HAYNES International

CORROSION-RESISTANT ALLOYS

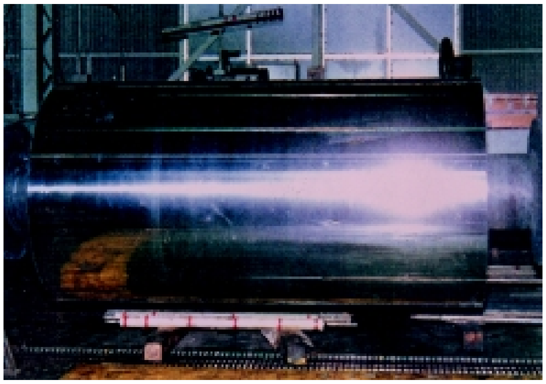
ULTIMET® alloy

A cobalt-base alloy with exceptional resistance to galling, cavitation erosion, slurry erosion, liquid droplet impact, and various forms of corrosive attack. ULTIMET alloy exhibits superior weldability and may be used to weld overlay critical surfaces to improve their resistance to corrosion-wear. The alloy is available in a variety of wrought forms, as well as castings and powders.

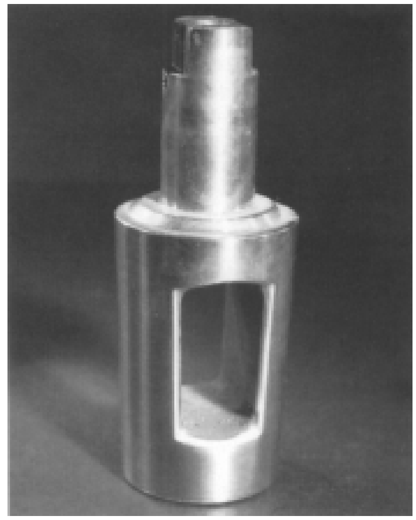
Contents

H-2082B

TYPICAL APPLICATIONS



ULTIMET alloy electrogalvanizing rolls have been used successfully in the production of galvanized steel for automobiles in the Far East and Europe. The corrosion/wear rate of ULTIMET alloy in this application is about half that of the previously used Ni-Cr-Mo alloy.



The use of an ULTIMET weld overlay on the plug of a valve solved a problem of failure by erosion at a large chemical company in the U.S. The valve protected with ULTIMET has so far lasted three times as long as the unprotected valve, and is still in service.

ULTIMET cast nozzles are now standard for a major incinerator scrubber manufacturer in Europe. In this application, ULTIMET alloy has outperformed ceramics and cast Co-Cr-W and Ni-Cr-Mo alloys.

ULTIMET is the standard shielding material for fans used by a large fiberglass company in North America. It has proved resistant to erosion/corrosion in fiberglass manufacturing, and is preferred over the Co-Cr-W alloys because of its relatively high ductility.

PRINCIPAL FEATURES

Outstanding Corrosion-Wear Resistance

ULTIMET® alloy is cobalt-chromium alloy which offers excellent corrosion resistance comparable to that of the HASTELLOY® alloys. ULTIMET alloy exhibits outstanding wear resistance similar to that of the STELLITE® alloys. Also, ULTIMET alloy possesses high tensile strength comparable to many duplex stainless steels combined with excellent impact toughness and ductility.

ULTIMET alloy is an ideal welding material with exceptional ductility and resistance to weld cracking. It is very easy to apply as an overlay, compared with the traditional cobalt-base wear alloys. With ULTIMET alloy, cracking of the overlay is not a consideration, and multiple layers may be applied, with little or no preheat.

Product Forms

ULTIMET alloy is available in most common wrought product forms: plate, sheet, billet, bar, wire, and covered electrodes.

Wrought forms of this alloy are furnished in the solution heat-treated condition, unless otherwise specified.

Licensees of Haynes International produce ULTIMET alloy remelt bar for castings and ULTIMET gas-atomized powders for plasma transferred arc, plasma spray, and high-velocity oxy-fuel processes.

Applications

Some of the areas of use for ULTIMET alloy are:

- Agitators
- Blenders
- Bolts
- Dies
- Extruders
- Fan Blades
- Filters
- Glass Plungers
- Nozzles
- Pumps
- Rolls
- Screw Conveyors
- Valve Parts

Field Test Program

Samples of ULTIMET alloy are readily available for laboratory or in-plant corrosion testing. An analysis of the tested material can be performed and the results provided to the customer as a technical service. Contact any of the locations shown on the back cover of this brochure for test coupons and information.

Specifications

ULTIMET alloy is covered by ASME Section VIII, Division 1, Code Case 2121. Plate, sheet, strip, and bar are covered by ASTM Specification B-815 and B-818. DIN specification is CoCr26Ni9Mo5W No. 2.4681 (all forms). The UNS number for ULTIMET alloy is R31233. ULTIMET alloy is covered by Section 4.1.6.3 of NACE Standard MR0175-94.

Material Safety Data Sheets

For information concerning material safety data, ask for Material Safety Data Sheet H1072.

