11411 East Coker Loop
San Antonio, Texas 78216
(210) 494-3651 ★ Fax (210) 494-6139
www.texastoolmakers.com

TEXAS TOOL MAKERS INC

A8306 ISO 9002

CERTIFICATE OF CONFORMANCE

TO: Southwest Research Institute
6220 Culebra Road
San Antonio, Tx. 78238-5166

CUSTOMER P.O. 383987S

TTI JOB #: 34851/1

DESCRIPTION 10 EA.; P/N 20-06002-01-081-005 XPS Specimen

WE CERTIFY THAT THE ITEM(S) ON THE ABOVE REFERENCED PURCHASE ORDER HAVE BEEN PROCESSED AND/OR MANUFACTURED IN ACCORDANCE WITH:

Drawing

RECORDS ARE ON FILE AT THIS FACILITY, WHICH VERIFY OUR PROCESS CONTROLS, AND AVAILABLE FOR REVIEW UPON REQUEST. INSPECTION RESULTS ARE AS FOLLOWS:

Accepted

TEXAS TOOLMAKERS,

BY : Casey Ridgway (Casey Ridgway)

TITLE: Q.A. Manager

DATE : 8/11/03

DIMENSIONAL INSPECTION REPORT

TEXAS TOOLMAKERS, INC.

Job No.:	Part No.:	Rev. No.:	P.O. No.:
34857/1	20-06002-01-081-005		383987S
Customer:	**Part Name:**		**Log No.:**
S.W.R.I.	XPS Specimen		3204005-C

Inspection Plan:	Quantity:	Sample Size:	Accept No.:	Reject No.:	NR No.:
☒ 100 % ☐ Specified Dim. ☐ 1st Article	10	10	10	⊖	⊖

Zone	Dim. / Char.	Tolerance*	Actual	Equipment S/N	Comments
1.	13mm		12.87	TTI-102	
2.	19mm		18.89	TTI-102	
3.	1.1 mm	±.01	1.11 - 1.09	TTI-103	
4.	.5mm ↓min.		5.4 - 5.7	TTI-102	
5.	3 mm		3.10	TTI-102	
6.	4 mm	±0.8 ±.02	3.86-3.89	TTI-102	

meets requirements of Drawing shown on page 21

Dennis Dunn 8/17/03

* Recorded if not affected by tolerance block.

Sheet 1 of 1

Inspection Performed by: Casey Ridgway Date 8-11-03

Customer (as applicable) Date

TTI Form QF-100201 Rev 2

Project No.
Book No.
TITLE Electrochemical Treatment Conditions for XPS Specimens

From Page No.

Surface Analysis of C-22 Specimens

Objective: Produce specimens under passive and transpassive conditions.

Alloy / Heat No. : C-22 / 2277-8-3175

Specimen Preparation: Specimen surfaces polished to 2000 Grit finish using SiC paper. Specimen cleaned in acetone and rinsed in DI water.

	Specimen #1	Specimen #3	Specimen #5	Specimen #6
Initial Weight:	7.83117g	7.85528g	7.86841g	7.85482g
Final Weight:	7.83294g	7.85557g	7.68673g	7.59946g
E applied vs. SCE	0.10 V	0.10 V	0.25 V	0.25 V
Data File:	C22XPS1	C22XPS3	C22XPS5	C22XPS6

Potentiostat: Solartron 1480 **SN:** 00240053
Last Verification Date: 8/1/03 **Verification Due:** 2/1/04

	Specimen #7	Specimen #8
Initial Weight:	7.72794g	7.64485g
Final Weight:	7.72375g	7.63979g
E applied vs. SCE	0.60 V	0.60 V
Data File:	C22XPS7	C22XPS8

Potentiostat: EG&G 273 & 273A **SN:** 41108 & 10120
Last Verification Date: 3/4/03 **Verification Due:** 9/4/03

Weight measured with: **Model:** Sartorius Genius **SN:** 12809099
Cal: 5/15/03 **Due:** 11/15/03

Solution: 0.028M of Cl (1000PPM) + DI Water to 2000mL

Test Temperature: 95 C
Counter Electrode: Platinum Flag
Reference Electrode: Fisher SCE
Gas: 99.999% Nitrogen

Time/Duration of Tests

C22XPS1 = 70 hrs
C22XPS3 = 70 hrs
C22XPS5 = 48 hrs
C22XPS6 = 48 hrs
C22XPS7 = 22.9 hrs.
C22XPS8 = 22.9 hrs.

11/8/04
Added Time/Duration

To Page No.

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Recorded by

Project No.
Book No.
TITLE XPS Analysis of Alloy 22 Specimens

From Page No.

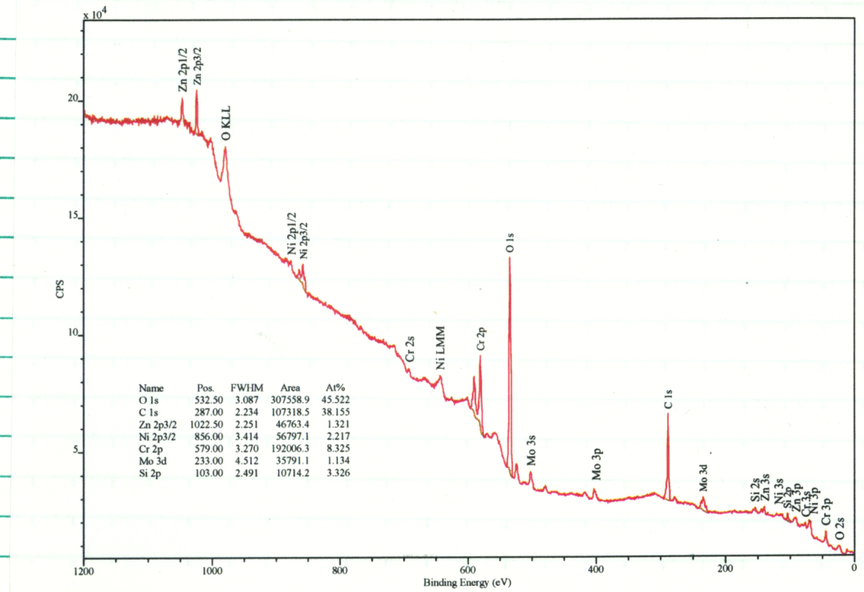
JPP 8/14/03

1. Wide-energy survey of the as-received surfaces

Experimental conditions:

Al K_α source
pass energy: 89.45 eV
take-off angle: 95°

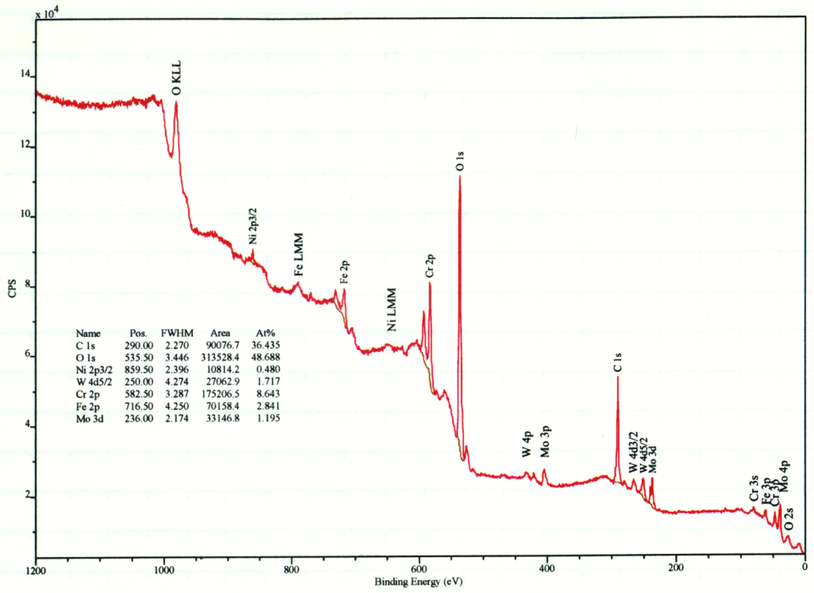
9) Specimen # 1



To Page No.

