ULTIMET® alloy

Principal Features

STELLITE alloy-like wear resistance and HASTELLOY alloy-like corrosion resistance in a single, highly weldable material

ULTIMET® alloy (UNS R31233) provides a unique blend of properties. From a wear standpoint, it behaves like the STELLITE® alloys with lower carbon contents. From a corrosion standpoint, it possesses many of the attributes of the C-type and G-type HASTELLOY® materials, in particular outstanding resistance to chloride-induced pitting and crevice corrosion. Its mechanical and welding characteristics are much closer to those of the HASTELLOY® alloys than those of the STELLITE® alloys, whose low ductilities can be problematic.

While ULTIMET® alloy has been used successfully in the form of wrought products, its largest applications have involved weld overlays, made with solid wire consumables and arc-welding processes such as GMAW (MIG) and GTAW (TIG).

Nominal Composition

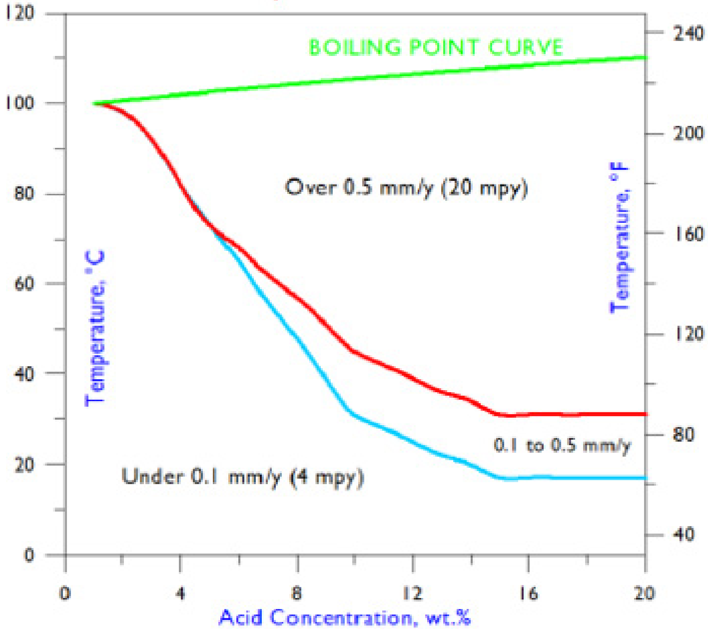
Weight %

Cobalt:	54 Balance
Chromium:	26
Nickel:	9
Molybdenum:	5
Iron:	3
Tungsten:	2
Manganese:	0.8
Silicon:	0.3
Nitrogen:	0.08
Carbon:	0.06

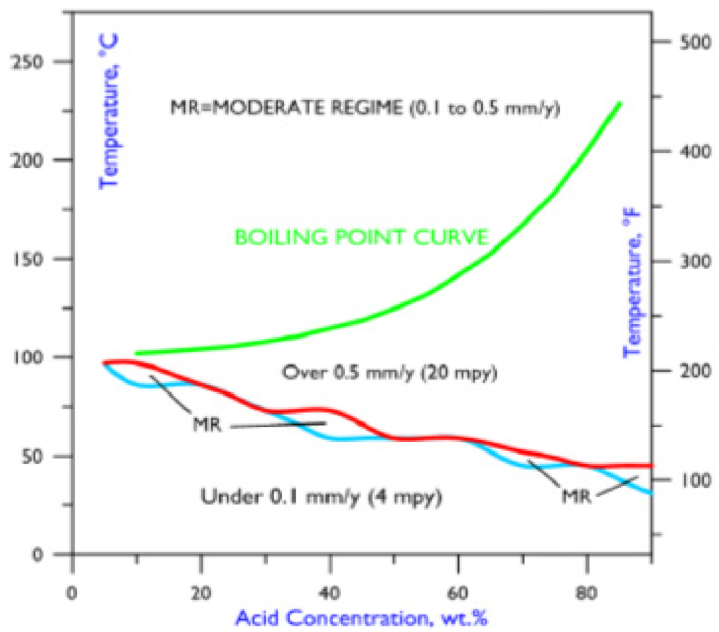
ISO-Corrosion Diagrams

Each of these iso-corrosion diagrams was constructed using numerous corrosion rate values, generated at different acid concentrations and temperatures. The blue line represents those combinations of acid concentration and temperature at which a corrosion rate of 0.1 mm/y (4 mils per year) is expected, based on laboratory tests in reagent grade acids. Below the line, rates under 0.1 mm/y are expected. Similarly, the red line indicates the combinations of acid concentration and temperature at which a corrosion rate of 0.5 mm/y (20 mils per year) is expected. Above the line, rates over 0.5 mm/y are expected. Between the blue and red lines, corrosion rates are expected to fall between 0.1 and 0.5 mm/y.

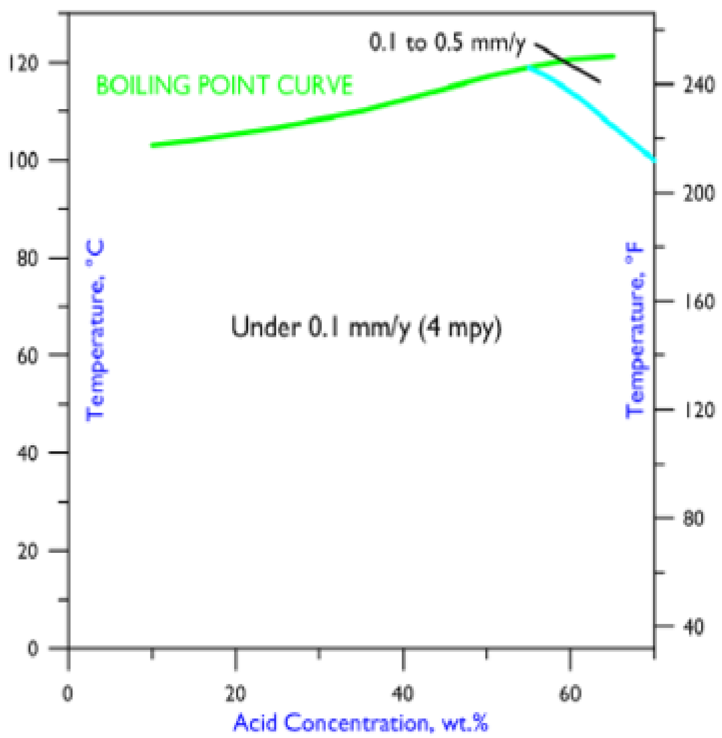
Iso-Corrosion Diagram for ULTIMET Alloy in Hydrochloric Acid



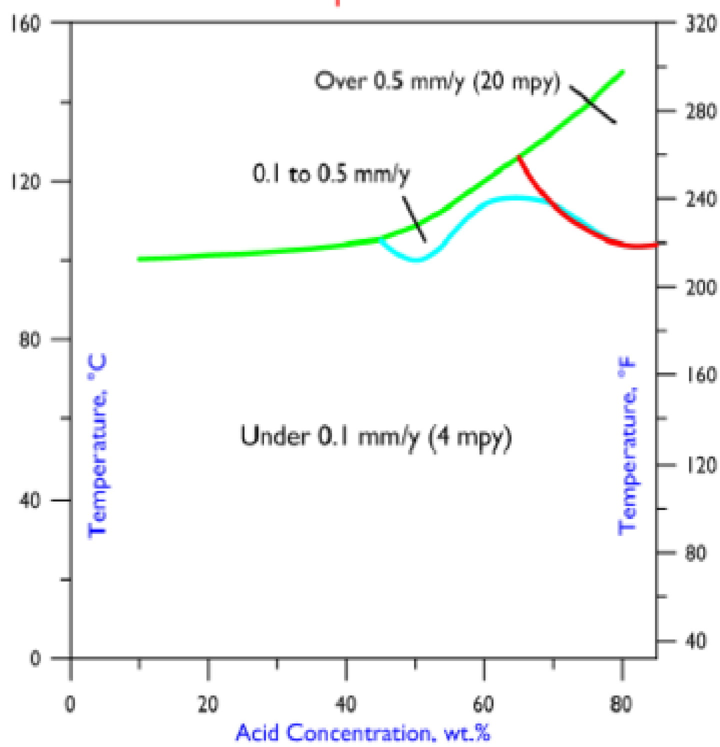
Iso-Corrosion Diagram for ULTIMET Alloy in Sulfuric Acid



