HASTELLOY® X alloy

HASTELLOY® X alloy (UNS N06002, W86002) is a nickel-chromium-iron-molybdenum alloy that has been in service in aerospace applications for nearly 50 years. The alloy offers very good balance of high-temperature strength, oxidation resistance, and fabricability. This alloy is widely used for aircraft and industrial gas turbine engine fabricated combustor and exhaust components, such as transition ducts, combustor cans, spray bars and flame holders, afterburners, and tailpipes.

Principal Features

Strong and Oxidation Resistance

HASTELLOY® X alloy (UNS N06002 (W86002) 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.

Ease of Fabrication

HASTELLOY® X alloy has excellent forming and welding characteristics. It may be forged or otherwise hot-worked, providing it is held at 2150°F (1177°C) for a time sufficient to bring the entire piece to temperature. As a consequence of its good ductility, HASTELLOY® X alloy is also readily formed by cold- working. All hot- or cold- worked parts should be annealed and rapidly cooled in order to restore the best balance of properties.

The alloy can be welded by a variety of techniques, including gas tungsten arc (GTAW), gas metal arc (GMAW), shielded metal arc (SMAW), and resistance welding.

Additional information regarding fabrication can be found here.

Heat Treatment

Wrought forms of HASTELLOY® X alloy are furnished in the solution heat-treated condition unless otherwise specified. X alloy is typically solution heat-treated at 2150°F (1177°C) and rapid cooled. Bright annealed products are cooled in hydrogen. Annealing at temperatures lower than the solution heat- treating may cause precipitation of secondary phases, which may affect the alloy’s strength and ductility.

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.

Nominal Composition

Weight %

Nickel:	47 Balance
Chromium:	22
Iron:	18
Molybdenum:	9
Cobalt:	1.5
Tungsten:	0.6
Carbon:	0.1
Manganese:	1 max.
Silicon:	1 max.
Boron:	0.008 max.
Niobium:	0.5 max.
Aluminum:	0.5 max.
Titanium:	0.15 max.

Creep and Stress-Rupture Strengths

Minimum Creep Rate, HASTELLOY® X Sheet, Solution-Annealed

Test Temperature		**Average Stress for Indicated Percent/Hour Minimum Creep Rate**							
		0.0001		**0.001**		**0.01**		**0.1**	
°F	**°C**	**ksi**	**MPa**	**ksi**	**MPa**	**ksi**	**MPa**	**ksi**	**MPa**
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

HASTELLOY® X Plate, Solution-annealed

Temperature		Creep	Approximate Initial Stress to Produce Specified Creep in							
			10 h		100 h		1,000 h		10,000 h	
°F	°C	%	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
1200	649	0.5	-	-	27.2	188	19	128	12.8	88
		1	-	-	30	207	21	145	15.5	107
		R	65*	448*	50	345	36	248	26	179
1300	704	0.5	25	172	16.2	112	11.1	77	8.2	57
		1	27	186	19	131	14	97	10.5	72
		R	46	317	32	221	23	159	17	117
1400	760	0.5	15	103	10.3	71	7.5	52	5.6	39
		1	18	124	13	90	9.5	66	7.1	49
		R	30	207	21	146	15.5	107	11.5	79
1500	816	0.5	9.9	68	7.2	50	5.3	37	3.85	27
		1	12.5	86	9.1	63	6.7	46	4.7	32
		R	21	141	15	103	10.5	72	7.2	50
1600	871	0.5	7.0	48	5.1	35	3.7	26	2.4	17
		1	8.9	61	6.4	44	4.5	31	2.9	20
		R	15	100	10.0	69	6.8	47	4.5	31
1700	927	0.5	5.1	35	3.6	25	2.3	16	1.3	9.0
		1	6.4	44	4.4	30	2.7	19	1.5	10
		R	10.0	69	6.6	46	4.3	30	2.6	18
1800	982	0.5	3.6	25	2.3	16	1.25	8.6	0.55	3.8
		1	4.4	30	2.7	19	1.45	10	0.65	4.5
		R	6.7	46	4.3	30	2.6	18	1.4	10
1900	1038	0.5	2.4	16	1.3	9.0	0.55	3.8	-	-
		1	2.8	19	1.5	10	0.65	4.5	-	-
		R	4.3	30	2.6	18	1.4	10	-	-
2000	1093	0.5	1.4	10	0.60	4.1	0.15*	1.0*	-	-
		1	1.6	11	0.70	4.8	0.20*	1.4*	-	-
		R	2.7	19	1.4	10	0.60*	4.1*	-	-