Nominal Chemical Composition, Weight Percent

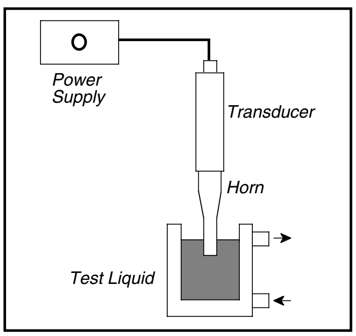
Co[a]	Cr	Ni	Mo	Fe	W	Mn	Si	N	C
54	26	9	5	3	2	0.8	0.3	0.08	0.06

[a] As balance

COMPARATIVE RESISTANCE TO EROSION

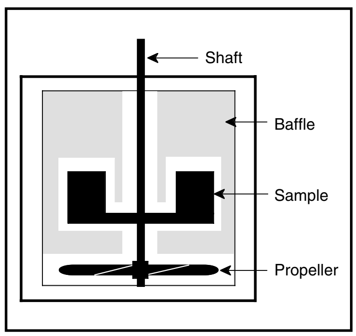
Material	Erosion Depth/Rate		
	Cavitation (mm)	Slurry (microns)	Solid Particle ($mm^3/g \times 10^4$)
ULTIMET alloy	0.0068	0.740	10.34
HAYNES 6B alloy	0.0073	0.460	10.44
HAYNES 625 alloy	0.0800	1.660	13.33
HASTELLOY C-276 alloy	0.1128	1.420	12.65
Carpenter 20CB-3® alloy	0.2743	1.980	11.06
Type 316L Stainless Steel	0.1802	1.310	12.38
FERRALIUM® alloy 255	0.1336	-	-

Cavitation Test



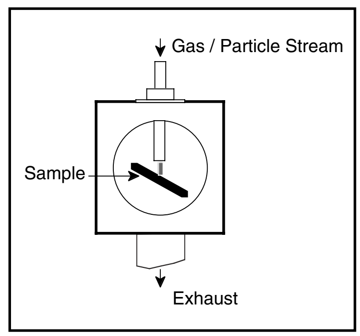
ASTM Standard G 32
Frequency-20 kHz
Amplitude-0.05 mm
Liquid-Distilled Water
Test Duration-24 hr.
Room Temperature

Slurry Test



Medium-80 microns Alumina in Tap Water
Velocity-5 m/s
Impact Angle-30°
Particle Loading-0.12 kg/l
Test Duration-40 hr.
Room Temperature

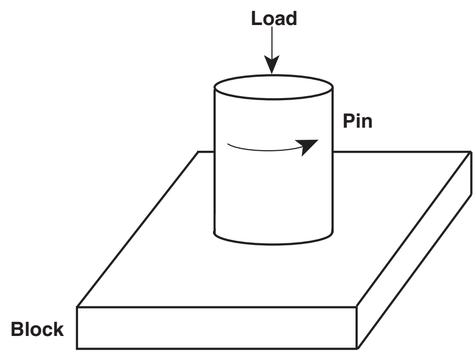
Solid Particle Test



ASTM Standard G 76 (Modified)
Erodent-400 microns Angular Silicon Carbide
Velocity-20 m/s
Impact Angle-60°
Total Flow-80 g of Erodent
Room Temperature

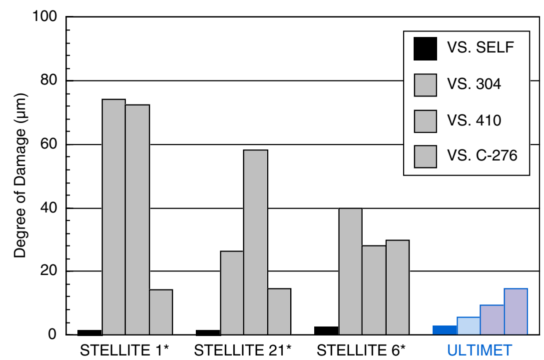
COMPARATIVE RESISTANCE TO GALLING

Galling Test



10 strokes / 120° arc

Galling Test (2722 kg/6000 lb. Load)
Room Temperature



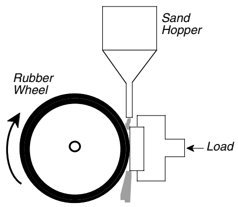
*GTA 2-layer deposit

Pin	Block	Degree of Damage, microns Load 1361 kg (3000 lb)	2722 kg (6000 lb)	4082 kg (9000 lb)
ULTIMET alloy	ULTIMET alloy	2.9	2.7	2.0
ULTIMET alloy	1045 Carbon Steel (HRC 32)	7.4	6.6	8.2
ULTIMET alloy	4140 Alloy Steel (HRC 46)	2.3	2.7	2.5
ULTIMET alloy	H-13 Tool Steel (HRC 48)	2.1	2.1	2.0
ULTIMET alloy	Type 304 Stainless Steel	2.5	5.5	18.3
ULTIMET alloy	Type 316L Stainless Steel	1.4	1.2	0.7
Type 316L Stainless Steel	Type 316L Stainless Steel	>100.0	-	-
ULTIMET alloy	Type 410 Stainless Steel	9.4	9.4	17.7
ULTIMET alloy	17-4-PH® Stainless Steel (HRC 39)	3.5	3.5	5.7
17-4-PH Stainless (HRC 39)	17-4-PH Stainless (HRC 39)	57.8	>100.0	>100.0
ULTIMET alloy	HASTELLOY C-276 alloy	11.4	14.6	17.6
ULTIMET alloy	HAYNES 718 alloy (HRC 47)	7.1	8.5	11.7
HAYNES 718 alloy (HRC 47)	HAYNES 718 alloy (HRC 47)	18.1	24.0	16.7
ULTIMET alloy	STELLITE® 6**	0.1	0.1	0.1
ULTIMET alloy	STELLITE 6H**	0.1	0.1	0.1
HAYNES 6B alloy	HAYNES 6B alloy	0.6	0.7	0.5
NITRONIC® 60 alloy	NITRONIC 60 alloy	2.5	120.0	111.3