Iso-Corrosion Diagram for ULTIMET Alloy in Nitric Acid

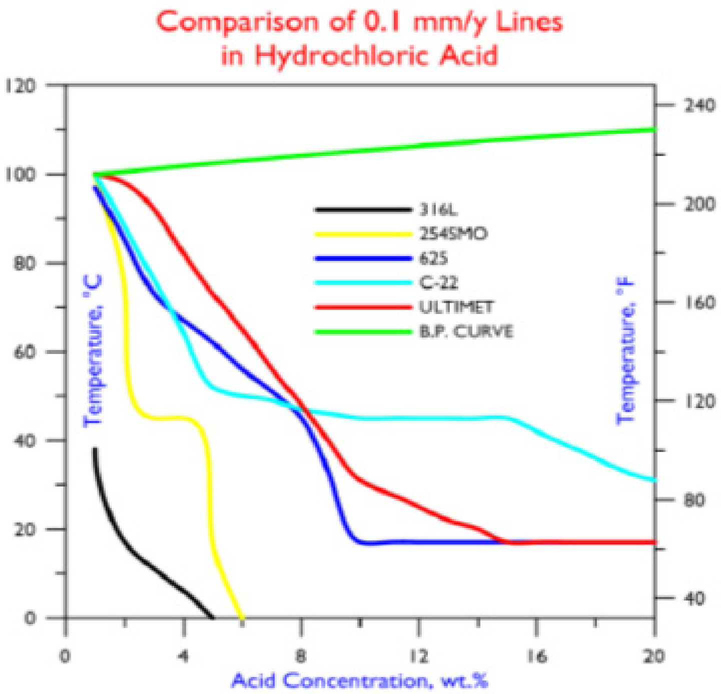


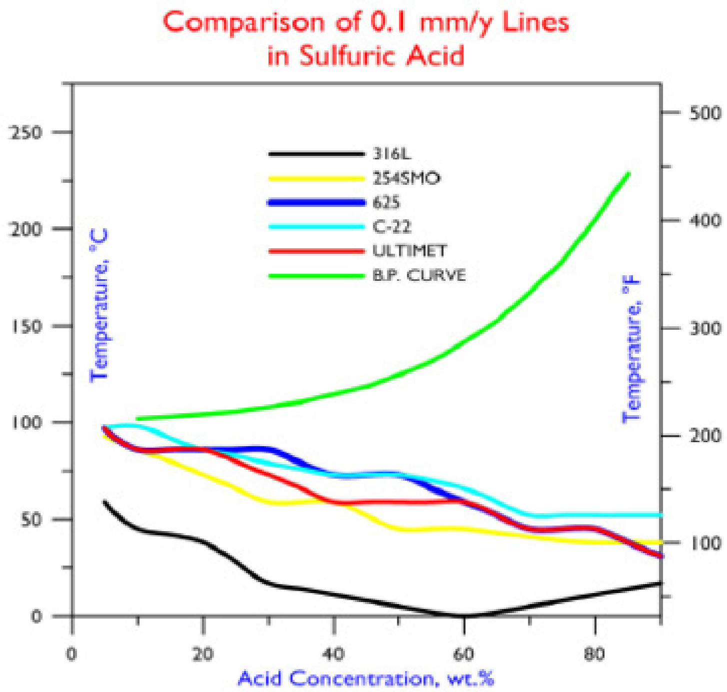
Iso-Corrosion Diagram for ULTIMET Alloy in Phosphoric Acid



Comparative 0.1 mm/y Line Plots

To compare the performance of ULTIMET® alloy with that of other materials, it is useful to plot the 0.1 mm/y lines. In the following graphs, the lines for ULTIMET® alloy are compared with those of two popular, austenitic stainless steels (316L and 254SMO), and two nickel alloys (625 and C-22), in hydrochloric and sulfuric acids. The tests in hydrochloric acid were limited to a concentration of 20% (the azeotrope). At hydrochloric acid concentrations up to 15%, the performance of ULTIMET® alloy exceeds that of alloy 625, and in sulfuric acid, the performance of ULTIMET® alloy matches that of alloy 625 at many concentrations.





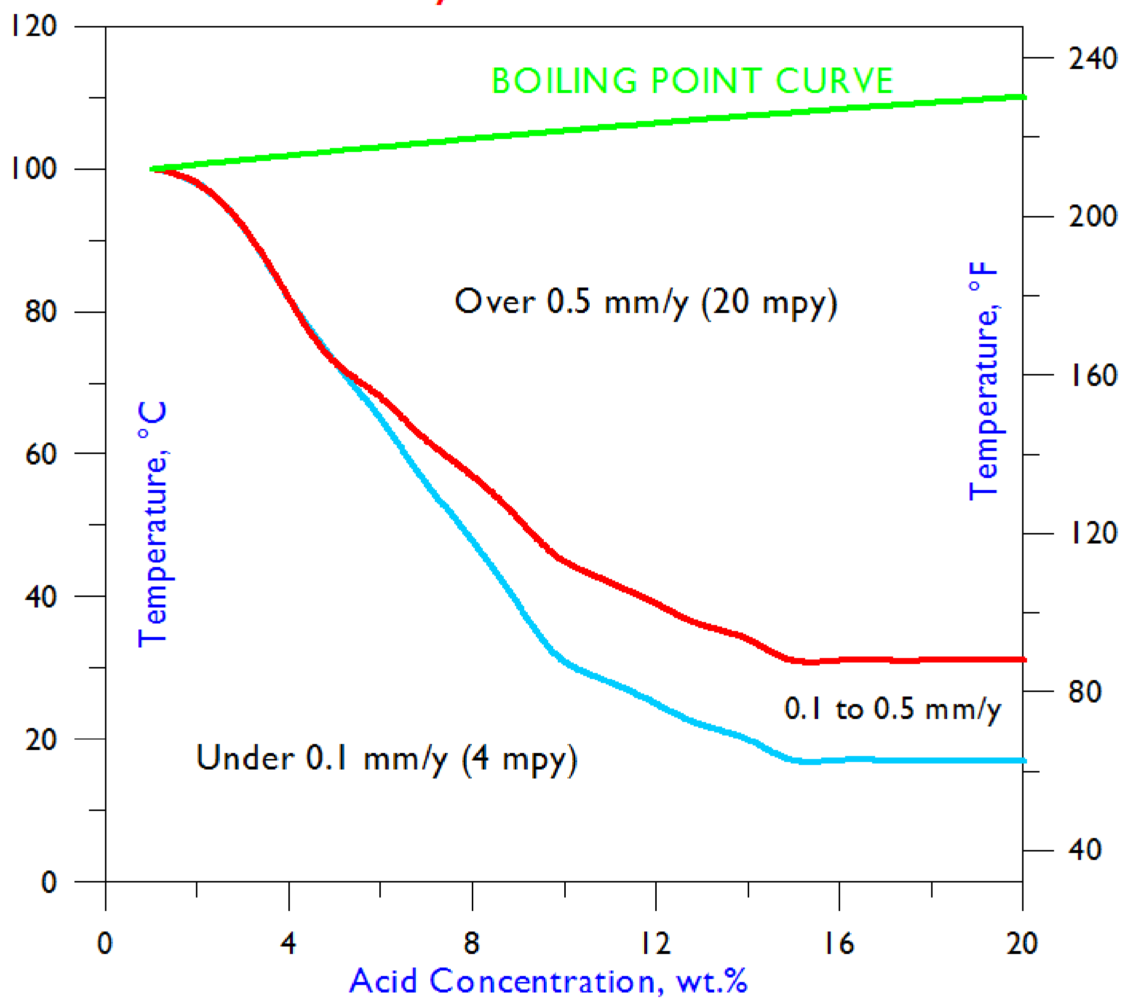
Selected Corrosion Data

Hydrochloric Acid

Conc. Wt.%	50°F 10°C	75°F 24°C	100°F 38°C	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	225°F 107°C	Boiling
1	-	-	-	-	-	-	-	-	<0.05
1.5	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
2.5	-	-	-	-	<0.01	<0.01	<0.01	-	43.85
3	-	-	-	-	-	-	-	-	-
3.5	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-
4.5	-	-	-	-	-	-	-	-	-
5	-	-	-	-	0.01	5.75	-	-	-
7.5	-	-	-	-	-	-	-	-	-
10	-	<0.01	0.16	0.8	1.74	-	-	-	-
15	-	0.15	0.73	1.83	4.75	-	-	-	-
20	-	0.17	0.56	1.04	2.58	-	-	-	-

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Job 181-90.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

