

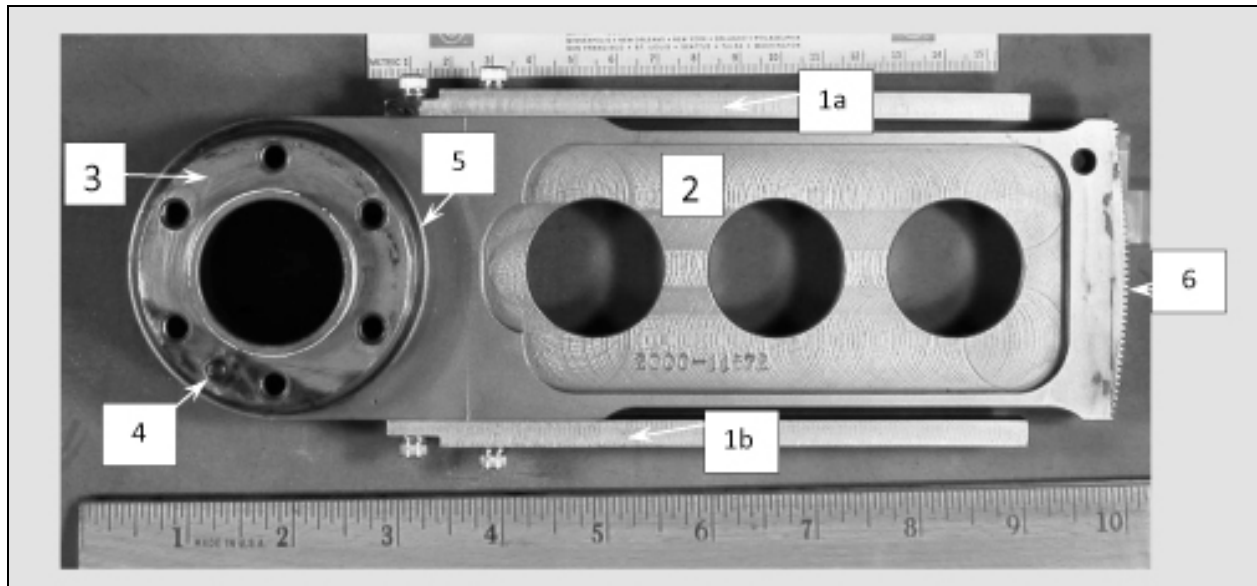
RTI Tracking Number:	1402032	Date: 2/11/2014
Core Task:	Chemical Analysis , Mechanical Testing, Metallurgical Testing	
Analytical Techniques	Chem/Mechanical/Microhardness	

**- Report of Analytical Services -**

RTI Lab#: 1402032-004A

Sample Receipt Date: 2/3/2014

**Metallographic observations:**



As-received for analysis.

Figure 1.  
Macro-image illustrates top view.

Reduced size.

To further the investigation part submitted for analysis was sectioned transversally throughout O.D surface at location #5, metallographically prepared in accordance with ASTM E3-11, and microscopically examined in the etched condition.

Metallographic examination of the etched cross-section at O.D. surface at Location #5 revealed no evidence of any type of welding present (see fig.2). The O.D. circumference portion of the part at the machined radius (top and bottom portion of the part) revealed the presence of severe overheating, which most likely occurred during aggressive CNC machining operation (see fig.3).

### **Physical tests:**

Analytical Method: ASTM E18-08B.

**Core Hardness** readings were taken in the core using Rockwell HRC with a 150 Kg load and a Brale Diamond Indenter. The samples were carefully prepared prior to the testing.