All Wrought Products except:
** All-Weld-Metal, GTA weld type

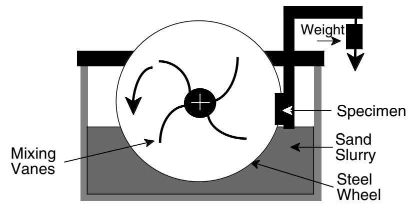
COMPARATIVE RESISTANCE TO ABRASION

Low Stress Abrasion Test



Load: 13.6 kg
Flow Rate: 390 g/min
Wheel Speed: 200 rev/min
Test Revolutions: 2000

High Stress Abrasion Test

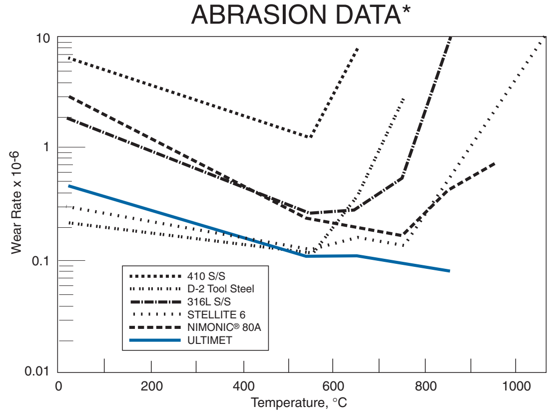


Load: 22.7 kg
Slurry: 1500g sand/940g water
Wheel Speed: 240 rev/min
Test Revolutions: 250

Material	Volume Loss, cu mm Low Stress*	High Stress**
ULTIMET alloy	90.4	56.1
HAYNES 6B alloy	15.3	57.0
HAYNES 625 alloy	119.3	63.4
HASTELLOY C-22 alloy	114.0	64.9
HASTELLOY C-276 alloy	123.5	49.8
FERRALIUM alloy 255	97.5	75.0
Type 316L Stainless Steel	140.4	64.8
Type D-2 Tool Steel (HRC 60)	15.2	56.9
Carpenter 20CB-3 alloy	127.9	56.4
NITRONIC 60	145.8	-
Type 1020 Carbon Steel	130.0	-
STELLITE 1***	29.4	-
STELLITE 6***	63.8	-
STELLITE 21***	80.3	-

* ASTM G-65
** ASTM B-611
*** GTAW, 2-layer

ABRASION DATA*



*Reference: Wear, Volume 162-164 (1993), page 441-449

LOCALIZED CORROSION RESISTANCE

Comparative Critical Pitting Temperatures in Oxidizing H_2SO_4-HCl Solution

The chemical composition of the solution used in this test is as follows: 11.5 percent H_2SO_4 + 1.2 percent HCl + 1 percent $FeCl_3$ + 1 percent $CuCl_2$. This test environment is a severely oxidizing acid solution which is used to evaluate the resistance of alloys to localized corrosion. Experiments were performed in increments of solution temperature of 5°C for a 24-hour exposure period to determine the lowest temperature at which pitting corrosion initiated (observed by examination at a magnification of 40X).

Material	Critical Pitting Temperature °C	°F
HASTELLOY C-22™ alloy	120	248
ULTIMET alloy	120	248
HASTELLOY C-276 alloy	110	230
HAYNES® 625 alloy	75	167
HAYNES 6B alloy	45	113
TYPE 316L Stainless Steel	25	77

Comparative Immersion Critical Crevice Corrosion Temperatures in Oxidizing 6% $FeCl_3$ Solution for 72 Hours

Material	Critical Crevice Corrosion Temperature °C	°F
HASTELLOY C-22 alloy	70	158
ULTIMET alloy	65	149
HASTELLOY C-276 alloy	65	149
HAYNES 625 alloy	30	86
HAYNES 6B alloy	25	77
TYPE 316L Stainless Steel	<0	<32

Comparative Stress-Corrosion Cracking Data

Material	45% $MgCl_2$ 154°C (309°F)	0.8% NaCl+ 0.2% H_3PO_4 141°C (286°F)
HASTELLOY C-22 alloy	No Cracks	No Cracks
ULTIMET alloy	Cracked	No Cracks
FERRALIUM® alloy 255	Cracked	No Cracks
Carpenter 20CB-3 alloy	Cracked	No Cracks
Type 316L Stainless Steel	Cracked	Cracked
HAYNES 6B alloy	Broke on Bending	Broke on Bending

