HAYNES International HIGH-TEMPERATURE ALLOYS

HASTELLOY® X ALLOY

A nickel-base alloy with an exceptional combination of oxidation resistance, fabricability and high-temperature strength.

Contents

H-3009A

PRINCIPAL FEATURES

Strong and Oxidation Resistance

HASTELLOY® X alloy is a nickel-chromium-iron-molybdenum alloy that possesses an exceptional combination of oxidation resistance, fabricability and high-temperature strength. It has also been found to be exceptionally resistant to stress-corrosion cracking in petrochemical applications. X alloy exhibits good ductility after prolonged exposure at temperatures of 1200, 1400, 1600°F (650, 760 and 870°C) for 16,000 hours.

Easily Fabricated

HASTELLOY X alloy has excellent forming and welding characteristics. It can be forged and, because of its good ductility, can be cold worked. X alloy can be welded by both manual and automatic methods including shielded metal arc (covered electrodes), gas tungsten arc (TIG) and gas metal arc (MIG). The alloy can also be resistance welded.

ASME Boiler and Pressure Vessel Code

HASTELLOY X alloy plate, sheet, strip, bar, tubing and pipe are covered by ASME specifications SB-435, SB-572, SB-619, SB-622 and SB-626 under UNS Number N06002.

Heat-Treatment

Wrought forms of HASTELLOY X alloy are furnished in the solution heat-treated condition unless otherwise specified. X alloy is solution heat-treated at 2150°F (1177°C) and rapid cooled. Bright annealed products are cooled in hydrogen.

Available in Convenient Forms

HASTELLOY X alloy is available in the form of plate, sheet, strip, billet, bar, wire, covered electrodes, pipe and tubing.

Useful for Aircraft, Furnace and Chemical Process Components

X alloy has wide use in gas turbine engines for combustion zone components such as transition ducts, combustor cans, spray bars and flame holders as well as in afterburners, tailpipes and cabin heaters. It is recommended for use in industrial furnace applications because it has unusual resistant to oxidizing, reducing and neutral atmospheres. Furnace rolls of this alloy were still in good condition after operating for 8,700 hours at 2150°F (1177°C). HASTELLOY X alloy is also used in the chemical process industry for retorts, muffles, catalyst support grids, furnace baffles, tubing for pyrolysis operations and flash drier components.

Specifications

For information on specifications to which this alloy can be ordered, please contact one of the locations shown on the back cover of this brochure and ask for bulletin H-1034.

Nominal Chemical Composition, Weight Percent

Ni	Cr	Fe	Mo	Co	W	C	Mn	Si	B
47[a]	22	18	9	1.5	0.6	0.10	1*	1*	0.008*

[a]As balance *Maximum

CREEP AND STRESS-RUPTURE STRENGTH

Minimum Creep Rate Data, Sheet*

Test Temperature °F	°C	Average Stress for Indicated Percent/Hour Minimum Creep Rate, Ksi (MPa) 0.0001		0.001		0.01		0.1	
1200	649	14.7	(101)	21.0	(145)	31.0	(214)	44.0	(303)
1400	760	7.2	(50)	10.0	(69)	14.0	(97)	19.5	(134)
1600	871	2.7	(19)	4.1	(28)	6.2	(43)	9.2	(63)
1800	982	0.7	(5)	1.3	(9)	2.2	(15)	3.7	(26)
2000	1093	-		-		-		0.9	(6)

* Solution heat-treated. Based on over 100 tests for sheet and over 150 tests for plate and bar.