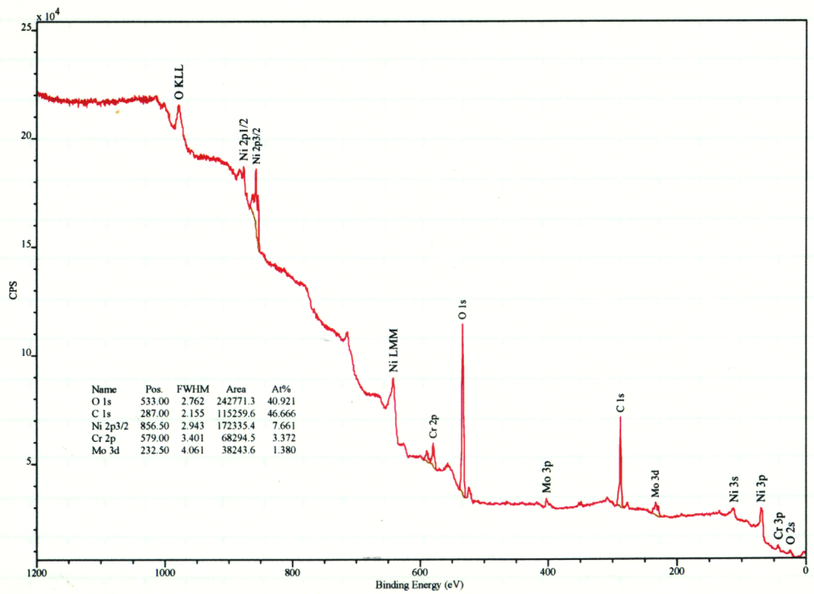
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Recorded by

b. Specimen #7



Name	Pos.	FWHM	Area	At%
C 1s	290.00	2.270	90076.7	36.435
O 1s	535.50	3.446	313528.4	48.688
Ni 2p3/2	859.50	2.396	10814.2	0.480
W 4d5/2	250.00	4.274	27062.9	1.717
Cr 2p	582.50	3.287	175206.5	8.643
Fe 2p	716.50	4.250	70158.4	2.841
Mo 3d	236.00	2.174	33146.8	1.195

c. Control specimen

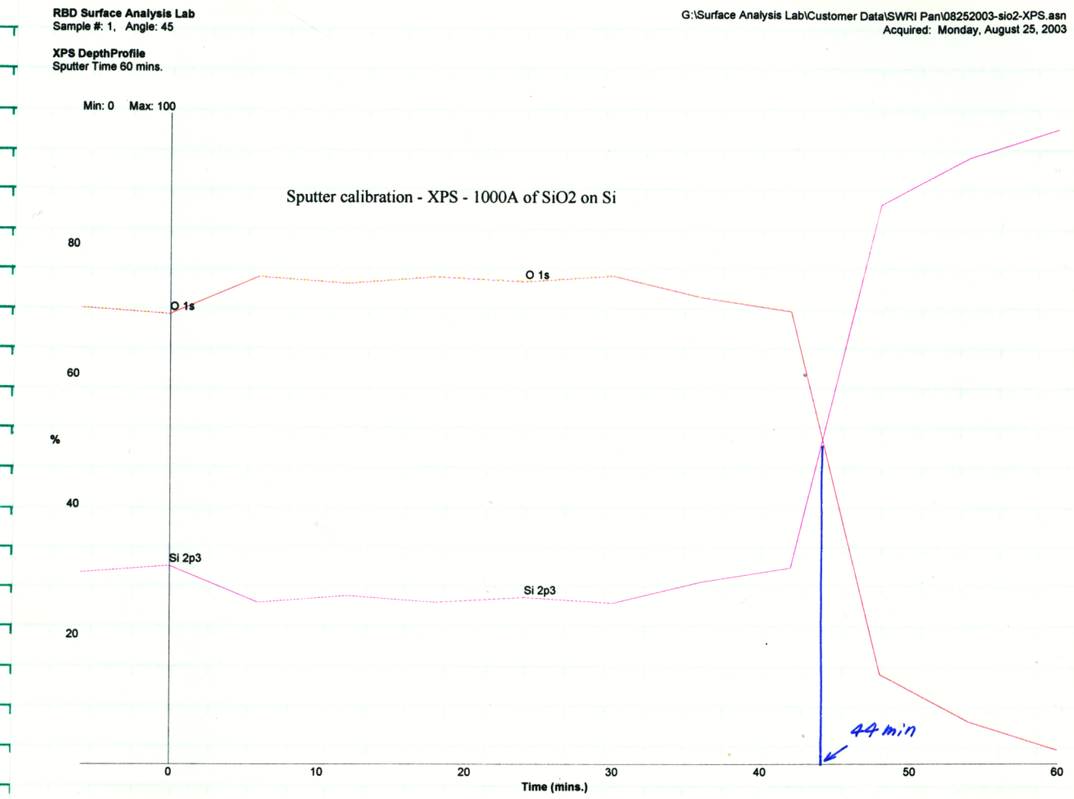


Name	Pos.	FWHM	Area	At%
O 1s	533.00	2.762	242771.3	40.921
C 1s	287.00	2.155	115259.6	46.666
Ni 2p3/2	856.50	2.943	172335.4	7.661
Cr 2p	579.00	3.401	68294.5	3.372
Mo 3d	232.50	4.061	38243.6	1.380

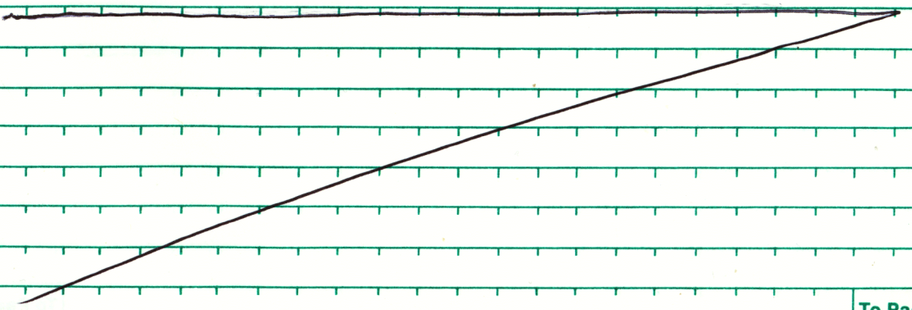
Witnessed & Understood by me, | Date | Invented by | Date 9/12/03 | Recorded by Mj Pan

2. Concentration depth profiling

a. Calibration of sputtering rate



Sputtering rate: 1000 Å / 44 min = 22.7 Å/min



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From Page No.

b. Elemental concentration data

100mV-Specimen#1

Time(sec)	SiO2 EQ(A)	C	Cr	Mo	Ni	O	Zn
0	0.0	26.44	12.32	1.28	3.32	54.19	2.44
9	3.4	4.6	21.59	2.32	7.67	60.7	3.11
18	6.8	1.91	24.59	2.79	8.52	59.36	2.82
27	10.2	2.32	26.68	2.93	10.03	56.08	1.97
36	13.6	0.31	27.98	3.2	12.53	54.28	1.7
45	17.0	0.05	28.55	3.35	16.04	50.84	1.16
54	20.4	0.28	29.41	3.64	19.87	45.68	1.12
63	23.8	0.45	29.42	3.77	23.71	41.83	0.81
72	27.2	0.36	27.51	3.76	31.05	36.55	0.75
81	30.6	0.3	25.65	4.24	36.94	32.02	0.84
90	34.1	0.004	23.52	4.73	43.76	27.41	0.57
99	37.5	0.24	22.17	5.17	47.06	25.1	0.26
108	40.9	0.46	20.96	5.23	50.75	22.45	0.14
117	44.3	1.4	19.16	5.6	54.29	19.18	0.36
126	47.7	0.03	19.09	6.03	56.44	18.08	0.32
135	51.1	0.36	17.94	6.01	59.17	16.29	0.23
144	54.5	0.51	18.03	6.2	60.47	14.65	0.12
153	57.9	0.003	16.97	6.38	62.95	13.44	0.26
162	61.3	0.31	17.18	6.85	63.07	12.5	0.07
171	64.7	0.06	17.07	6.92	63.97	11.85	0.11

600mV-Specimen#7

Time(sec)	SiO2 EQ(A)	C	Cr	Mo	Ni	O	W	Fe
0	0.0	19.74	12.4	1.16	1.14	55.78	1.28	8.51
12	4.5	7.25	16.38	1.77	1.17	59.86	1.75	11.81
24	9.1	3.23	18.34	2.03	0.82	59.5	2.78	13.3
36	13.6	2.33	20.06	2.11	0.97	58.18	2.5	13.84
48	18.2	2.02	20.8	2.09	1.22	57.81	2.93	13.12
60	22.7	1.05	21.66	2.16	0.97	57.85	2.91	13.39
72	27.2	3.62	21.88	2.15	1.4	55.04	2.79	13.11
84	31.8	4.97	21.04	2.13	1.45	52.77	3.14	14.5
96	36.3	2.46	22.63	2.22	2.14	53.89	2.95	13.69
108	40.9	1.83	23.23	2.22	1.86	52.73	3.06	15.07
120	45.4	2.66	22.88	2.35	3.11	52.77	2.55	13.67
132	49.9	4.68	21.94	2.45	2.87	51.19	2.89	13.96
144	54.5	2.37	22.29	2.55	3.48	50.3	2.83	16.18
204	77.2	0	25.57	2.15	5.95	51.48	2.19	12.65
264	99.9	0	23.43	2.74	8.68	47.69	2.35	15.1
324	122.6	0	23.2	3.23	10.97	44.85	2.53	15.22
384	145.3	0	22.68	3.51	11.58	44.14	2.58	15.5
444	168.0	0	22.36	3.72	12.58	43.59	2.78	14.97
504	190.7	0	22.48	3.93	12.5	43.29	2.57	15.23
564	213.4	0	23.29	4.03	12.47	41.95	2.96	15.3
624	236.1	0	23.2	3.95	12.09	42.59	2.54	15.63

Control Specimen

Time(sec)	SiO2 EQ(A)	C	Cr	Mo	Ni	O
0	0.0	33.45	5.36	1.64	16.17	43.39
9	3.4	4.83	13.6	3	39.52	39.04
18	6.8	3.57	15.52	3.34	48.07	29.49
27	10.2	1.33	15.8	3.41	56.69	22.76
36	13.6	0.89	15.12	3.57	61.76	18.65
45	17.0	0.92	13.82	3.79	66.3	15.16
54	20.4	0.3	13.58	4.1	68.95	13.08
63	23.8	0.57	12.92	4.28	70.41	11.81
72	27.2	1.63	12.76	4.72	70.74	10.15

