

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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SAMPLE DESCRIPTION: A heat exchanger failed and a test protocol was developed for the failure analysis of the component. This test protocol and its addendum, as of this date and contained in Attachment 1, were developed and signed by Tesoro Companies, Division of Occupational Safety and Health and U.S. Chemical Safety Board. FirstEnergy BETA Laboratory was selected as the referee test laboratory to perform the testing requirements of the test protocol. The test protocol was not specific as to the test samples to be removed from the heat exchanger or the test locations/test parameters for each specific test within the test sample. Therefore it was agreed

“The laboratory, acting as a referee laboratory, will be supplied the locations to take the test samples and the type of test and test parameters to be performed at each location on the test sample, i.e. magnification, hardness load/test method. The signatory parties or their technical representatives that are present in the laboratory at the time shall make those decisions and give that information directly to the laboratory. Comments from other technical experts will be considered and factored into the signatory parties or their technical representative’s decisions but all decisions on protocol or samples shall remain as decisions of the signatory parties or their representatives.”

Additionally it was determined that BETA laboratory as a referee test laboratory is to report the data obtained but not give any interpretation or conclusion on any data, or on details in the photo.

On June 5, 2010 the heat exchanger arrived at Halvorsen Company's warehouse, in a June 11, 2010 meeting locations were selected for sample removal and on June 12, 2010 samples were cut by Halvorsen for submittal to BETA laboratory.

This report is the seventh of a series on the failed parts of the 6600E heat exchanger. The LS# and CS# refer to longitudinal and circumferential weld seams while the part number refers to the chain of custody number.

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Below is the list of the reports issued previously:

- | | |
|---|---|
| M10198- Receipt Inspection July 29, 2010 | M10198-LS3 Bottom Findings July 30, 2010. |
| M10198- CS4 Findings August 5, 2010 | M10198 LS2-CS3 Tee Indications Findings
Aug. 13, 2010 |
| M10198- CS4-01/LS3 Bottom August 25, 2010 | M10198- Tesoro LS1-CS2 LS2-CS3 CS4
Mechanical Tests, August 27, 2010 |

TEST PERFORMED: The tests on the LS3 Top part of the exchanger included visual examination, thickness measurements, fracture surfaces recording, magnetic particle inspection and photo-microscopy. The details of the apparatus utilized and the test procedures are given in Table 1 and Attachment 2.

TEST RESULTS: The heat exchanger weld seams had been previous labeled as shown in Figure 1 and the same labeling was used for this report.

The fracture surfaces were photographed and are shown on Figures 4 through 8. The thickness measurement results by micrometer are in Table 5. The magnetic particle test results (performed by others) are on Figures 9 through 13, the NDE Report is in Attachment 3.

This report concerns the evaluation of three mounts from Part 15 which are matching parts of the mounts from part 14 evaluated in the previous report M10198-LS3 Bottom Findings July 30, 2010. The locations for the three samples were selected by others for mounting. The mounted pieces are shown in Figure 14 with the matching parts.

The mounts were examined in the un-etched and etched conditions and photomicrographs were taken as selected by others. The photomicrographs are shown in Figures 15 through 33.

Samples of the can 3 and the ID and OD crowns of CS3, and LS3 were obtained and chemically analyzed (see Table 2). The can is the designation for the rolled plate that has been longitudinally welded to make a cylinder. The various cylinders or cans are then welded together with circumferential welds to make the heat exchanger shell.

Rockwell hardness testing was performed at approximately the mid wall on transverse section for can 3 plate material and the results are reported in Table 3. Additionally micro-hardness measurements in the 500gm Vickers scale were performed, as directed, on some of the mounts. The locations and the summary results are in Table 4.

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TABLE 1
TESTS PERFORMED

(See Attachment 2 for Test/Equipment Specifications)

TEST	METHOD OR INSTRUMENT	PERFORMED BY	LOCATION, DATE	RESULTS LOCATION
VISUAL EXAMINATION	LECO SZH STEREO MACROSCOPE OR PORTRAIT CAMERA	M. BRIDAVSKY & J. BLOUGH	BETA, VARIOUS	TEST RESULTS
OPTICAL METALLOGRAPHY	LECO PMG-3 OPTICAL MICROSCOPE	M. BRIDAVSKY & J. BLOUGH	BETA, VARIOUS	FIGURES 14 - 32
WET MAGNETIC PARTICLE TESTING	WET FLUORESCENT AC YOKE	TEAM INDUSTRIAL SERVICE ,MICHAEL BUCKLEY	BETA, 6-15-2010	ATTACHMENT 3 FIGURES 9-13
WALL THICKNESS	MICROMETER	M. TASCAR	BETA, 6/15 & 7/26/10	TABLE 5
FRACTURE SURFACES RECORDING	PHOTO CAMERA	M. BRIDAVSKY & J. BLOUGH	BETA, VARIOUS	FIGURES 4-8

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TABLE 2
CHEMICAL ANALYSIS FOR BASE METAL AND WELD DEPOSITS
(THE DATA ARE FROM PREVIOUS REPORT M10198-LS3 BOTTOM FINDINGS JULY 30, 2010)

SAMPLE IDENTIFICATION	CHEMICAL COMPOSITION, WT. %											
	C	SI	P	S	MN	NI	CR	MO	V	CU	CO	AL
CAN 3	0.26	0.23	0.008	0.021	0.60	0.12	0.13	0.02	<0.001	0.18	0.01	0.01
SA- 515 GRADE 70	0.31 MAX	0.13- 0.45	0.035 MAX	0.035 MAX	1.30 MAX	NS	NS	NS	NS	NS	NS	NS
CS3 OD CROWN	0.08	0.57	0.011	0.018	1.14	0.05	0.08	0.01	0.002	0.15	0.01	0.005
CS3 ID WELD SURFACE	0.09	0.64	0.017	0.022	1.31	0.05	0.09	0.01	0.002	0.24	0.01	0.005
LS3 OD CROWN	0.10	0.50	0.011	0.019	1.12	0.06	0.08	0.01	0.001	0.14	0.01	0.005
LS3 ID WELD SURFACE	0.16	0.37	0.010	0.021	1.04	0.08	0.09	0.02	0.001	0.14	0.01	0.005
SFA 5.1 (E7016, E7018)*	NS	0.75 MAX	NS	NS	1.60 MAX	0.30 MAX	0.20 MAX	0.30 MAX	0.08 MAX	NS	NS	NS
SFA 5.17 (EM11K)	0.07- 0.15	0.65- 0.85	0.030 MAX	0.025 MAX	1.00- 1.50	NS	NS	NS	NS	0.35	NS	NS
SFA 5.17 (EL12)	0.04- 0.14	0.10 MAX	0.030 MAX	0.030 MAX	0.25- 0.60	NS	NS	NS	NS	0.35	NS	NS
SFA 5.17 (EM12K)	0.05- 0.15	0.10- 0.35	0.030 MAX	0.030 MAX	0.80- 1.25	NS	NS	NS	NS	0.35	NS	NS

NS = NOT SPECIFIED

ALL ANALYSIS IS OPTICAL EMISSION SPECTROSCOPY EXCEPT THE CARBON WHICH IS LECO

NO ALLOYS OR WELD WIRE GRADES WERE SPECIFIED SO TYPICAL ARE PRESENTED

* TOTAL OF MN+NI+CR+MO+V 1.75 MAX

SA-515 SPECIFICATION FOR PRESSURE VESSEL PLATES, CARBON STEEL, FOR INTERMEDIATE-AND HIGHER-TEMPERATURE SERVICE – JULY 2003 ADDENDUM

SFA 5.1 SPECIFICATION FOR CARBON STEEL ELECTRODES FOR SHIELD METAL ARC WELDING-JULY 2003 ADDENDUM

SFA 5.17 SPECIFICATION FOR CARBON STEEL ELECTRODES AND FLUXES FOR SUBMERGED ARC WELDING- JULY 2003 ADDENDUM

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TABLE 3
ROCKWELL (HRB) HARDNESS MEASUREMENTS
ON PLATE CROSS SECTIONS

(THE DATA ARE FROM PREVIOUS REPORT M10198-LS3 BOTTOM FINDINGS JULY 30, 2010)

SAMPLE IDENTIFICATION	HARDNESS			
	MINIMUM	MAXIMUM	AVERAGE	NUMBER OF INDENTATIONS
CAN 3	82.5	83.7	83.1	7

TABLE 4
SUMMARY OF MICRO-HARDNESS MEASUREMENTS
VICKERS 500Gm

(THE DATA ARE FROM PREVIOUS REPORT M10198-LS3 BOTTOM FINDINGS JULY 30, 2010)

TEST OBJECT	14 M3 LS3	14 M4 LS3	14 TO LS3
Base Metal 3	182-215	181-193	129-149
HAZ 3	203-245	181-204	
Weld Metal	178-255		134-147

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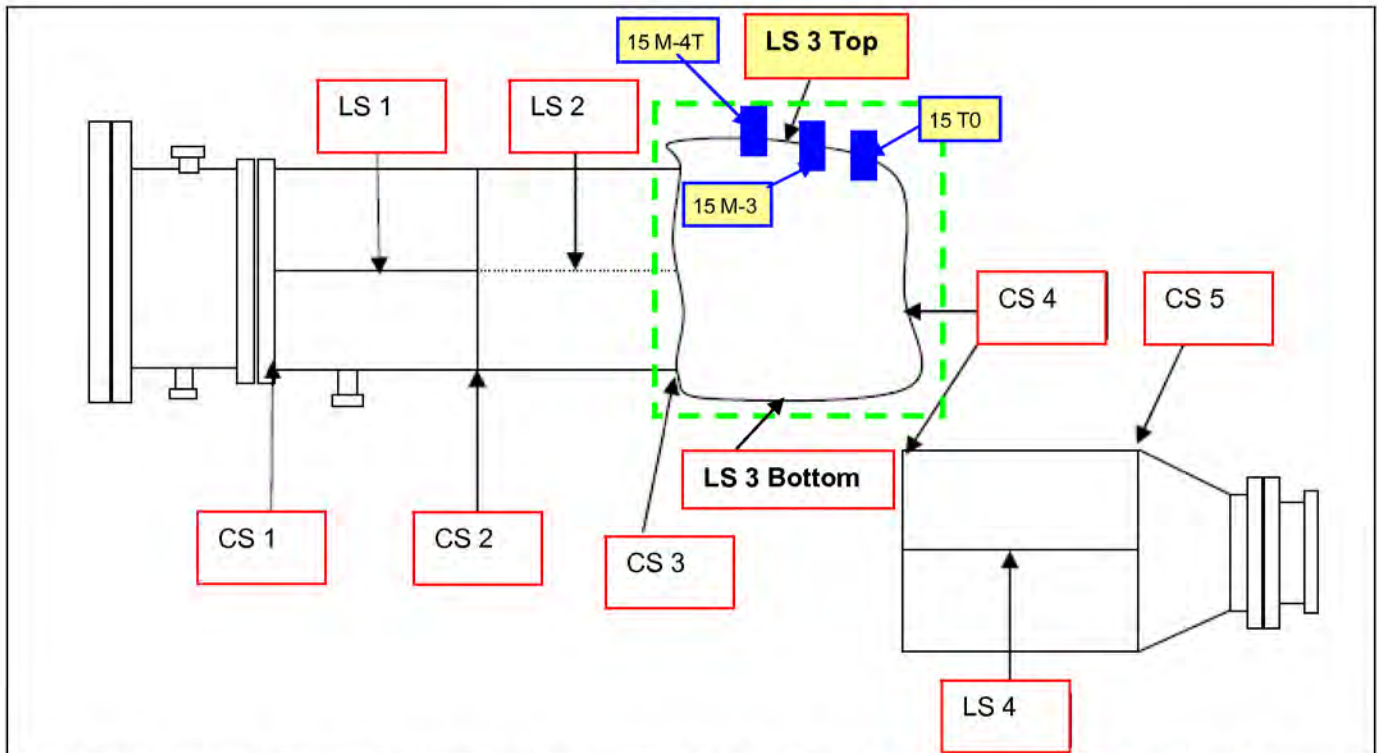
TABLE 5. WALL THICKNESS MEASUREMENTS

WALL THICKNESSES ALONG THE LS-3		WALL THICKNESSES ALONG THE CS-3		WALL THICKNESSES ALONG THE CS-4	
LOCATION OF THE READING, INCHES ALONG LS-3	MICROMETER READINGS, IN 2" FROM FRACTURE	LOCATION OF THE READING, IN ALONG THE FRACTURE	MICROMETER READINGS, IN 2" FROM FRACTURE	LOCATION OF THE READING, IN ALONG THE FRACTURE	MICROMETER READINGS, IN 2" FROM FRACTURE
0 (at CS-3)	0.938*	0 (at the C-3)	Not measured	0 (at CS-4)	Not measured
2	0.854	2	0.830	2	0.851
4	0.864	4	0.831	4	0.852
6	0.861	6	0.830	6	0.846
8	0.861				
10	0.875				
12	0.857				
14	0.858				
16	0.854				
18	0.859				
20	0.856				
22	0.857				
24	0.862				
26	0.865				
28	0.865				
30	0.873				
32	0.870				
34	0.872				
36	0.866				
38	0.864				
40	0.866				
42	0.866				
44	0.871				
46	0.869				
48	0.884				
50	0.879				
52	0.870				
54	0.875				
56	0.879				
58	0.870				
60	0.862				
62	0.859				
64	0.856				
66	0.856				
68	0.852				
70	0.849				
72	0.854				
74	0.851				
76	0.852				
78	0.854				
80	0.857				
82	0.854				
84 (at CS-4)	0.852				

*Reading on weld

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Sketch of main heat exchanger Cans 1-3 and separated back head can 4. The approximate locations of the samples evaluated in this report are shown in blue.