Iso-Corrosion Diagram for ULTIMET Alloy in Hydrochloric Acid



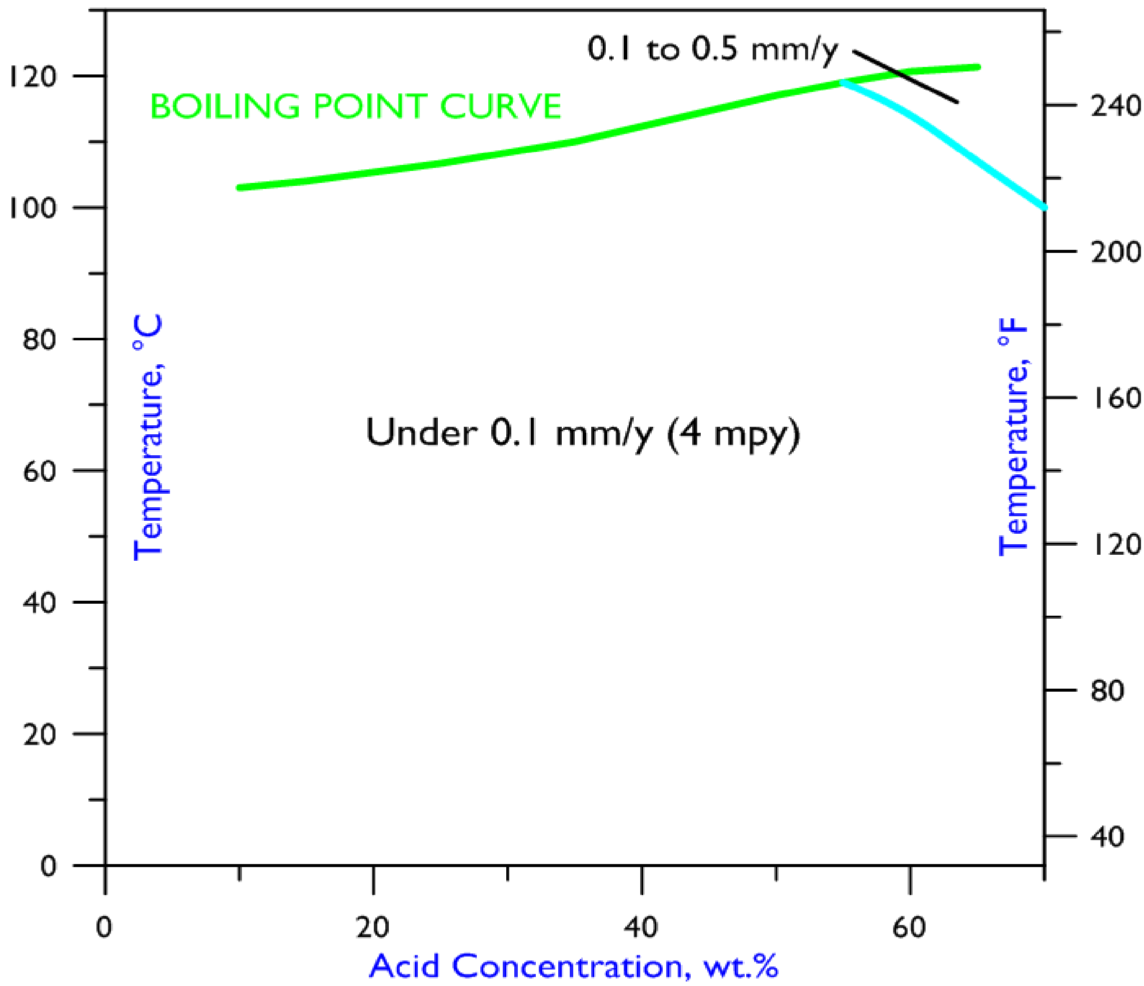
Selected Corrosion Data Continued

Nitric Acid

Conc. Wt.%	50°F 10°C	75°F 24°C	100°F 38°C	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	225°F 107°C	Boiling
10	-	-	-	-	-	-	-	-	<0.01
20	-	-	-	-	-	-	-	-	<0.01
30	-	-	-	-	-	-	-	-	0.01
40	-	-	-	-	-	-	-	-	0.03
50	-	-	-	-	-	-	-	-	0.07
60	-	-	-	-	-	-	0.03	-	0.12
65	-	-	-	-	-	-	0.04	-	0.15
70	-	-	-	-	-	-	0.06	-	0.18

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Job 182-90.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

Iso-Corrosion Diagram for ULTIMET Alloy in Nitric Acid



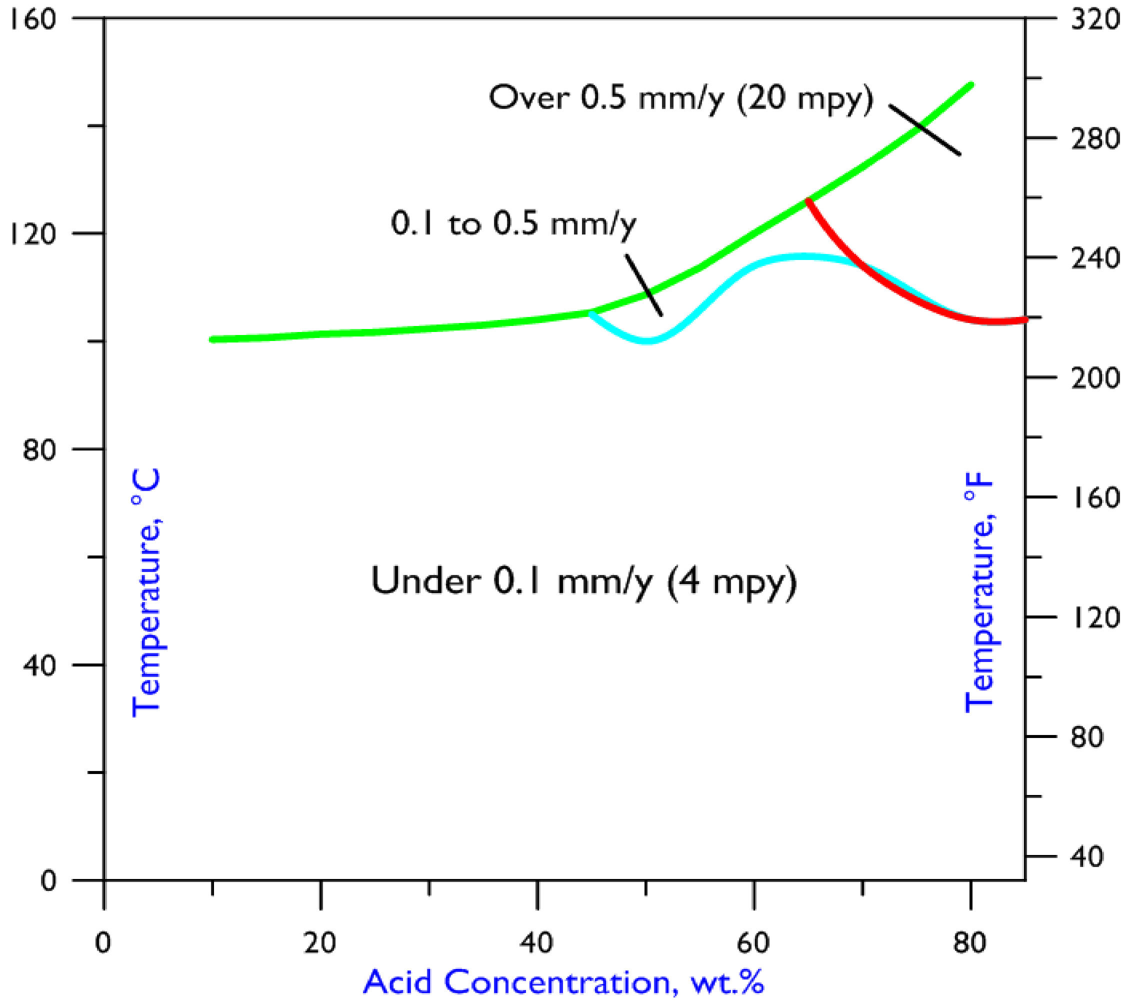
Selected Corrosion Data Continued

Phosphoric Acid

Conc. Wt.%	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	225°F 107°C	250°F 121°C	Boiling
10	-	-	-	-		-	<0.01
20	-	-	-	-		-	0.01
30	-	-	-	-		-	0.01
40	-	-	-	-		-	0.03
50	-	-	-	<0.01	-	-	0.14
60	-	-	-	0.01	-	0.01	0.25
70	-	-	-	0.01	0.01	0.02	0.46
80	-	-	-	0.01	0.07	0.55	10.95
85	-	-	-	0.01	0.07	0.57	30.58

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Job 183-90.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

