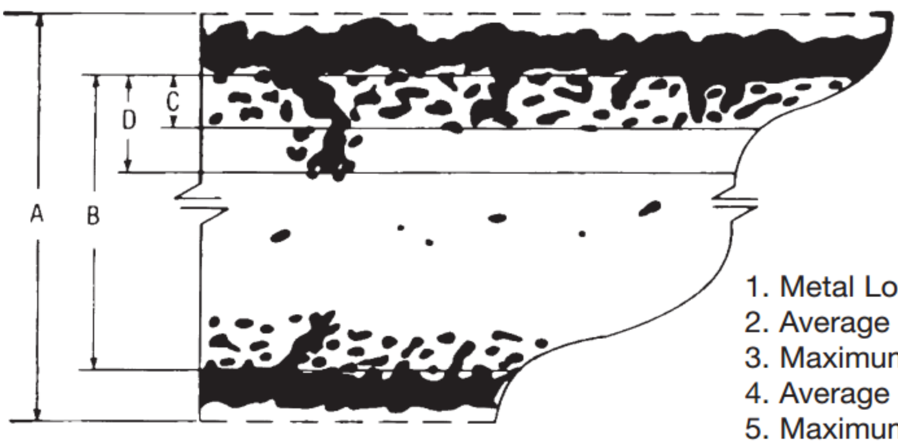
Dynamic Oxidation Testing (Burner Rig)

Alloy	1600°F (871°C)/2000 Hours				1800°F (982°C)/1000 Hours			
	Metal Loss		Average Metal Affected		Metal Loss		Average Metal Affected	
	Mils	µm	Mils	µm	Mils	µm	Mils	µm
214®	1.3	33	1.3	33	1.5	38	1.8	46
625	1.2	30	2.2	56	3.7	94	6.0	152
188	1.1	28	2.9	74	1.1	28	3.2	81
230®	0.9	23	3.9	99	2.8	71	5.6	142
556®	1.5	38	3.9	99	4.1	104	6.7	170
X	1.7	43	5.3	135	4.3	109	7.3	185
617	**2.0**	**51**	**7.8**	**198**	**2.4**	**61**	**5.7**	**145**
601	1.9	48	9.6	244	5.7	145	Through thickness	
HR-120®	-	-	-	-	6.3	160	8.3	211

Alloy	2000°F (1093°C)/500 Hours				2100°F (1149°C)/200 Hours			
	Metal Loss		Average Metal Affected		Metal Loss		Average Metal Affected	
	Mils	µm	Mils	µm	Mils	µm	Mils	µm
214®	1.2	30	1.5	38	2.0	51	2.1	53
625	Consumed		-	-	-	-	-	-
188	10.9	277	12.5	318	8.0	203	9.7	246
230®	7.1	180	9.9	251	6.4	163	13.1	333
556®	9.9	251	12.1	307	11.5	292	14	356
X	11.6	295	14.0	356	13.9	353	15.9	404
617	**13.3**	**338**	**20.9**	**531**	**13.8**	**351**	**15.3**	**389**
601	-	-	-	-	16.3	414	Through thickness	
HR-120®	-	-	-	-	-	-	-	-

Burner rig oxidation tests were conducted by exposing, in a rotating holder, samples 0.375 inch x 2.5 inches x thickness (9.5mm x 64mm x thickness) to the products of combustion of fuel oil (2 parts No. 1 and 1 part No. 2), burned at an air to fuel ratio of about 50:1. The gas velocity was about 0.3 mach. Samples were automatically removed from the gas stream every 30 minutes and fan cooled to less than 500°F (260°C) and then reinserted into the flame tunnel.

Metallographic Technique used for Evaluating Environmental Tests



1. Metal Loss = (A - B)/2
2. Average Internal Penetration = C
3. Maximum Internal Penetration = D
4. Average Metal Affected = ((A - B)/2) + C
5. Maximum Metal Affected = (A - B)/2) + D

Tensile Properties

Typical Tensile Properties, Plate

Test Temperature		0.2% Offset Yield Strength		Ultimate Tensile Strength		Elongation
°F	°C	ksi	MPa	ksi	MPa	%
RT	RT	53.4	368	117.2	808	53.3
1000	538	36.6	252	89.1	614	65.8
1200	469	34.4	237	91.2	629	69.2
1400	760	34.9	241	70.8	488	87.2
1600	871	31.0	214	41.3	285	97.9
1800	982	15.7	108	22.2	153	97.6
2000	1093	7.8	54	11.3	78	94.6