Average Creep Data, Sheet*

Test Temperature °F	°C	Creep, Percent	Approximate Initial Stress, Ksi (MPa) to Produce Specified Creep in: 10 Hours		100 Hours		1,000 Hours		10,000 Hours	
1200	649	0.5	40.0	(276)	27.0	(186)	17.5	(121)	-	
		1.0	44.0	(303)	30.0	(207)	21.0	(145)	-	
		2.0	48.0	(331)	33.0	(227)	22.5	(155)	-	
1400	760	0.5	16.5	(114)	10.5	(72)	6.5	(45)	-	
		1.0	19.0	(131)	13.0	(90)	9.0	(62)	6.2	(43)
		2.0	21.0	(145)	15.0	(103)	10.8	(74)	7.6	(52)
1600	871	0.5	7.8	(54)	4.9	(34)	3.1	(21)	-	
		1.0	9.0	(62)	6.1	(42)	3.6	(25)	2.1**	(14)
		2.0	10.5	(72)	7.2	(50)	4.3	(30)	2.3	(16)
1800	982	0.5	3.1	(21)	1.7	(12)	0.9	(6)	-	
		1.0	3.6	(25)	1.9	(13)	1.0	(7)	-	
		2.0	4.2	(29)	2.2	(15)	1.1	(8)	-	
2000	1093	0.5	-		-		-		-	
		1.0	0.8	(6)	-		-		-	
		2.0	1.1	(8)	-		-		-	

* Solution heat-treated. Based on over 100 tests.
** Extrapolated

Average Creep Data, Plate and Bar***

Test Temperature °F	Test Temperature °C	Creep, Percent	Approximate Initial Stress, Ksi (MPa) to Produce Specified Creep in: 10 Hours		100 Hours		1,000 Hours		10,000 Hours	
1200	649	1.0	48.0	(331)	32.0	(220)	22.0	(151)	15	(103)
		5.0	64.0	(441)	43.0	(296)	29.0	(200)	20**	(138)
1350	732	1.0	27.0	(186)	19.0	(131)	13.0	(89)	9	(62)
		5.0	34.0	(234)	24.0	(165)	16.5	(113)	11.5**	(79)
1500	816	1.0	15.0	(103)	10.4	(71)	7.3	(50)	5.1	(35)
		5.0	18.0	(124)	13.0	(89)	9.0	(62)	6.2**	(43)
1650	899	1.0	8.0	(55)	5.4	(37)	3.7	(25)	2.5	(17)
		5.0	10.5	(72)	6.8	(46)	4.2	(28)	2.8**	(19)
1800	982	1.0	4.2	(28)	2.6	(17)	1.6	(11)	1.0**	(7)
		5.0	5.4	(37)	3.3	(22)	2.0	(14)	-	

** Extrapolated
*** Solution heat-treated. Based on over 90 tests for 1.0 percent creep and on over 60 tests for 5.0 percent creep.

Average Rupture Data, Sheet*

Test Temperature °F	Test Temperature °C	Approximate Rupture Life Strength for Time Indicated, Ksi (MPa): 10 Hours		100 Hours		1,000 Hours		10,000 Hours	
1200	649	67.0	(462)	48.0	(331)	34.0	(170)	24.9	(170)
1400	760	32.0	(221)	22.5	(155)	15.8	(77)	11.1	(77)
1600	871	17.0	(117)	10.6	(73)	6.5	(28)	4.0	(28)
1800	982	6.5	(45)	3.7	(26)	2.1	(8)	1.2	(8)
2000	1093	2.4	(17)	1.2	(8)	0.6	(4)	-	

* Solution heat-treated. Based on over 100 tests.

Average Rupture Data, Plate and Bar*

Test Temperature °F	Test Temperature °C	Approximate Rupture Life Strength for Time Indicated, Ksi (MPa): 10 Hours		100 Hours		1,000 Hours		10,000 Hours	
1200	649	72.0	(496)	47.9	(330)	34.0	(234)	24.0	(165)
1350	732	36.0	(248)	25.0	(172)	18.0	(124)	12.5	(86)
1500	816	21.0	(145)	14.0	(96)	10.0	(69)	6.8	(47)
1650	899	12.0	(83)	7.5	(52)	4.7	(32)	3.0	(21)
1800	982	7.0	(48)	4.2	(29)	2.4	(17)	1.4	(10)
1950	1066	3.7	(26)	1.9	(13)	1.0**	(7)	-	
2100	1149	1.7	(12)	0.7	(5)	0.3**	(2)	-	