Iso-Corrosion Diagram for ULTIMET Alloy in Phosphoric Acid



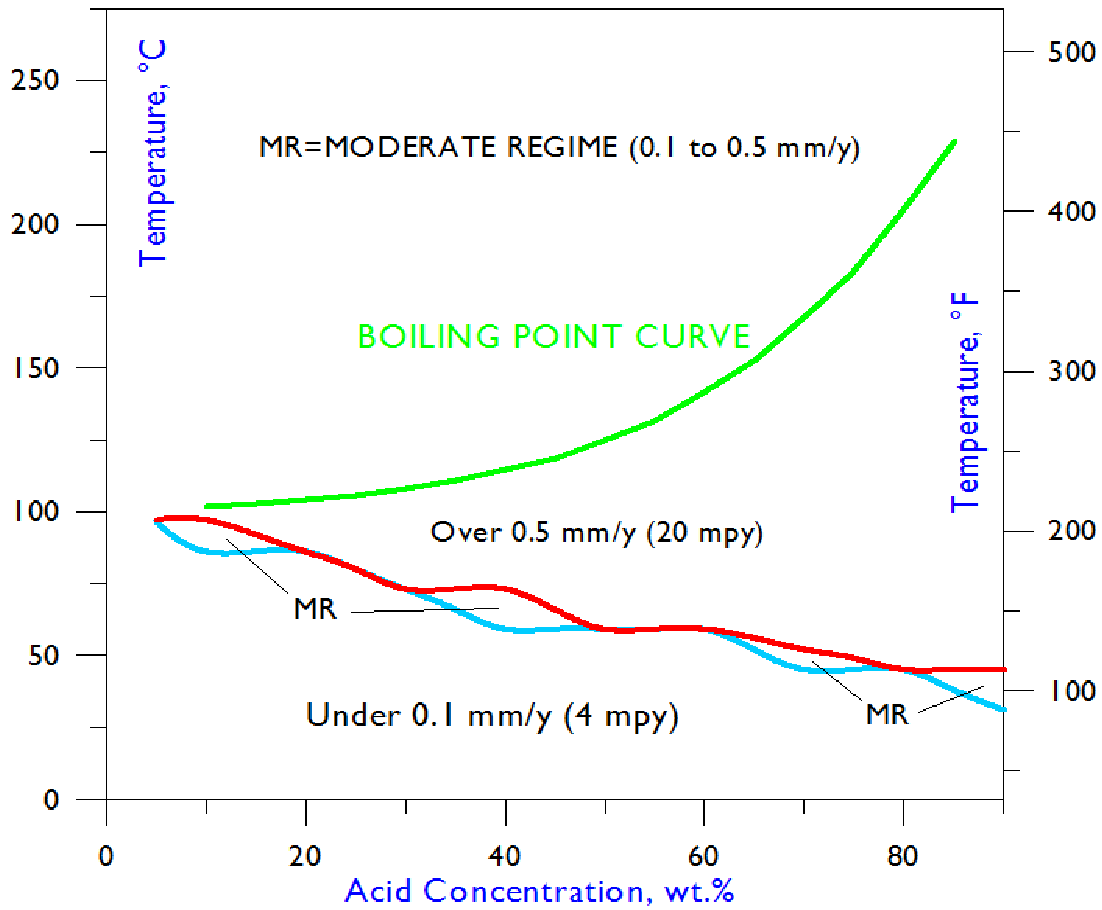
Selected Corrosion Data Continued

Sulfuric Acid

Conc. Wt.%	75°F 24°C	100°F 38°C	125°F 52°C	150°F 66°C	175°F 79°C	200°F 93°C	225°F 107°C	250°F 121°C	275°F 135°C	300°F 149°C	350°F 177°C	Boiling
1	-	-	-	-	-	-	-	-	-	-	-	0.13
2	-	-	-	-	-	<0.01	-	-	-	-	-	0.27
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	<0.01	-	0.01	-	-	-	-	-	1.26
10	-	-	-	-	-	0.43	-	-	-	-	-	1.92
20	-	-	-	<0.01	0.01	1.83	-	-	-	-	-	4.48
30	-	-	-	<0.01	1.36	3.58	-	-	-	-	-	10.54
40	-	<0.01	<0.01	0.29	2.25	-	-	-	-	-	-	20.94
50	-	<0.01	-	0.96	-	-	-	-	-	-	-	-
60	-	<0.01	<0.01	1.48	-	-	-	-	-	-	-	-
65	-	-	0.63	-	-	-	-	-	-	-	-	-
70	-	<0.01	0.55	-	-	-	-	-	-	-	-	-
80	-	<0.01	1.02	1.64	-	-	-	-	-	-	-	-
85	-	0.03	-	-	-	-	-	-	-	-	-	-
90	<0.01	0.26	1.68	-	-	-	-	-	-	-	-	-
96	<0.01	0.21	1.76	2.24	-	-	-	-	-	-	-	-

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Jobs 159-90 and 8-91.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

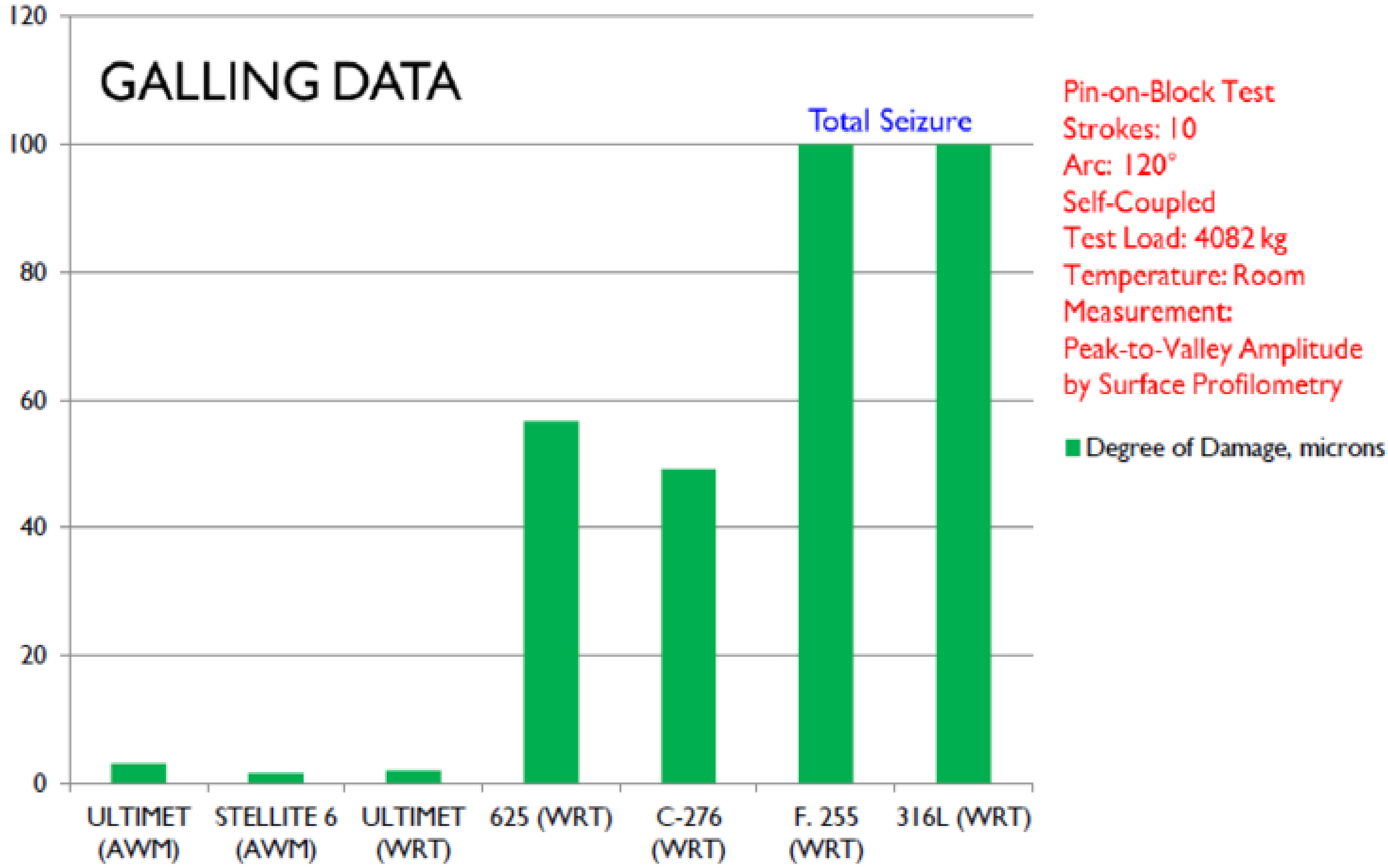
Iso-Corrosion Diagram for ULTIMET Alloy in Sulfuric Acid