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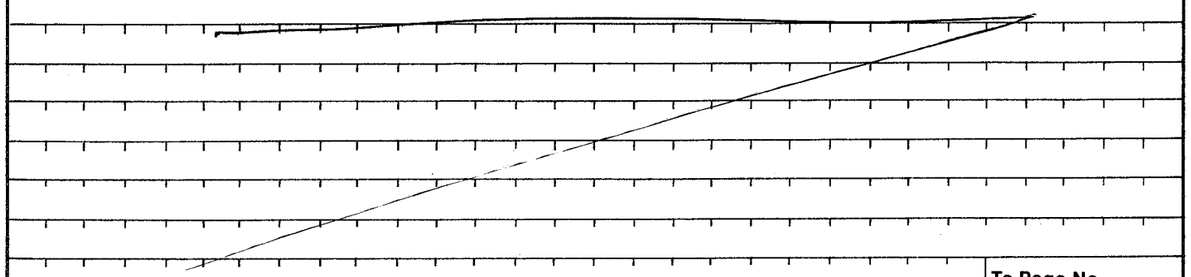
c. Chemical state data

specimen #1 - species concentration results

Etch Time(sec)	C 1s %	Cr metal %	Cr2O3 %	Mo IV %	Mo O2 %	Mo V %	Mo VI %	Mo metal %	Ni metal %	Ni2O3 %	NiO %	O2- %	OH- %	Zn 2p3 %
0	31.61	0.66	10.99	0.13	0.07	0.25	0.52	0.18	0.71	1.65	0.26	0.75	50.00	2.21
9	6.50	1.59	19.18	0.32	0.18	0.68	0.69	0.43	1.55	3.00	1.43	19.46	41.68	3.32
18	2.36	3.20	20.80	0.43	0.31	0.76	0.73	0.68	2.62	2.92	1.42	27.63	33.34	2.79
27	1.54	4.29	22.40	0.42	0.41	0.70	0.64	0.91	4.08	2.07	1.53	30.51	28.27	2.22
36	1.37	5.85	21.68	0.30	0.47	0.62	0.68	1.25	5.04	1.48	2.17	31.08	26.12	1.88
45	0.66	7.19	21.67	0.32	0.55	0.49	0.51	1.57	8.50	1.45	1.55	30.56	23.59	1.40
54	2.25	8.45	21.21	0.27	0.50	0.52	0.45	2.02	11.68	0.63	1.73	28.28	20.97	1.07
63	0.91	9.69	20.58	0.28	0.42	0.44	0.32	2.47	14.99	0.99	2.02	26.10	19.89	0.87
72	1.16	10.48	18.51	0.06	0.54	0.44	0.25	2.82	20.29	1.22	1.49	22.71	19.25	0.78
81	1.45	11.15	16.31	0.38	0.44	0.34	0.29	3.30	24.33	0.53	2.68	21.05	16.95	0.80
90	1.58	11.20	14.10	0.40	0.41	0.33	0.25	3.89	26.83	1.17	4.98	18.42	15.74	0.71
99	1.70	11.70	12.38	0.31	0.51	0.43	0.19	4.43	30.80	1.23	5.22	16.99	13.73	0.38
108	1.56	12.31	11.15	0.23	0.74	0.22	0.29	4.73	33.29	1.47	6.05	14.99	12.63	0.35
117	1.91	12.36	8.84	0.15	0.58	0.44	0.34	5.20	36.31	0.73	7.27	12.56	12.78	0.53
126	2.43	12.77	7.63	0.11	0.68	0.38	0.29	5.59	38.47	1.58	7.22	13.21	9.36	0.28
135	2.63	12.76	6.89	0.46	0.56	0.23	0.24	5.77	39.57	2.07	7.81	10.81	9.85	0.35
144	3.31	13.03	6.64	0.31	0.42	0.26	0.15	6.27	38.07	2.28	10.04	11.41	7.50	0.31
153	2.60	13.12	5.70	0.42	0.45	0.11	0.20	6.48	42.92	1.88	8.15	8.55	9.14	0.27
162	3.52	13.50	4.35	0.39	0.35	0.31	0.30	6.87	42.97	1.91	9.13	8.42	7.93	0.05
171	3.80	13.73	4.90	0.43	0.32	0.30	0.19	7.15	43.42	1.74	8.78	8.50	6.66	0.08

specimen #1 - species contribution results

Etch Time(sec)	SiO2 EQ(A)	Cr metal %	Cr2O3 %	Mo IV %	Mo O2 %	Mo V %	Mo VI %	Mo metal %	Ni metal %	Ni2O3 %	NiO %	O2- %	OH- %
0	0.0	5.67	94.33	10.81	6.13	21.88	45.29	15.89	27.00	63.23	9.77	1.48	98.52
9	3.4	7.67	92.33	13.83	7.67	29.57	30.03	18.91	25.89	50.13	23.97	31.83	68.17
18	6.8	13.34	86.66	14.82	10.68	26.03	25.02	23.45	37.66	41.93	20.41	45.32	54.68
27	10.2	16.07	83.93	13.44	13.35	22.82	20.86	29.53	53.13	26.92	19.95	51.91	48.09
36	13.6	21.24	78.76	8.97	14.17	18.70	20.54	37.62	57.95	17.07	24.98	54.34	45.66
45	17.0	24.90	75.10	9.19	16.05	14.20	14.80	45.77	73.95	12.61	13.44	56.43	43.57
54	20.4	28.48	71.52	7.09	13.33	13.81	11.98	53.78	83.24	4.47	12.30	57.43	42.57
63	23.8	32.02	67.98	7.19	10.75	11.20	8.16	62.71	83.24	5.52	11.24	56.74	43.26
72	27.2	36.16	63.84	1.43	13.15	10.79	6.16	68.46	88.21	5.29	6.50	54.11	45.89
81	30.6	40.61	59.39	7.98	9.24	7.20	6.11	69.47	88.35	1.93	9.72	55.39	44.61
90	34.1	44.27	55.73	7.53	7.67	6.27	4.77	73.76	81.35	3.55	15.10	53.93	46.07
99	37.5	48.58	51.42	5.25	8.68	7.37	3.20	75.50	82.68	3.31	14.02	55.31	44.69
108	40.9	52.49	47.51	3.77	11.85	3.59	4.69	76.11	81.58	3.59	14.82	54.28	45.72
117	44.3	58.30	41.70	2.26	8.60	6.63	5.09	77.42	81.95	1.65	16.40	49.56	50.44
126	47.7	62.61	37.39	1.55	9.69	5.33	4.13	79.31	81.38	3.34	15.28	58.51	41.49
135	51.1	64.94	35.06	6.37	7.70	3.19	3.25	79.49	80.01	4.19	15.80	52.32	47.68
144	54.5	66.24	33.76	4.17	5.62	3.49	2.08	84.64	75.56	4.53	19.92	60.34	39.66
153	57.9	69.71	30.29	5.49	5.92	1.49	2.60	84.50	81.05	3.55	15.40	48.33	51.67
162	61.3	75.61	24.39	4.78	4.30	3.82	3.60	83.50	79.56	3.54	16.90	51.49	48.51
171	64.7	73.71	26.29	5.08	3.86	3.55	2.29	85.21	80.49	3.23	16.28	56.09	43.91



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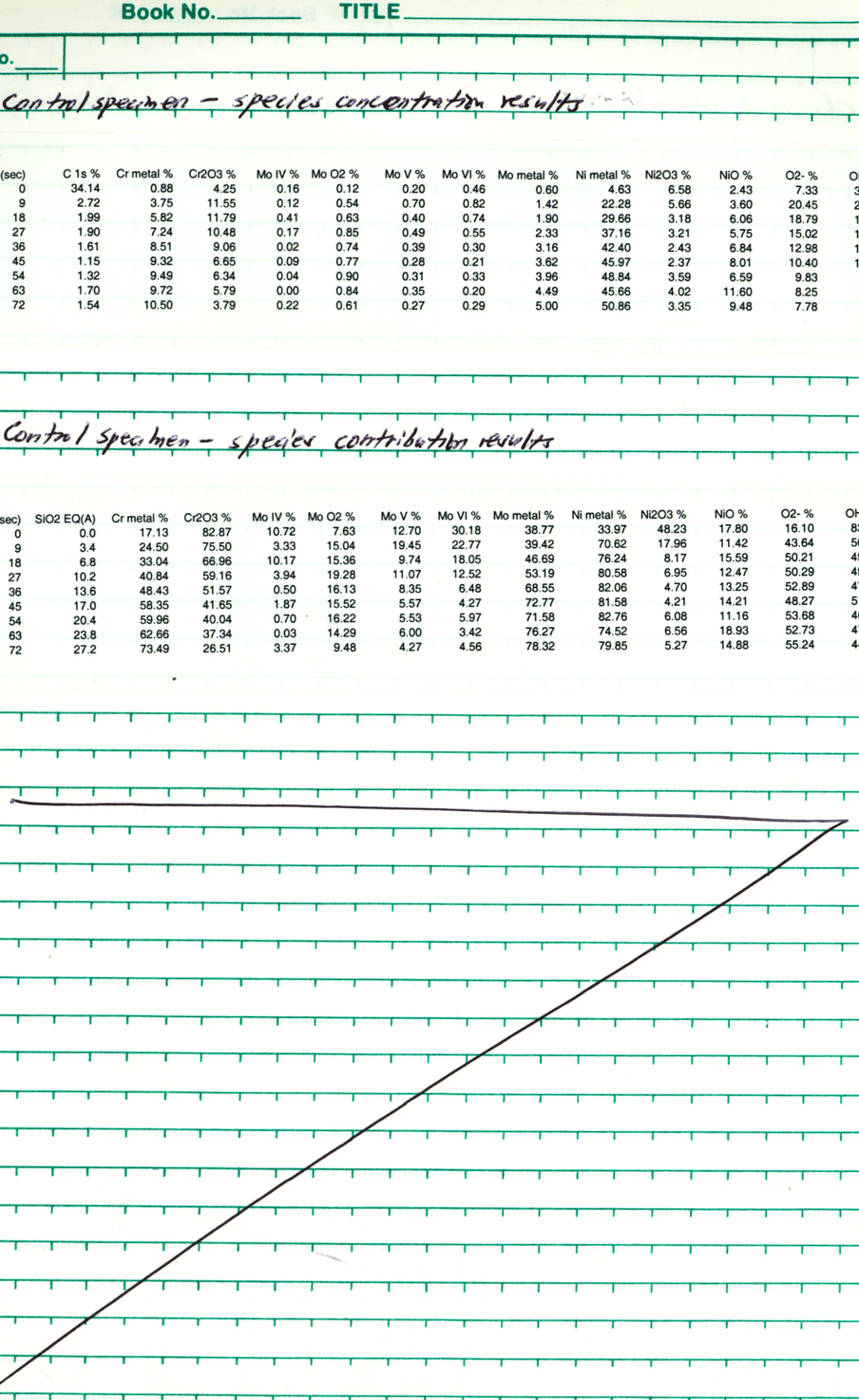
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Control specimen – species concentration results