* Solution heat-treated. Based on over 100 tests for sheet and over 150 tests for plate and bar.
** Extrapolated

TYPICAL TENSILE PROPERTIES

Average Room Temperature Tensile Data*

Form	Condition	Ultimate Tensile Strength		Yield Strength at 0.2% Offset		Elongation in 2 in. (50.8 mm)
		Ksi	MPa	Ksi	MPa	%
Sheet, 0.091 to 0.312 in. (2.3) to 7.9mm) thick	Heat-treated at 2150°F (1177°C), Rapid Cooled	109.5	755	55.9	385	45
Plate, 3/8 to 2 in. (9.5 to 50.8mm) thick	Heat-treated at 2150°F (1177°C), Rapid Cooled	107.7	743	49.1	339	51

* Based on 58-69 tests.

Average Tensile Data*

Form	Condition	Test Temperature		Ultimate Tensile Strength		Yield Strength at 0.2% Offset		Elongation in 2 in. (50.8 mm)
		°F	°C	Ksi	MPa	Ksi	MPa	%
Sheet 0.045-0.060 in. (1.1-1.5 mm) thick	Bright Annealed at 2150°F (1177°C), Hydrogen Cooled	Room		111.2	767	54.9	379	44
		1000	538	89.0	614	35.6	245	49
		1200	649	84.2	581	35.4	244	54
		1400	760	67.1	463	34.4	237	53
		1600	871	44.9	310	28.1	194	59
		1800	982	25.6	177	13.2	91	66
		2000	1093	14.0	97	6.3	43	60

* Strain rate was 0.005-inch/inch/minute to 0.2% yield point and 0.5-inch/inch/minute to failure.

Average Effect of Cryogenic Temperatures on Tensile Properties

Form	Condition	Test Temperature		Ultimate Tensile Strength		Yield Strength at 0.2% Offset		Elongation in 2 in. (50.8 mm)
		°F	°C	Ksi	MPa	Ksi	MPa	%
Plate	Heat-treated at 2150°F (1177°C), Rapid Cooled	-321	-196	150.2	1036	-		46
		-108	-78	118.8	819	-		51
		72	22	104.5	721	47.0	324	46

Average Short-Time Tensile Data, Cold-Reduced and Welded 0.109 in. (2.8mm) Sheet

Condition	Form	Ultimate Tensile Strength Ksi	Ultimate Tensile Strength MPa	Yield Strength at 0.2% Offset Ksi	Yield Strength at 0.2% Offset MPa
As Cold-Reduced	Reduced 5 percent	123.0	848	82.0	565
	Reduced 15 percent	137.0	945	106.0	731
	Reduced 30 percent	161.0	1110	137.0	945
Cold-Reduced and Welded, As-Welded	Reduced 5 percent	114.9	792	68.0	469
	Reduced 15 percent	113.1	780	72.1	497
	Reduced 30 percent	112.9	778	69.9	482

NOTE: All cold-reduced sheet and the various weld samples were produced from material which had been solution heat-treated prior to cold reduction or welding. All data were obtained at room temperature and are the result of a limited numlber of tests.