AQUEOUS CORROSION DATA

Comparative Aqueous Corrosion Data on Wrought Products

	Concentration, % by weight	Test Temperature °F	°C	Average Corrosion Rate per Year, mils ULTIMET alloy	6B alloy	C-276 alloy	alloy 20CB-3
Hydrochloric Acid	1	Boiling		0.3	170	13	81
Nitric Acid	65	Boiling		6	5434	848	8
P_2O_5 (Commercial Grade)	54	240	116	8	15	28	36
Sulfuric Acid	10	Boiling		99	232	18	22
Sulfuric Acid + 1.2% HCl + 1% $FeCl_3$ + 1% $CuCl_2$ (ASTM G28B)	11.5	Boiling		2	2888	55	2720
Sulfuric Acid + 42 g/l $Fe_2(SO_4)_3$ (ASTM G28A)	50	Boiling		8	14	250	10

* To convert mils per year (mpy) to mm per year, divide by 40.

Comparative Aqueous Corrosion Data on Cast Product

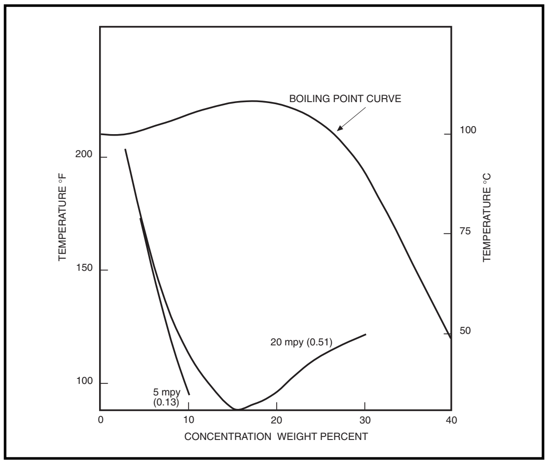
	Concentration, % by weight	Test Temperature °F	°C	Average Corrosion Rate per Year, mils ULTIMET alloy[1]	CX-2MW[2] (C-22)	AMS 5373 alloy 6[1]	CF-3M[2] (316LSS)
Ferric Chloride	10	Boiling		1	156	19989	20925
Nitric Acid	65	Boiling		8	117	2890	14
P_2O_5 (Commercial Grade)	54	240	116	8	13	35	28
Sulfuric Acid	10	Boiling		84	26	7269	634
Sulfuric Acid + 1.2 HCl + 1% $FeCl_3$ + 1% $CuCl_2$ (ASTM G28B)	11.5	Boiling		41	27	3181	3557
Sulfuric Acid + 42 g/l $Fe_2(SO_4)_3$ (ASTM G28A)	50	Boiling		10	71	61	27

[1]As-Cast Condition [2]Cast + Annealed Condition

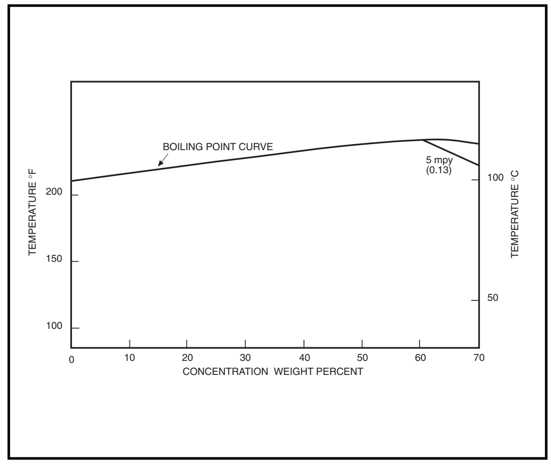
ISOCORROSION DIAGRAMS*

The isocorrosion diagrams shown on this page were plotted using data obtained in laboratory tests in reagent grade acids. These data should be used only as a guide. It is recommended that samples be tested under actual plant conditions.

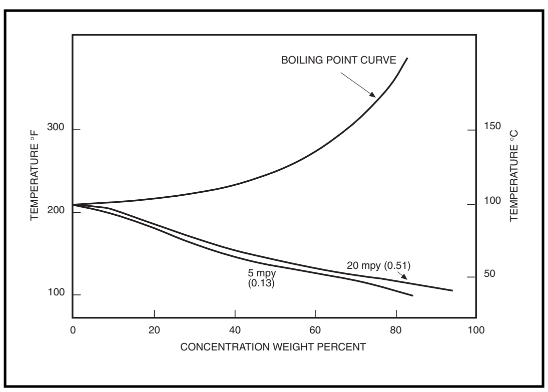
Resistance to Hydrochloric Acid



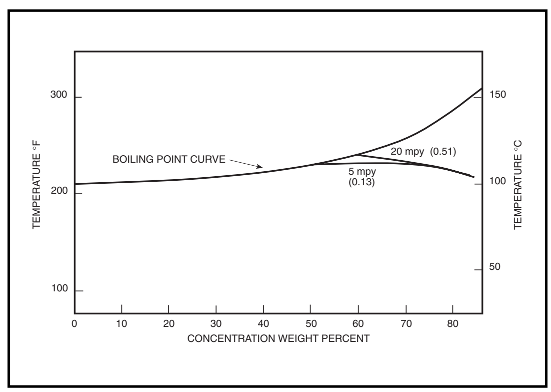
Resistance to Nitric Acid



Resistance to Sulfuric Acid



Resistance to Phosphoric Acid



Corrosion rates in parentheses are in mm/year.
* All test specimens were heat-treated at 2050°F (1121°C), water quenched and in the unwelded condition.