Etch Time(sec)	C 1s %	Cr metal %	Cr2O3 %	Mo IV %	Mo O2 %	Mo V %	Mo VI %	Mo metal %	Ni metal %	Ni2O3 %	NiO %	O2- %	OH- %
0	34.14	0.88	4.25	0.16	0.12	0.20	0.46	0.60	4.63	6.58	2.43	7.33	38.22
9	2.72	3.75	11.55	0.12	0.54	0.70	0.82	1.42	22.28	5.66	3.60	20.45	26.40
18	1.99	5.82	11.79	0.41	0.63	0.40	0.74	1.90	29.66	3.18	6.06	18.79	18.64
27	1.90	7.24	10.48	0.17	0.85	0.49	0.55	2.33	37.16	3.21	5.75	15.02	14.85
36	1.61	8.51	9.06	0.02	0.74	0.39	0.30	3.16	42.40	2.43	6.84	12.98	11.56
45	1.15	9.32	6.65	0.09	0.77	0.28	0.21	3.62	45.97	2.37	8.01	10.40	11.15
54	1.32	9.49	6.34	0.04	0.90	0.31	0.33	3.96	48.84	3.59	6.59	9.83	8.48
63	1.70	9.72	5.79	0.00	0.84	0.35	0.20	4.49	45.66	4.02	11.60	8.25	7.39
72	1.54	10.50	3.79	0.22	0.61	0.27	0.29	5.00	50.86	3.35	9.48	7.78	6.31

Control specimen – species contribution results

Etch Time(sec)	SiO2 EQ(A)	Cr metal %	Cr2O3 %	Mo IV %	Mo O2 %	Mo V %	Mo VI %	Mo metal %	Ni metal %	Ni2O3 %	NiO %	O2- %	OH- %
0	0.0	17.13	82.87	10.72	7.63	12.70	30.18	38.77	33.97	48.23	17.80	16.10	83.90
9	3.4	24.50	75.50	3.33	15.04	19.45	22.77	39.42	70.62	17.96	11.42	43.64	56.36
18	6.8	33.04	66.96	10.17	15.36	9.74	18.05	46.69	76.24	8.17	15.59	50.21	49.79
27	10.2	40.84	59.16	3.94	19.28	11.07	12.52	53.19	80.58	6.95	12.47	50.29	49.71
36	13.6	48.43	51.57	0.50	16.13	8.35	6.48	68.55	82.06	4.70	13.25	52.89	47.11
45	17.0	58.35	41.65	1.87	15.52	5.57	4.27	72.77	81.58	4.21	14.21	48.27	51.73
54	20.4	59.96	40.04	0.70	16.22	5.53	5.97	71.58	82.76	6.08	11.16	53.68	46.32
63	23.8	62.66	37.34	0.03	14.29	6.00	3.42	76.27	74.52	6.56	18.93	52.73	47.27
72	27.2	73.49	26.51	3.37	9.48	4.27	4.56	78.32	79.85	5.27	14.88	55.24	44.76



To Page No.____

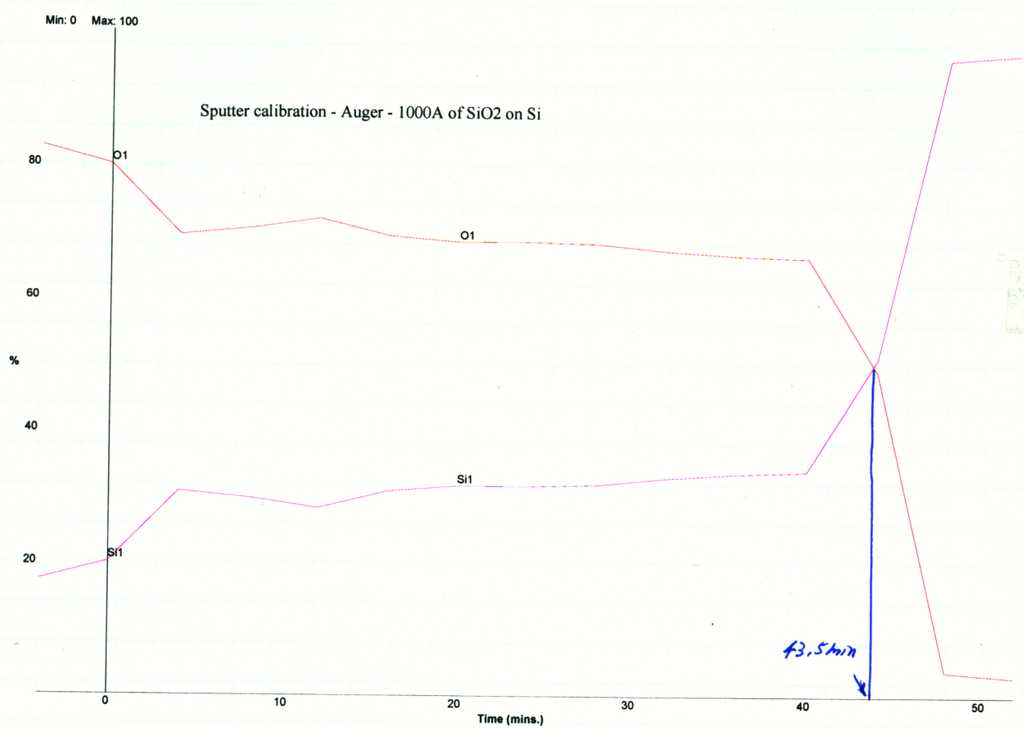
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TITLE AES Analysis of Alloy 22 Specimen #3

Project No.____
Book No.____

From Page No.____

1. Sputtering rate calibration



Sputtering rate: 1000Å/43.5min = 23.0 Å/min

To Page No.____

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Project No.
Book No.
TITLE

From Page No.

ppp 9/27/03

2. Wide-energy survey of the as-received surface

RBD Surface Analysis Lab

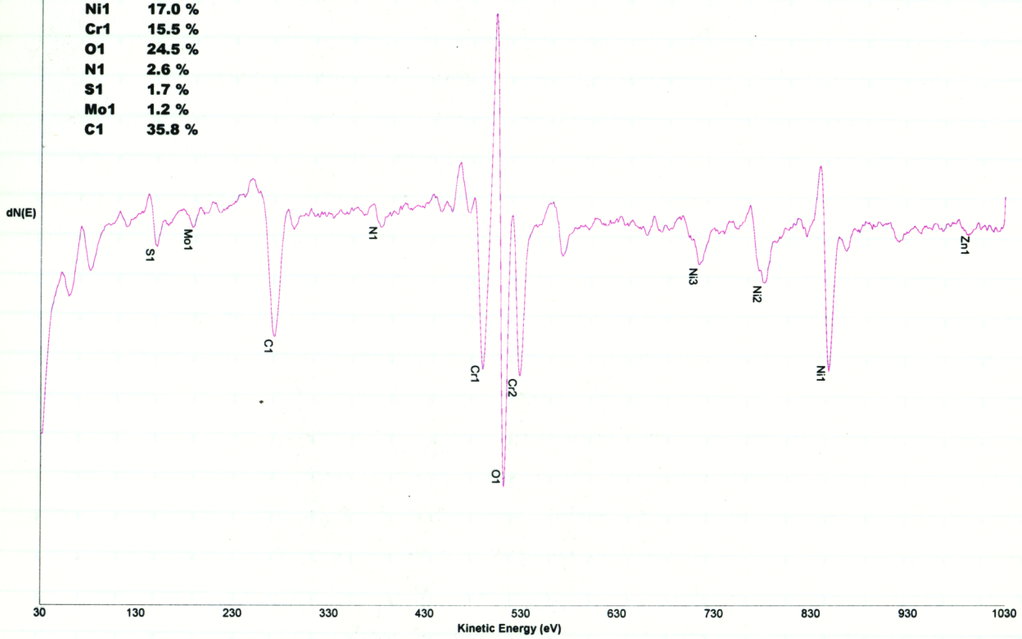
G:\Surface Analysis Lab\Customer Data\SWRI Pan\08272003-SWRI-sample3b-10kV-001.asn
Acquired: Wednesday, August 27, 2003