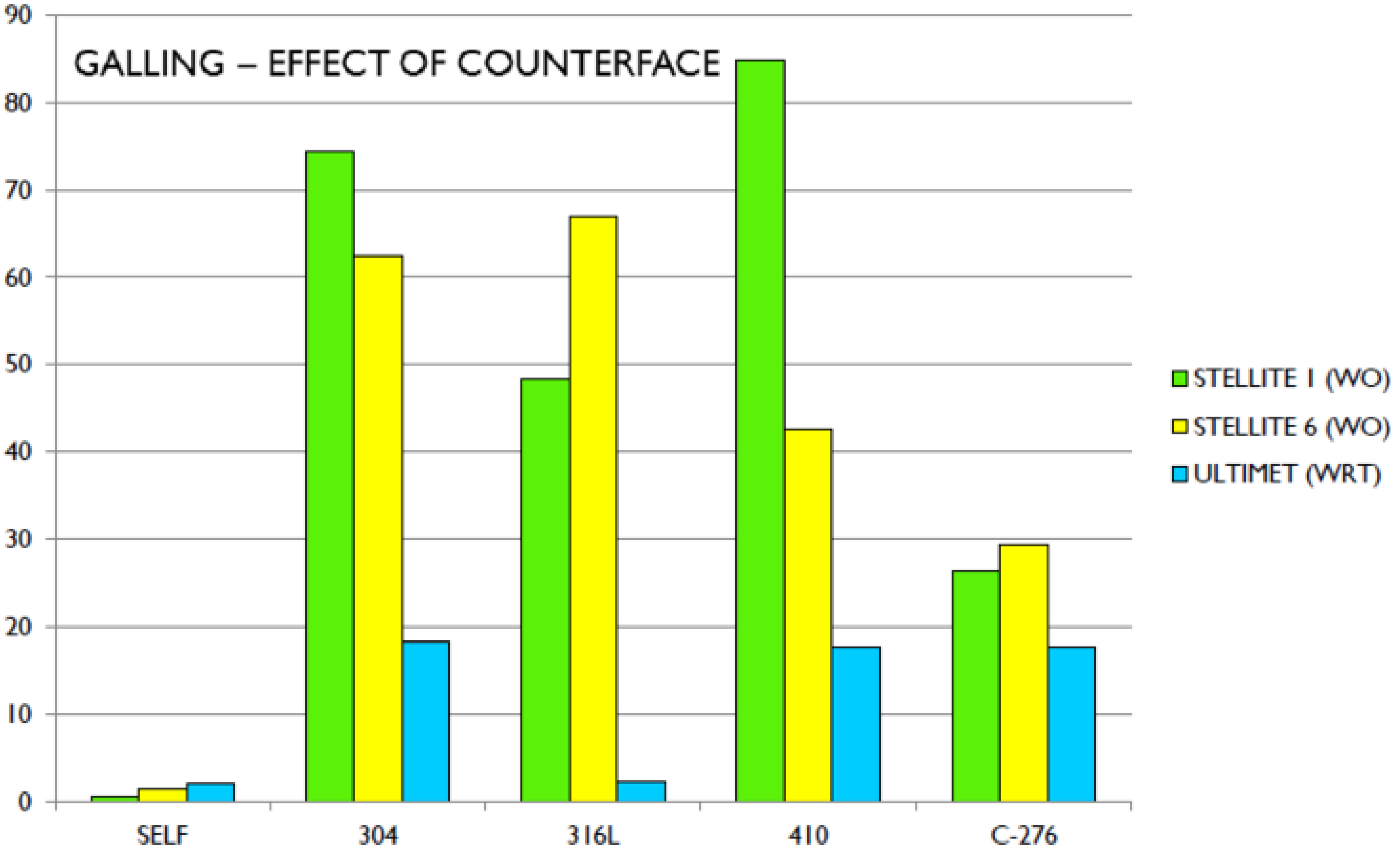


Selected Corrosion Data (Reagent Grade Solutions, mm/y)

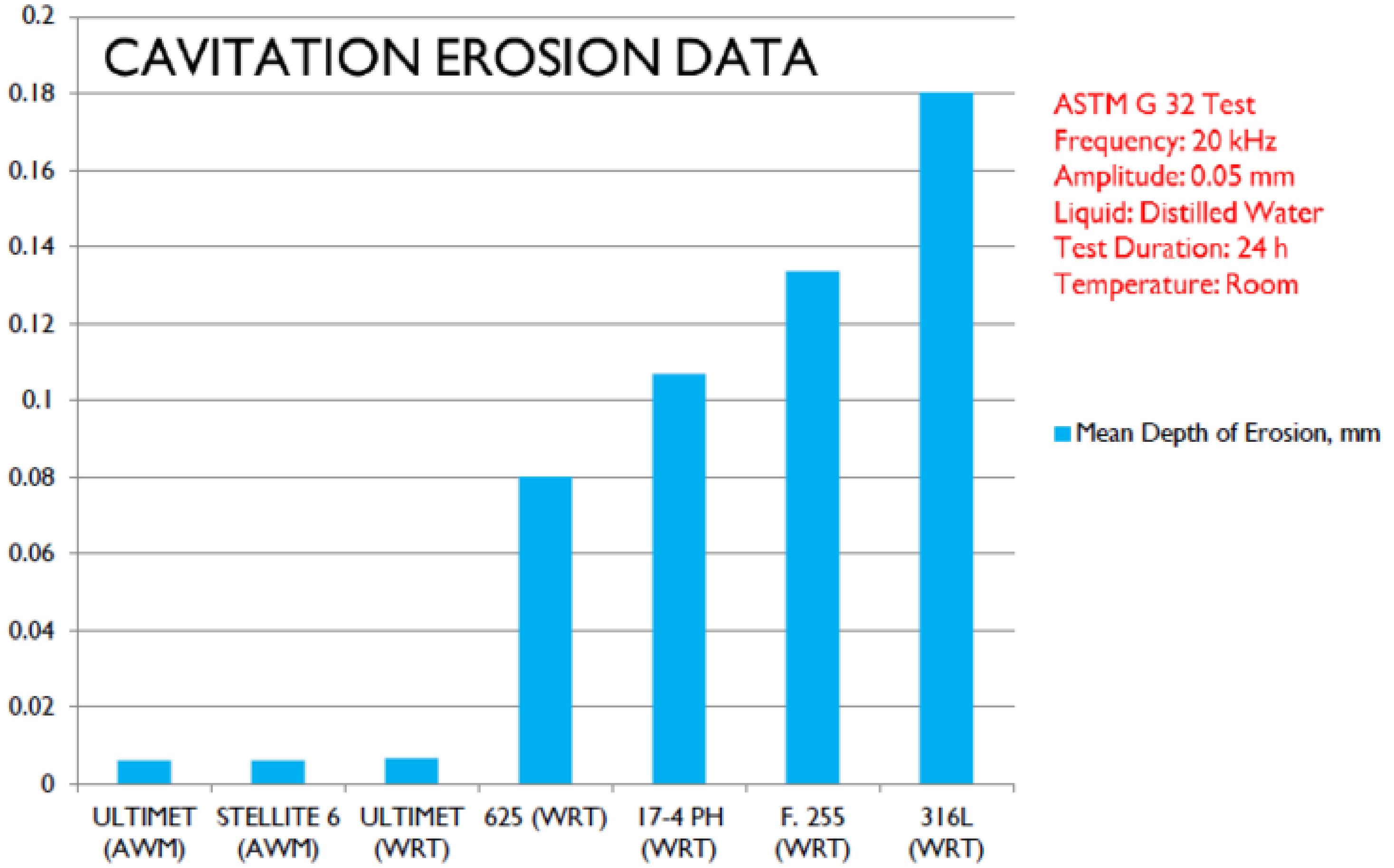
Chemical	Concentration wt. %	100°F 38°C	125°F 52°C	150°F 60°C	175°F 79°C	200°F 93°C	Boiling
Acetic Acid	99	-	-	-	-	-	<0.01
Hydrochloric Acid	1	-	-	-	-	-	0.05
	2.5	-	-	<0.01	<0.01	<0.01	43.85
	5	-	-	0.01	-	-	-
	10	0.16	0.8	1.74	-	-	-
	15	0.73	1.83	-	-	-	-
	20	0.56	1.04	-	-	-	-
Nitric Acid	10	-	-	-	-	-	<0.01
	20	-	-	-	-	-	<0.01
	30	-	-	-	-	-	0.01
	40	-	-	-	-	-	0.03
	50	-	-	-	-	-	0.07
	60	-	-	-	-	0.03	0.12
	65	-	-	-	-	0.04	0.15
	70	-	-	-	-	0.06	0.18
Phosphoric Acid	10	-	-	-	-	-	<0.01
	20	-	-	-	-	-	0.01
	30	-	-	-	-	-	0.01
	40	-	-	-	-	-	0.03
	50	-	-	-	-	<0.01	0.14
	60	-	-	-	-	0.01	0.24
	70	-	-	-	-	0.01	0.45
	80	-	-	-	-	0.01	10.92
	85	-	-	-	-	0.01	30.58
Sulfuric Acid	1	-	-	-	-	-	0.13
	2	-	-	-	-	<0.01	0.27
	5	-	-	<0.01	-	0.01	1.26
	10	-	-	-	-	0.43	1.92
	20	-	-	<0.01	0.01	1.83	-
	30	-	-	<0.01	1.36	-	-
	40	<0.01	<0.01	0.29	2.25	-	-
	50	<0.01	-	0.96	-	-	-
	60	<0.01	<0.01	1.48	-	-	-
	70	<0.01	0.55	-	-	-	-
	80	<0.01	1.02	-	-	-	-
	90	0.26	1.68	-	-	-	-
	96	0.21	1.76	-	-	-	-