*Significant extrapolation

HASTELLOY® X Sheet, Solution-annealed

Temperature		Creep	Approximate Initial Stress to Produce Specified Creep in							
			10 h		100 h		1,000 h		10,000 h	
°F	°C	%	ksi	MPa	ksi	MPa	ksi	MPa	ksi	MPa
1200	649	0.5	-	-	26	178	18	124	-	-
		1	-	-	28	193	21	145	-	-
		R	66*	455*	48	331	35	241	26	179
1300	704	0.5	23.5	162	16	112	12	83	-	-
		1	26	179	19	131	14	97	-	-
		R	44	303	32	221	23	159	17	117
1400	760	0.5	15	103	11	76	8.1	56	-	-
		1	18	124	13	90	9.5	66	7.1	49
		R	30	207	21	146	16	107	11.5	79
1500	816	0.5	10.5	72	7.7	53	5.4	37	-	-
		1	12.5	86	9.1	63	6.5	45	4.3	30
		R	21	141	15	103	11	72	7.2	50
1600	871	0.5	7.5	52	5.1	35	3.2	22	-	-
		1	8.9	61	6.2	43	3.9	27	2.3	16
		R	15	100	10	69	6.8	47	4.2	29
1700	927	0.5	5.1	35	3.1	21	1.5	11	-	-
		1	6.2	43	3.8	26	2.2	15	1.1*	7.2*
		R	10	69	6.6	46	4.0	28	2.4	17
1800	982	0.5	3.1	21	1.5	11	0.48	3.3	-	-
		1	3.8	26	2.2	15	1.0	6.9	0.33*	2.3*
		R	6.7	46	4.0	28	2.3	16	1.2	8.3
1900	1038	0.5	1.6	11	-	-	-	-	-	-
		1	2.2	15	1.0	6.9	0.33*	2.3*	-	-
		R	4.1	28	2.4	17	1.2	8.3	-	-
2000	1093	0.5	0.62	4.3	-	-	-	-	-	-
		1	1.1	7.6	0.35	2.4	0.10*	0.69*	-	-
		R	2.5	17	1.3	8.6	0.40	2.8	-	-

*Significant extrapolation

Tensile Properties

Tensile Data, Plate

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		Elongation
°F	°C	ksi	MPa	ksi	MPa	%
70	21	49.3	340	110.2	760	48.9
1000	538	32.5	224	87.6	604	60.2
1200	649	30.7	212	80.9	558	63.5
1400	760	31.6	218	61.0	421	74.5
1600	871	27.4	189	37.0	255	98.1
1800	982	13.6	94	20.0	138	98.1
2000	1093	6.5	45	10.4	72	95.3

Tensile Data, Sheet

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		Elongation
°F	°C	ksi	MPa	ksi	MPa	%
70	21	54.5	376	113.5	783	46.5
1000	538	36.7	253	91.0	628	53.6
1200	649	34.9	241	84.2	580	65.5
1400	760	33.8	233	61.6	424	95.6
1600	871	28.0	193	36.5	251	117.9
1800	982	12.8	88	18.9	130	81.5
2000	1093	6.2	43	9.5	65	50.6

Average Effect of Cryogenic Temperatures on Tensile Properties

Form	Condition	Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		Elongation
-	-	°F	°C	ksi	MPa	ksi	MPa	%
Plate	Heat-treated at 2150°F(1177°C), Rapid Cooled	-311	-196	-	-	150.2	1036	46
		-108	-78	-	-	118.8	819	51
		72	22	47.0	324	104.5	721	46

All Weld Metal

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		Elongation	
°F	°C	ksi	MPa	ksi	MPa	%	
RT	RT	66.4	458	98.6	680	28	in 1 inch
600	316	52.1	359	80.4	554	27	in 1.125 inches
1000	538	49.2	339	76.3	526	28	in 1.125 inches
1500	816	38.2	263	56.7	391	45	in 1.125 inches