TYPICAL PHYSICAL PROPERTIES

Physical Property	Temp., °F	British Units	Temp., °C	Metric Units
Density	75	0.306 lb/in.^{3}	24	8.47 g/cm.^{3}
Melting Temperature	2430-2470		1332-1354	
Electrical Resistivity	75	34.2 microhm-in.	23	0.87 microhm-m
	212	35.4 microhm-in.	100	0.89 microhm-m
	392	36.6 microhm-in.	200	0.93 microhm-m
	572	38.1 microhm-in.	300	0.96 microhm-m
	752	39.3 microhm-in.	400	1.00 microhm-m
	932	40.5 microhm-in.	500	1.03 microhm-m
	1112	41.3 microhm-in.	600	1.05 microhm-m
Mean Coefficient of	78-200	7.2 microinches/in.-°F	26-93	13.0 x 10^{-6} m/m-K
Thermal Expansion	78-400	7.5 microinches/in.-°F	26-204	13.5 x 10^{-6} m/m-K
	78-600	7.8 microinches/in.-°F	26-316	14.0 x 10^{-6} m/m-K
	78-800	8.0 microinches/in.-°F	26-427	14.5 x 10^{-6} m/m-K
	78-1000	8.2 microinches/in.-°F	26-538	14.8 x 10^{-6} m/m-K
	78-1200	8.4 microinches/in.-°F	26-649	15.1 x 10^{-6} m/m-K
	78-1400	8.8 microinches/in.-°F	26-760	15.9 x 10^{-6} m/m-K
	78-1600	9.1 microinches/in.-°F	26-871	16.4 x 10^{-6} m/m-K
	78-1800	9.4 microinches/in.-°F	26-982	16.9 x 10^{-6} m/m-K
Thermal Diffusivity	73	0.005 in.^{2}/sec.	23	3.3 x 10^{-6} m^2/s
	212	0.005 in.^{2}/sec.	100	3.5 x 10^{-6} m^2/s
	392	0.006 in.^{2}/sec.	200	3.8 x 10^{-6} m^2/s
	572	0.006 in.^{2}/sec.	300	4.2 x 10^{-6} m^2/s
	752	0.007 in.^{2}/sec.	400	4.5 x 10^{-6} m^2/s
	932	0.007 in.^{2}/sec.	500	4.7 x 10^{-6} m^2/s
	1112	0.007 in.^{2}/sec.	600	5.0 x 10^{-6} m^2/s
Thermal Conductivity	73	85 Btu-in./ft.^{2} hr.-°F	23	12.3 W/m-K
	212	96 Btu-in./ft.^{2} hr.-°F	100	13.8 W/m-K
	392	108 Btu-in./ft.^{2} hr.-°F	200	15.6 W/m-K
	572	121 Btu-in./ft.^{2} hr.-°F	300	17.5 W/m-K
	752	134 Btu-in./ft.^{2} hr.-°F	400	19.4 W/m-K
	932	149 Btu-in./ft.^{2} hr.-°F	500	21.5 W/m-K
	1112	166 Btu-in./ft.^{2} hr.-°F	600	23.9 W/m-K
Specific Heat	73	0.109 Btu/lb.-°F	23	456 J/kg-K
	212	0.112 Btu/lb.-°F	100	470 J/kg-K
	392	0.115 Btu/lb.-°F	200	482 J/kg-K
	572	0.121 Btu/lb.-°F	300	504 J/kg-K
	752	0.126 Btu/lb.-°F	400	525 J/kg-K
	932	0.130 Btu/lb.-°F	500	545 J/kg-K
	1112	0.137 Btu/lb.-°F	600	573 J/kg-K

Typical Dynamic Modulus of Elasticity

Form	Condition	Test Temperature °F	Test Temperature °C	Average Dynamic Modulus of Elasticity 10^6 psi	Average Dynamic Modulus of Elasticity GPa
Plate	Heat-treated at 2050°F Water Quenched	400	204	31.2	215
		600	316	29.9	206
		800	427	28.6	197
		1000	538	27.4	189
		1200	649	26.1	180

HARDNESS

Average Room Temperature Hardness

Condition	Form	Hardness, Rockwell
Mill Annealed	Sheet	Rc 30
10% Cold Worked	Sheet	Rc 40
20% Cold Worked	Sheet	Rc 43
40% Cold Worked	Sheet	Rc 49
As-Cast	Investment	Rb 96

Comparative Elevated Temperature Hardness

Temperature °F	Temperature °C	Diamond Pyramid Hardness, HV ULTIMET alloy	HAYNES 6B alloy	HAYNES 25 alloy
Room		296	374	285
800	427	173	269	171
1000	538	162	247	160
1200	649	158	225	150
1400	760	134	153	134
1600	871	89	91	93
1800	982	50	55	52