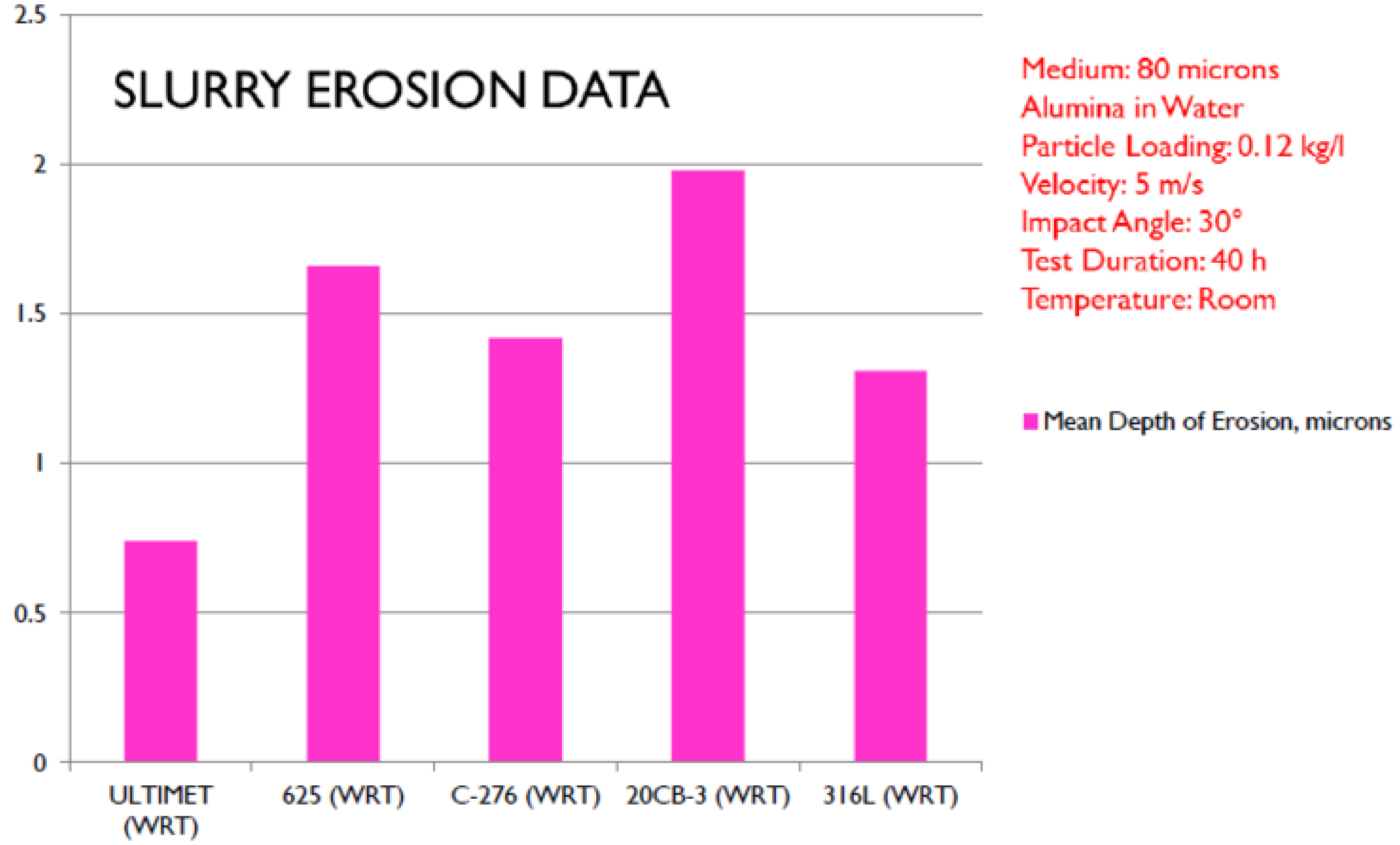
Galling Resistance



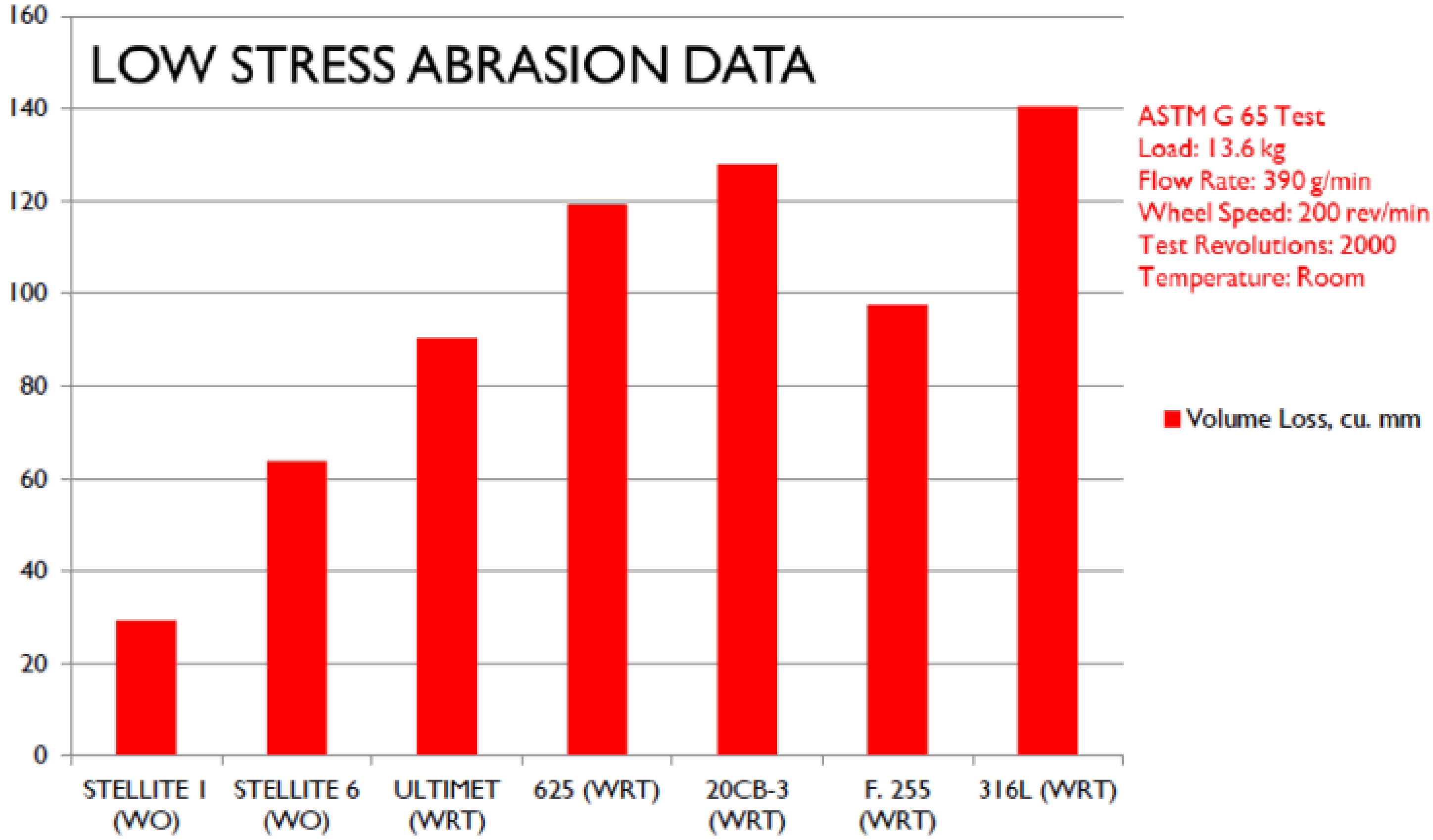


Erosion Resistance

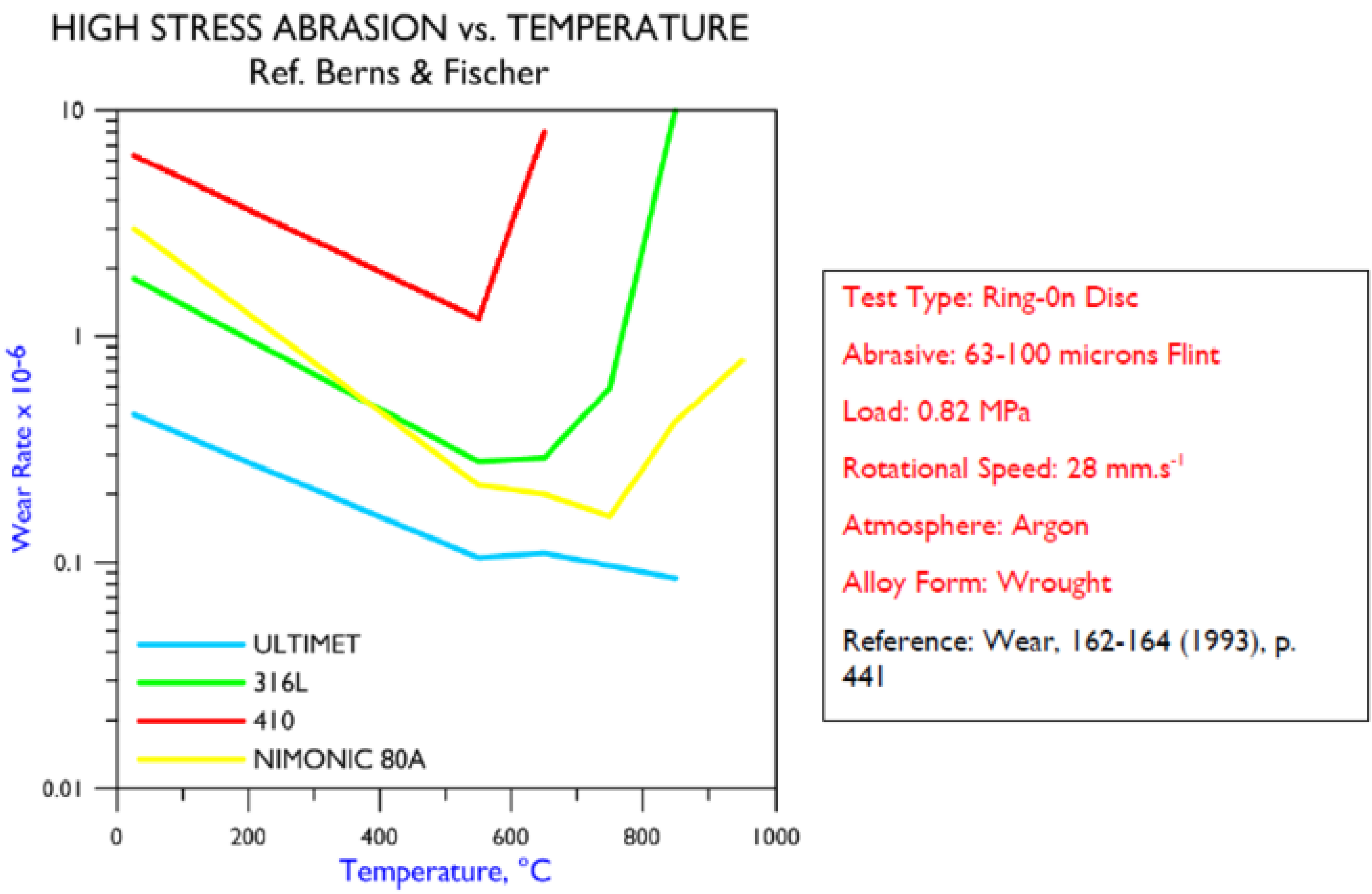




Abrasion Wear



AWM = All weld metal WO = Weld overlay WRT = Wrought



Resistance to Pitting & Crevice Corrosion

ULTIMET® alloy exhibits very high resistance to chloride-induced pitting and crevice attack, forms of corrosion to which the austenitic stainless steels are particularly prone.
To assess the pitting resistance of ULTIMET® alloy relative to other corrosion-resistant materials, it has been subjected to tests in Green Death (11.5% H_2SO_4 + 1.2% HCl + 1% $FeCl_3$ + 1% $CuCl_2$). Experiments wereperformed at various temperatures (in increments of 5°C) to determine the lowest temperature at which pitting occurs in a 24 h test period (the so-called Critical Pitting Temperature for Green Death). The results were as follows:

Alloy	Critical Pitting Temperature	
-	°F	°C
ULTIMET®	**248**	**120**
C-22®	248	120
C-276	230	110
625	167	75
6B	113	45
316L	77	25

Resistance to Stress Corrosion Cracking

Sulfide Stress Cracking

Wrought ULTIMET® alloy has been tested according to NACE TM0177, which defines sulfide stress cracking as a room temperature phenomenon, resulting from hydrogen embrittlement.

The TM0177 tests involved 5% NaCl + 0.5% glacial acetic acid, saturated with H_2S, proof-ring apparatus, and samples coupled to carbon steel and stressed to the point of yield. ULTIMET® alloy was able to withstand these conditions, both annealed and cold-reduced (15%), indicating good resistance to hydrogen embrittlement.

H_2S – Induced Stress Corrosion Cracking

Cracking at elevated temperatures in environments containing H_2S is defined as a form of stress corrosion cracking.

Wrought ULTIMET® alloy has been tested in 20% NaCl + 0.517 MPa (75 psi) H_2S + 4.83 MPa (700 psi) CO_2, with and without 0.5 g/l sulfur, at 121°C and 177°C; the tests were conducted according to the recommendations of ASTM Standard G 39, the fixtures being made of ULTIMET alloy, to prevent galvanic effects.

Like other materials, ULTIMET® alloy was prone to cracking in the cold-reduced condition, but resistant to H_2S-induced stress corrosion cracking in the annealed condition, at these temperatures.

Resistance to Seawater Crevice Corrosion

Seawater is probably the most common aqueous salt solution. Not only is it encountered in marine transportation and offshore oil rigs, but it is also used as a coolant in coastal facilities. Listed are data generated as part of a U.S. Navy study at the LaQue Laboratories in Wrightsville Beach, North Carolina (and published by D.M. Aylor et al, Paper No. 329, CORROSION 99, NACE International, 1999). Crevice tests were performed in both still (quiescent) and flowing seawater, at 29°C, plus or minus 3°C. Two samples (A & B) of each alloy were tested in still water for 180 days, and likewise in flowing water. Each sample contained two possible crevice sites. The results indicate that ULTIMET® alloy is even more resistant to crevice corrosion in seawater than C-276 alloy.

Alloy	Quiescent		Flowing	