RT= Room Temperature

Average Aged Tensile Data, Room Temperature*

Form	Aging Temperature		Aging Time	0.2% Yield Strength		Ultimate Tensile Strength		Elongation
-	°F	°C	h	ksi	MPa	ksi	MPa	%
Sheet 0.125 in. (3.2mm) thick	SHT	SHT	-	55.2	381	114.3	788	57
	1200	649	1000	61.0	421	125.0	862	35
			4000	76.2	525	143.8	991	19
			8000	78.6	542	147.9	1020	19
			16000	78.1	538	148.0	1020	15
	1400	760	1000	65.3	450	137.0	945	23
			4000	64.3	443	134.6	928	18
			8000	61.3	423	131.0	903	19
			16000	59.3	409	126.1	869	17
	1600	871	1000	53.2	369	123.0	848	26
			4000	49.3	340	117.9	813	29
			8000	48.2	332	115.0	793	30
			16000	46.1	318	111.1	766	29
Plate 1/2 in. (12.7mm) thick	SHT	SHT	-	49.5	341	109.9	758	47
	1200	649	1000	56.5	390	121.4	837	33
			4000	73.4	506	142.5	983	18
			8000	73.0	503	143.6	990	18
	1400	760	1000	56.9	392	129.4	892	23
			4000	56.9	392	129.9	896	21
			8000	56.3	388	129.2	891	20
	1600	871	1000	47.6	328	119.0	820	31
			4000	44.9	310	116.7	805	28
			8000	43.9	303	113.7	784	26
			16000	42.7	394	109.0	752	26

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

Physical Properties

Physical Property	British Units		Metric Units	
Density	72°F	0.297 lb/in^3	22°C	8.22 g/cm^3
Melting Range	2300 - 2470 °F		1260 - 1355°C	

Electrical Resistivity	-400°F	43.8 µohm-in	-250°C	16.86 µohm-cm
	-300°F	43.2 µohm-in	-200°C	16.96 µohm-cm
	-200°F	43.8 µohm-in	-150°C	17.14 µohm-cm
	-100°F	44.3 µohm-in	-100°C	17.34 µohm-cm
	0°F	45.0 µohm-in	-50°C	17.55 µohm-cm
	75°F	45.4 µohm-in	25°C	17.87 µohm-cm
Thermal Conductivity	70°F	63 Btu-in/ft.^{2}hr.-°F	25°C	9.2 W/m-°C
	200°F	76 Btu-in/ft.^{2}hr.-°F	100°C	11.2 W/m-°C
	500°F	98 Btu-in/ft.^{2}hr.-°F	200°C	14.1 W/m-°C
	1100°F	144 Btu-in/ft.^{2}hr.-°F	600°C	20.9 W/m-°C
	1200°F	151 Btu-in/ft.^{2}hr.-°F	650°C	21.9 W/m-°C
	1300°F	159 Btu-in/ft.^{2}hr.-°F	700°C	22.8 W/m-°C
	1400°F	166 Btu-in/ft.^{2}hr.-°F	750°C	23.8 W/m-°C
	1500°F	174 Btu-in/ft.^{2}hr.-°F	800°C	24.7 W/m-°C
	1600°F	182 Btu-in/ft.^{2}hr.-°F	850°C	25.7 W/m-°C
	1700°F	189 Btu-in/ft.^{2}hr.-°F	900°C	26.7 W/m-°C
Specific Heat	RT	0.116 Btu/lb.-°F	RT	486 J/kg-°C
	200°F	0.117 Btu/lb.-°F	100°C	487 J/kg-°C
	400 °F	0.118 Btu/lb.-°F	200°C	484 J/kg-°C
	600°F	0.119 Btu/lb.-°F	300°C	491 J/kg-°C
	800°F	0.123 Btu/lb.-°F	400°C	507 J/kg-°C
	1000°F	0.130 Btu/lb.-°F	500°C	531 J/kg-°C
	1200°F	0.139 Btu/lb.-°F	600°C	564 J/kg-°C
	1400°F	0.151 Btu/lb.-°F	700°C	606 J/kg-°C
	1600°F	0.167 Btu/lb.-°F	800°C	657 J/kg-°C
	1800°F	0.186 Btu/lb.-°F	900°C	716 J/kg-°C
	2000°F	0.205 Btu/lb.-°F	1000°C	784 J/kg-°C
Mean Coefficient of Thermal Expansion	79 - 200°F	7.7 µin/in.-°F	26 - 100°C	13.9 10^{-6} m/m-°C
	79 - 1000°F	8.4 µin/in.-°F	26 - 500°C	15.0 10^{-6} m/m-°C
	79 - 1200°F	8.6 µin/in.-°F	26 - 600°C	15.3 10^{-6} m/m-°C
	79 - 1350°F	8.8 µin/in.-°F	26 - 700°C	15.7 10^{-6} m/m-°C
	79 - 1400°F	8.9 µin/in.-°F	26 - 750°C	15.9 10^{-6} m/m-°C
	79 - 1500°F	8.9 µin/in.-°F	26 - 800°C	16.0 10^{-6} m/m-°C
	79 - 1600°F	9.1 µin/in.-°F	26 - 850°C	16.2 10^{-6} m/m-°C
	79 - 1650°F	9.1 µin/in.-°F	26 - 900°C	16.4 10^{-6} m/m-°C
	79 - 1800°F	9.2 µin/in.-°F	26 - 975°C	16.6 10^{-6} m/m-°C
Dynamic Modulus of Elasticity	RT	29.8 x 10^6 psi	RT	205 GPa
	200°F	29.4 x 10^6 psi	100°C	202 GPa
	400°F	28.6 x 10^6 psi	200°C	198 GPa
	600°F	27.8 x 10^6 psi	300°C	192 GPa
	800°F	26.7 x 10^6 psi	400°C	187 GPa
	1000°F	25.8 x 10^6 psi	500°C	180 GPa
	1200°F	24.7 x 10^6 psi	600°C	173 GPa
	1400°F	23.3 x 10^6 psi	700°C	165 GPa
	1600°F	22.2 x 10^6 psi	800°C	157 GPa
	1800°F	20.4 x 10^6 psi	900°C	148 GPa
Poisson's Ratio	-108°F	0.328	-78 °C	0.328
	72°F	0.320	22 °C	0.320
Magnetic Permeability	RT	1.002 at 200 oersteds (15,900 A/m)		