AES Survey
EV/Step: 1 eV, Time/Step: 50 mSec, Sweeps: 3 Beam: 10000 V

Min: -25943 Max: 22890

Atomic Concentration

Zn1	1.6 %
Ni1	17.0 %
Cr1	15.5 %
O1	24.5 %
N1	2.6 %
S1	1.7 %
Mo1	1.2 %
C1	35.8 %



3. Elemental concentration data

Auger specimen#3

Time(sec)	SiO2 EQ(A)	C	Cr	Mo	Ni	O
0	0.0	35.80	15.50	1.20	17.00	24.50
9	3.4	13.74	27.08	1.75	17.23	40.18
18	6.8	9.10	28.97	2.26	18.22	41.44
27	10.2	6.99	28.55	2.79	21.68	39.98
36	13.6	5.99	30.44	2.27	24.15	37.14
45	17.0	6.57	28.94	3.28	28.08	33.12
54	20.4	4.87	27.61	4.13	33.30	30.08
63	23.8	6.15	26.80	4.68	37.42	24.94
72	27.2	7.06	24.66	5.92	40.92	21.43
81	30.6	8.11	23.11	5.74	44.66	18.37
90	34.1	7.77	22.94	5.87	46.45	16.96
99	37.5	7.80	23.13	6.72	47.62	14.73
108	40.9	8.51	19.72	8.01	49.89	13.86
117	44.3	8.79	21.39	7.44	49.81	12.55
126	47.7	8.83	17.59	8.33	52.71	12.53

To Page No.

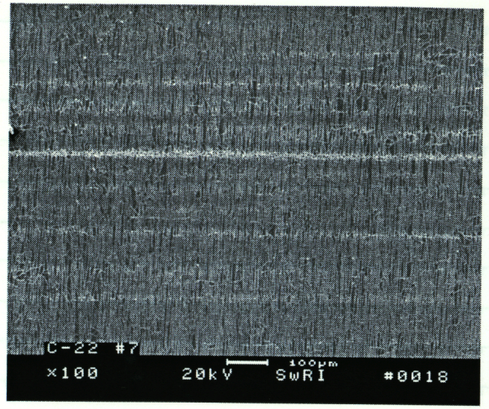
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Recorded by
Date 9/12/03

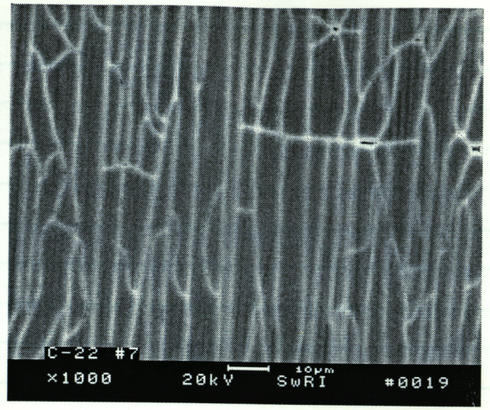
TITLE SEM Examination of the Alloy 22 specimens
Project No.
Book No.

From Page No.

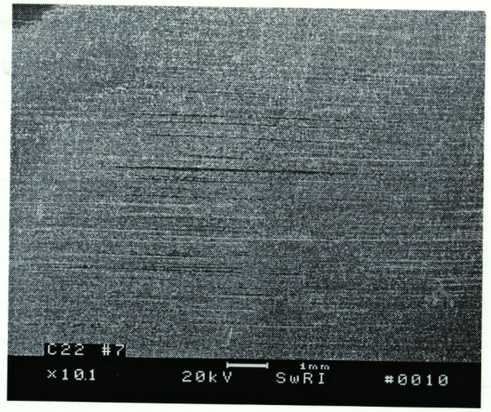
1. Specimen #7

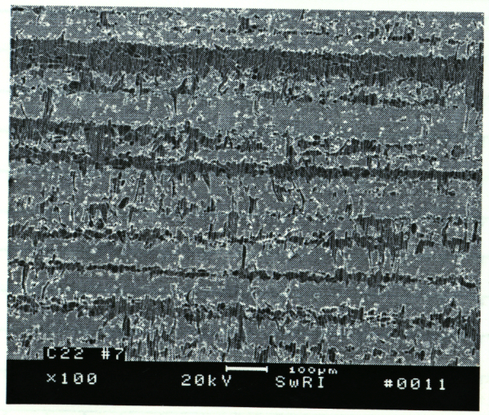
a. As-received surface

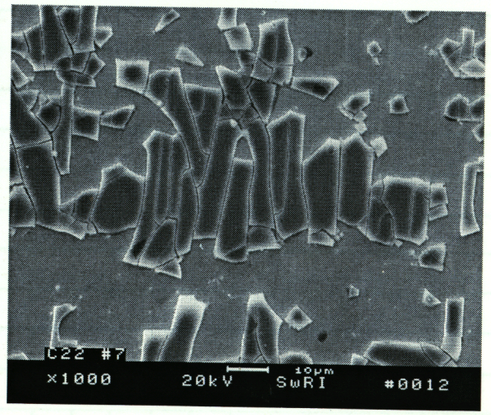




b. Inside crater after depth profiling





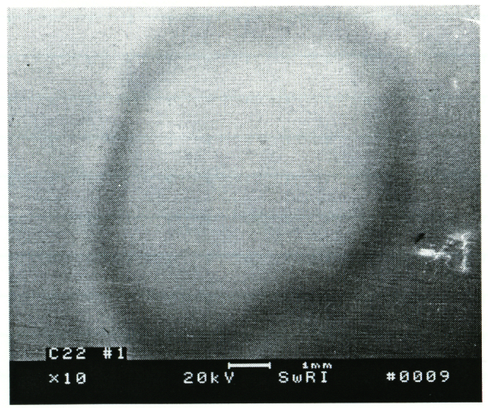


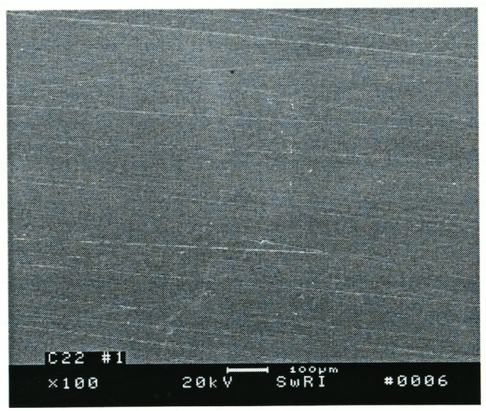
To Page No.

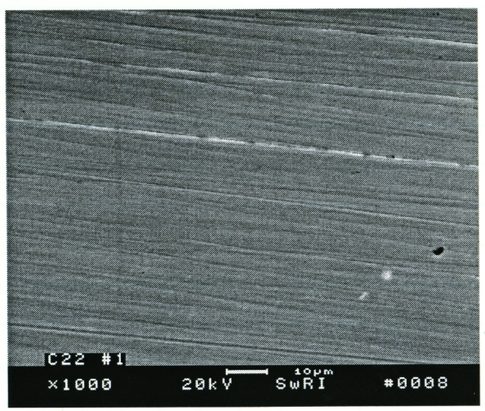
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Date 9/17/03

From Page No.

2. Specimen #1
Inside crater after depth profiling





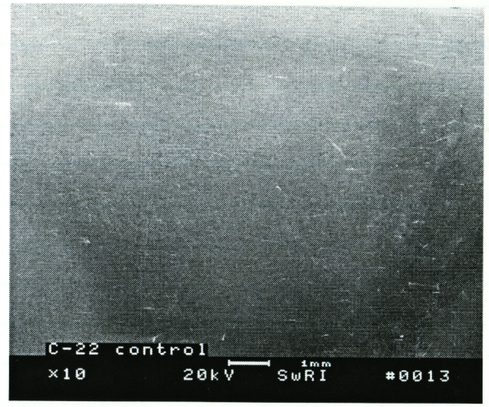


To Page No.

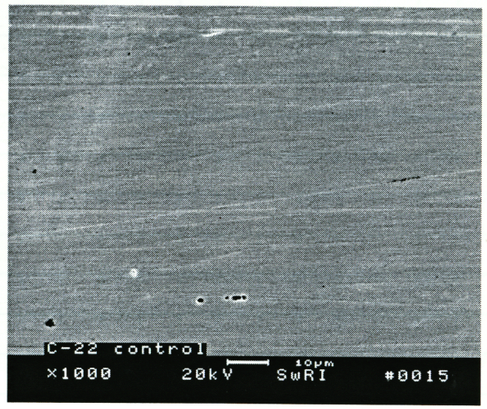
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		Recorded by Zijo Pan	9/17/03

From Page No.

3. Control specimen
Inside crater after depth profiling







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Zijo Pan 10/1/03

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		Recorded by Zijo Pan	9/17/03

From Page No.

Objective: To calculate the liquidus, solidus, and solvus temperatures for Alloy 22 affected by element segregation in the weld.

