

# MSi Testing & Engineering, Inc.

Your Source for Metallurgical Testing and Failure Analysis

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## Background

Our Weld Testing Laboratory was requested to perform Charpy V-Notch Impact Testing, Corrosion Testing, Weld Ferrite Determination, Weld Microexamination and Vickers microhardness testing to document any evidence of detrimental weld related conditions.

## SAMPLE IDENTIFICATION

ID	Size	Material	Specification
2209-2	¼" Plate	Duplex Stainless	API 938-C

## TEST RESULTS \*

### Charpy Impact Testing

Location	Size (mm)	Temp	Energy (ft-lbs)	Lat. Exp. (.001")
Weld Centerline	10 x 5.0	-40°C	16	24
Weld Centerline	10 x 5.0	-40°C	16	23
Fusion Line	10 x 5.0	-40°C	51	68
Fusion Line	10 x 5.0	-40°C	44	58
Fusion Line + 2.5mm	10 x 5.0	-40°C	77	85
Fusion Line + 2.5mm	10 x 5.0	-40°C	69	79
Fusion Line + 4.75mm	10 x 5.0	-40°C	56	71
Fusion Line + 4.75mm	10 x 5.0	-40°C	88	93

### Corrosion Testing

Test Temperature: 22°C Test Duration: 24 Hrs.

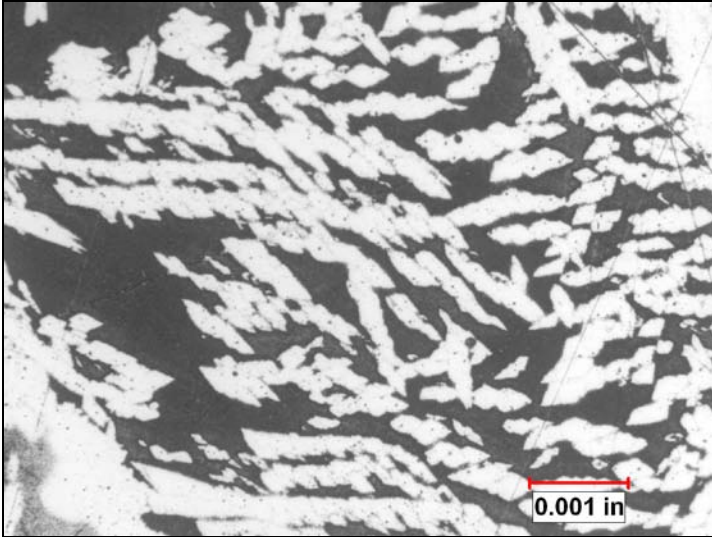
Area (dm <sup>2</sup> )	Wt Loss (mg)	Corrosion Rate (mdd)
.307	0.0	0
.302	0.0	0

### Percent Ferrite Testing – Automated Image Analysis

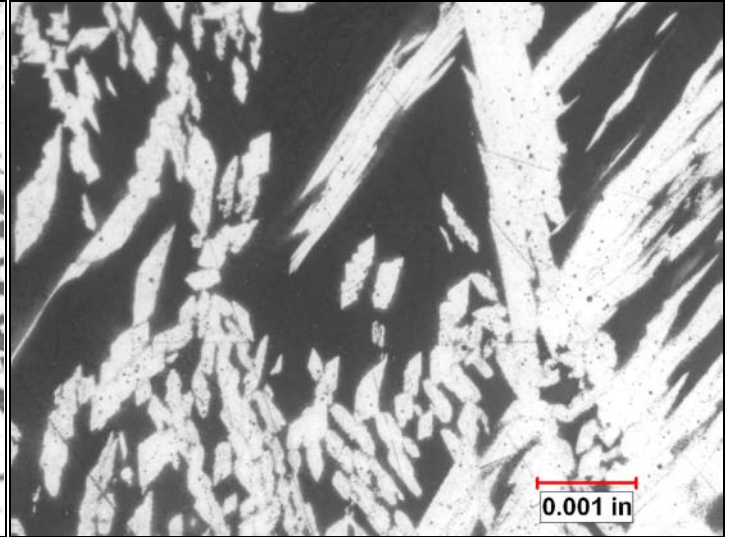
Location	Ferrite Content
Weld Cap	52.5% ± 0.5%
Weld Mid-Thickness	53.0% ± 0.5%
Weld Root	50.0% ± 0.5%
HAZ of Base A at Root	61.5% ± 0.5%
HAZ of Base B at Root	62.0% ± 0.5%
Base A	51.5% ± 0.5%
Base B	51.0% ± 0.5%