TENSILE DATA

Typical Tensile Data, Solution Heat-Treated

Form	Test Temperature °F	°C	Ultimate Tensile Strength, ksi*	Yield Strength at 0.2% Offset, ksi*	Elongation in 2 in. (50.8 mm), %
Sheet	Room		138	72	42
0.063 in.	200	93	135	58	50
(1.6 mm)	400	204	134	45	62
	600	316	130	43	75
	800	427	120	41	76
Plate	Room		148	79	36
1/4 - 1 1/2 in.	200	93	143	70	40
(6.3 - 38.1 mm)	400	204	143	55	61
	600	316	138	48	70
	800	427	133	45	70
	1000	538	125	38	70
	1200	649	99	37	66
	1400	760	76	39	70
	1600	871	51	28	77
	1800	982	31	16	100
Bar	Room		147	76	38
1/2 - 2 in.	200	93	140	70	49
(12.7 - 50.8 mm)	400	204	140	52	66
	600	316	132	44	77
	800	427	131	43	84
	1000	538	115	40	79

* ksi can be converted to MPa (megapascals) by multiplying by 6.895.

Typical Room Temperature Tensile Data, Aged Material

Condition	Ultimate Tensile Strength, ksi*	Yield Strength at 0.2% Offset, ksi*	Elongation in 2 in. (50.8 mm), %
Mill Annealed	148	79	36
Aged 1000 Hrs 400°F 204°C	148	79	34
Aged 1000 Hrs 600°F 316°C	155	80	47
Aged 1000 Hrs 800°F 427°C	155	81	47
Aged 1000 Hrs 1000°F 538°C	149	77	44
Aged 1000 Hrs 1200°F 649°C	146	85	29
Aged 1000 Hrs 1400°F 760°C	138	77	14
Aged 1000 Hrs 1600°F 871°C	139	71	28
Aged 1000 Hrs 1800°F 982°C	145	71	41

Typical Impact Strength, Plate

Aging Temperature °F	Aging Temperature °C	Aging Time hours	V-Notch Impact Strength Room Temperature ft.-lb.	Room Temperature Joules	-320°F ft.-lb.	-196°C Joules
Mill Annealed		-	130	176	68	92
400	204	100	141	191		
		1000	150	203		
600	316	100	150	203		
		1000	160	217		
1000	538	100	160	217		
		1000	152	206		
1200	649	100	117	159		
		1000	19	26		
1400	761	100	19	26		
		1000	7	9		
1600	871	100	23	31		
		1000	17	23		
1800	982	100	56	76		
		1000	44	60		

Comparative Impact Strength

Material	V-Notch Impact Strength Room Temperature ft.-lb.	Room Temperature Joules
ULTIMET alloy	130	176
HAYNES 6B alloy	6	8
Type 316 Stainless Steel	80	108

HIGH TEMPERATURE CORROSION

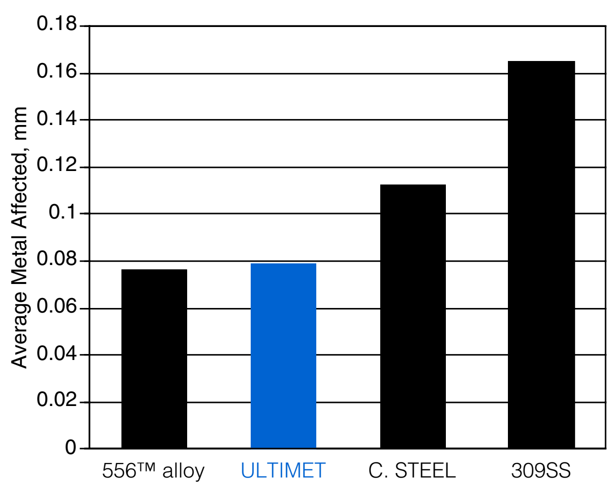
Comparative Oxidation Data

Static Oxidation Tests
1008 Hours

Material	1800°F 982°C		2000°F 1093°C	
	Metal Loss (mm)	**Avg. Metal Affected (mm)**	**Metal Loss (mm)**	**Avg. Metal Affected (mm)**
625	0.01	0.02	0.08	0.12
6B	0.01	0.03	0.35	0.39
ULTIMET	0.01	0.05	0.40	0.47
800HT®	<0.01	0.09	0.16	0.31
HR-160®	0.02	0.15	0.04	0.26

Resistance to Molten Zinc

Molten Zinc Attack
50 Hours at 850°F (454°C)



Comparative Resistance to Sulfidation Attack

Environment: Argon-5% Hydrogen-5% Carbon Monoxide-1% Carbon Dioxide-0.15% Hydrogen Sulfide

Material	Metal Loss (mm)	Internal Attack Average (mm)	Internal Attack Maximum (mm)
6B	<0.01	0.06	0.06
ULTIMET alloy	<0.01	0.06	0.08
HAYNES HR-160 alloy	<0.01	0.09	0.11
HAYNES 556 alloy	0.11	0.29	0.36
alloy 800H	0.19	0.41	0.50
alloy 625	Partially Consumed		

Time: 215 Hours
Temperature: 1600°F 871°C

WELDING

ULTIMET alloy is readily welded by gas tungsten arc (GTAW), gas metal arc (GMAW), shielded metal arc (SMAW) and submerged arc (SAW) welding techniques. ULTIMET alloy possesses excellent resistance to hot cracking. The oxyacetylene welding process is not recommended. Post-weld annealing is not necessary with ULTIMET alloy.