Typical Tensile Properties, Sheet

Test Temperature		0.2% Offset Yield Strength		Ultimate Tensile Strength		Elongation
°F	°C	ksi	MPa	ksi	MPa	%
RT	RT	55.1	380	121.4	837	50.9
1000	538	38.1	263	103.9	716	58.9
1200	469	38.0	262	104.9	723	75.2
1400	760	37.6	259	73.9	510	89.8
1600	871	28.7	198	38.3	264	131.7
1800	982	13.2	91	19.6	135	111.4
2000	1093	6.4	44	9.7	67	92.2

Thermal Stability

Room-Temperature Properties of Plate After Thermal Exposure

Condition	0.2% Yield Strength		Ultimate Tensile Strength		4D Elongation	Reduction of Area	Impact Strength	
	ksi	MPa	ksi	MPa	%	%	ft.-lbs.	J
Solution Annealed	50.2	346	116.3	802	56.3	50.9	186.5*	253*
+ 1200°F (649°C)/1,000 hr.	83.3	574	145.9	1006	37.6	40.0	53.5	73
+ 1200°F (649°C)/4,000 hr.	88.5	610	152.4	1051	34.4	36.4	53.4	72
+ 1200°F (649°C)/8,000 hr.	90.4	623	152.8	1054	34.3	36.6	51.5	70
+ 1400°F (760°C)/1,000 hr.	71.6	494	138.7	956	39.7	45.2	57.0	77
+ 1400°F (760°C)/4,000 hr.	67.9	468	136.5	941	38.6	41.2	51.3	70
+ 1400°F (760°C)/8,000 hr.	64.5	445	136.0	938	37.1	36.9	35.5	48
+ 1400°F (760°C)/1,000 hr.	50.7	350	121.2	836	49.9	51.7	90.0	122
+ 1600°F (871°C)/4,000 hr.	49.7	343	119.7	825	48.0	51.3	80.6	109
+ 1600°F (871°C)/8,000 hr.	47.6	328	118.8	819	49.8	50.5	67.0	91

*Did not break

Physical Properties

Physical Property	British Units		Metric Units	
Density	RT	8.36 g/cm³	RT	0.302 lb/in³
Melting Range	2430- 2510°F	-	1330-1375°C	-
Thermal Conductivity	400°F	113 BTU-in/ft²-hr-°F	200°C	16.2 W/m-°C
	800°F	137 BTU-in/ft²-hr-°F	400°C	19.4 W/m-°C
	1000°F	149 BTU-in/ft²-hr-°F	500°C	20.9 W/m-°C
	1200°F	161 BTU-in/ft²-hr-°F	600°C	22.5 W/m-°C
	1400°F	173 BTU-in/ft²-hr-°F	700°C	24.0 W/m-°C
	1600°F	185 BTU-in/ft²-hr-°F	800°C	25.6 W/m-°C
	1800°F	197 BTU-in/ft²-hr-°F	900°C	26.1 W/m-°C
	2000°F	209 BTU-in/ft²-hr-°F	1000°C	28.7 W/m-°C
Mean Coefficient of Thermal Expan-sion	70-800°F	7.6 µin/in -°F	20-450°C	13.7 µm/m- °C
	70-1000°F	7.7 µin/in -°F	20-500°C	13.8 µm/m- °C
	70-1200°F	8.0 µin/in -°F	20-600°C	14.2 µm/m- °C
	70-1400°F	8.4 µin/in -°F	20-700°C	14.7 µm/m- °C
	70-1600°F	8.7 µin/in -°F	20-800°C	15.3 µm/m- °C
	70-1800°F	9.0 µin/in -°F	20-900°C	15.8 µm/m- °C
	70-2000°F	9.2 µin/in -°F	20-1000°C	16.2 µm/m- °C
Electrical Resistivity	70°F	48.1 µohm-in	21°C	122 µohm-cm
	400°F	49.5 µohm-in	200°C	126 µohm-cm
	800°F	50.3 µohm-in	400°C	128 µohm-cm
	1000°F	51.5 µohm-in	500°C	130 µohm-cm
	1200°F	52.4 µohm-in	600°C	131 µohm-cm
	1400°F	52.8 µohm-in	700°C	133 µohm-cm
	1600°F	52.7 µohm-in	800°C	134 µohm-cm
	1800°F	53.9 µohm-in	900°C	134 µohm-cm
Dynamic Modulus of Elasticity	70°F	30.6 x 10^6 psi	20°C	211 GPa
	400°F	29.0 x 10^6 psi	200°C	201 GPa
	800°F	26.9 x 10^6 psi	400°C	188 GPa
	1000°F	25.8 x 10^6 psi	500°C	180 GPa
	1200°F	24.6 x 10^6 psi	600°C	173 GPa
	1400°F	23.3 x 10^6 psi	700°C	166 GPa
	1600°F	21.9 x 10^6 psi	800°C	157 GPa
	1800°F	20.5 x 10^6 psi	900°C	148 GPa
	2000°F	18.8 x 10^6 psi	1000°C	139 GPa