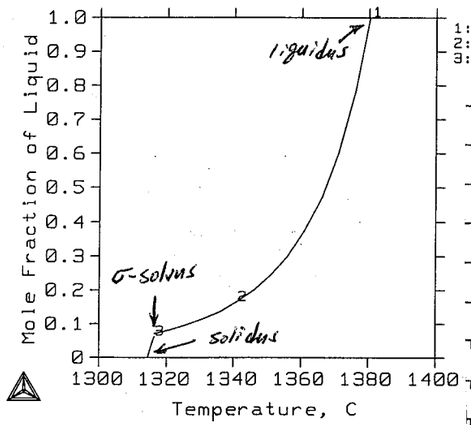
Software: THERMOCALC Version N
Database: Thermotech Ni-Data Version 5

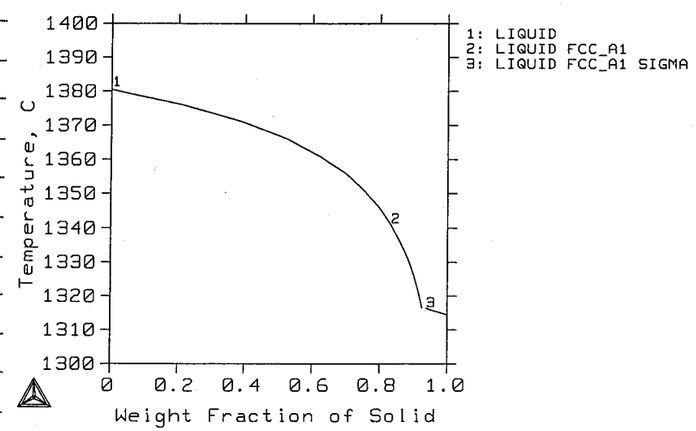
1. Scheil simulations

The Scheil modulus was used with the input of the alloy composition. The simulations were started at a temperature above the liquidus temperature and stepped down in temperature in 5°C increments until solidification was complete. The solidification process was under Scheil conditions (N. Saunders and A.P. Miodownik, CALPHAD Calculation of Phase Diagrams – A Comprehensive Guide, Pergamon, 1998, p.443). Both stable and metastable (with suspension of σ-phase) calculations were conducted.

@ Base alloy composition Ni – 21.4Cr – 13.6Mo – 3W – 3.08Fe in wt.%.

a1. stable calculation



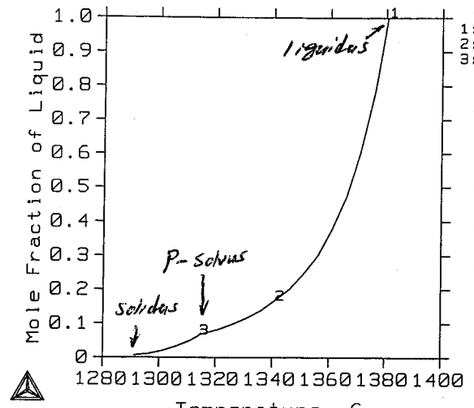


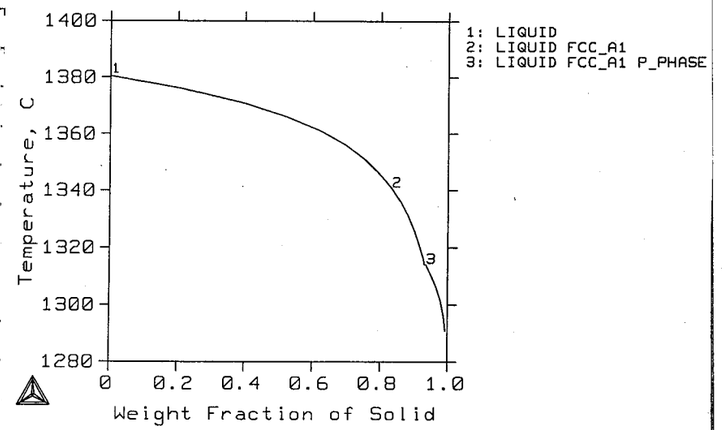
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Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by	2/26/04

From Page No.

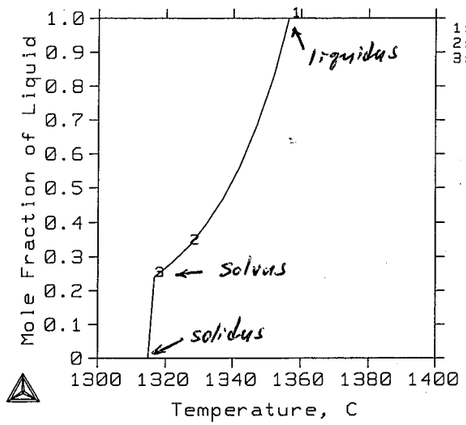
a2. metastable calculation

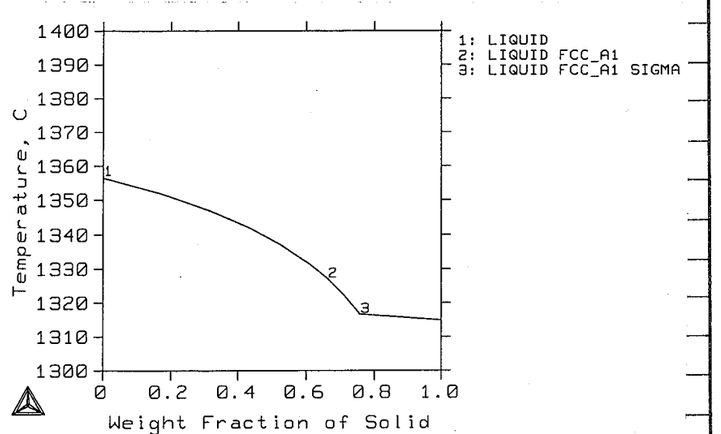




ⓑ Interdendritic composition Ni – 22.6Cr – 18Mo – 2.48W – 2.48Fe in wt.%

a1. stable calculation



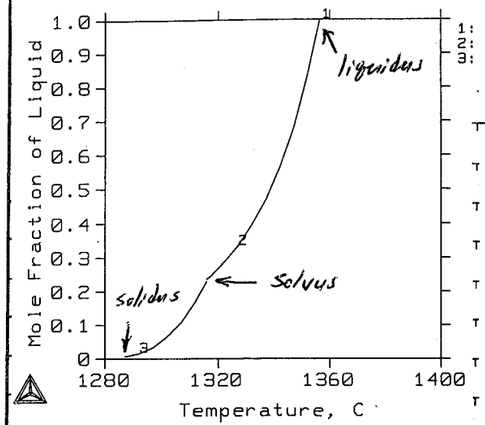


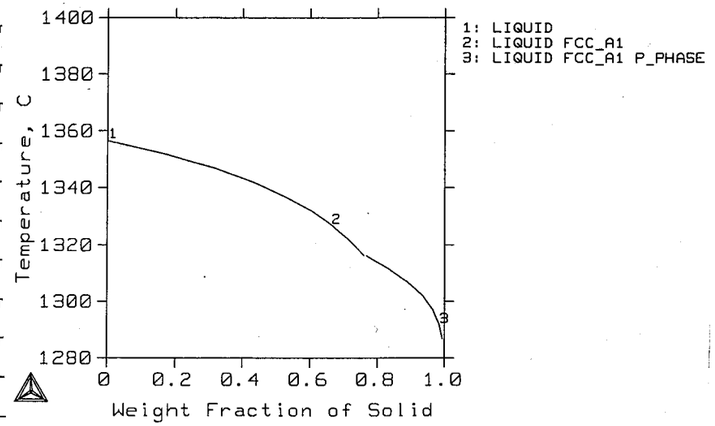
To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
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From Page No.