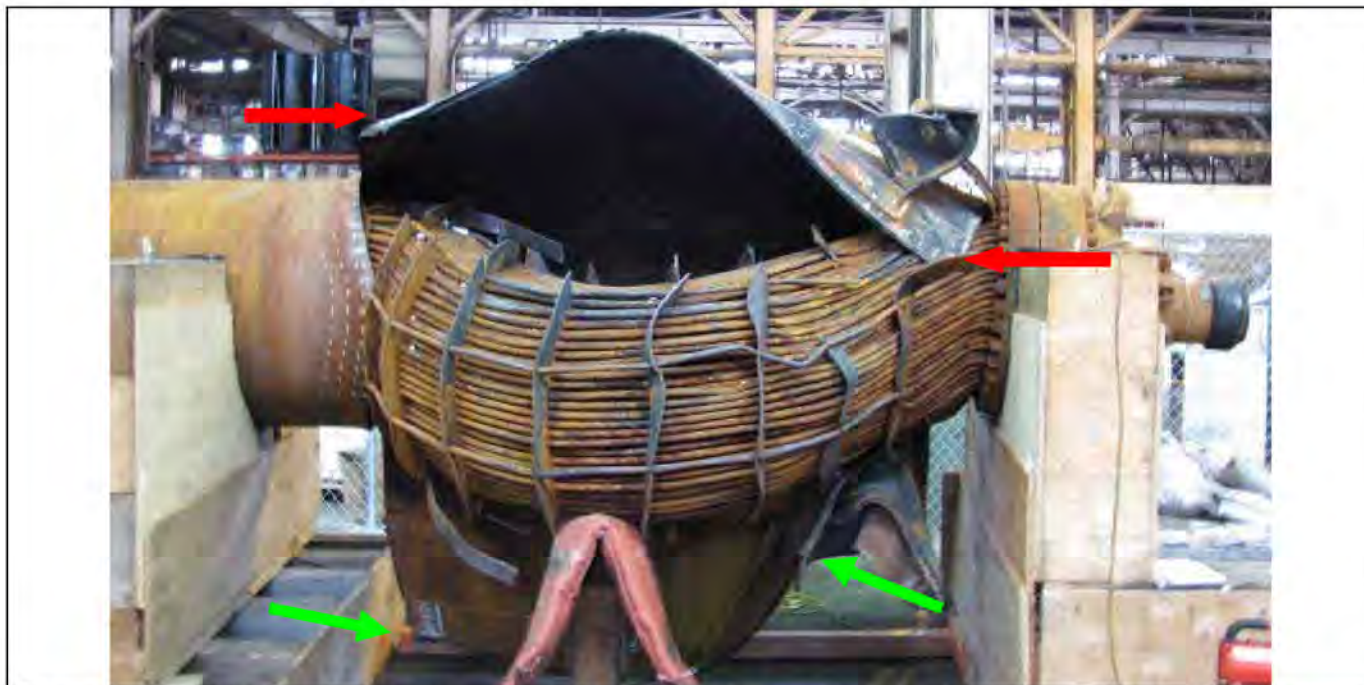


Overall main heat exchanger with "fish mouth " rupture primarily along LS3 and CS4 as shown by green box above

Figure 1 Un-packed main heat exchanger

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Fracture along LS3 seam between the green arrows for the bottom part of the fracture, and for the LS3 top – between the red arrows

Figure 2 Photo showing the fracture along LS3 where an approximate 6 inch wide portion was removed

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Figure 3. Part 15 with LS-3 and parts of CS-3 (left end) and CS-4 (right end).



Location V1



Location V2

Figure 4. Fracture surfaces along the CS4 weld. ID is on the right.

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Location H1



Location H2



Location H3



Location H4



Location H5



Location H6-cut is where the mate 14 M3 LS3 mount was removed



Location H7



Location H8

Figure 5. Fracture surfaces along the LS3 weld. ID is on the bottom, where the measure tape is located.

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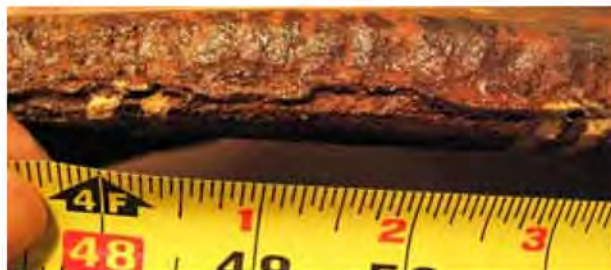
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Location H9



Location H10



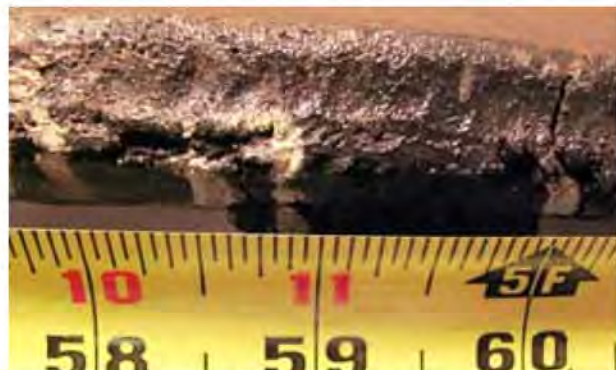
Location H11



Location H12



Location H13



Location H14



Location H15



Location H16

Figure 6. Fracture surfaces along the LS3 weld. ID is on the bottom, where the measure tape is located.

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Location H17



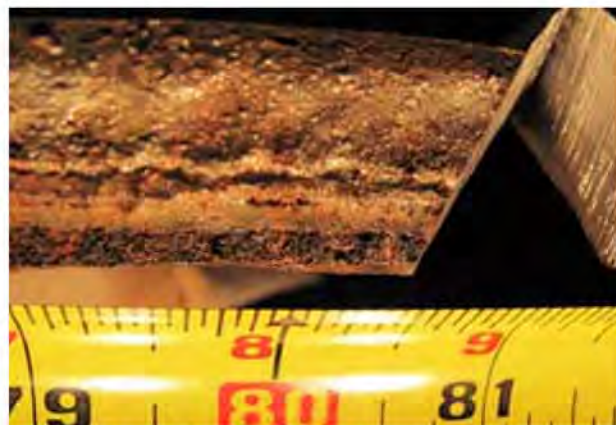
Location H18



Location H19



Location H20



Location H21-cut is where the mate 14 M3 TO mount was removed



Location H22

Figure 7. Fracture surfaces along the LS3 weld. ID is on the bottom, where the measure tape is located.

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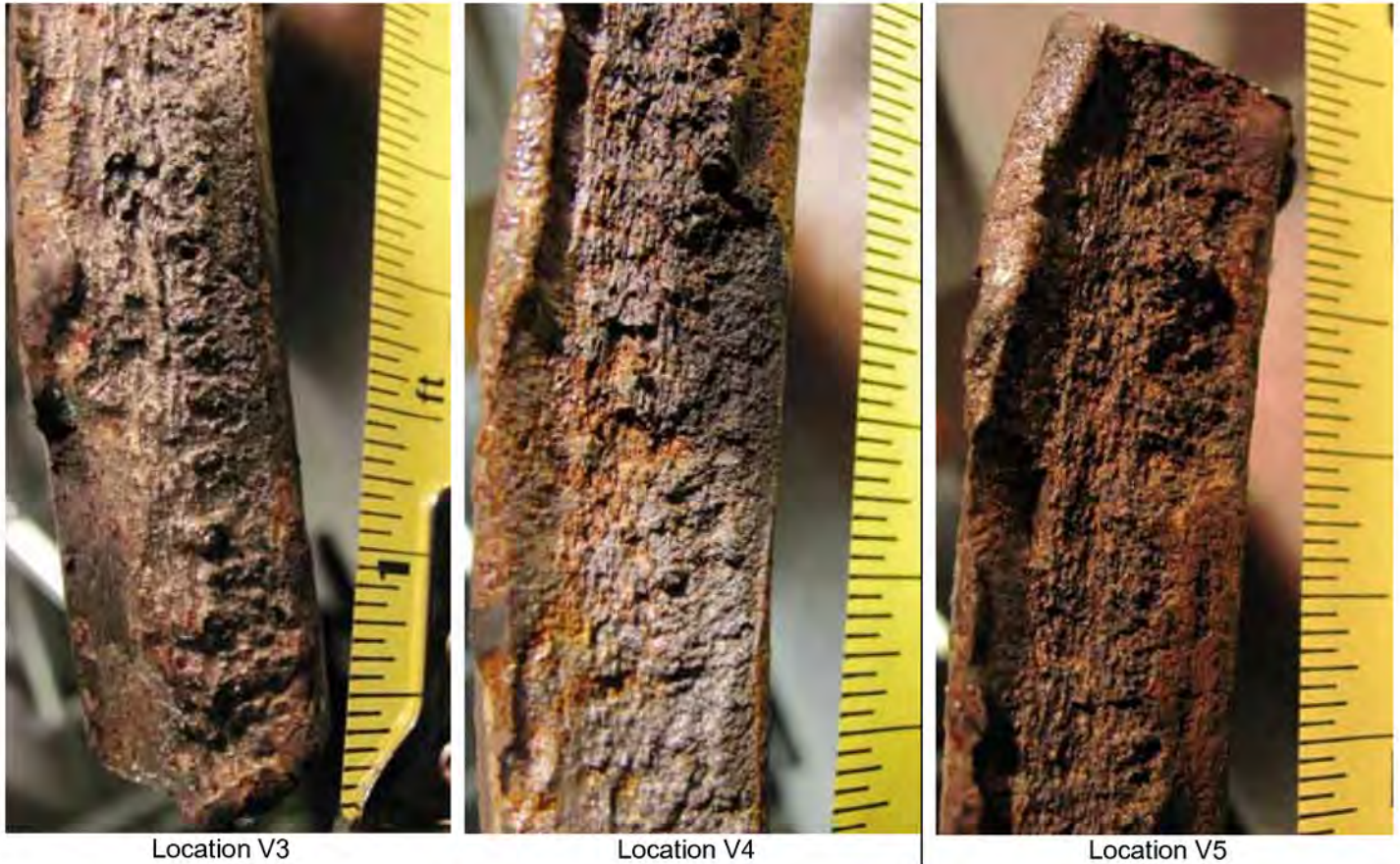


Figure 8. Fracture surfaces along the CS4 weld. ID is on the right, where the measure tape is located.

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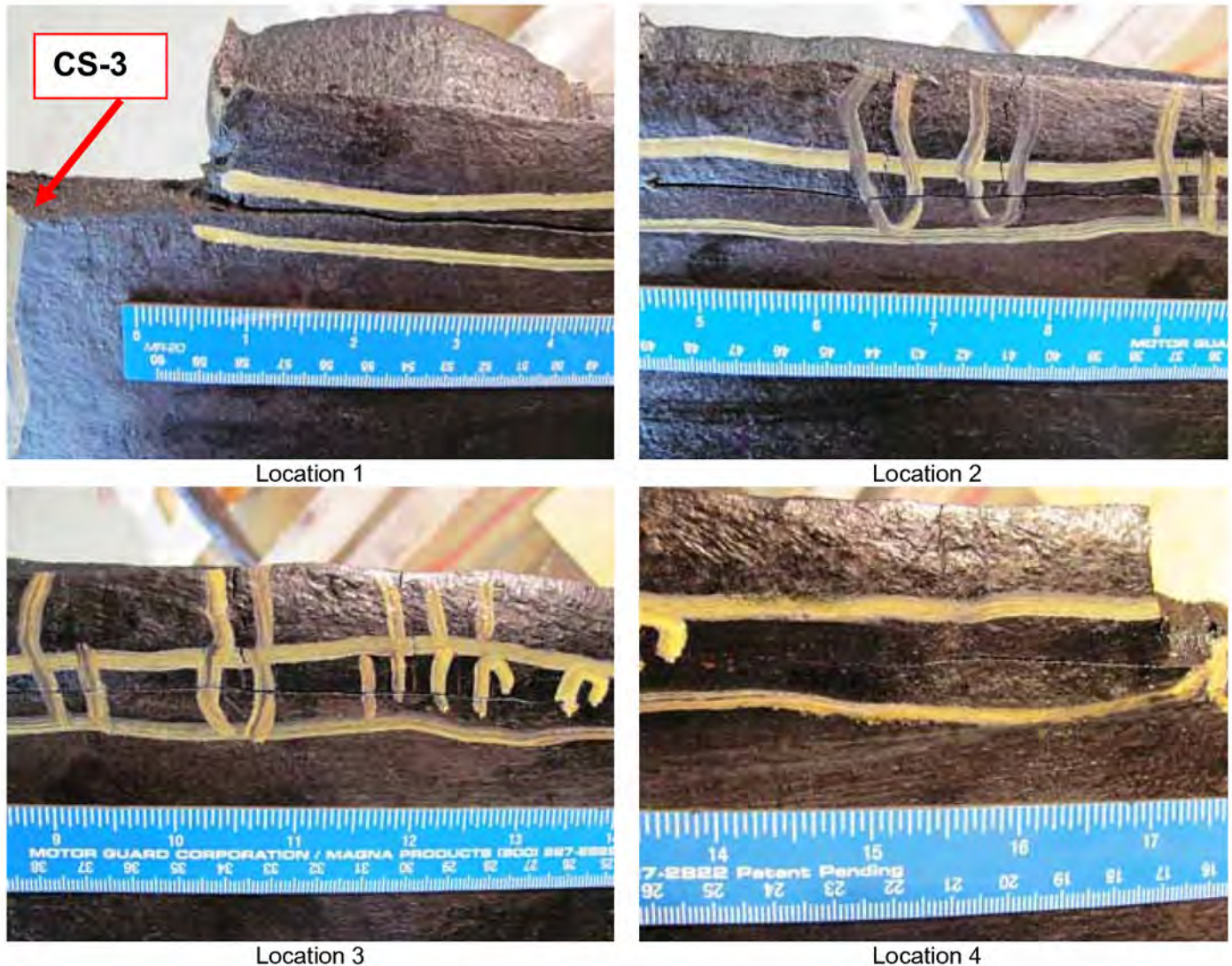


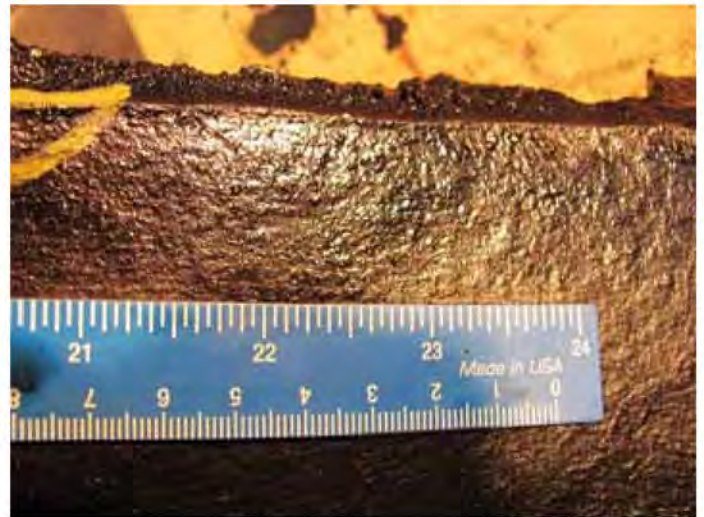
Figure 9. Magnetic Particle Inspection. Indications circled (fracture on top and looking at ID surface)