RT= Room Temperature

Heat Treatment

Unless otherwise specified, wrought HAYNES® 617 alloy is normally supplied in the solution annealed condition. The alloy is usually solution annealed in the range of 2100°F to 2150°F (1149°C to 1177°C), depending on product form, for a time commensurate with section thickness and rapidly cooled or water-quenched for optimum properties.

Hardness and Grain Size

Form	Hardness	Typical ASTM Grain Size
Sheet	88 HRBW	3 - 4.5
Plate	91 HRBW	3 - 5
Bar	88 HRBW	3 - 4.5

All samples tested in solution-annealed condition.
HRBW = Rockwell Hardness "B", Tungsten Indentor.

Fabrication and Welding

HAYNES® 617 alloy is readily welded by Gas Tungsten Arc (GTAW), Gas Metal Arc (GMAW), Shielded Metal Arc (SMAW), electron bean welding, and resistance welding techniques. Submerged Arc welding is not recommended, as this process is 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 joint surface and adjacent area should be thoroughly cleaned before welding. All grease, oil, crayon marks, sulfur compounds, and other foreign matter should be removed. Contact with copper or copper-bearing materials in the joint area should be avoided. It is preferable, but not necessary, that the alloy be in the solution-annealed condition when welded.

Filler Metal Selection

Matching composition filler metal is recommended for joining alloy 617. Please see the Haynes Welding SmartGuide for suggested filler metals for dissimilar welds.

Preheating, Interpass Temperatures, and Post-Weld Heat Treatment

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. Post-weld heat treatment is not generally required for 617 alloy.

Specifications and Codes

Specifications

HAYNES® 617 alloy (N06617, W86117)	
Sheet, Plate & Strip	AMS 5888 AMS 5889 SB 168/B 168 P= 43
Billet, Rod & Bar	SB 166/B 166 B 472 AMS 5887 P= 43
Coated Electrodes	SFA 5.11/ A 5.11 (ENiCrCoMo-1) F= 43
Bare Welding Rods & Wire	SFA 5.14/ A 5.14 (ERNiCrCoMo-1) F= 43
Seamless Pipe & Tube	SB 167/B 167 P= 43
Welded Pipe & Tube	-
Fittings	-
Forgings	SB 564/B 564 P= 43
DIN	-
Others	-

Codes

HAYNES® 617 alloy (N06617, W86117)			
ASME	**Section I**	1650°F (899°C)[1]	
	Section III	**Class 1**	-
		Class 2	-
		Class 3	-
	Section IV	**HF-300.2**	-
	Section VIII	**Div. 1**	1800°F (982°C)[1] Code Case 2776 1650°F (899°C)[2]
		Div. 2	-
	Section XII	-	
	B16.5	-	
	B16.34	-	
	B31.1	1200°F (649°C)[1]	
	B31.3	-	

[1]Approved material forms: Plate, Sheet, Bar, Forgings, seamless pipe/tube
[2]Approved material forms: Bolting

Disclaimer:
Haynes International makes all reasonable efforts to ensure the accuracy and correctness of the data in this document but makes no representations or warranties as to the data's accuracy, correctness or reliability. All data are for general information only and not for providing design advice. Alloy properties disclosed here are based on work conducted principally by Haynes International, Inc. and occasionally supplemented by information from the open literature and, as such, are indicative only of the results of such tests and should not be considered guaranteed maximums or minimums. It is the responsibility of the user to test specific alloys under actual service conditions to determine their suitability for a particular purpose.

For specific concentrations of elements present in a particular product and a discussion of the potential health affects thereof, refer to the Safety Data Sheets supplied by Haynes International, Inc. All trademarks are owned by Haynes International, Inc., unless otherwise indicated.