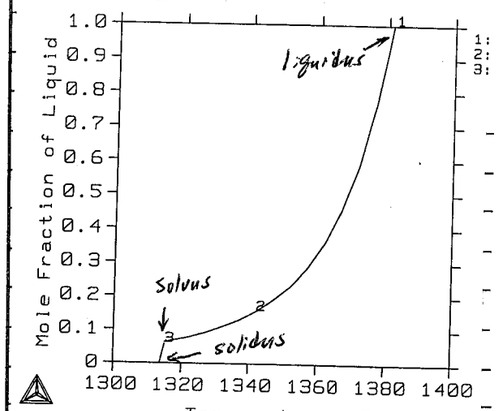
b2. metastable calculation

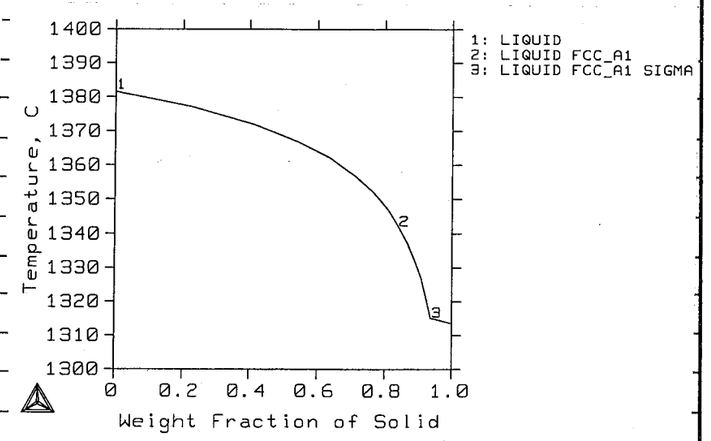




C. Dendrite core composition Ni-21.8Cr-13Mo-2.6W-3.75Fe in wt%

C1. stable calculation





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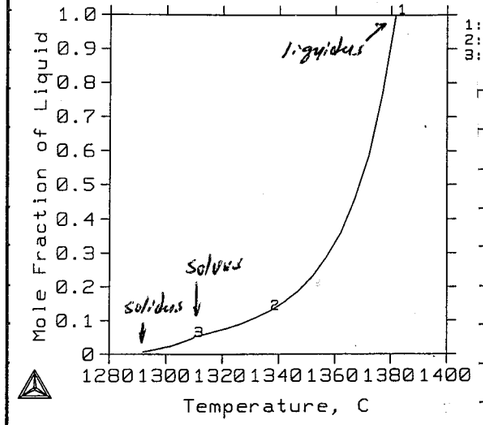
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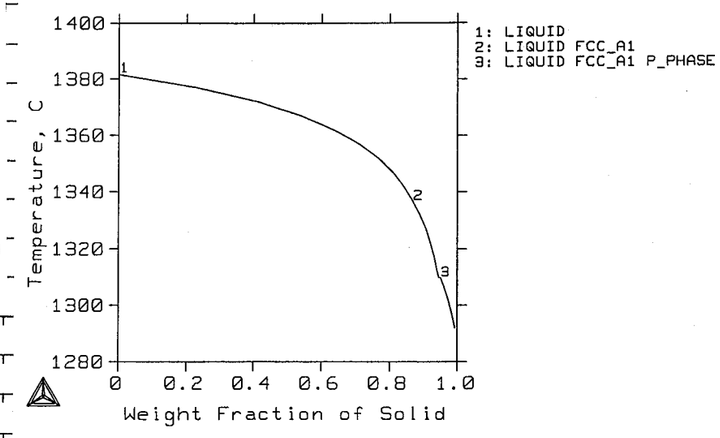
Recorded by

Date 2/26/04

From Page No.

C2. metastable calculation





~~2. Equilibrium simulation~~ Scheil

D Summary of calculated liquidus, solidus, and solvus temperatures

Location	Stable Calculation			Metastable Calculation (σ-Phase Suspended)		
	Liquidus	Solidus	σ-Solvus	Liquidus	Solidus	P-Solvus
Dendrite Core	1382	1314	1315	1382	1292	1310
Interdendritic Region	1357	1315	1316	1357	1287	1316
Base Alloy	1380	1314	1315	1380	1291	1314

To Page No.

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Date

Invented by

Recorded by

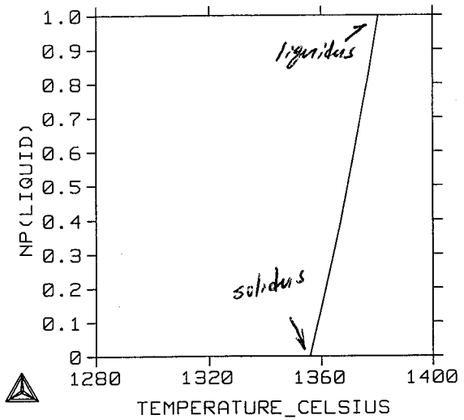
Date 2/26/04

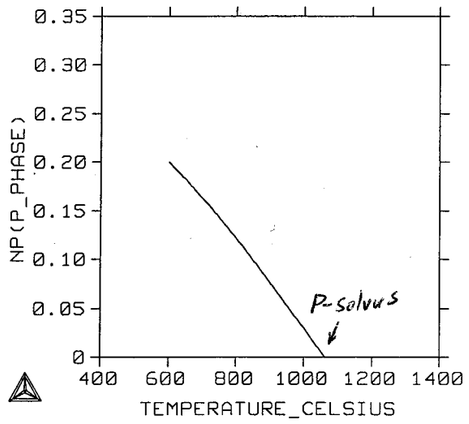
From Page No.

2. Equilibrium simulations

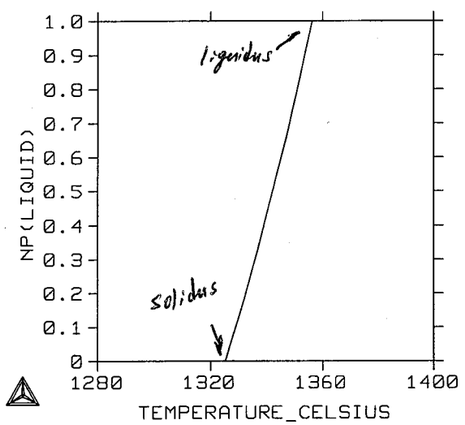
In the equilibrium calculations, a step of 5°C increment was also used and the phase equilibria state was determined at each temperature step. The calculations proceeded to step down in temperature until solidification was complete.

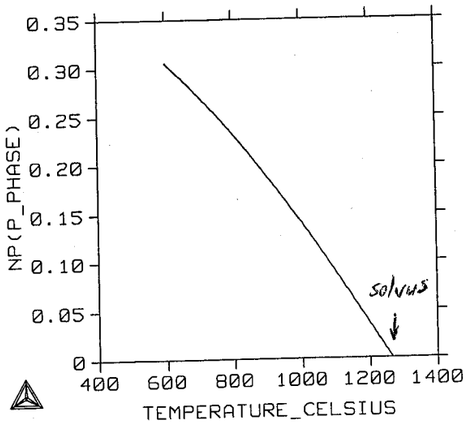
(a) Base alloy composition





(b) Interdendritic composition



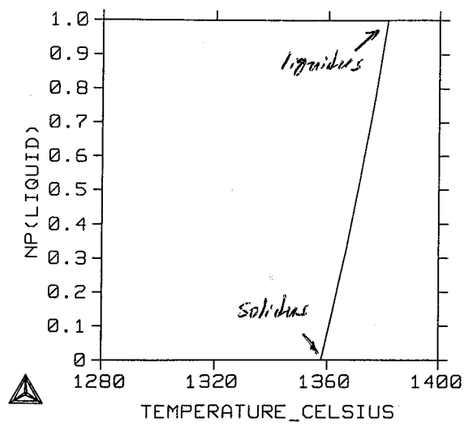


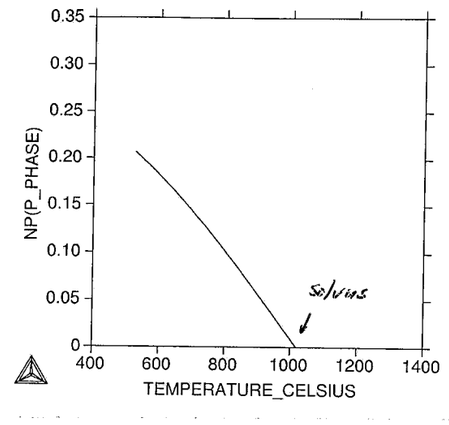
To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by	2/26/04

From Page No.

(c) Dendrite Core composition





(d) Summary of liquidus, solidus, and solvus temperatures

Location	Stable Calculation		
	Liquidus	Solidus	P-Solvus
Dendrite Core	1382	1358	1018
Interdendritic Region	1357	1325	1265
Base Alloy	1380	1356	1062

To Page No.

Witnessed & Understood by me,	Date	Invented by	Date
		Recorded by	2/26/04

Project No.
Book No.
TITLE Heat Treatments of GTAW and GMAW Alloy 22 Welds

From Page No.

Alloy 22 weld materials:

(A) GTAW material

Alloy 22 base metal heat 2277-1-3164

Filler heat WN 813 (Alloy 622)

(B) GMAW material

Alloy 22 base metal heat 2277-1-3164

Filler heats WN 813/XX19 77BG11 (Alloy 622)

Specimen ID and heat treatment conditions:

GTAW Material	GMAW Material	Condition
T1	M1	1125°C for 20 min
T2	M2	1125°C/20min plus 870°C/60min
T3	M3	870°C for 30 min.
T4	M4	870°C for 60min
T5	M5	870°C for 10hrs
T6	M6	As-welded

Heat treatments:

Thermocouple SN # 332, Cal: 1/22/04, Due: 7/22/04

Thermometer Model DH22, SN# 94440, Cal: 11/5/03, Due: 5/5/04

1125°C-treatment: oven set point 1125°C, measured temp. 1134.6°C

870°C-treatment: oven set point 870°C, measured temp. 886.4°C

At the end of all the treatments, the specimens were water-quenched.

To Page No.

Witnessed & Understood by me, | Date | Invented by | Date 4/15/04

Recorded by

Project No.
Book No.
TITLE Precipitate Volume Fraction Measurements for GTAW and GMAW Welds

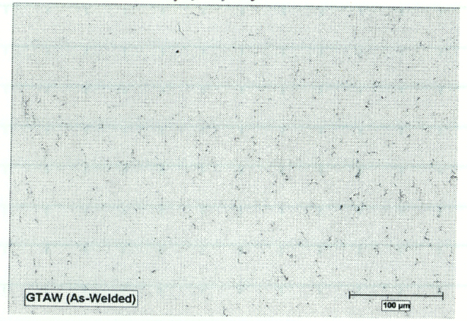
From Page No.