Average Short-Time Tensile Data, Weldments

Condition	Weld Method	Material	Ultimate Tensile Strength Ksi	Ultimate Tensile Strength MPa	Yield Strength at 0.2% Offset Ksi	Yield Strength at 0.2% Offset MPa	Elongation in 2 in. (50.8 mm) %
As-Welded	Shielded Metal Arc (covered electrodes)	Sheet, 0.125 in. (3.2mm)	110.2	760	55.2	381	26
		Plate, 0.250 in. (6.4mm)	109.8	757	56.7	391	26
		Plate, 0.375 in. (9.5mm)	110.2	760	55.4	382	26
As-Welded	Gas Tungsten Arc (TIG)	Sheet, 0.125 in. (3.2mm)	110.2	759	59.1	407	26
		Plate, 0.250 in. (6.4mm)	107.1	738	53.1	365	25
		Plate, 0.375 in. (9.5mm)	107.6	742	54.9	379	22
As-Welded	Gas Metal Arc (MIG)	Sheet, 0.125 in. (3.2mm)	103.7	715	53.1	366	22
		Plate, 0.250 in. (6.4mm)	110.8	764	55.0	379	33
		Plate, 0.375 in. (9.5mm)	106.4	734	57.0	393	24

Average Aged Tensile Data, Room Temperature*

Form	Aging Temperature °F	Aging Temperature °C	Aging Time, Hours	Ultimate Tensile Strength Ksi	Ultimate Tensile Strength MPa	Yield Strength at 0.2% Offset Ksi	Yield Strength at 0.2% Offset MPa	Elongation in 2 in. (50.8 mm) %
Sheet, 0.125 in. (3.2mm) thick	SHT		-	114.3	788	55.2	381	57
	1200	649	1000	125.0	862	61.0	421	35
			4000	143.8	991	76.2	525	19
			8000	147.9	1020	78.6	542	19
			16000	148.0	1020	78.1	538	15
	1400	760	1000	137.0	945	65.3	450	23
			4000	134.6	928	64.3	443	18
			8000	131.0	903	61.3	423	19
			16000	126.1	869	59.3	409	17
	1600	871	1000	123.0	848	53.2	369	26
			4000	117.9	813	49.3	340	29
			8000	115.0	793	48.2	332	30
			16000	111.1	766	46.1	318	29
Plate, 1/2 in. (12.7mm) thick	SHT		-	109.9	758	49.5	341	47
	1200	649	1000	121.4	837	56.5	390	33
			4000	142.5	983	73.4	506	18
			8000	143.6	990	73.0	503	18
	1400	760	1000	129.4	892	56.9	392	23
			4000	129.9	896	56.9	392	21
			8000	129.2	891	56.3	388	20
	1600	871	1000	119.0	820	47.6	328	31
			4000	116.7	805	44.9	310	28
			8000	113.7	784	43.9	303	26
			16000	109.0	752	42.7	294	26

* Test data for each form are from a single heat.
SHT=Solution heat-treated (not aged)

Average Welded and Aged Tensile Data, Room Temperature*

Form	Aging Temperature °F	Aging Temperature °C	Aging Time, Hours	Ultimate Tensile Strength Ksi	Ultimate Tensile Strength MPa	Yield Strength at 0.2% Offset Ksi	Yield Strength at 0.2% Offset MPa	Elongation in 2 in. (50.8 mm) %	Reduction of area %
Plate, 1/2 in. (12.7mm) thick	1600	871	8000	109.0	752	47.9	330	-	22
Gas Tungsten Arc Welded Plate, 1/2 in. (12.7mm) thick	1200	649	1000	126.9	875	66.0	455	-	33
			4000	150.1	1035	86.5	596	-	19
			8000	145.5	1003	82.9	572	-	18
	1400	760	1000	128.2	884	58.2	401	-	19
			4000	127.4	878	62.3	430	-	18
			8000	125.2	863	62.3	430	-	15
	1600	871	4000	105.3	726	49.7	343	-	15
			8000	98.0	676	46.9	323	-	16
All Weld Metal**	1200	649	1000	123.0	848	87.5	603	4	8
			4000	139.3	960	86.0	593	7	8
			8000	131.8	909	86.8	598	6	9
	1400	760	1000	113.5	783	62.7	432	10	12
			4000	110.5	762	60.6	418	7	6
			8000	97.7	674	59.8	412	4	7
	1600	871	1000	92.8	640	48.3	330	8	9
			8000	92.7	639	46.3	319	13	11

* Test data for each form are from a single heat.
** Single test data. Gas tungsten arc welded.