-	No. of Sites Attacked	Maximum Depth of Attack, mm	No. of Sites Attacked	Maximum Depth of Attack, mm
316L	A:2, B:2	A:1.33, B:2.27	A:2, B:2	A:0.48, B:0.15
254SMO	A:2, B:2	A:0.76, B:1.73	A:2, B:2	A:0.01, B:<0.01
625	A:2, B:2	A:0.18, B:0.04	A:2, B:2	A:<0.01, B:<0.01
C-276	A:1, B:1	A:0.10, B:0.13	A:0, B:0	A:0, B:0
C-22®	A:0, B:0	A:0, B:0	A:0, B:0	A:0, B:0
ULTIMET®	**A:0, B:0**	**A:0, B:0**	**A:0, B:0**	**A:0, B:0**

Corrosion Resistance of Welds

One of the most important product forms of ULTIMET® alloy is welding wire, since many applications involve ULTIMET® weld overlays. These overlays are, of course, subject to dilution from the substrate material, often a steel or stainless steel. To provide some idea of the influence of dilution upon the corrosion resistance of ULTIMET® weld overlays, a study was undertaken whereby pre-diluted consumables were made by the aspiration casting process, and all-weld-metal (AWM) samples made by deposition on chilled copper blocks. Thus, it was possible to conduct regular (rather than one-sided) corrosion tests in acid solutions on homogeneous samples, diluted with specific substrate materials.

ULTIMET® Alloy	Corrosion Rate, mm/y		
	3% HCl, 66°C (150°F)	Boiling 65% HNO_3	Boiling 2% H_2SO_4
Undiluted	0.68	0.15	0.41
Diluted with 9.1%/G10400	1.8	0.3	0.69
Diluted with 9.1%/S31603	1.42	0.25	0.58
Diluted with 16.7%/G10400	2.13	0.3	0.84
Diluted with 16.7%/S31603	2.08	0.23	0.48

Physical Properties

Physical Property	British Units		Metric Units	
Density	RT	0.306 lb/in.^{3}	RT	8.47 g/cm.^{3}
Electrical Resistivity	RT	34.3 µohm.in	RT	0.87 µohm.m
	200°F	35.2 µohm.in	100°C	0.89 µohm.m
	400°F	36.7 µohm.in	200°C	0.93 µohm.m
	600°F	38.2 µohm.in	300°C	0.96 µohm.m
	800°F	39.6 µohm.in	400°C	1.00 µohm.m
	1000°F	40.9 µohm.in	500°C	1.03 µohm.m
	-	-	600°C	1.05 µohm.m
Thermal Conductivity	RT	87 Btu.in/h.ft^2.°F	RT	12.3 W/m.°C
	200°F	95 Btu.in/h.ft^2.°F	100°C	13.8 W/m.°C
	400°F	109 Btu.in/h.ft^2.°F	200°C	15.6 W/m.°C
	600°F	123 Btu.in/h.ft^2.°F	300°C	17.5 W/m.°C
	800°F	138 Btu.in/h.ft^2.°F	400°C	19.4 W/m.°C
	1000°F	155 Btu.in/h.ft^2.°F	500°C	21.5 W/m.°C
	-	-	600°C	23.9 W/m.°C
Thermal Diffusivity	RT	0.005 in.^{2}/s	RT	0.033 x 10^{-6}cm^2/s
	200°F	0.005 in.^{2}/s	100°C	0.035 x 10^{-6}cm^2/s
	400°F	0.006 in.^{2}/s	200°C	0.038 x 10^{-6}cm^2/s
	600°F	0.007 in.^{2}/s	300°C	0.042 x 10^{-6}cm^2/s
	800°F	0.007 in.^{2}/s	400°C	0.045 x 10^{-6}cm^2/s
	1000°F	0.007 in.^{2}/s	500°C	0.047 x 10^{-6}cm^2/s
	-	-	600°C	0.050 x 10^{-6}cm^2/s
Mean Coefficient of Thermal Expansion	78-200°F	7.2 µin/in.°F	26-100°C	13.0 µm/m.°C
	78-400°F	7.5 µin/in.°F	26-200°C	13.4 µm/m.°C
	78-600°F	7.8 µin/in.°F	26-300°C	14.0 µm/m.°C
	78-800°F	8.0 µin/in.°F	26-400°C	14.3 µm/m.°C
	78-1000°F	8.2 µin/in.°F	26-500°C	14.8 µm/m.°C
	78-1200°F	8.4 µin/in.°F	26-600°C	15.0 µm/m.°C
	78-1400°F	8.8 µin/in.°F	26-700°C	15.4 µm/m.°C
	78-1600°F	9.1 µin/in.°F	26-800°C	16.1 µm/m.°C
Specific Heat	100°F	0.110 Btu/lb.°F	RT	456 J/kg.°C
	200°F	0.112 Btu/lb.°F	100°C	470 J/kg.°C
	400°F	0.116 Btu/lb.°F	200°C	482 J/kg.°C
	600°F	0.121 Btu/lb.°F	300°C	504 J/kg.°C
	800°F	0.127 Btu/lb.°F	400°C	525 J/kg.°C
	1000°F	0.133 Btu/lb.°F	500°C	545 J/kg.°C
	-	-	600°C	573 J/kg.°C