RT= Room Temperature

Hardness and Grain Size

Room Temperature Hardness of Material Solution Annealed at 2150°F

Form	Hardness, HRBW	Typical ASTM Grain Size
Sheet	86	3 - 5
Plate	87	3.5 - 6
Bar	88	2 - 5

HRBW = Hardness Rockwell “B”, Tungsten Indentor.

Aged Hardness

Aged Hardness at Room Temperature*

Form	Aging Temperature		Aging Time	HRBW
-	°F	°C	h	-
Sheet	SHT	SHT	-	54
	1200	649	1000	56
			4000	62
			8000	63
	1400	760	1000	62
			4000	61
			8000	60
	1600	871	000	61
			4000	58
			8000	55
Plate	SHT	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

HRBW = Hardness Rockwell “B”, Tungsten Indentor.

Formability

Sheet

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

Impact Strength

Average Impact Strength, Plate*

Condition	Test Temperature	Average Charpy V-Notch Impact Strength	
		ft. - lb.	J
Heat-treated at 2100°F (1149°C), Water Quenched	RT	103	140

*Average of 28 samples from multiple heats, 0.413" - 1.25" thick, tested during years 2007 - 2014.

Aged Plate*

Aging Temperature		Aging Time	Average Charpy V-Notch Impact Strength	
°F	°C	h	ft.-lb.	J
SHT	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.