TYPICAL PHYSICAL PROPERTIES

	Temperature, °F	British Units	Temperature, °C	Metric Units
Density	72	0.297 lb/in^3	22	8.22 g/cm^3
Melting Range	2300-2470		1260-1355	
Electrical Resistivity	72	46.6 microhm-in. (712 ohms per cir. mil-ft.)	22	1.18 microhm-cm
Thermal Conductivity	70	63 Btu-in./ft.^{2} hr.-°F	21	9.1 W/m-K
	200	76 Btu-in./ft.^{2} hr.-°F	93	11.0 W/m-K
	500	98 Btu-in./ft.^{2} hr.-°F	200	14.1 W/m-K
	1100	144 Btu-in./ft.^{2} hr.-°F	593	20.8 W/m-K
	1300	159 Btu-in./ft.^{2} hr.-°F	704	22.9 W/m-K
	1500	174 Btu-in./ft.^{2} hr.-°F	816	25.1 W/m-K
	1700	189 Btu-in./ft.^{2} hr.-°F	927	27.2 W/m-K
Specific Heat	Room	0.116 Btu/lb.-°F	Room	486 J/Kg-K
	200	0.117 Btu/lb.-°F	93	490 J/Kg-K
	400	0.118 Btu/lb.-°F	204	494 J/Kg-K
	600	0.119 Btu/lb.-°F	316	498 J/Kg-K
	800	0.123 Btu/lb.-°F	427	515 J/Kg-K
	1000	0.130 Btu/lb.-°F	538	544 J/Kg-K
	1200	0.139 Btu/lb.-°F	649	582 J/Kg-K
	1400	0.151 Btu/lb.-°F	760	632 J/Kg-K
	1600	0.167 Btu/lb.-°F	871	699 J/Kg-K
	1800	0.186 Btu/lb.-°F	982	799 J/Kg-K
	2000	0.205 Btu/lb.-°F	1093	858 J/Kg-K
Mean Coefficient of	79-200	7.7 microinches/in.-°F	26-93	13.9 10^{-6} m/m-°C
Thermal Expansion	79-1000	8.4 microinches/in.-°F	26-538	15.1 10^{-6} m/m-°C
	79-1200	8.6 microinches/in.-°F	26-649	15.5 10^{-6} m/m-°C
	79-1350	8.8 microinches/in.-°F	26-732	15.8 10^{-6} m/m-°C
	79-1500	8.9 microinches/in.-°F	26-816	16.0 10^{-6} m/m-°C
	79-1650	9.1 microinches/in.-°F	26-899	16.4 10^{-6} m/m-°C
	79-1800	9.2 microinches/in.-°F	26-982	16.6 10^{-6} m/m-°C
Poisson's	-108	0.328	-78	0.328
Ratio	72	0.320	22	0.320
Magnetic Permeability	Room	1.002 at 200 oersteds (15,900 A/m)		

Dynamic Modulus of Elasticity, Plate

Condition	Temperature, °F	Dynamic Modulus of Elasticity, 10^6 psi	Temperature, °C	Dynamic Modulus of Elasticity, GPa
Heat-treated at 2150°F (1177°C) Rapid Cooled	Room	29.8	Room	205
	200	29.4	93	203
	400	28.6	204	197
	600	27.8	316	192
	800	26.7	427	184
	1000	25.8	538	178
	1200	24.7	649	170
	1400	23.3	760	161
	1600	22.2	871	153
	1800	20.4	982	141