Core Hardness HRC \*measurements:

Locations	Reading # 1	Reading # 2	Reading # 3	Reading # 4	Reading # 5	Average
Location #1	47.3	47.4	46.9	47.2	47.0	<b>47</b>
Location #2	32.8	32.7	33.3	33.6	32.3	<b>33</b>
Location #3	35.4	35.6	35.6	35.6	35.4	<b>35</b>

### **Mechanical properties:**

Sample tested in accordance with the current revision of ASTM A370-11, E8/E8M-09

Designation	Mechanical properties and Results			
	Tensile Strength (ksi)	Yield Strength (0.2% offset) (ksi)	Elongation in 1.00" in. (%)	Reduction in area (%)
Location #1	221.4	220.1	8.80	42.5
Location #2	154.3	151.4	9.5	--

### **Chemical Analysis:**

Analytical methods:

ASTM E1019-11: Determination of Carbon, Sulfur, Nitrogen and Oxygen in Steel and Iron, Nickel, and Cobalt Alloys.

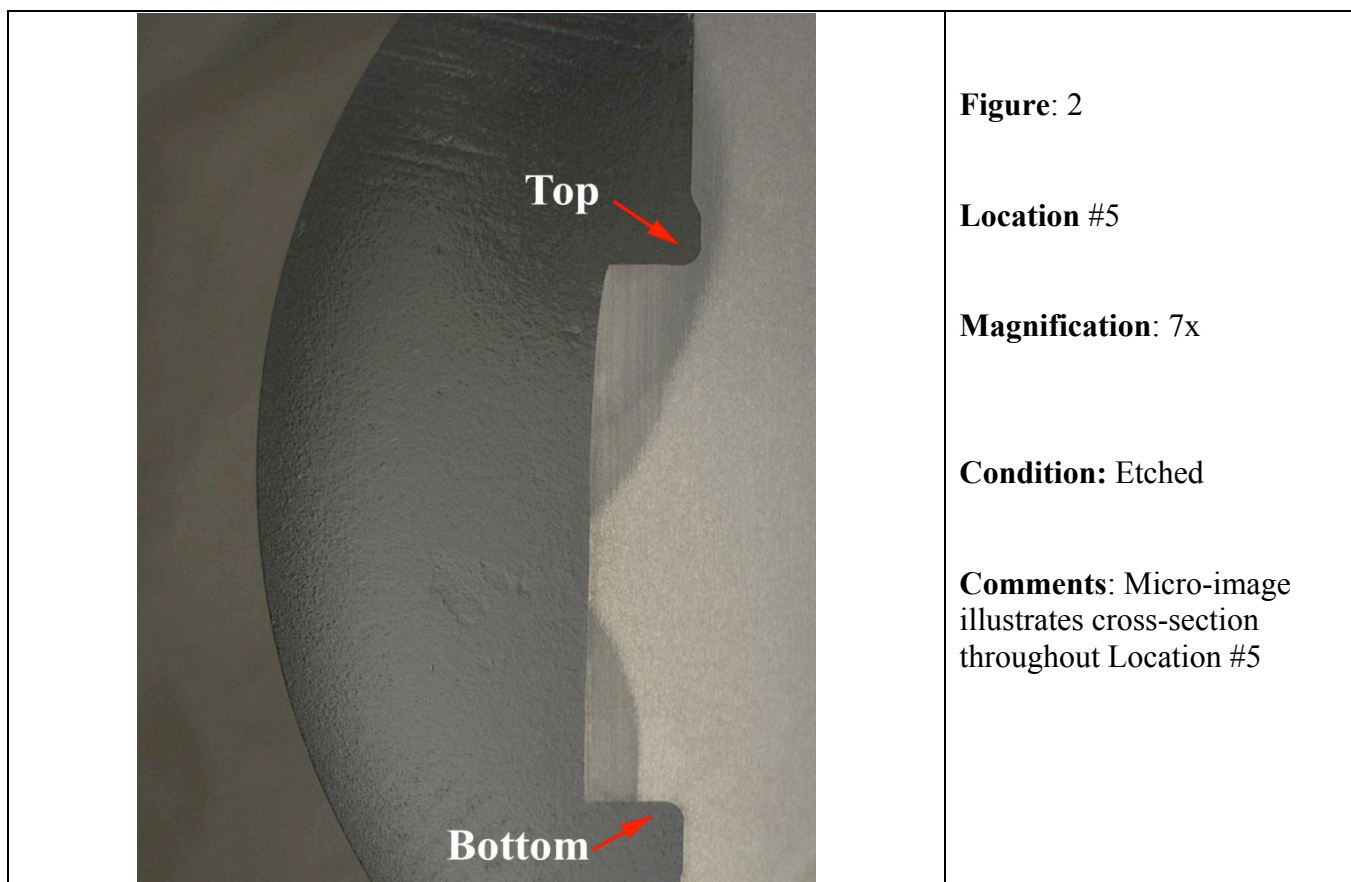
Bulk chemical analysis by Glow Discharge- Optical Emission Spectrometry (GD-OES) in accordance with LECO GDS-850A Glow Discharge Spectrometer.