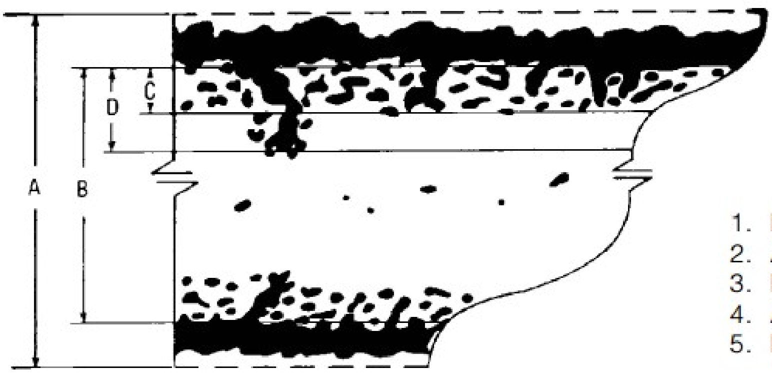
Oxidation Resistance

Comparative Static Oxidation Data in Flowing Air for 1008 Hours*

Alloy	1800°F (980°C)				2000°F (1095°C)			
	Metal Loss/Side		Metal Loss + CIP**/Side		Metal Loss/Side		Metal Loss + CIP**/Side	
-	mils	mm	mils	mm	mils	mm	mils	mm
X	**0.29**	**0.007**	**0.74**	**0.019**	**1.5**	**0.038**	**2.7**	**0.069**
INCONEL® 600	0.32	0.008	0.90	0.023	1.1	0.028	1.6	0.041
INCONEL® 601	0.53	0.013	1.3	0.033	1.2	0.031	2.6	0.06
625	0.32	0.008	0.72	0.018	3.3	0.083	4.8	0.12
800H®	0.024	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

Schematic Representation of Metallographic Technique used for Elevating 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		Test Period	Total Metal Affected/Side					
			X		S		188	
°F	°C	h	mils	mm	mils	mm	mils	mm
1650	900	200	**3.0**	**0.08**	2.7	0.07	2.1	0.05
1650	900	1000	**6.8**	**0.17**	7.5	0.19	3.7	0.09

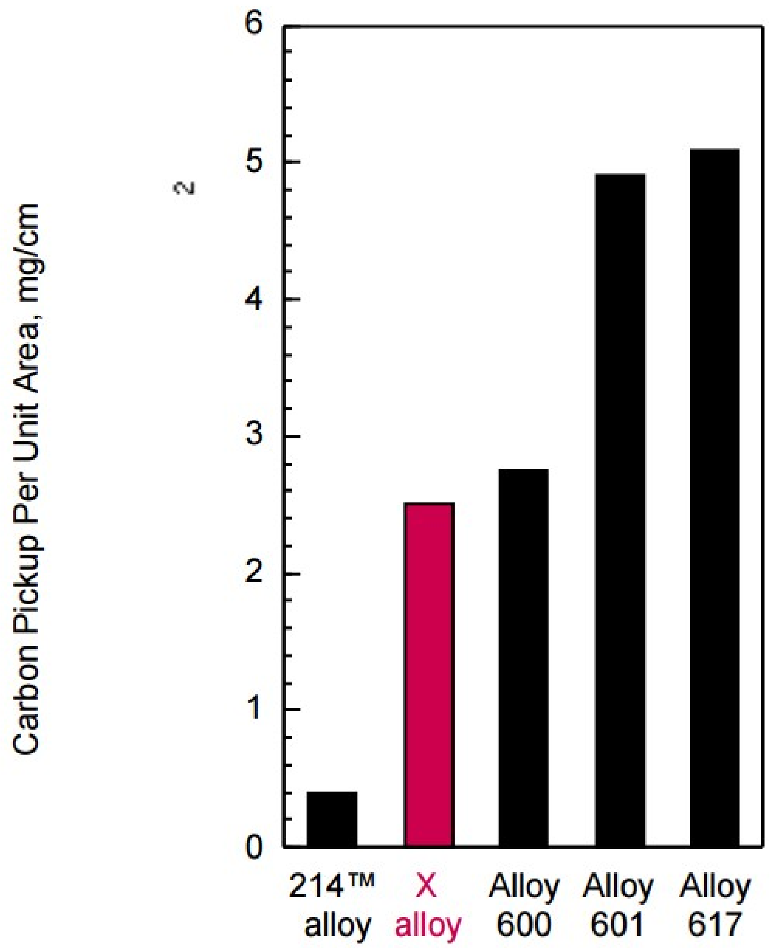
*All tests performed by exposure to the combustion products of No. 2 fuel oil (0.4 percent sulfur) and 5 ppm of sea salt. Gas velocity over samples was 13 ft./sec. (4m/s). Thermal shock frequency was one/hour.