Average Hardness, Room Temperature

Form	Condition	Average Hardness, Rockwell B
Sheet, 0.012 to 0.090 in. (0.30 to 2.3mm) thick	Heat Treated at 2150°F (1177°C), Rapid Cooled	87*
Sheet, 0.091 to 0.312 in. (2.3 to 7.8mm) thick	Heat-treated at 2150°F (1177°C), Rapid Cooled	92*
Plate, 3/8 to 2 in. (9.5 to 50.8mm) thick	Heat-treated at 2150°F (1177°C), Rapid Cooled	89*

* Based on 58-65 tests

Average Hardness, Welded Sheet

Weld Method	Test Area	Average Hardness, Rockwell B
Shielded Metal Arc (covered electrodes)	Weld area	92
	Heat-affected zone	93
	Base metal	91
Gas Tungsten Arc (TIG)	Weld area	89
	Heat-affected zone	93
	Base metal	91
Gas Metal Arc (MIG)	Weld area	90
	Heat-affected zone	93
	Base metal	91

Note: Sheet was solution heat-treated prior to welding. Hardness was determined at room temperature in the as-welded condition.

Aged Hardness, Room Temperature*

Form	Aging Temperature °F	Aging Temperature °C	Aging Time, Hours	Hardness, Rockwell A
Sheet	SHT		-	54
	1200	649	1000	56
			4000	62
			8000	63
	1400	760	1000	62
			4000	61
			8000	60
	1600	871	1000	61
			4000	58
			8000	55
Plate	SHT		-	54
	1200	649	1000	57
			4000	62
			8000	63
	1400	760	1000	60
			4000	59
			8000	58
	1600	871	1000	56
			4000	56
			8000	54
All Weld Metal**	1200	649	1000	64
			4000	65
			8000	63
	1400	760	1000	62
			4000	60
			8000	60
	1600	871	1000	56
			4000	55
			8000	54

SHT=Solution heat-treated (not aged)
* Single tests from a single heat for each form
**Gas tungsten arc welded

Formability, Sheet

Condition	Typical Olsen cup depth, in.	mm
Heat Treated at 2150°F (1177°C), Rapid Cooled	0.48	12.3

Average Impact Strength, Plate

Condition	Test Temperature °F	°C	Average Charpy V-Notch Impact Strength Ft. lb.	Joules
Heat-treated at 2150°F (1177°C) Rapid Cooled	-321	-196	37	50
	-216	-157	44	60
	-108	-78	51	69
	-20	-29	56	76
	Room		54	73
	1500	815	58	79

Average Impact Strength, Aged Plate*

Aging Temperature °F	°C	Aging Time, Hours	Average Charpy V-Notch Impact Strength ft.-lb.	Joules
SHT		-	95	129
1200	649	1000	24	33
		4000	12	16
		8000	15	20
1400	760	1000	10	14
		4000	10	14
		8000	8	11
1600	871	1000	15	20
		4000	12	16
		8000	15	20
		16000	12	16

SHT=Solution heat-treated (not aged)
* Average of four tests on 1/2-in. (12.7mm) plate from a single heat.