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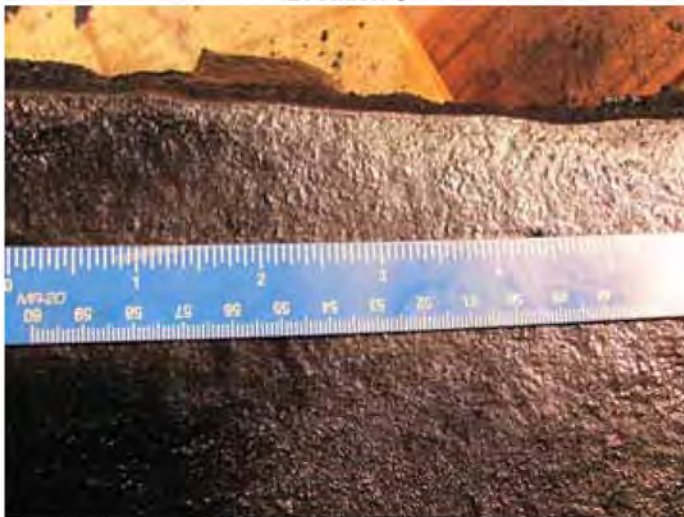
LABORATORY REPORT-LS3 TOP



Location 5



Location 6



Location 7



Location 8

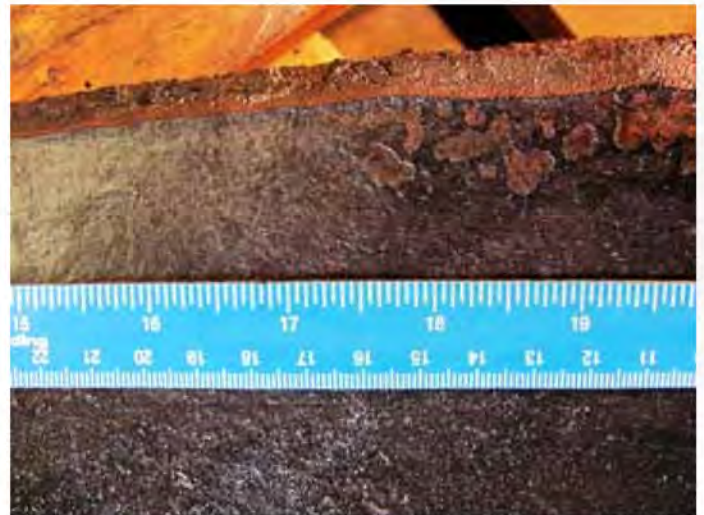
Figure 10. Magnetic Particle inspection. Indications circled (fracture on top and looking at ID surface)

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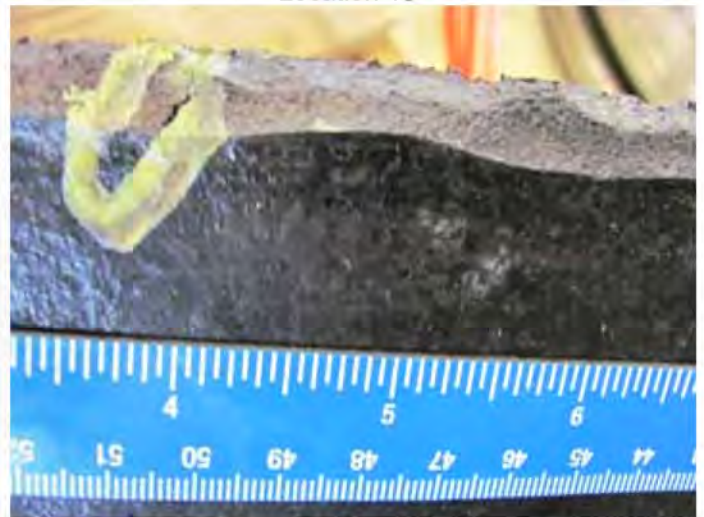
Location 9



Location 10



Location 11



Location 12

Figure 11. Magnetic Particle inspection. Indications circled (fracture on top and looking at ID surface)

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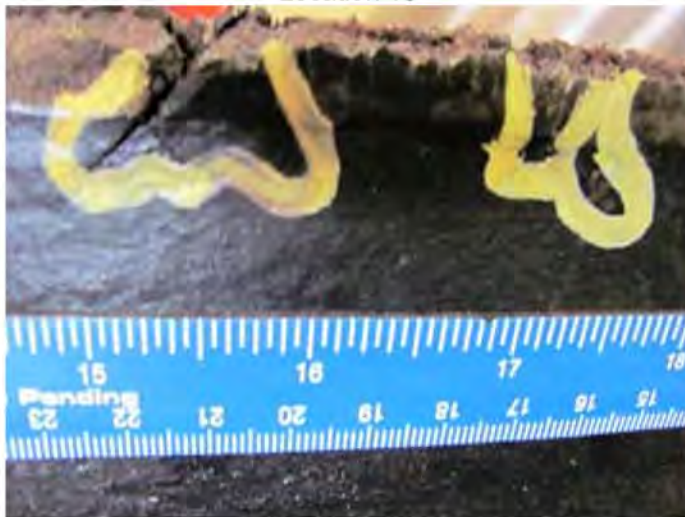
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Location 13



Location 14



Location 15



Location 16

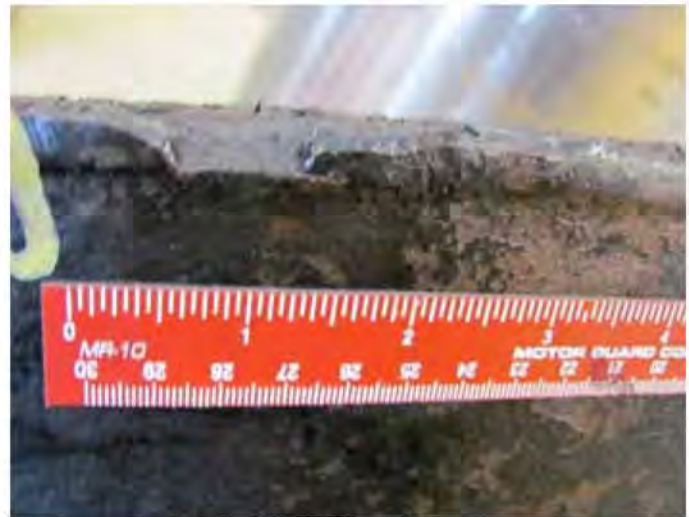
Figure 12. Magnetic Particle inspection. Indications circled (fracture on top and looking at ID surface)

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Location 17



Location 18



Location 19

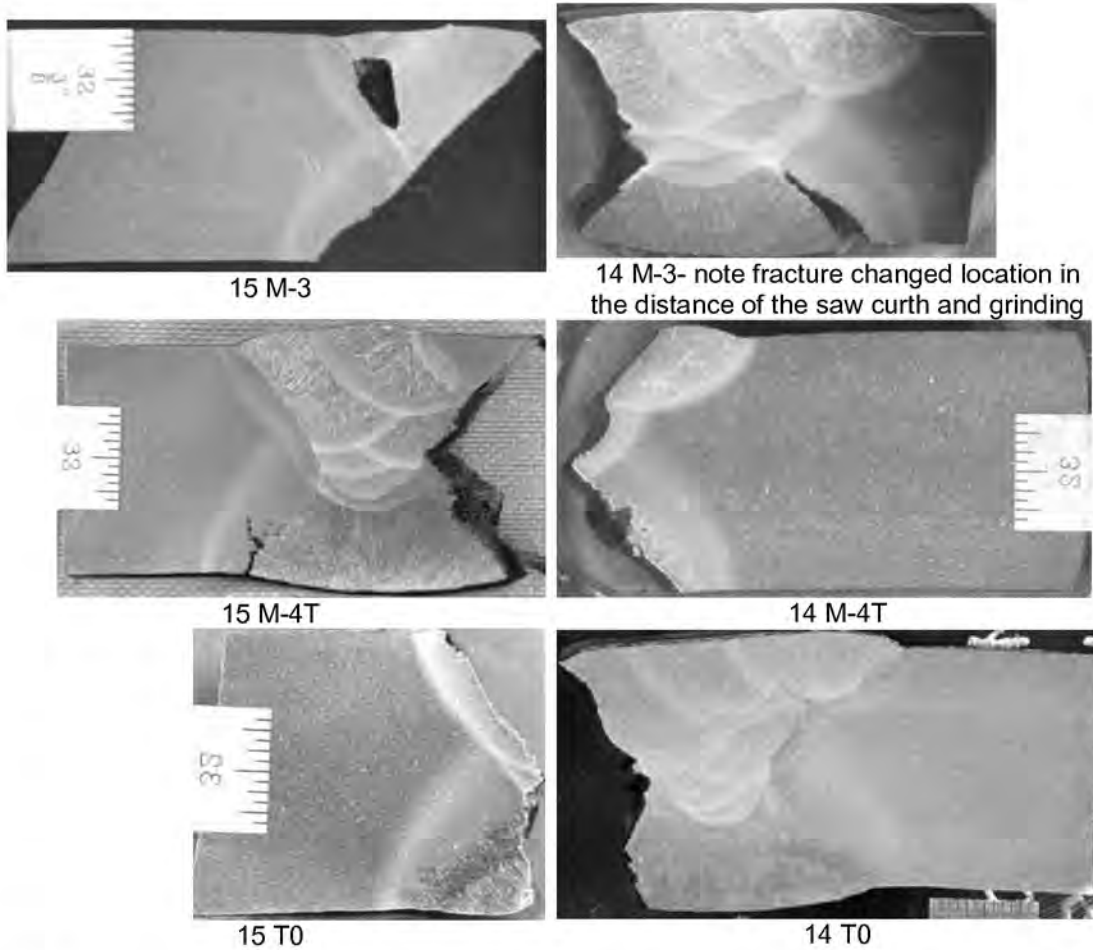
CS-4

Figure 13. Magnetic Particle inspection. Indications circled (fracture on top and looking at ID surface)

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MACROS OF THE MOUNTS ANALYSED IN THIS REPORT



MACROS OF THE MOUNTS ANALYZED AND REPORTED IN M10198-LS3 BOTTOM FINDINGS JULY 30, 2010

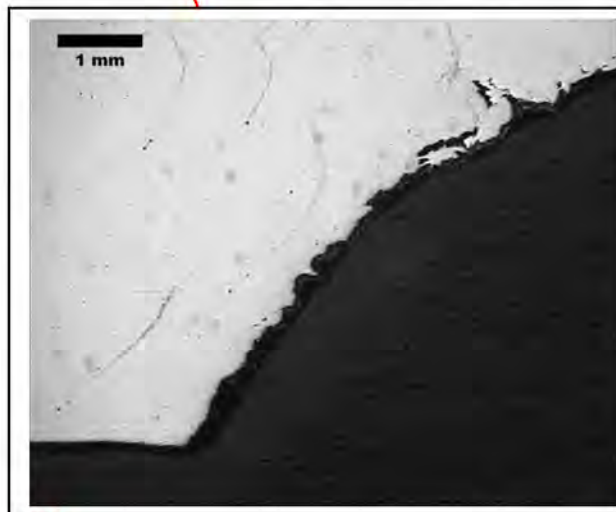
Figure 14. Macro photographs of the samples evaluated in this report with matching samples. In these photographs O.D. is on the top.

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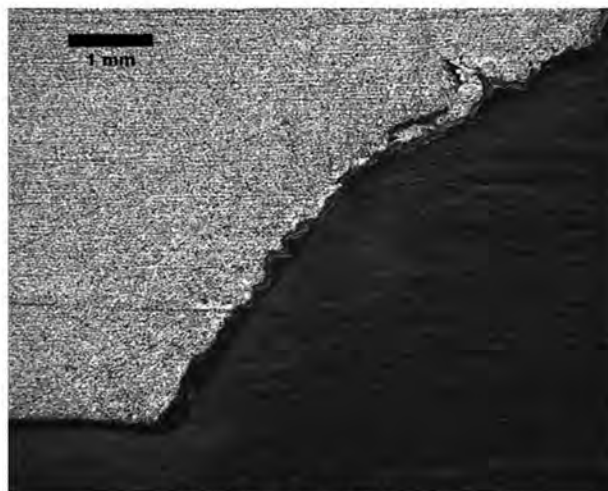
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MOUNT 15 M-3

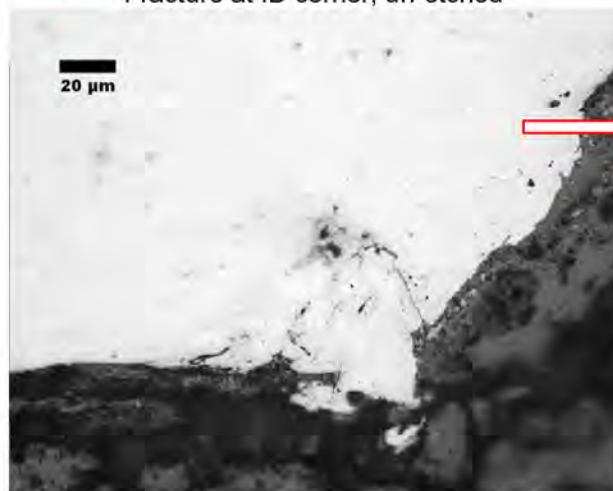
ID IS ON THE BOTTOM



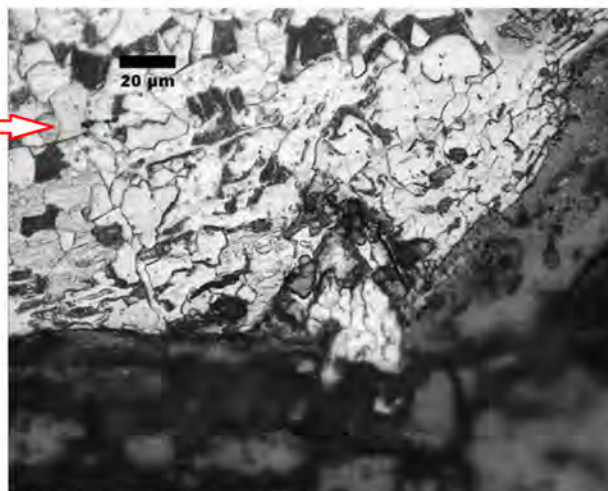
Fracture at ID corner, un-etched



Same as at left, etched



Same as above at higher magnification



Same as at left, etched

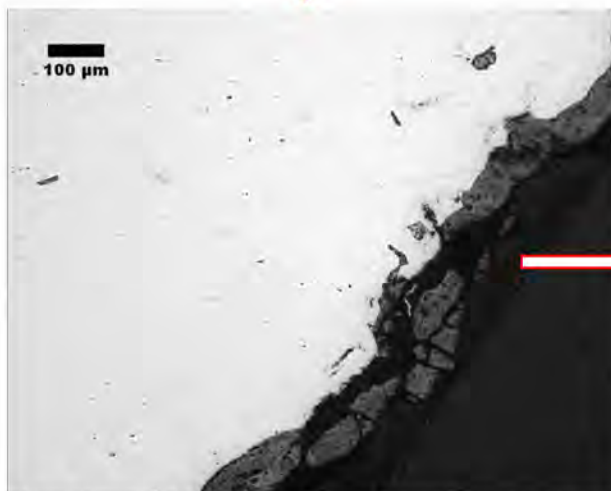
Figure 15

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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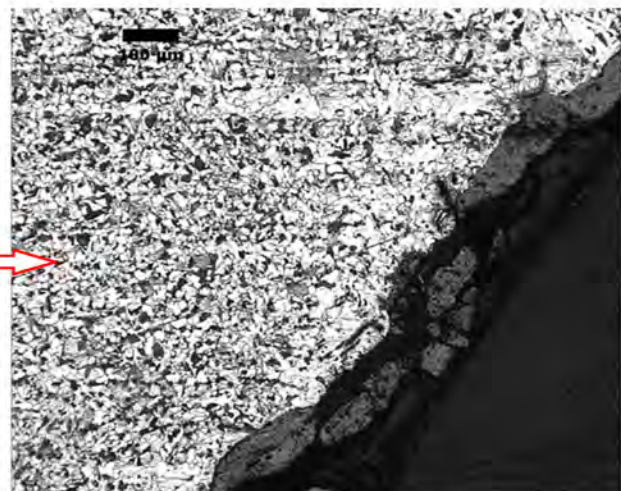
LABORATORY REPORT-LS3 TOP