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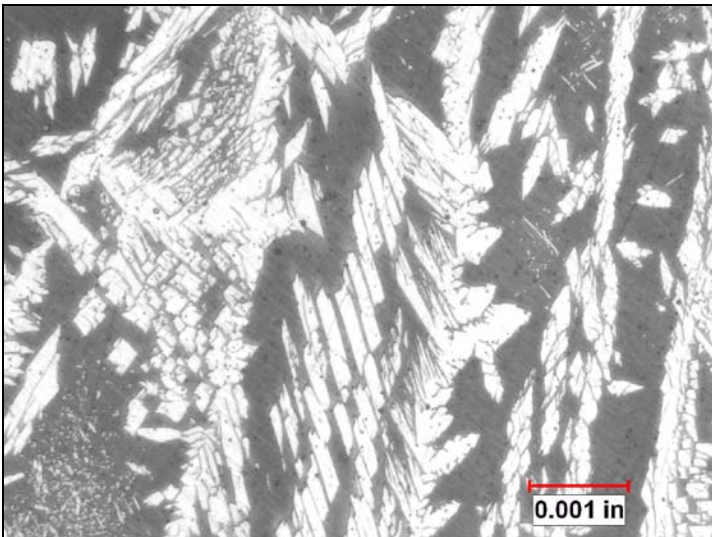
**Ferrite Testing (Continued)**



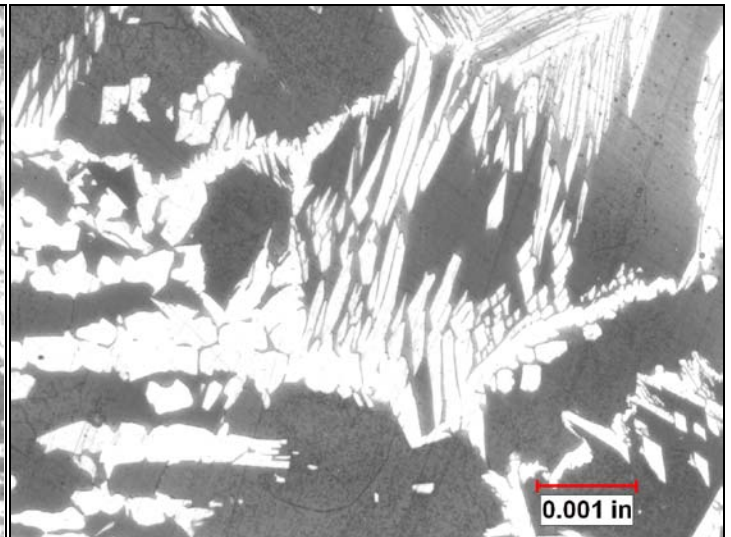
**Photo 1:** Mag: 500X; Etchant: Beraha Reagent  
Location: Weld at Cap



**Photo 2:** Mag: 500X; Etchant: Beraha Reagent  
Location: Weld at Mid-Thickness



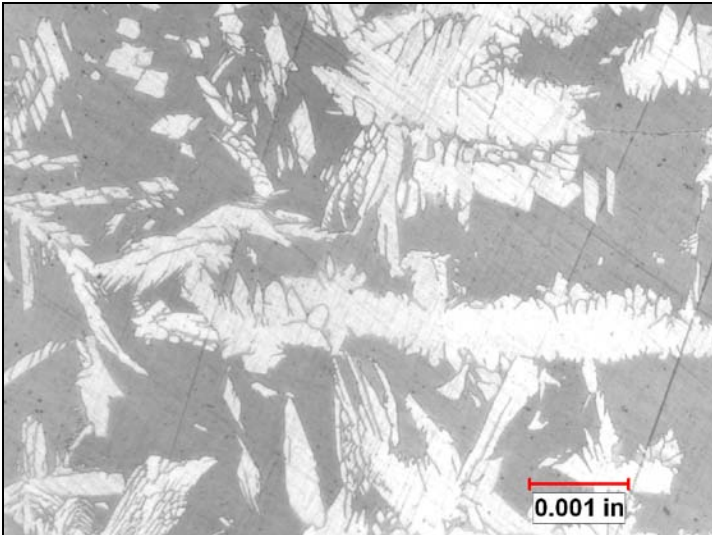
**Photo 3:** Mag: 500X; Etchant: Beraha Reagent  
Location: Weld at Root