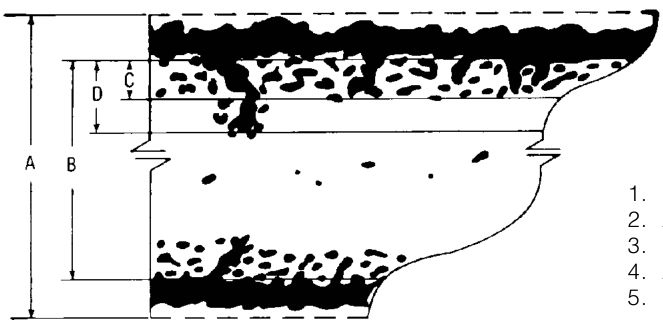
OXIDATION RESISTANCE

Comparative Static Oxidation Data in Flowing Air for 1008 Hours*

Alloy	1800°F (980°C) Metal Loss/side, Mils	1800°F (980°C) Metal Loss/side, µm	1800°F (980°C) Metal Loss + CIP**/side, Mils	1800°F (980°C) Metal Loss + CIP**/side, µm	2000°F (1095°C) Metal Loss/side, Mils	2000°F (1095°C) Metal Loss/side, µm	2000°F (1095°C) Metal Loss + CIP**/side, Mils	2000°F (1095°C) Metal Loss + CIP**/side, µm
HASTELLOY® X alloy	0.29	0.007	0.74	0.019	1.5	0.038	2.7	0.069
INCONEL® alloy 600	0.32	0.008	0.90	0.023	1.1	0.028	1.6	0.041
INCONEL alloy 601	0.53	0.013	1.3	0.033	1.2	0.031	2.6	0.06
Alloy 625	0.32	0.008	0.72	0.018	3.3	0.083	4.8	0.12
Alloy 800H	0.94	0.024	1.8	0.046	5.4	0.137	7.4	0.19

* Cycled to room temperature once a week
**CIP=Continuous Internal Penetration
INCONEL is a trademark of Inco Family of Companies

Schematic Representation of Metallographic Technique used for Evaluating Oxidation 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

Comparative Average Hot Corrosion Resistance*

Test Temperature °F	Test Temperature °C	Test Period, Hours	Total Metal Affected/side, Mils (mm): HASTELLOY® X alloy, Mils	HASTELLOY® X alloy, mm	HASTELLOY S alloy, Mils	HASTELLOY S alloy, mm	HAYNES® 188 alloy, Mils	HAYNES® 188 alloy, mm
1650	900	200	3.0	0.8	2.7	0.07	2.1	0.05
1650	900	1000	6.8	0.17	7.5	0.19	3.7	0.09

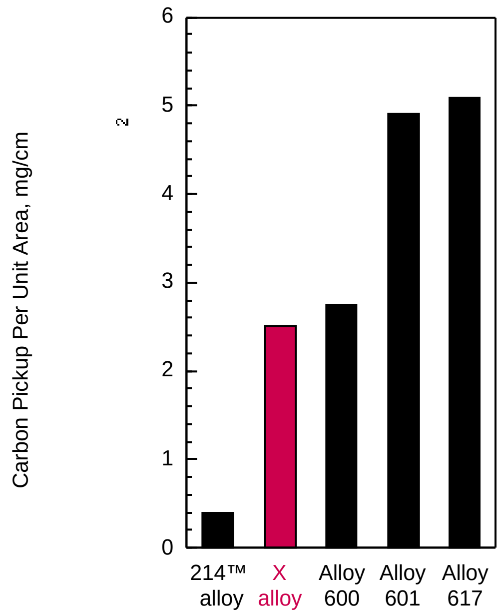
* All tests performed by exposure to the combustion products of No. 2 fuel oil (0.4 percent sulfur) and 5 ppm of sea salt. Gas velocity over samples was 13 ft./sec. (4m/s). Thermal shock frequency was one/hour.

CARBURIZATION RESISTANCE

Tests were performed in a carburizing environment with an inlet gas mixture (volume %) of 5.0% H_2, 5.0% CO, 5.0% CH_4 and the balance argon. The calculated oxygen potential and carbon activity at 1800°F (980°C) were 9×10^{-22} atm. and 1.0, respectively.

The results are presented in terms of the mass of carbon pickup per unit area, which was obtained from the equation M = C (W/A) where M = the mass of carbon pickup per unit area (mg/cm²), C = difference in carbon (weight fraction) before and after exposure, W = weight of the unexposed specimen (mg) and A = surface area of the specimen exposed to the test environment (cm²).

Comparative Carburization Resistance at 1800°F (980°C) for 55 Hours



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 Material Safety Data Sheets (MSDS) available from Haynes International, Inc.

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 4 (Protection of Personnel) and 5 (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

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HAYNES ® Family of Heat-Resistant Alloys

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6B

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Standard Forms:

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