Metallurgical samples were prepared using standard polishing techniques and electrochemical etching in a solution of 5g oxalic acid in 95 ml of 37% HCl solution at 6V for a few seconds. Amount of precipitates was measured from optical micrographs using imaging analysis software along the centerline of the fusion zone of the welded samples.

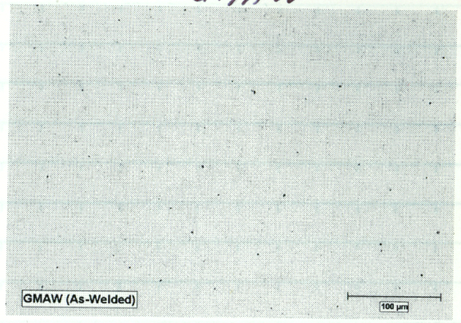
Results: Representative optical micrographs

GTAW

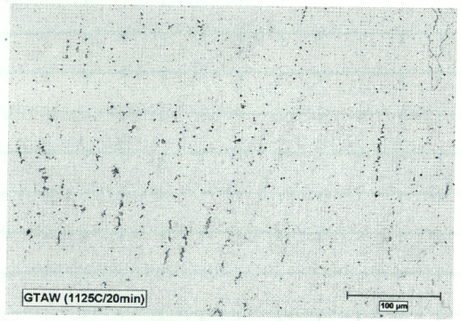
GMAW



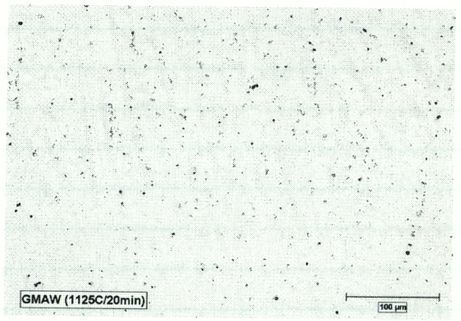
(a) As-Welded



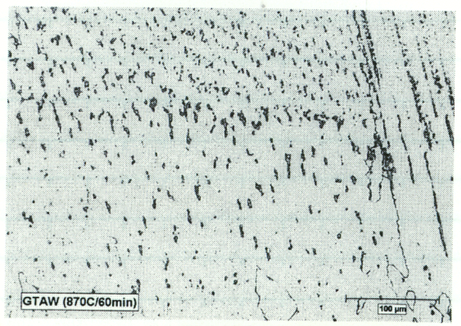
(d) As-Welded



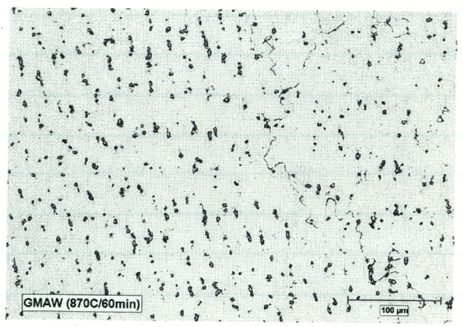
(b) 1,125 °C/20 Minutes



(e) 1,125 °C/20 Minutes



(c) 870 °C/60 Minutes



(f) 870 °C/60 Minutes

Witnessed & Understood by me, | Date | Invented by | Date 4/26/04

Recorded by

From Page No. GTAW welds

T6(As-welded)

image	% Precip.	% Matrix
M1906	0.8	99.2
M1907	0.7	99.3
M1908	0.6	99.4
M1909	0.8	99.2
M1910	0.8	99.2
M1911	0.9	99.1
M1912	1.0	99.0
M1913	1.4	98.6
M1914	0.9	99.1
M1915	1.6	98.4
M1916	0.7	99.3
M1917	1.0	99.0
M1918	1.2	98.8
M1919	1.1	98.9
M1920	1.1	98.9
M1921	1.2	98.8
M1922	1.2	98.8
M1923	1.3	98.7
M1924	0.6	99.4
M1925	0.5	99.5

Summary Statistics	
Mean	0.97
Standard Deviation	0.29
Minimum	0.50
Maximum	1.60
Sum	19.40
Count	20

T1(1125C/20min)

image	% Precip.	% Matrix
M1866	2.3	97.7
M1867	1.4	98.6
M1868	2.8	97.2
M1869	1.9	98.1
M1870	2.5	97.5
M1871	2.8	97.2
M1872	3.3	96.7
M1873	3.8	96.2
M1874	2.7	97.3
M1875	3.5	96.5
M1876	3.8	96.2
M1877	3.8	96.2
M1878	3.2	96.8
M1879	3.0	97.0
M1880	1.7	98.3
M1881	2.6	97.4
M1882	3.5	96.5
M1883	3.8	96.2
M1884	3.1	96.9
M1885	3.4	96.6

Summary Statistics	
Mean	2.9
Standard Deviation	0.7
Minimum	1.4
Maximum	3.8
Sum	58.9
Count	20

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T4(870C/60min)

image	% Precip.	% Matrix
M1886	7.0	93.0
M1887	7.6	92.4
M1888	8.3	91.7
M1889	3.4	96.6
M1890	5.9	94.1
M1891	4.7	95.3
M1892	7.2	92.8
M1893	6.4	93.6
M1894	4.8	95.2
M1895	5.7	94.3
M1896	4.8	95.2
M1897	5.4	94.6
M1898	8.1	91.9
M1899	7.1	92.9
M1900	8.2	91.8
M1901	6.6	93.4
M1902	11.5	88.5
M1903	9.4	90.6
M1904	7.6	92.4
M1905	6.1	93.9

Summary Statistics	
Mean	6.8
Standard Deviation	1.9
Minimum	3.4
Maximum	11.5
Sum	135.8
Count	20

GMAW welds

M6(As-welded)

image	% Precip.	% Matrix
M1966	0.052	99.948
M1967	0.027	99.973
M1968	0.097	99.903
M1969	0.050	99.950
M1970	0.100	99.900
M1971	0.088	99.912
M1972	0.100	99.900
M1973	0.100	99.900
M1974	0.200	99.800
M1975	0.200	99.800
M1976	0.068	99.932
M1977	0.059	99.941
M1978	0.045	99.955
M1979	0.060	99.940
M1980	0.100	99.900
M1981	0.030	99.970
M1982	0.068	99.932
M1983	0.200	99.800
M1984	0.077	99.923
M1985	0.037	99.963

Summary Statistics	
Mean	0.09
Standard Deviation	0.05
Minimum	0.03
Maximum	0.20
Sum	1.76
Count	20

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M1(1125C/20min)

image	% Precip.	% Matrix
M1926	1.7	98.3
M1927	1.1	98.9
M1928	1.1	98.9
M1929	1.6	98.4
M1930	0.8	99.2
M1931	1.6	98.4
M1932	1.1	98.9
M1933	1.4	98.6
M1934	1.9	98.1
M1935	1.7	98.3
M1936	0.5	99.5
M1937	1.5	98.5
M1938	1.6	98.4
M1939	1.7	98.3
M1940	1.5	98.5
M1941	1.4	98.6
M1942	1.1	98.9
M1943	1.6	98.4
M1944	1.4	98.6
M1945	0.9	99.1

Summary Statistics

Mean	1.4
Standard Deviation	0.4
Minimum	0.5
Maximum	1.9
Sum	27.2
Count	20

M4(870C/60min)

image	% Precip.	% Matrix
M1946	9.1	90.9
M1947	9.9	90.1
M1948	9.5	90.5
M1949	7.5	92.5
M1950	5.1	94.9
M1951	6.3	93.7
M1952	6.4	93.6
M1953	6.0	94.0
M1954	3.7	96.3
M1955	5.7	94.3
M1956	6.7	93.3
M1957	4.9	95.1
M1958	2.8	97.2
M1959	7.1	92.9
M1960	6.2	93.8
M1961	3.8	96.2
M1962	4.4	95.6
M1963	8.1	91.9
M1964	6.4	93.6
M1965	8.5	91.5

Summary Statistics

Mean	6.4
Standard Deviation	2.0
Minimum	2.8
Maximum	9.9
Sum	128.1
Count	20

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List of Publications Using Data from Scientific Notebook No. 498

D.S. Dunn, D. Daruwalla, and Y.-M. Pan. Effect of Fabrication Processes on Material Stability—Characterization and Corrosion. CNWRA 2004-01. San Antonio, Texas: CNWRA. 2003.

Y.-M. Pan, D.S. Dunn, and G.A. Cragnolino. Phase Instability and Corrosion of Alloy 22 as a High-Level Waste Container Material. Proceedings of the Mike Meshii Symposium: Electron Microscopy—Its Role in Materials Research. Warrendale, Pennsylvania: The Minerals, Metals and Materials Society. pp. 201-208. 2003.

Y.-M. Pan, D.S. Dunn, and G.A. Cragnolino. Phase Stability of Alloy 22 High-Level Waste Container Weldments: Experiments and Thermodynamic Calculations. Presentation at the CALPHAD XXXIII—An International Conference on Phase Diagram Calculations and Computational Thermochemistry, Krakow, Poland on May 30–June 4, 2004.

Y.-M. Pan, D.S. Dunn, and G.A. Cragnolino. Topologically Close-Packed Phase Precipitation and Thermal Stability in Alloy 22. *Metallurgical and Materials Transactions*. Vol. 36A. pp. 1143-1151. 2005.

I have reviewed this scientific notebook and find it in compliance with QAP-001. There is sufficient information regarding procedures used for conducting tests, acquiring and analyzing data so that another qualified individual could repeat the activity.

4/12/06