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 x 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/cm^2), 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 (cm^2).

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



Welding

HASTELLOY® X alloy is readily welded by Gas Tungsten Arc Welding (GTAW), Gas Metal Arc Welding (GMAW), Shielded Metal Arc Welding (SMAW), and resistance welding techniques. Submerged Arc Welding (SAW) 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 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. It is preferable, but not necessary, that the alloy be in the solution- annealed condition when welded.

Filler Metal Selection

HASTELLOY® X filler wire (AWS A5.14, ERNiCrMo-2) is recommended for joining X alloy by Gas Tungsten Arc or Gas Metal Arc welding. Coated electrodes of X alloy are also available for Shielded Metal Arc welding in non-ASME code construction. For dissimilar metal joining of X alloy to nickel-, cobalt-, or iron- base materials, X filler wire, HAYNES® 556® alloy (AWS A5.9 ER3556, AMS 5831) , HASTELLOY® S alloy (AMS 5838) or HASTELLOY® W alloy (AMS 5786, 5787) welding products may all be considered, depending upon the particular case. Please click here or the Haynes Welding SmartGuide for more information.

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 X alloy. For further information, please click here.

Nominal Welding Parameters

Details for GTAW, GMAW and SMAW welding are given here. Nominal welding parameters are provided as a guide for performing typical operations and are based upon welding conditions used in our laboratories.

Mechanical Properties of Welded Material

Room Temperature Hardness of Welded Sheet

Weld Method	Test Area	HRBW
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.
HRBW = Hardness Rockwell “B”, Tungsten Indentor.

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

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

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 number of tests.

Average Tensile Data, Weldments

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

All Weld Metal

Test Temperature		0.2% Yield Strength		Ultimate Tensile Strength		Elongation	
°F	°C	ksi	MPa	ksi	MPa	%	
RT	RT	66.4	458	98.6	680	28	in 1 inch
600	316	52.1	359	80.4	554	27	in 1.125 inches
1000	538	49.2	339	76.3	526	28	in 1.125 inches
1500	816	38.2	263	56.7	391	45	in 1.125 inches

RT= Room Temperature

Average Welded and Aged Tensile Data, Room Temperature*

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

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

Specifications and Codes

Specifications

Codes

HASTELLOY® X alloy (N06002, W86002)	
Sheet, Plate & Strip	AMS 5536 SB 435/B 435 P= 43
Billet, Rod & Bar	AMS 5754 SB 572/B 572 B 472 P= 43
Coated Electrodes	SFA 5.11/ A 5.11 (ENiCrMo-2) F= 43
Bare Welding Rods & Wire	SFA 5.14/ A 5.14 (ERNiCrMo-2) AMS 5798 F=43
Seamless Pipe & Tube	SB 622/B 622 P= 43
Welded Pipe & Tube	AMS 5588 SB 619/B 619 SB 626/B 626 P= 43
Fittings	SB 366/B 366 P= 43
Forgings	AMS 5754
DIN	17742 No. 2.4665 NiCr22Fe18Mo
Others	NACE MR0175 ISO 15156

HASTELLOY® X alloy (N06002, W86002)			
ASME	**Section I**	-	
	Section III	**Class 1**	800°F (427°C)[1]
		Class 2	800°F (427°C)[5]
		Class 3	800°F (427°C)[5]
		Classes TC and SC	800ºF (427ºC)[2]
	Section IV	**HF-300.2**	-
	Section VIII	**Div. 1**	1650°F (899°C)[2]
		Div. 2	900ºF (482ºC)[6] 1650°F (899°C)[5] 800°F (427°C) (Bolting)
	Section XII	650°F (343°C)[2]	
	B16.5	1500°F (816°C)[3]	
	B16.34	1500°F (816°C)[4]	
	B31.1	-	
	B31.3	1500°F (816°C)[5]	
MMPDS	6.3.1		

[1]Plate, Sheet, Bar, welded pipe/tube, seamless pipe/tube
[2]Plate, Sheet, Bar, fittings, welded pipe/tube, seamless pipe/tube, Bolting
[3]Plate, Bar
[4]Plate, Bar, seamless pipe/tube
[5]Welded pipe/tube, seamless pipe/tube
[6]Plate, Sheet, and Rod

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