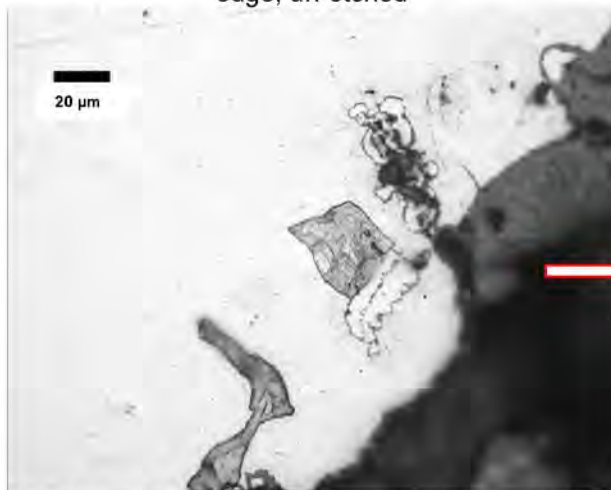
MOUNT 15 M-3
ID IS ON THE BOTTOM



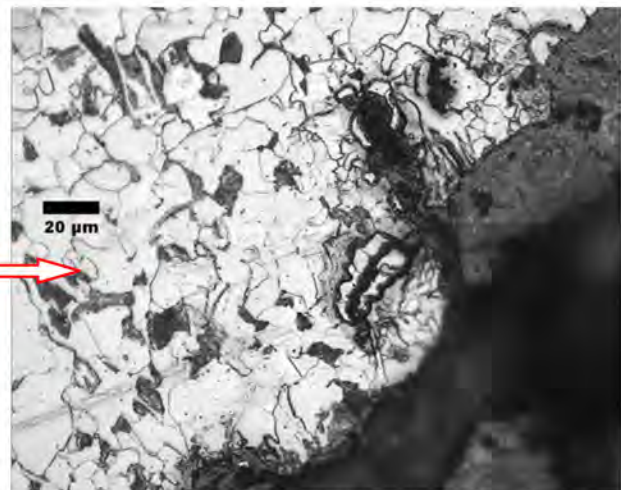
One field up from the ID corner along the fracture edge, un-etched



Same as at left, etched



Same as above at higher magnification, un-etched

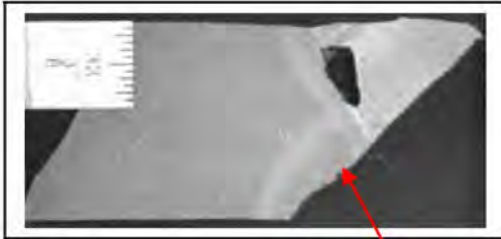


Same as at left, etched

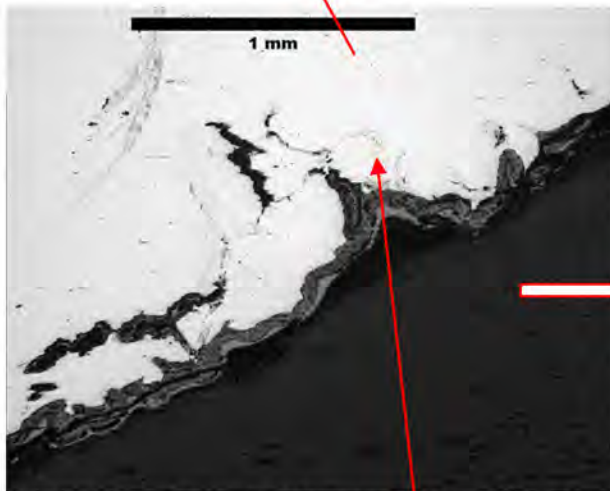
Figure 16

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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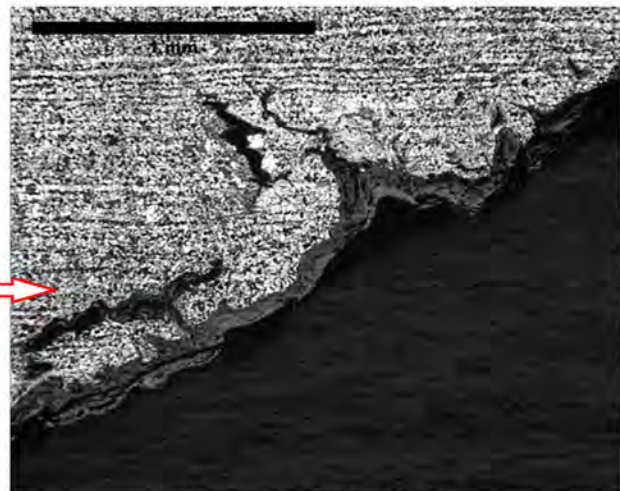
LABORATORY REPORT-LS3 TOP



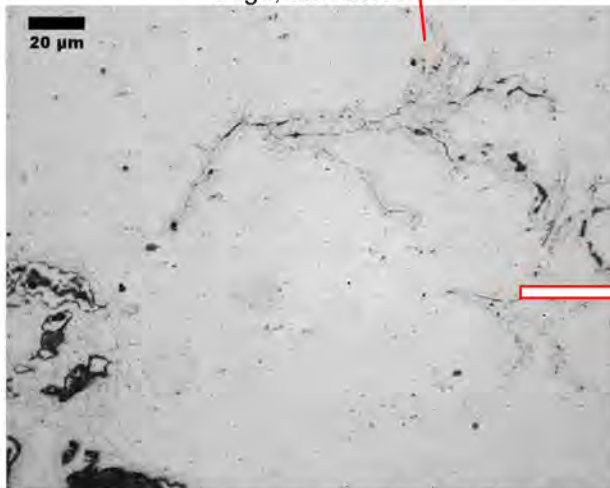
MOUNT 15 M-3
ID IS ON THE BOTTOM



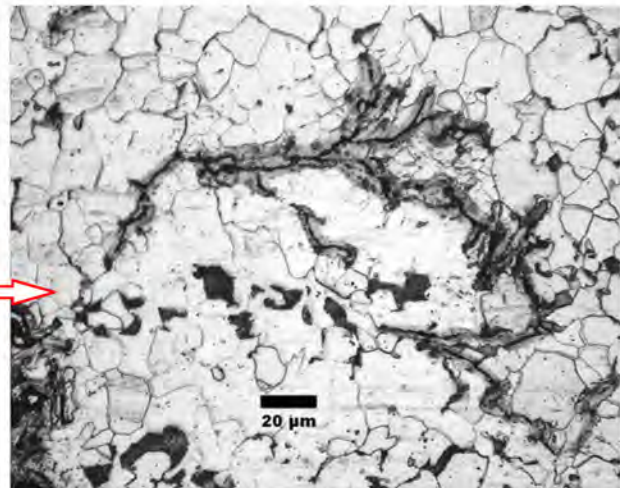
Two fields up from the ID corner along the fracture edge, un-etched



Same as at left, etched



Same as above at higher magnification, un-etched



Same as at left, etched

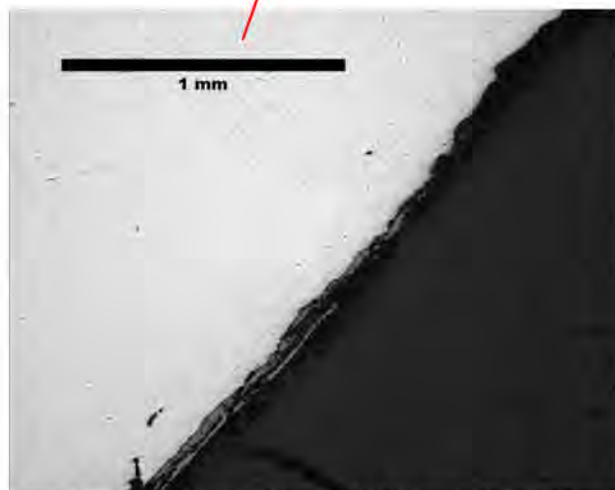
Figure 17

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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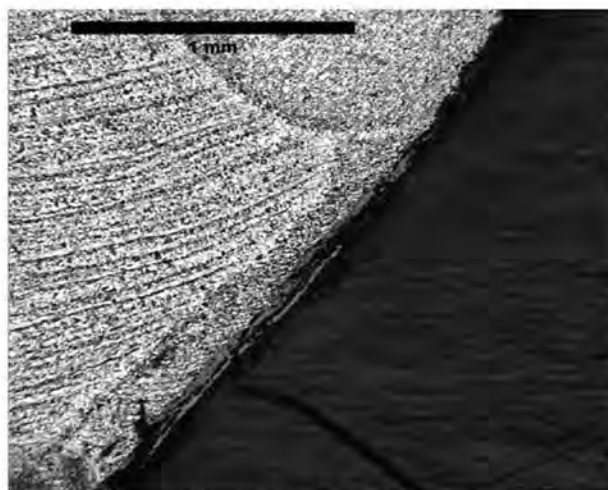
LABORATORY REPORT-LS3 TOP



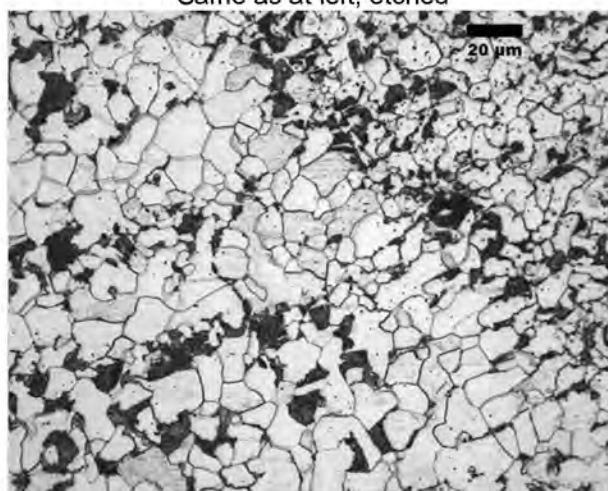
MOUNT 15 M-3
ID IS ON THE BOTTOM



Area at HAZ and Weld Metal, un-etched



Same as at left, etched

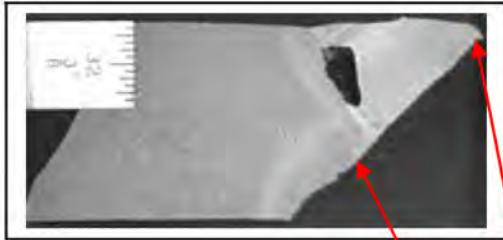


Area at HAZ-WM from the photo above at higher magnification, etched

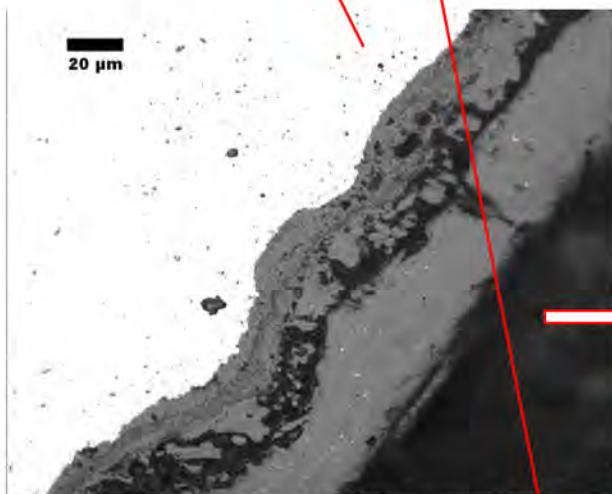
Figure 18

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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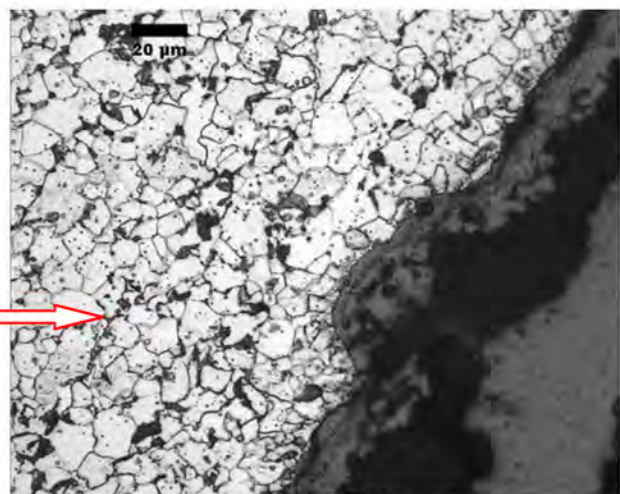
LABORATORY REPORT-LS3 TOP