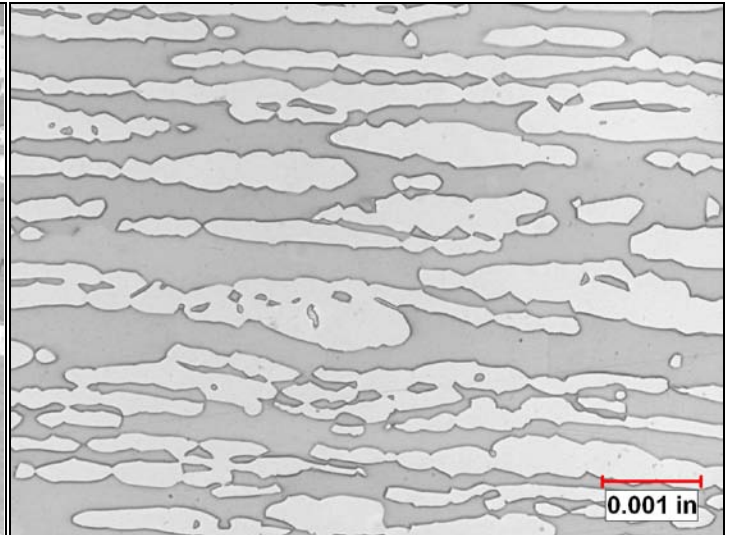
**Photo 4:** Mag: 500X; Etchant: Beraha Reagent  
Location: HAZ of Base A at Root

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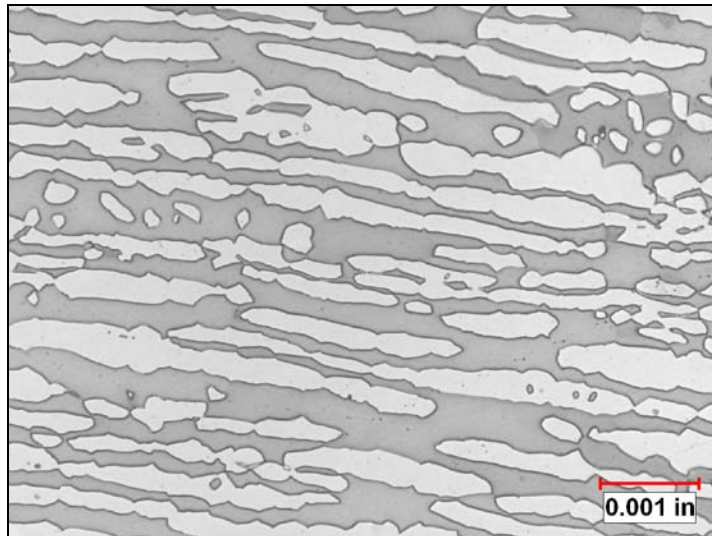
**Ferrite Testing (Continued)**



**Photo 5:** Mag: 500X; Etchant: Beraha Reagent  
Location: HAZ of Base B at Root



**Photo 6:** Mag: 500X; Etchant: Electrolytic NaOH  
Location: Base A at Mid-Thickness



**Photo 7:** Mag: 500X; Etchant: Electrolytic NaOH  
Location: Base B at Mid-Thickness

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MSi Report No. [REDACTED]

**TEST RESULTS (Continued)****Vicker's Microhardness Testing**

Indentation	HVN-1kg
1	256
2	262
3	278
4	284
5	290
6	274
7	279
8	279
9	288
10	278
11	281
12	279
13	276
14	288
15	278
16	272
17	309
18	281
19	288
20	281
21	285
22	286

Indentation	HVN-1kg
23	303
24	288
25	321
26	266
27	278
28	266
29	268
30	258
31	278
32	257
33	286
34	285
35	279
36	278
37	279
38	297
39	278
40	297
41	311
42	293
43	293
44	297

\* Testing performed in accordance with ASTM A923 – Method B & C, E92 and E562 using Clemex Vision Analysis system.