RT= Room Temperature

Physical Properties Continued

Physical Property	British Units		Metric Units	
Dynamic Modulus of Elasticity	RT	33.2×10^6 psi	RT	229 GPa
	200°F	32.6×10^6 psi	100°C	224 GPa
	400°F	31.2×10^6 psi	200°C	216 GPa
	600°F	29.9×10^6 psi	300°C	208 GPa
	800°F	28.6×10^6 psi	400°C	199 GPa
	1000°F	27.4×10^6 psi	500°C	192 GPa
	1200°F	26.1×10^6 psi	600°C	184 GPa
Melting Range	2430-2470°F	-	1332-1354°C	-

RT= Room Temperature

Impact Strength

These impact strengths were generated using Charpy V-notch samples, machined from mill annealed plate of thickness 12.7 mm (0.5 in).

Test Temperature		Impact Strength	
°F	**°C**	**ft-lbf**	**J**
RT	RT	130	176
-40	-40	125	169
-80	-62	119	161
-320	-196	68	92

RT= Room Temperature

Tensile Strength & Elongation

Form	Test Temperature		Thickness/ Bar Diameter		0.2% Offset Yield Strength		Ultimate Tensile Strength		Elongation
	°F	°C	in	mm	ksi	MPa	ksi	Mpa	%
Sheet	RT	RT	0.063	1.6	72	496	138	951	42
Sheet	200	93	0.063	1.6	58	400	135	931	50
Sheet	400	204	0.063	1.6	45	310	134	924	62
Sheet	600	316	0.063	1.6	43	296	130	896	75
Sheet	800	427	0.063	1.6	41	283	120	827	76
Plate	RT	RT	0.25-1.5	6.4-38.1	79	545	148	1020	36
Plate	200	93	0.25-1.5	6.4-38.1	70	483	143	986	40
Plate	400	204	0.25-1.5	6.4-38.1	55	379	143	986	61
Plate	600	316	0.25-1.5	6.4-38.1	48	331	138	951	70
Plate	800	427	0.25-1.5	6.4-38.1	45	310	133	917	70
Plate	1000	538	0.25-1.5	6.4-38.1	38	262	125	862	70
Plate	1200	649	0.25-1.5	6.4-38.1	37	255	99	683	66
Plate	1400	790	0.25-1.5	6.4-38.1	39	269	76	524	70
Plate	1600	871	0.25-1.5	6.4-38.1	28	193	51	352	77
Plate	1800	982	0.25-1.5	6.4-38.1	16	110	31	214	100
Bar	RT	RT	0.5-2.0	12.7-50.8	76	524	147	1014	38
Bar	200	93	0.5-2.0	12.7-50.8	70	483	140	965	49
Bar	400	204	0.5-2.0	12.7-50.8	52	359	140	965	66
Bar	600	316	0.5-2.0	12.7-50.8	44	303	132	910	77
Bar	800	427	0.5-2.0	12.7-50.8	43	296	131	903	84
Bar	1000	538	0.5-2.0	12.7-50.8	40	276	114	793	79

RT= Room Temperature

Hardness

In the annealed condition, ULTIMET® alloy is not very hard. However, it has a high work-hardening rate, and even stretching of sheets and flattening of plates during mill processing can increase its hardness. The hardnesses in this table were measured on mill sheets, and indicate how rapidly the alloy hardens upon cold working.

Condition	Hardness, HRC
Mill Annealed	30
10% Cold-Work	40
20% Cold-Worked	43
40% Cold-Worked	49

HRC= Hardness Rockwell “C”.

Welding & Fabrication

ULTIMET® alloy is very amenable to the Gas Metal Arc (GMA/MIG), Gas Tungsten Arc (GTA/TIG), and Shielded Metal Arc (SMA/Stick) welding processes. Matching filler metals (i.e. spools, reels, coils, and cut straight lengths of solid wire, and coated electrodes) are available for these processes. Guidelines for weld surfacing with ULTIMET® alloy are detailed in a separate Haynes International document (HW-2099). Other arc processes have been used to weld ULTIMET® alloy; for more information on consumable availability for these other processes, please consult Haynes International. Matching filler metals (i.e. solid wires and coated electrodes) are available for these processes, and welding guidelines are given in our “Welding and Fabrication” brochure.

Wrought products of ULTIMET® alloy are supplied in the Mill Annealed (MA) condition, unless otherwise specified. This solution annealing procedure has been designed to optimize the alloy’s corrosion resistance and ductility. Following all hot forming operations, the material should be re-annealed, to restore optimum properties. The alloy should also be re-annealed after any cold forming operations that result in an outer fiber elongation of 7% or more. The annealing temperature for ULTIMET® alloy is 1177°C (2150°F), and water quenching is advised (rapid air cooling is feasible with structures thinner than 10 mm (0.375 in). A hold time at the annealing temperature of 10 to 30 minutes is recommended, depending on the thickness of the structure (thicker structures need the full 30 minutes).

ULTIMET® alloy can be hot worked and cold worked. However, it is very strong, and work-hardens rapidly during cold working. The alloy may therefore require frequent, intermediate anneals, if cold working is employed. Please consult Haynes International for more details.

While cold work does not usually affect the resistance of ULTIMET® alloy to general corrosion, and to chloride-induced pitting and crevice attack, it can affect resistance to stress corrosion cracking. For optimum corrosion performance, therefore, the re-annealing of cold worked parts (following an outer fiber elongation of 7% or more) is important.

Welding & Fabrication Continued

Welding Data

Typical Transverse Tensile Data, Weldments

Form	Weld Type	Test Temperature		0.2% Offset Yield Strength	Ultimate Tensile Strength	Elongation
-	-	°F	°C	ksi*	ksi*	%
Plate 1/2 in. (12.7mm) thick	GTAW	RT	RT	89	127	11
	GMAW (Short)	RT	RT	98	121	6
		500	260	65	121	19
		1000	538	53	114	28
	GMAW (Spray)	RT	RT	93	133	11
		500	260	67	121	19
		1000	5.38	65	113	30
	SMAW	RT	RT	97	135	9
Plate 3/4 (19.1mm) thick	GMAW (Short)	RT	RT	86	123	10
		500	260	62	116	20
		1000	538	45	98	26
	GMAW (Spray)	RT	RT	90	136	15
		500	260	64	121	23
		1000	538	50	113	32
	SMAW	RT	RT	87	130	13
		1000	538	48	109	32

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

Welding & Fabrication Continued

Typical Tensile Data, All-Weld Metal

Weld Type	Test Temperature		0.2% Offset Yield Strength	Ultimate Tensile Strength	Elongation
-	°F	°C	ksi*	ksi*	%
GTAW	RT	-	95	133	10
GMAW (Short)	RT	-	89	132	17
GMAW (Spray)	RT	-	85	123	18
SMAW	RT	-	93	13	16
	1000	-	61	100	31

Typical Impact Strength, Weldments

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

Typical Bend Test Data, Welded Plate

Weld Type	Face Bend		Side Bend	
-	2T	3T	2T	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.

Specifications and Codes

Specifications

ULTIMET® (R31233)	
Sheet, Plate & Strip	SB818/B818
Billet, Rod & Bar	B815
Coated Electrodes	-
Bare Welding Rods & Wire	-
Seamless Pipe & Tube	-
Welded Pipe & Tube	-
Fittings	-
Forgings	-
DIN	No. 2.4681 CoCr26Ni9Mo5W
TÜV	-
Others	NACE MR0175/MR0103 ISO 15156

Codes

<table>
<tr><th colspan="4">ULTIMET®
(R31233)</th></tr>
<tr><td rowspan="11">ASME</td><td>Section I</td><td colspan="2">-</td></tr>
<tr><td rowspan="3">Section III</td><td>Class 1</td><td>-</td></tr>
<tr><td>Class 2</td><td>-</td></tr>
<tr><td>Class 3</td><td>-</td></tr>
<tr><td rowspan="2">Section VIII</td><td>Div. 1</td><td>800°F (427°C)[1]</td></tr>
<tr><td>Div. 2</td><td>-</td></tr>
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<tr><td>B16.5</td><td colspan="2">-</td></tr>
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<tr><td colspan="2">VdTÜV (doc #)</td><td colspan="2">-</td></tr>
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[1]Approved material forms: Plate, Sheet, Bar