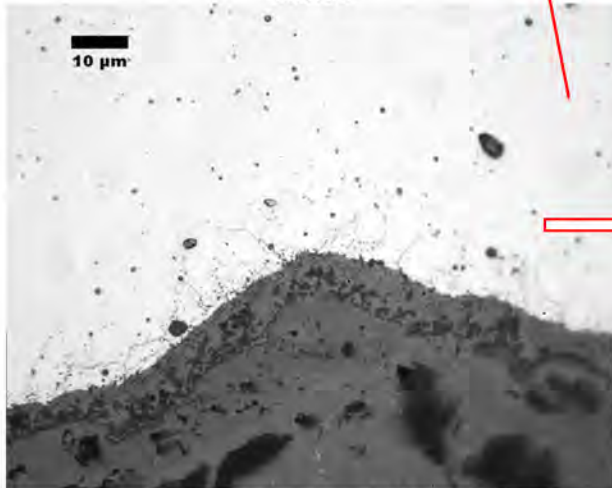
MOUNT 15 M-3
ID IS ON THE BOTTOM



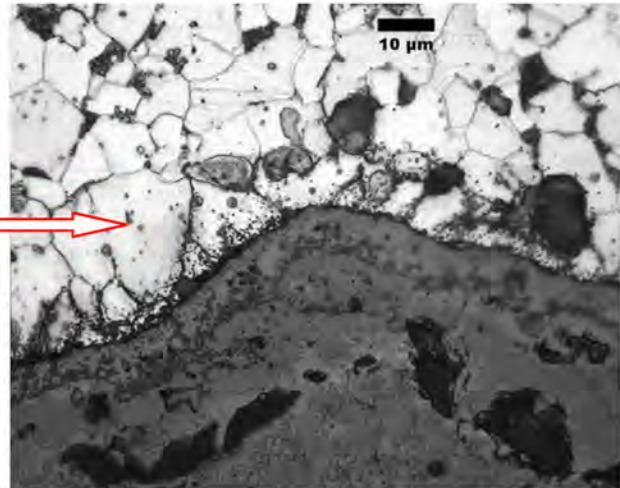
Approximately mid-wall along the fracture edge, un-etched



Same as at left, etched



Area at fracture edge near OD, un-etched



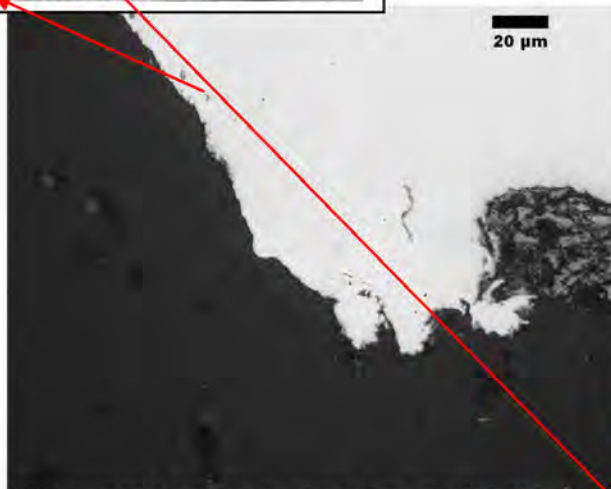
Same as at left, etched

Figure 19

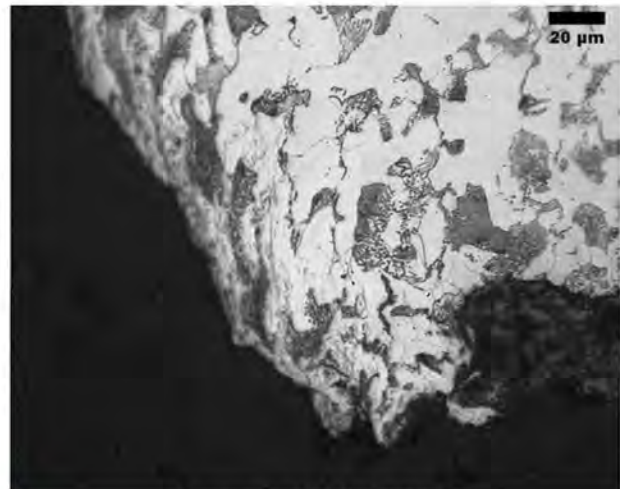
BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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LABORATORY REPORT-LS3 TOP

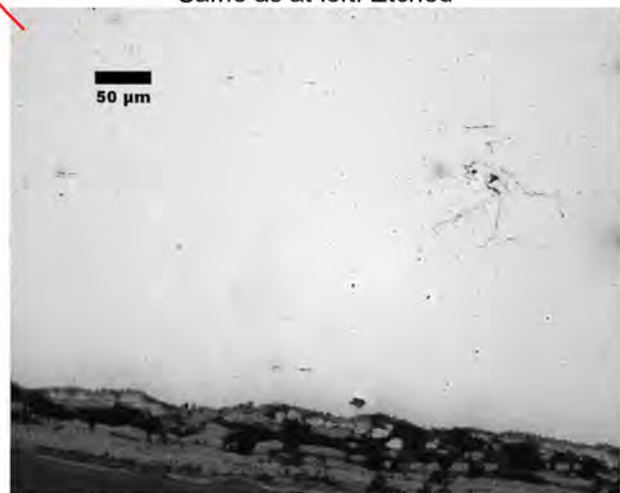
MOUNT 15 M-4T
ID IS ON THE BOTTOM



Base Metal at ID corner at the cut. Un-etched



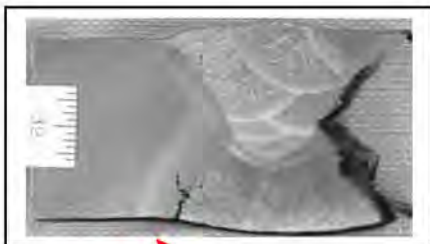
Same as at left. Etched



Area approximately 3 mm from the crack

UPPER ARROW OFF
Figure 20

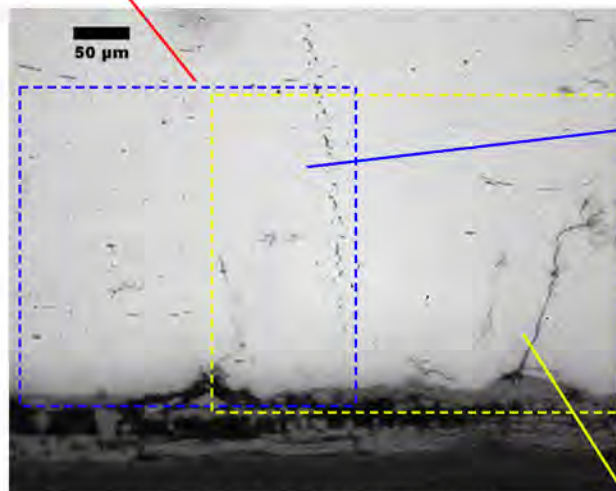
BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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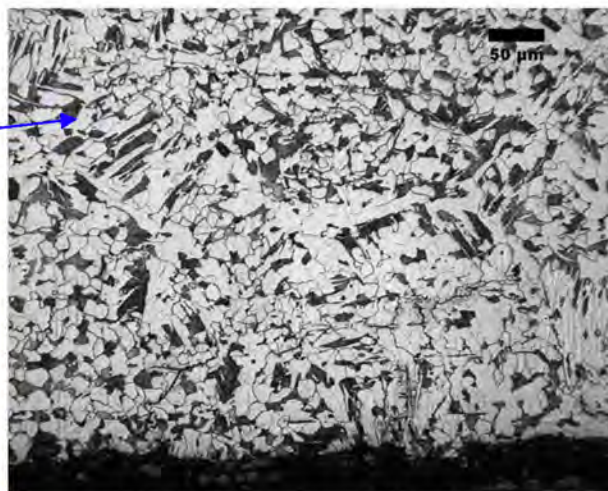
LABORATORY REPORT-LS3 TOP

MOUNT 15 M-4T

ID IS ON THE BOTTOM



Area near the crack, un-etched



Area from the micro at left, etched



Area from the micro at left, etched

Figure 21

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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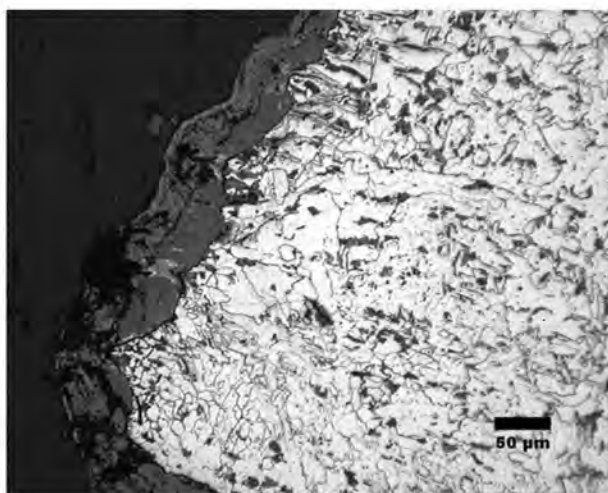


LABORATORY REPORT-LS3 TOP

MOUNT 15 M-4T
ID IS ON THE BOTTOM



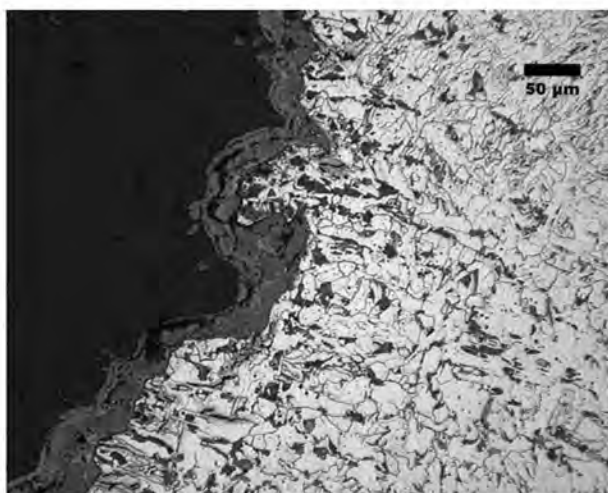
Wed toe at the weld metal side of the crack, un-etched



Same as at left, etched



One field up along the crack edge, un-etched



Same as at left, etched

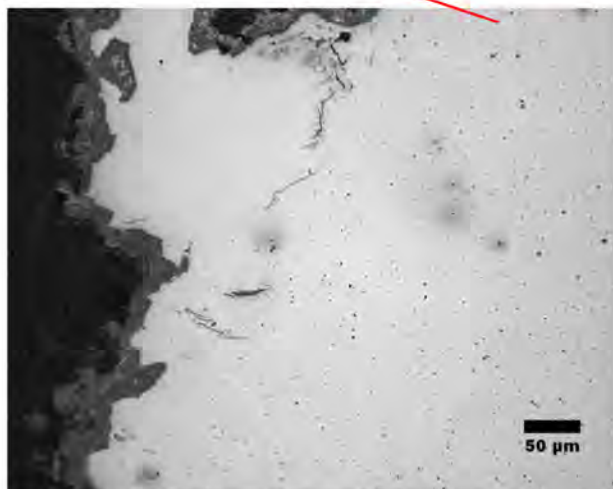
Figure 22

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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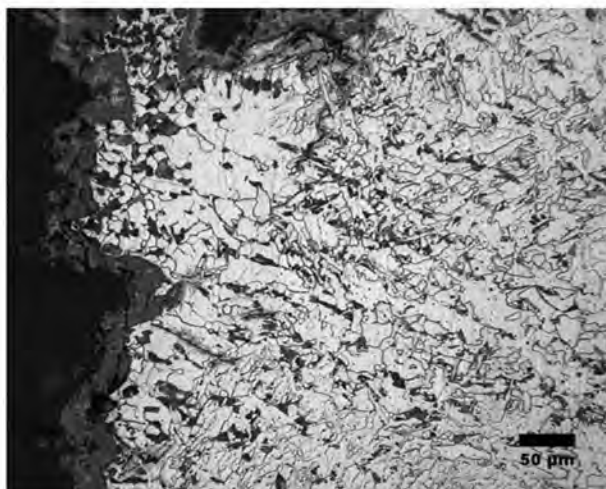


LABORATORY REPORT-LS3 TOP

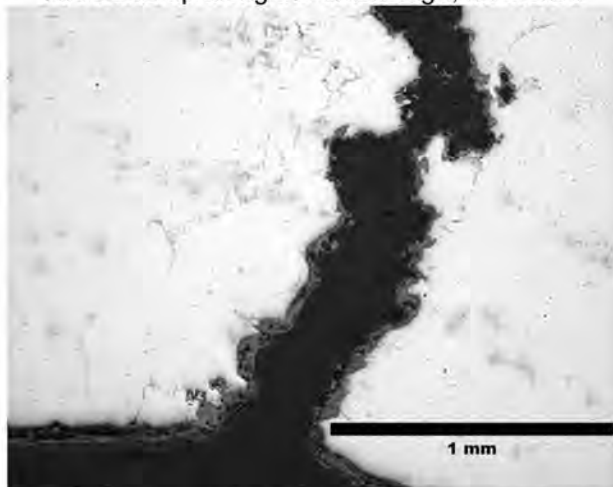
MOUNT 15 M-4T
ID IS ON THE BOTTOM



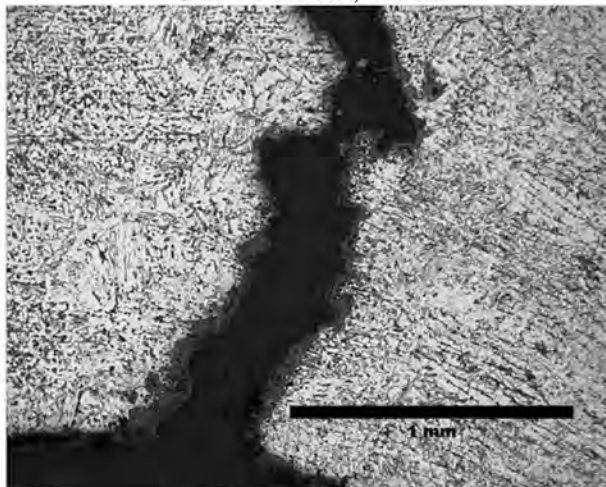
Two fields up along the crack edge, un-etched



Same as at left, etched



Both sides of the crack at ID. Un-etched



Same as at left, etched

Figure 23

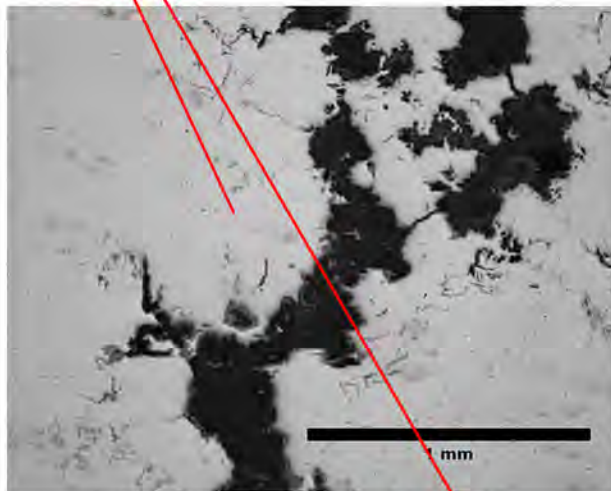
BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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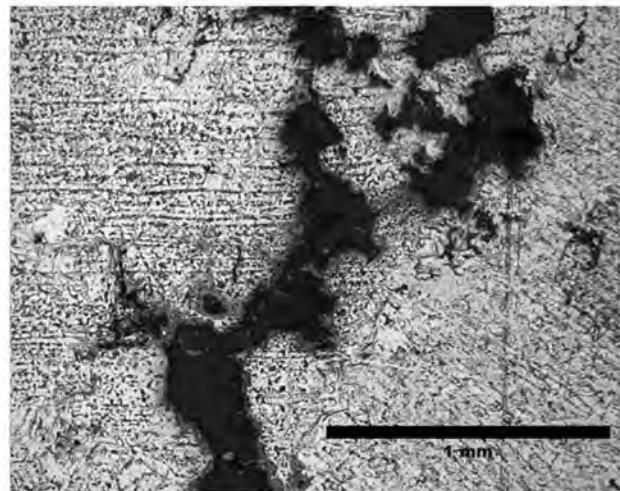
LABORATORY REPORT-LS3 TOP