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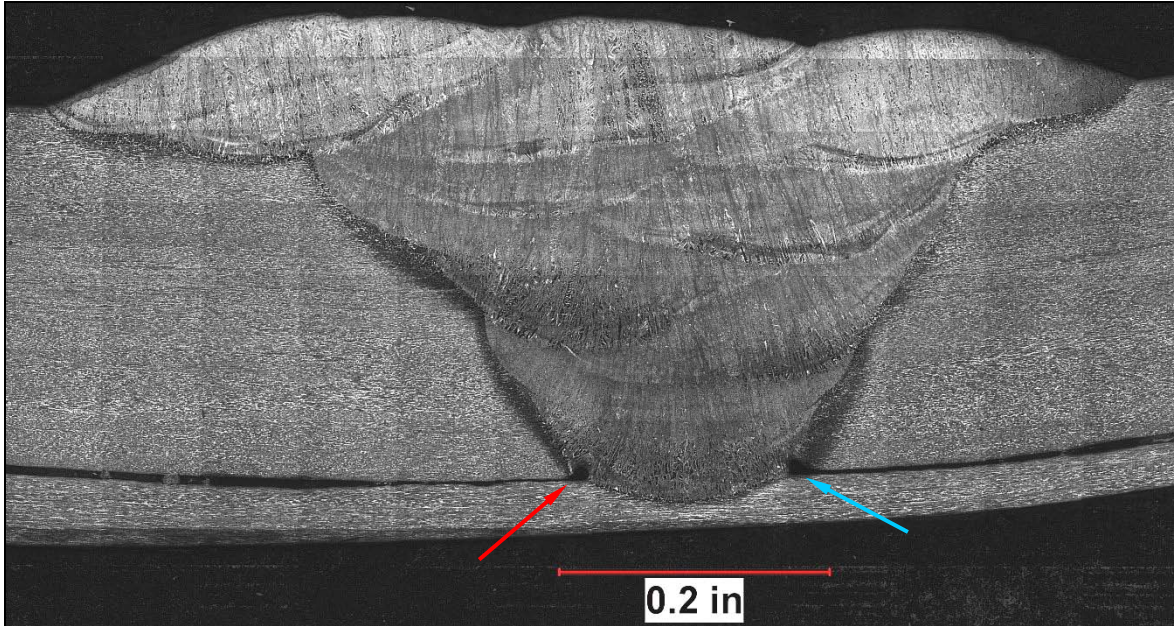


MSi Report No. [REDACTED]

**TEST RESULTS (Continued)**

**Macro-Examination**

The macro-examination revealed complete fusion between the weld and the base metal as well as between individual weld passes, however weld slag inclusions and a weld underfill condition was observed on both sides of the weld root (see Photos 8 - 10).

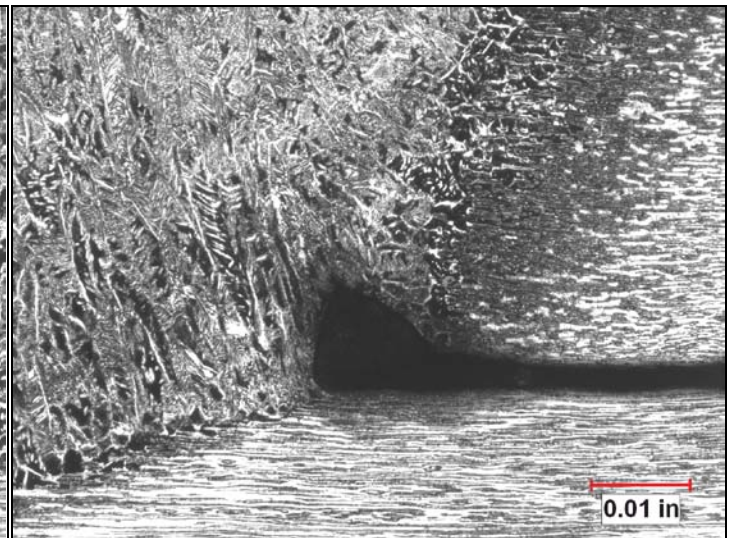


**Photo 8:** Weld profile

Etchant: Hot HCl solution



**Photo 9:** Mag: 50X; Etchant: Hot HCl solution  
Weld underfill condition (denoted with red arrow on Photo 8)



**Photo 10:** Mag: 50X; Etchant: Hot HCl solution  
Weld underfill condition (denoted with blue arrow on Photo 8)