Instrument Operation of Perkin-Elmer Optima 30000 Inductively Coupled Plasma-Atomic Emission Spectrometer (ICP-AES).

Designation	Elements (All units are % by wt.)												
	C	S	P	Si	Mn	Cr	Ni	Mo	V	Al	Cu	Ti	Nb
Location #1	0.03	0.022	0.018	0.56	0.54	15.2	4.43	0.12	0.070	<0.008	3.46	<0.008	0.15
Location #2	0.02	0.024	0.024	0.23	0.37	15.2	4.69	0.21	0.060	<0.005	3.58	<0.008	0.40
Location #3	0.04	0.021	0.016	0.42	0.51	15.7	4.42	0.02	0.078	0.046	3.29	0.006	0.28

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### Appendix:



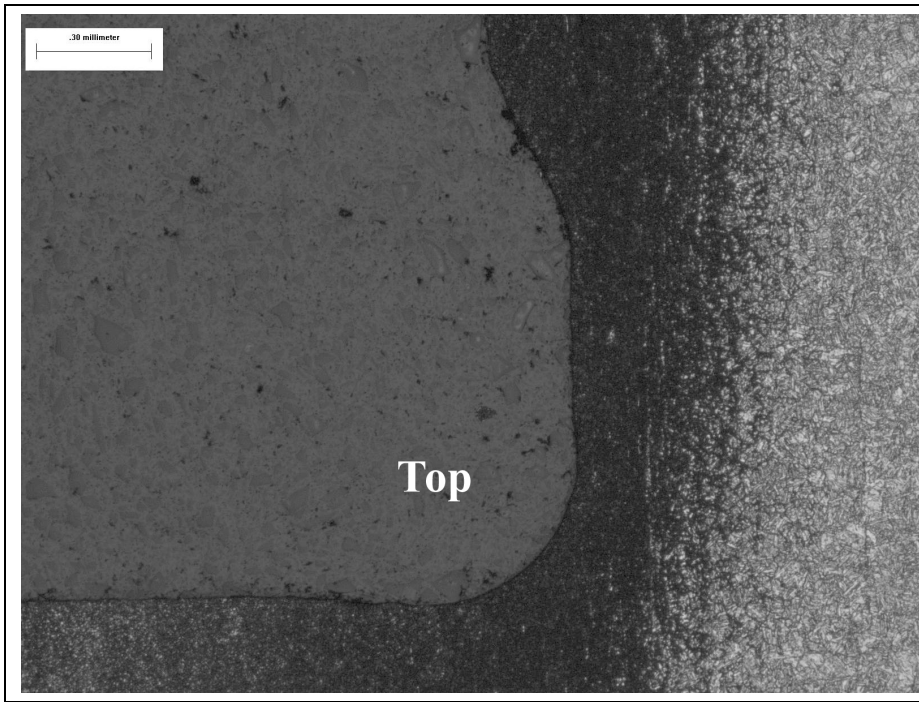
**Figure: 2**

**Location #5**

**Magnification: 7x**

**Condition: Etched**

**Comments:** Micro-image illustrates cross-section throughout Location #5



**Figure: 3**

**Location #5**

**Magnification: 50x**

**Condition: Etched**

**Comments:** Micro-image illustrates presence of the overheating at the machined radius.

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