MOUNT 15 M-4T

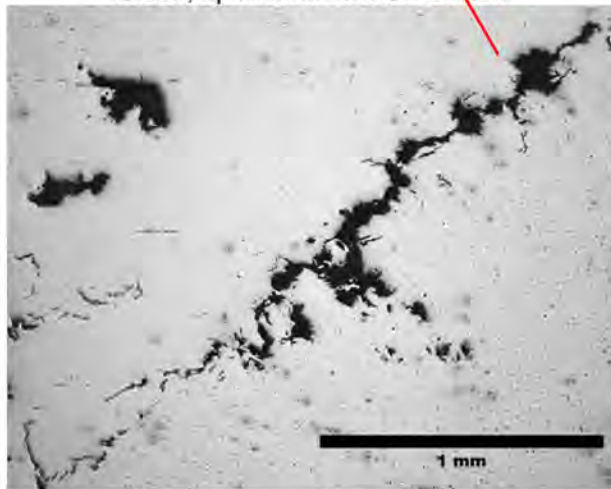
ID IS ON THE BOTTOM



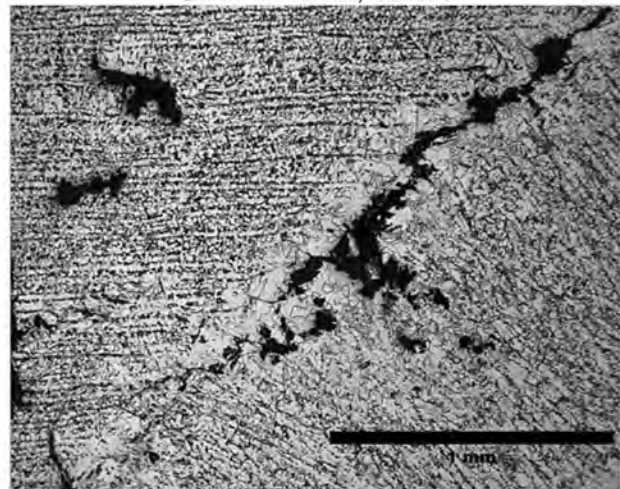
Crack, up from the ID. Un-etched



Same as at left, etched



Tip of the crack along fusion line, un-etched

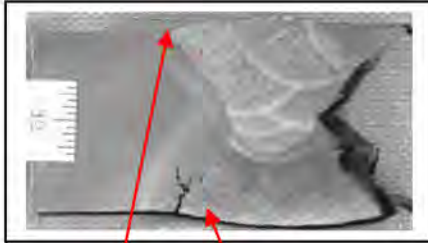


Same as at left, etched

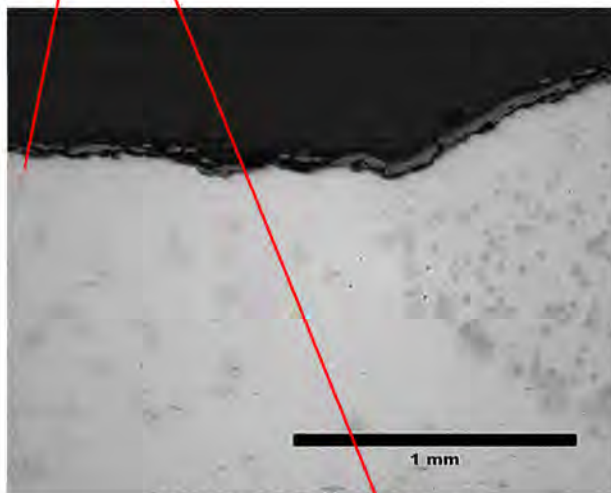
Figure 24

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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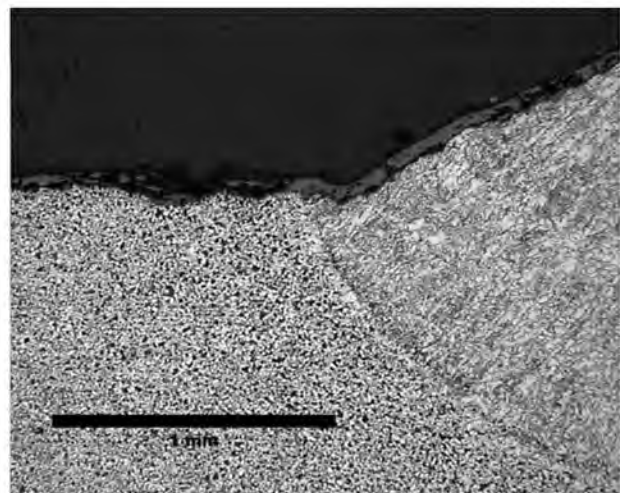
LABORATORY REPORT-LS3 TOP



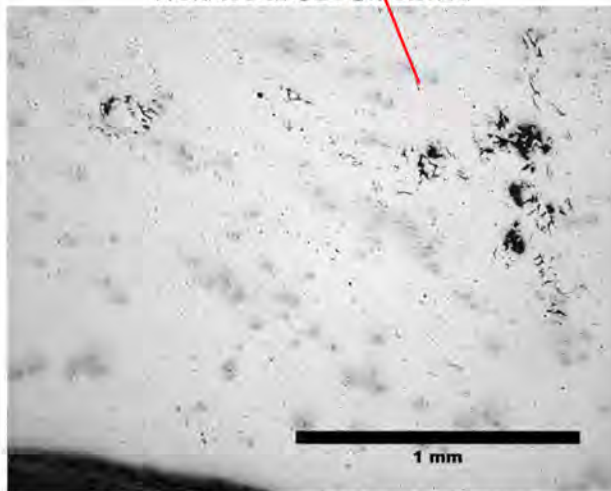
MOUNT 15 M-4T
ID IS ON THE BOTTOM



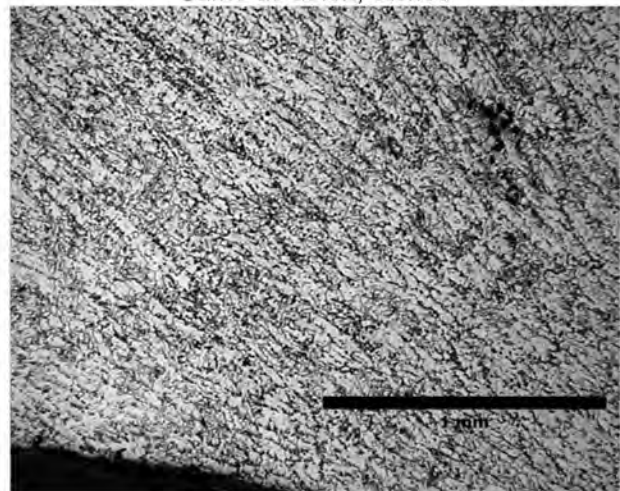
Weld toe at OD. Un-etched



Same as at left, etched



Cracks in the Weld Metal, un-etched



Same as at left, etched

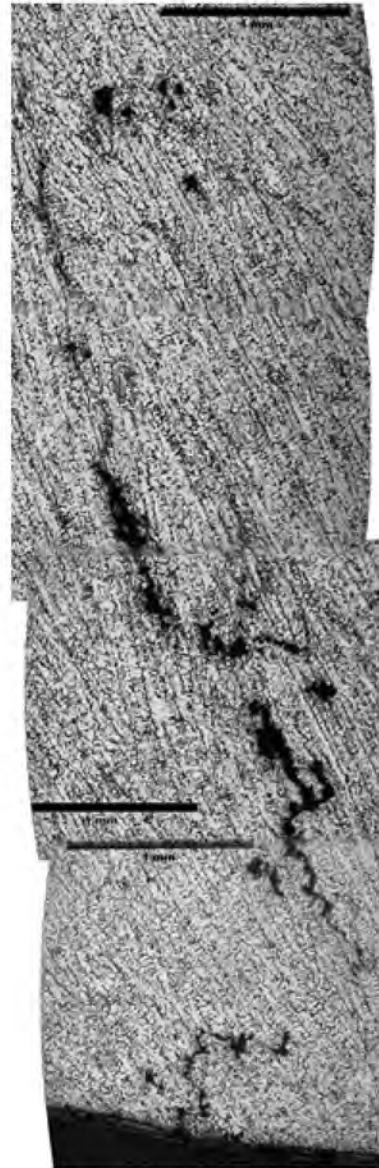
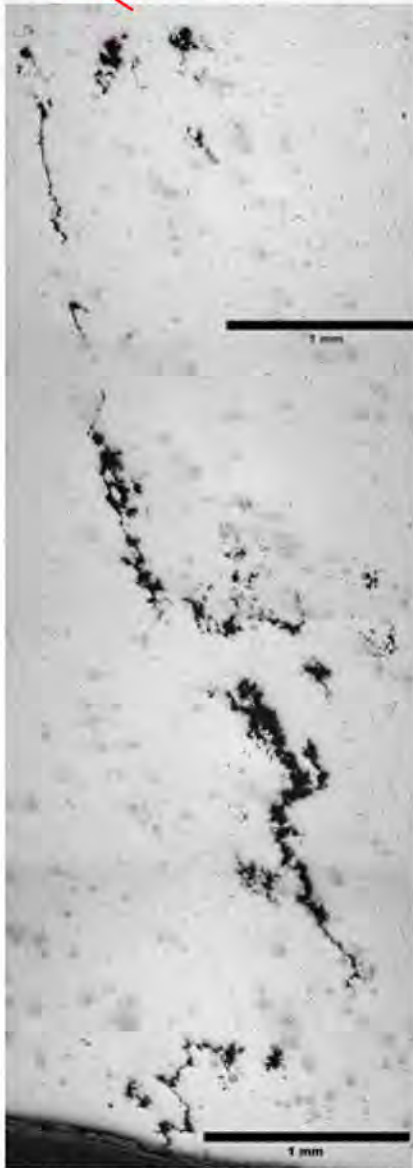
Figure 25

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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LABORATORY REPORT-LS3 TOP

MOUNT 15 M-4T
ID IS ON THE BOTTOM



One of the cracks in the Weld Metal. Four microphotographs stitched together. Un-etched

Same as at left, etched

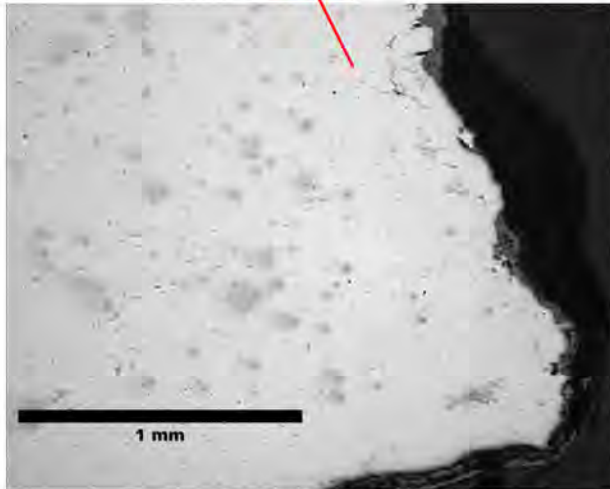
Figure 26

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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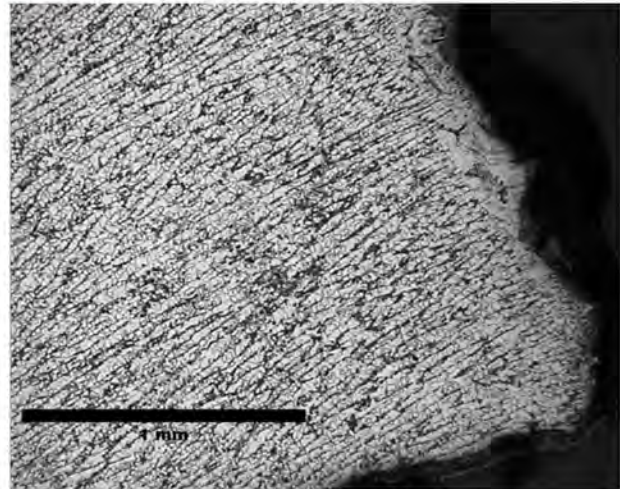
LABORATORY REPORT-LS3 TOP