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.

Preheating is not required, and weld interpass temperatures should be kept below 93°C (200°F) when possible.

Filler Metal Selection

Matching composition filler metal is recommended for joining ULTIMET alloy. For gas tungsten arc, gas metal arc welding, and submerged arc ULTIMET filler wire is recommended. For shielded metal arc welding, ULTIMET covered electrodes are recommended. Detailed information for ULTIMET alloy is available in Haynes publications H-2089 and H-2099.

ULTIMET alloy was selected for this green pigment mixer bowl and blade to provide enhanced corrosion and wear resistantce. The mixer bowl has been lined with ULTIMET sheet and the blade was weld overlayed with ULTIMET wire.

Typical Transverse Tensile Data, Weldments

Form	Weld Type	Test Temperature °F	°C	Ultimate Tensile Strength, ksi*	Yield Strength at 0.2% Offset, ksi*	Elongation in 2 in. (50.8 mm), %
Plate 1/2 in. (12.7 mm) thick	GTAW	Room		127	89	11
	GMAW (Short)	Room		121	98	6
		500	260	121	65	19
		1000	538	114	53	28
	GMAW (Spray)	Room		133	93	11
		500	260	121	67	19
		1000	538	113	65	30
	SMAW	Room		135	97	9
Plate 3/4 in. (19.1 mm) thick	GMAW (Short)	Room		123	86	10
		500	260	116	62	20
		1000	538	98	45	26
	GMAW (Spray)	Room		136	90	15
		500	260	121	64	23
		1000	538	113	50	32
	SMAW	Room		130	87	13
		1000	538	109	48	32

* ksi can be converted to MPa (megapascals) by multiplying by 6.895.

Typical Tensile Data, All-Weld Metal

Weld Type	Test Temperature °F	Test Temperature °C	Ultimate Tensile Strength, ksi*	Yield Strength at 0.2% Offset, ksi*	Elongation in 2 in. (50.8 mm), %
GTAW	Room	-	133	95	10
GMAW (Short)	Room	-	132	89	17
GMAW (Spray)	Room	-	123	85	18
SMAW	Room	-	134	93	16
	1000	-	100	61	31

Typical Impact Strength, Weldments

Weld Type	V-Notch Impact Strength Room Temperature ft.-lb.	Joules
GTAW	94	127
SMAW	42	57

Typical Bend Test Data, Welded Plate

Weld Type	Face Bend 2T	Face Bend 3T	Side Bend 2T	Side Bend 3T
GMAW (Short)	Failed	Passed	Failed	Passed
GMAW (Spray)	Failed	Passed	Failed	Passed
SMAW	-	Passed	-	-

Duplicate specimens, 3/4 in. (19.10 mm) thick. Tested using AWS Specification 5.11 as a guide.

HEALTH AND SAFETY

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 concentration, 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 provision 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.

WELD OVERLAY

ULTIMET alloy is an ideal weld overlay material. Not only does it provide corrosion and wear protection to critical surfaces, it is very easy to apply compared with the traditional cobalt-base hardfacing alloys. This ease of application stems from its relatively high ductility. ULTIMET alloy may be applied in multiple layers with little or no preheat. Deposit cracking does not occur under most circumstances.

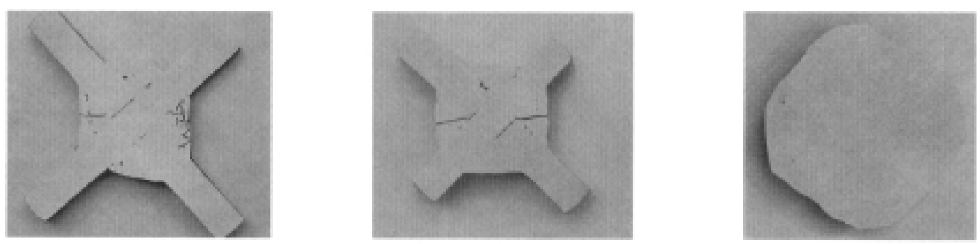
Weld overlays of ULTIMET alloy have been applied by gas tungsten arc, gas metal arc, shielded metal arc, submerged arc and plasma transferred arc welding techniques.

Oxyacetylene process is not recommended. For submerged arc welding, Lincoln Blue-Max 2000 flux is recommended.

Postweld Heat Treatment
Under most conditions, the postweld heat treatment of ULTIMET weld deposits is not required. If bending or cold-forming of the deposits is necessary, an annealing treatment at 2050°F (1121°C), followed by water quenching, may be required depending on the bend radius. The effects of annealing on the substrate material should be considered.

Stress-relief heat treatments in the temperature range of 1100 to 1200°F (593 to 649°C) do not markedly affect the properties of ULTIMET weld overlays. For further information, please consult Haynes publication H-2089 and H-2099.