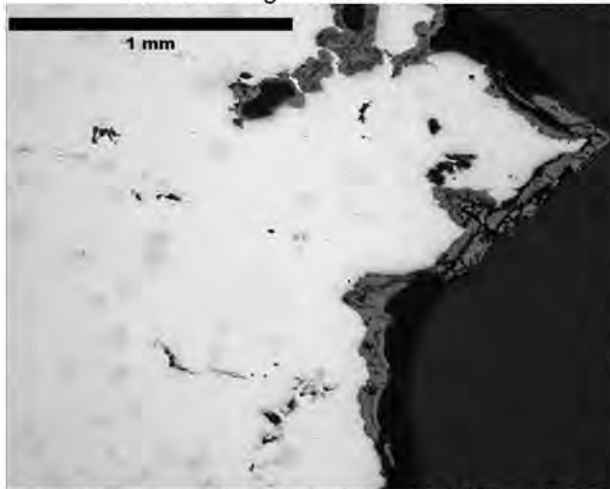
MOUNT 15 M-4T
ID IS ON THE BOTTOM



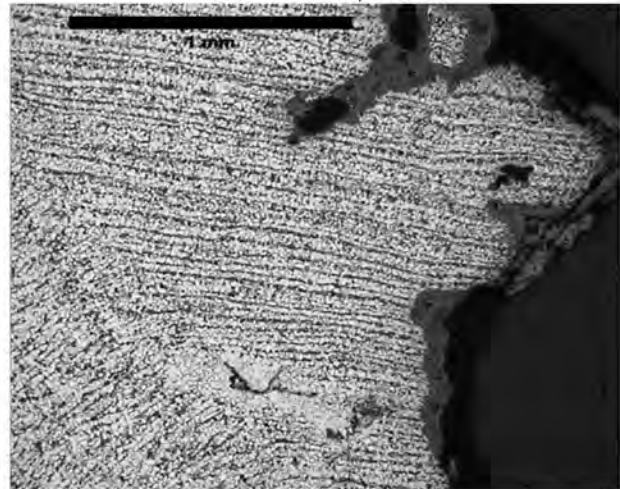
Fracture edge at ID. Un-etched



Same as at left, etched



Fracture edge, four fields up from ID, un-etched



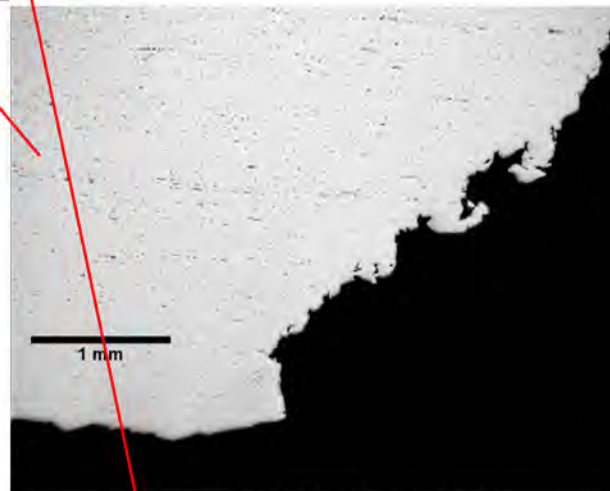
Same as at left, etched

Figure 27

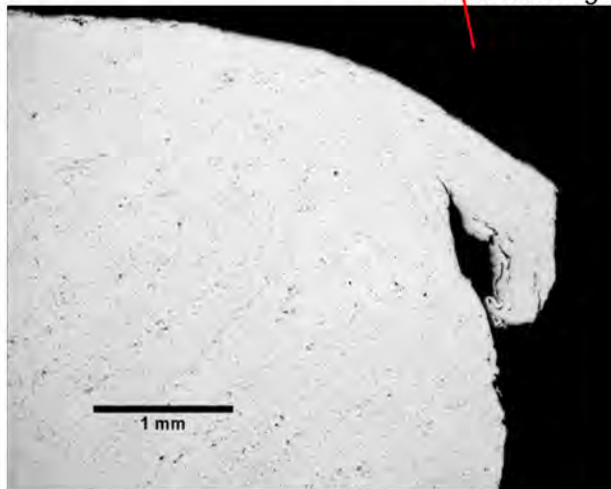
BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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LABORATORY REPORT-LS3 TOP

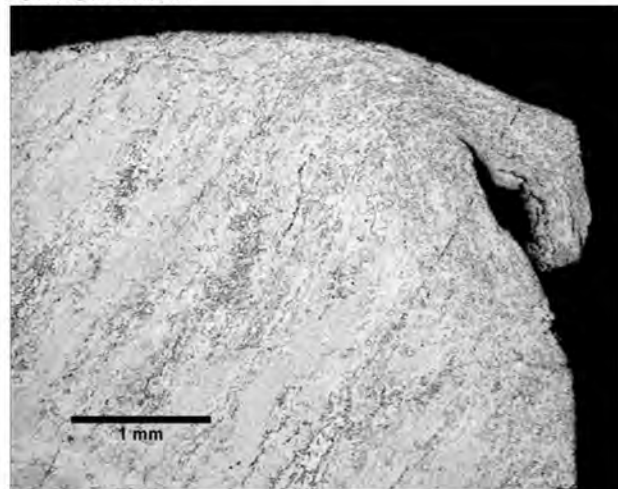
**MOUNT 15 TO
ID IS ON THE TOP**



Fracture edge at OD. Un-etched



Fracture edge at ID. Un-etched



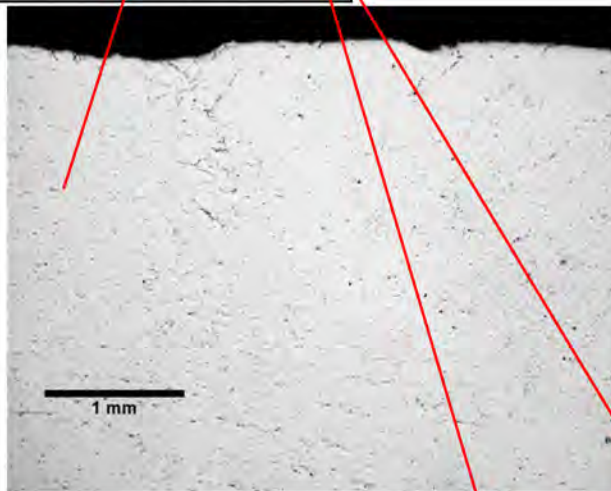
Same as at left. Etched

Figure 28

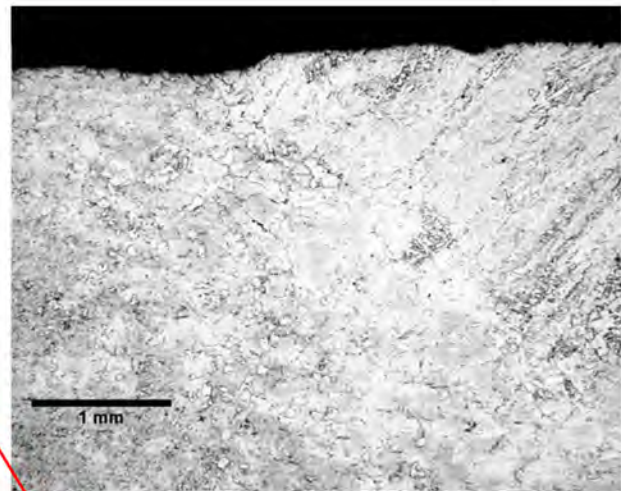
BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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LABORATORY REPORT-LS3 TOP

MOUNT 15 TO
ID IS ON THE TOP



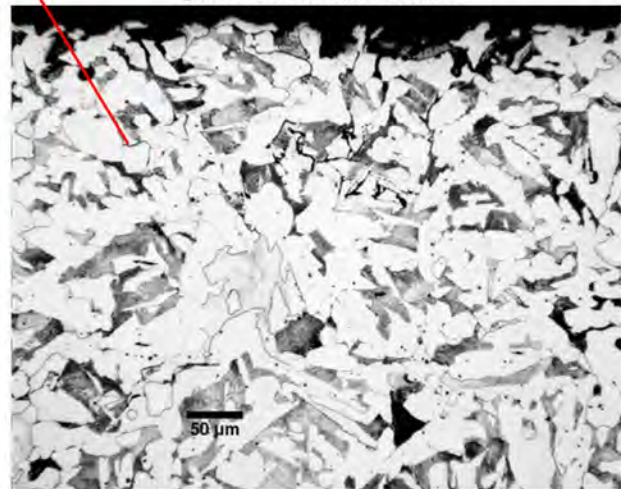
Area at the weld toe at ID



Same as at left. Etched



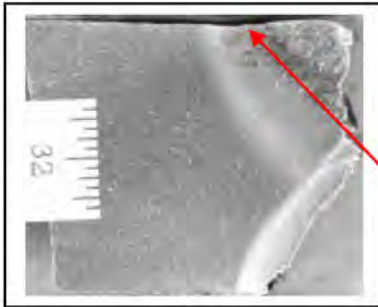
Weld metal near ID. Etched



Area of the base metal 1.5 fields down from the toe of the weld. Etched.

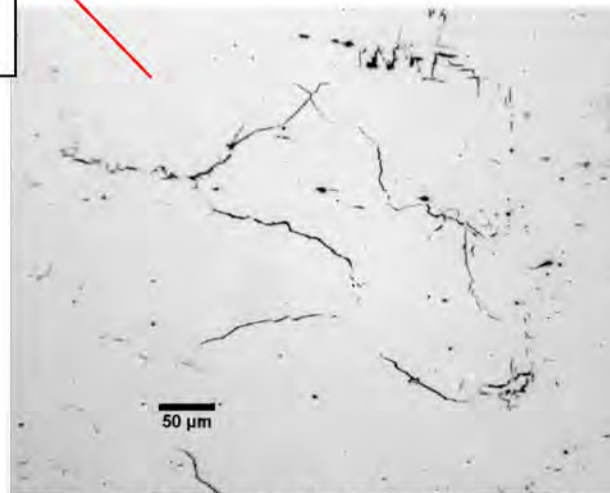
Figure 29

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15	10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	DATE: SEPTEMBER 20, 2010
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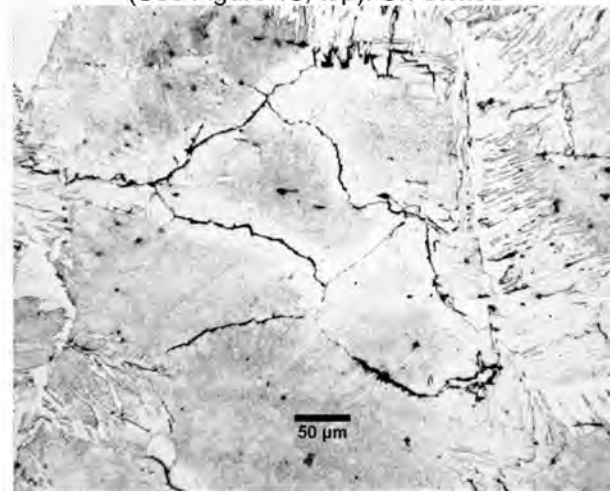


LABORATORY REPORT-LS3 TOP

**MOUNT 15 T0
ID IS ON THE TOP**



Area at weld toe near ID at higher magnification
(See Figure 18, top). Un-etched



Same as above. Etched

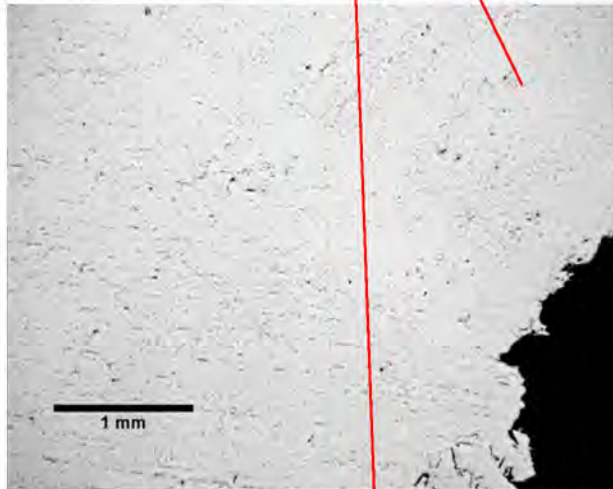
Figure 30

BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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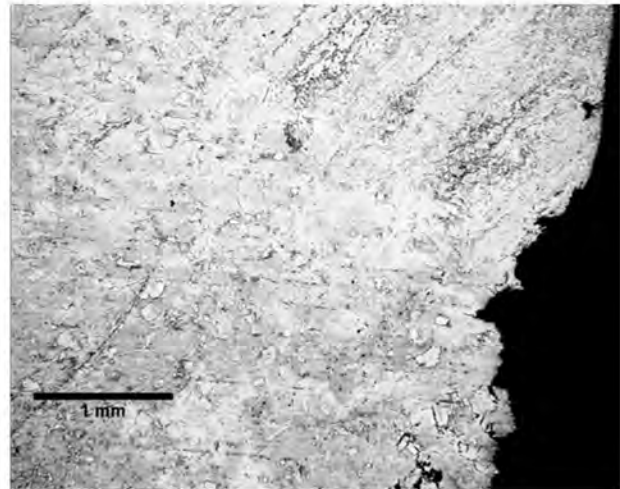


LABORATORY REPORT-LS3 TOP

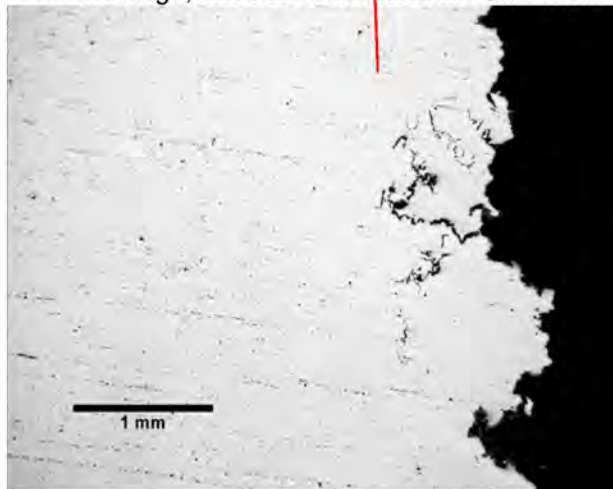
**MOUNT 15 TO
ID IS ON THE TOP**



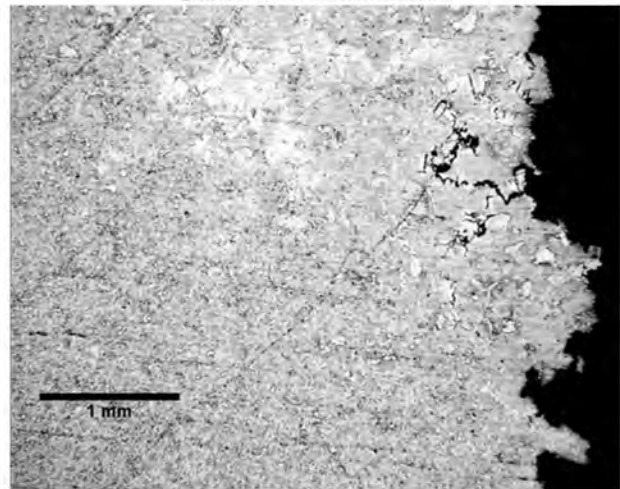
Fracture edge, one field down from ID. Un-etched