Cruciform Test For Weld Cracking Sensitivity (Coated Electrodes)



STELLITE 1
Hot cracked at 1st layer
(stopped after 16 beads)

STELLITE 6
Hot cracked at 3rd layer
(stopped after 24 beads)

ULTIMET alloy
No observed cracking
(Total of 160 beads)

MACHINING

ULTIMET alloy can be successfully turned, drilled, and milled providing appropriate tooling and parameters are employed. The alloy possesses high strength, and therefore resists metal removal. It also work hardens rapidly. The alloy is most easily machined in the solution annealed condition. The following are guidelines for performing typical machining operations upon ULTIMET alloy wrought stock. Exact details for specific machining jobs will vary with circumstances of the particular job. Other tool materials not listed here may be suitable for machining ULTIMET alloy under various conditions. For further information, please consult Haynes publication H-2086.

Recommended Tools Types and Machining Conditions

Operations	Carbide Tools
Drilling	Carbide-tipped drills are recommended. Use 135° included angle on point. Speed: 30-35 sfm. Feed: 0.002 in. rev. ≤ 1/4 in. dia.,0.004 in. rev. > 1/4 in. dia. Oil[1] or water-base[2] coolant. Coolant-feed carbide tipped drills may be economical in some setups.
Roughing; Turning or Facing	C-2 or C-4 grade: Positive rake square insert, 15° or 45° SCEA[3], 1/32 in. nose radius. Tool holder: 5° pos. back rake, 5° pos. side rake. Speed: 90-100 sfm depending on rigidity of set up, 0.010 in. feed, 0.050-0.100 in. depth of cut Dry[4], oil, or water-base coolant.
Finishing; Turning or Facing	C-2 or C-4 grade; Positive rake square insert, if possible, 15° or 45° SCEA, 1/32 in. nose radius. Tool holder: 5° pos. back rake, 5° pos. side rake. Speed: 110-115 sfm, 0.010-0.015 in. feed, 0.010-0.015 in. depth of cut. Dry or water-base coolant.
Milling:	C-2 grade Speed: 25-30 sfm Feed: 0.02 in. tooth ≤ 3/4 in. dia., 0.003 in. tooth > 3/4 in. dia. Oil or Water-base coolant

NOTES:
1 Oil coolant should be a premium quality, sulfochlorinated oil with extreme pressure additives. A viscosity at 100°F from 50 to 125 SSU.
2 Water-base coolant should be premium quality, sulfochlorinated water soluble oil or chemical emulsion with extreme pressure additives. Dilute with water to make 15:1 mix. Water-base coolant may cause chipping and rapid failure of carbide tools in interrupted cuts.
3 SCEA - Side cutting edge angle or lead angle of the tool.
4 At any point where dry cutting is recommended, an air jet directed on the tool may provide substantial tool life increase. A water-base coolant mist may also be effective.

Acknowledgments:

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AVAILABILITY

For More Technical Detail Request the Following Haynes International Brochures:

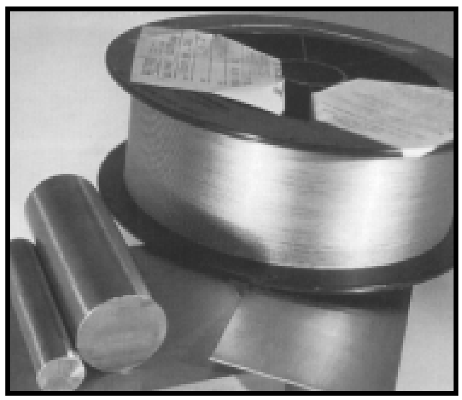
H-2087	Reference Guide for Optimum Protection Against Corrosion and Wear
H-2099	Guidelines for Weld Surfacing with ULTIMET Wire
H-2089	ULTIMET alloy Welding Guidelines
H-2086	ULTIMET alloy Machining Guidelines
H-1034	Applicable Specifications

ULTIMET alloy Specifications

UNS	R31233
ASTM	B-815 (Rod)
ASTM	B-818 (Plate, Sheet, Strip)
ASME	Section VIII, Div. 1, Code Case 2121
DIN	CoCr26Ni9Mo5W No. 2.4681
NACE	MR0175-94 Section 4.1.6.3

Available Wrought Product Forms

Bar	(≥12.7 mm/0.5 in.)
Billet	Standard Sizes
Plate	Standard Sizes
Sheet	(≥1.6 mm/0.063 in.)
Wire	Standard Sizes
Weld Products	(GTA, GMA, SMA, SAW)



Castings

AOD Refined Master Alloy
(Remelt Bar) from
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Tel: 616-755-1681
Fax: 616-755-4016

Powders

Gas Atomized Powders For:
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ANVAL
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Fax: 201-939-1608

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, D-205™, G-3, G-30®, G-50®, H-9M™ and N

HASTELLOY Family of Heat-Resistant Alloys

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25, 31, R-41, 75, HR-120™, 150, 188, 214™, 230™, 230-W™, 242™, 263, 625, 718, X-750, MULTIMET® and WASPALOY

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ULTIMET®

Wear-Resistant Alloy

6B

Super Stainless Steel

FERRALIUM® 255

HAYNES Titanium Alloy Tubular

Ti-3Al-2.5V

Standard Forms:

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

Properties Data:

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