Same as at left. Etched



Fracture edge, two fields down from ID. Un-etched



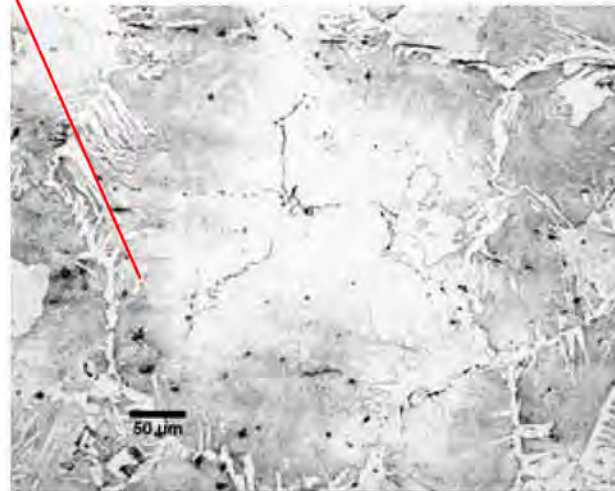
Same as at left. Etched

Figure 31

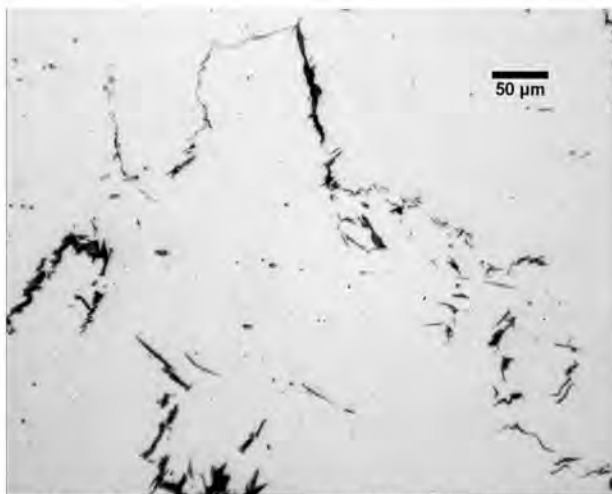
BETA LAB No.M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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LABORATORY REPORT-LS3 TOP

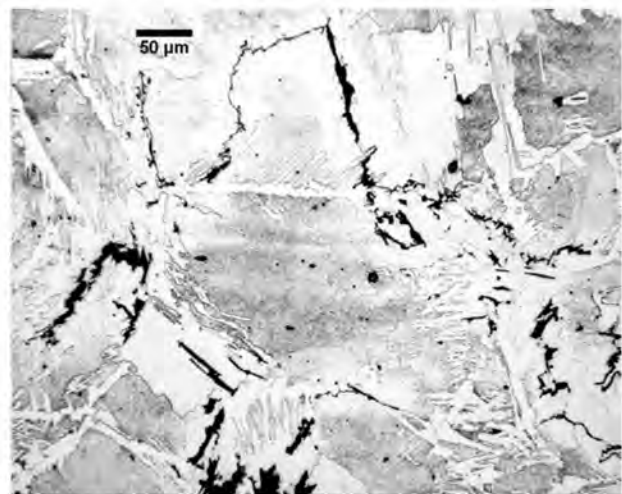
**MOUNT 15 T0
ID IS ON THE TOP**



Area down one field (see picture in Figure 31 above) from the ID and near the fracture edge.
Etched



Area down two fields (see picture in Figure 31 above) from the ID and near the fracture edge.
Un-etched



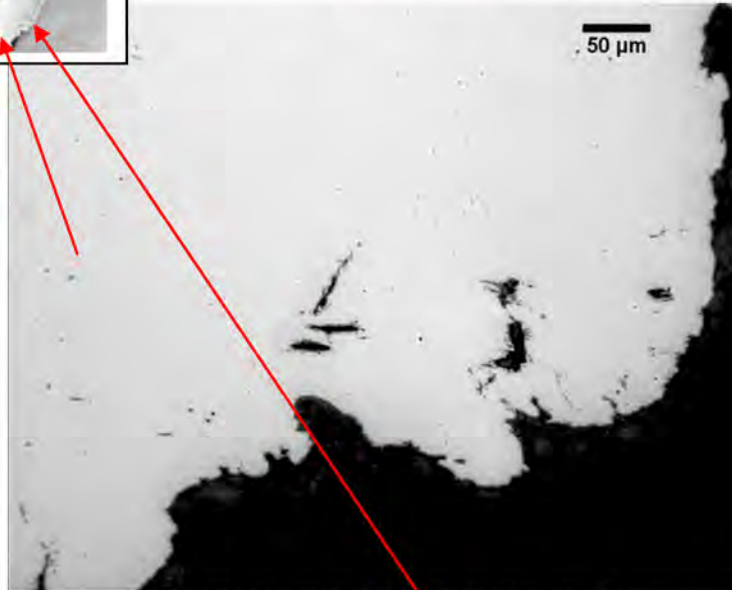
Area down two fields (see picture in Figure 31 above) from the ID and near the fracture edge.
Etched

Figure 32

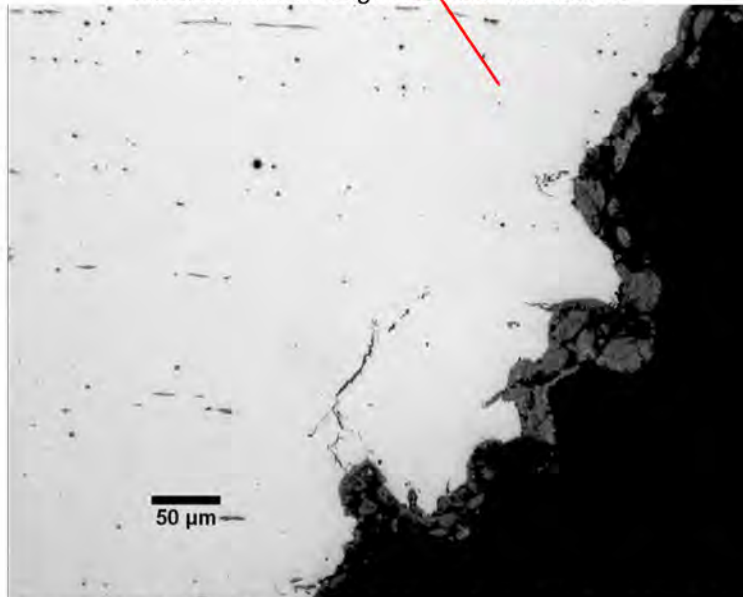
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MOUNT 15 T0
ID IS ON THE TOP



Area at fracture edge near OD-Un-etched



Area at the fracture edge 1.5 fields up from the OD-Un-etched

Figure 33

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**LABORATORY REPORT-LS3 TOP
ATTACHMENT 1 TEST PROTOCOL AND ADDENDUM**

Tesoro Exchanger E Failure Examination Protocol

Part 1. Field Visual and Nondestructive Examination

Part 1 of this protocol identifies visual and non-destructive testing that is approved to be conducted on the shell of exchanger 6600-E by a contractor acceptable to the parties to this agreement. Prior to performing any visual inspection or non-destructive testing, 3 business days notice must be provided to all parties to the agreement to allow the opportunity to observe. Parties to this agreement may elect not to perform aspects of the visual inspection or non-destructive testing described in this protocol. Should parties identify the need to conduct additional inspection or non-destructive testing not described in Part 1 of this protocol, 2 days notice must be provided to all parties to this agreement in order to register any objections.

Detailed visual inspection and testing will not be permitted until the equipment is placed in the secure evidence storage location.

All field visual and nondestructive tests shall be appropriately documented indicating examinations performed, scope of examinations, test equipment used in examinations, results of testing and the qualifications of the examiner as appropriate. All reports will be signed and dated by the examiner(s). Data reports shall be distributed within 48 hours of examinations by the third party conducting these examinations to all parties simultaneously. No party shall have the opportunity to review any data results in advance of the other parties. Any part requesting clarification or correction of anything in the report shall submit their request to all parties.

Data generated as a result of the execution of this protocol will be shared with all parties to the agreement simultaneously. Visual inspection reports, analysis or conclusion will not be shared.

Each party conducting field visual and nondestructive examination shall be assigned a unique set of alpha-numeric sets of markings. The format of the markings shall be AXXX, BXXX, CXXX, etc. The markings shall be applied to the external surfaces of the shell only and shall be permanent in nature (etch, stamp, etc.). Any markings shall be applied at least two (2) inches from any fracture surface. The markings shall be used for purposes described in Part 1 of this protocol and may also be used to identify locations of specific areas of interest determined by any examination conducted in Part 1. Each party using the markings shall supply a drawing identifying unique markings used and locations of these markings on the shell for information to all parties.

Field Visual Examination

1. Photographically document the heat exchanger in the "as-found" condition before initiating the metallurgical analysis. Documentation should include the following:
 - Any reference points needed
 - Fracture area and surface
 - Seams

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- Welds
 - Anomalies (dents, cracks, appurtenance)
 - Manufacturing flaws or defects
 - Pitting and/or evidence of corrosion on internal and external surfaces
2. Videotape the failed heat exchanger and surrounding heat exchangers and piping in the "as-found" condition. The videotape should similarly scan all items listed in (1) above. One scan should also offer a panoramic view of all affected surrounding equipment shot from a location immediately adjacent to the point of failure on the failed exchanger.
 3. Perform an initial field visual examination of the internal and external surfaces in the "as-found" condition, and document any anomalies that may be present such as the following:
 - Cracks
 - Crevices
 - Dents
 - Gouges
 - Manufacturing defects
 - Pitting and/or evidence of corrosion on internal and external surfaces
 - Presence of corrosion products and/or deposits
 - Examine the surface for evidence of cracks
 - Examine for evidence of arc burns, grinding around the surface area near the fracture

Additional considerations

- a. Fracture Surfaces: All fracture surfaces should be reviewed and photographed to check for:
 - thinning due to apparent corrosion
 - thinning due to necking
 - scaling (indicating an older crack)
 - beach or ratchet (chevron) marks pointing to the initiation site
 - proximity to welds and whether the crack propagates through weld metal, base metals or HAZs (Heat Affected Zones).
 - proximity to the end of the cladding
 - geometrical anomalies – e.g. gouges, sharp weld corners, mismatch, incomplete penetration of welds, etc
- b. Characterization of Internal Corrosion: Visible thinning or pitting on shell, tubes and baffles. Record description of all visible areas, with:
 - locations of corrosion on shell with length from outlet tubesheet and height from the bottom of the exchanger),
 - appearance of corrosion type on shell – thinning , pitting, etc
 - descriptions of scales
 - estimates of depths of observable corrosion and scales.

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- c. Characterization of Fouling or Other Deposits:
 - Describe by color, volume, location, density, tenacity of adhering to surface, whether initiating on tubes or shell.
 - Use initial photos for comparison to see if fouling has been affected by atmospheric and weather exposure in the last few weeks.
 - Report any areas near fracture surface where the fouling seems to be removed due to the flow escaping from the fracture (to help define initial leak point).
- d. Characterization of Distortion – Possible Pre- or Post-Explosion:
 - Look for tube distortion such as pulling out of tubesheet or breaking behind tubesheet or baffles, or having contact with shell.
 - Look for bundle distortion which may be an affect of the explosion, and may indicate the initial leak point.
- e. Tracing Initial Leak Point by Surrounding Impingement or Damage:
 - Inspect adjacent equipment in the direction of the rupture and cracking, and report any signs of flow impingement, high temperature exposures, explosion pressure-wave, etc.

Field Visual and Nondestructive Examination

1. Positive Materials Identification (PMI)

Perform PMI testing on all shell components and full penetration welds within two feet of the fracture surfaces using portable x-ray emission analyzers.

- Conduct all tests on external surfaces at least 6 inches away from all fracture surfaces.
- Conduct one test per weld located in the areas of interest on an external surface at least one foot away from all fracture surfaces.
- Unique numeric markings for identification purposes shall be made on the external surfaces of the shell where any PMI test was conducted.

2. Deposit Collection

Deposits from the lower section of the bundle and representative deposits found adhered to the shell shall be collected and stored in clean glass covered jars for subsequent laboratory analysis. Unique numeric markings for identification purposes shall be made on the external surfaces of the shell and on the surface of the bundle where the deposits were collected. Photographs should be taken of locations where deposits are to be removed prior to removal.

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Prior to collection of any samples, 3 business days notice shall be given to all parties to this agreement to provide the opportunity to observe sample collection. Analysis of collected samples must be approved by all parties to the agreement.

3. Field Crack Detection Ultrasonic Testing

Conduct ultrasonic examination adjacent to all fracture surfaces using techniques suitable for stress corrosion cracking or other potential service cracking mechanisms. Phased array is preferred for macro-cracking and AUBT is preferred for fissuring due to HTHA.

4. Physical Measurements

- Measure the wall thickness around fracture surfaces and any damaged areas. If corrosion is identified near or around the fracture surfaces, a "corrosion map" including reference points should be produced detailing the extent of the corrosion on the surfaces and the wall thicknesses in those areas. Measurements may be made using straight beam ultrasonic testing from the external surface.
- Record any markings detected on the inside or outside surfaces of the shell. Record name plate data.
- Measure rupture lengths tip-to-tip.
- Measure the shortest circumferential distance from each fracture origin to the nearest longitudinal weld and any attachment weld or structural discontinuity, such as nozzles, saddle supports, tubesheets, etc.
- Measure the axial distance from each fracture origin to the nearest circumferential weld, if any, and any attachment weld or structural discontinuity.
- Map wall thickness of each sample within 12 inches of each rupture origin using straight beam ultrasonic testing. Measurements will be taken on a 2-inch square grid pattern that is centered on the fracture origin.

5. Shell Course Match Marking

Suitable markings shall be made on external surfaces of shell sections on both sides of the separation at the circumferential weld to permit accurate recreation of the shell alignment of the two sections at the time of failure.

A minimum of 3 business days notice shall be given to all parties to this agreement to allow the opportunity to be present and determine the location of the shell course match markings. Mutual agreement of the parties present is required prior to making shell course markings.

Part 2. Laboratory Examination

The 6600-E exchanger will be submitted to a laboratory acceptable to all parties in as found condition for disassembly, further testing and evaluation. The parties will agree on a protocol

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for disassembly and cutting prior to any such work. Some of the work below is redundant with the field inspections listed above and may be eliminated with concurrence from all parties if the field data is thought sufficient.

The laboratory will provide a schedule of activities and testing 3 business day prior to commencing any work to the parties to this agreement in order to receive the opportunity to be present and observe testing.

1. Material Preparation for Shipment and Receipt

- All materials shall be photographed as found, once secured for shipping, and as received.
- The 6600-E exchanger will be submitted to the laboratory in as found condition for disassembly, further testing and evaluation. Spray fracture surfaces with clear lacquer (Krylon or Rustoleum clear spray) dissolvable in acetone to protect fracture surfaces from corrosion. Fracture surfaces shall be protected from mechanical damage during transport (e.g. a split rubber hose pressed along the edge of the sample).
- The exchanger will be secured to a transport trailer, and protected by a hard cover (e.g. wood box or "conex" with the bottom removed) with a door secured by a tamperproof seal prior to shipment.
- An inspection of the tamperproof seal will be documented on the chain of custody prior to shipment. The chain of custody will be signed by the representative of each interested party indicating the exchanger is ready for shipment
- Shipping details will be provided to the lab of choice.
- A representative of the laboratory will be present take receipt of the exchanger, photograph the as received condition and document any apparent shipping damage.
- The exchanger and any samples collected will be stored in a secure indoor location.

Laboratory NDE Examinations

1. Take caliper readings for thickness of middle of plate and all edges and document. If there is pitting corrosion damage, pits within the area of interest will be counted and the pit length, width and depth will be recorded. Take macro hardness readings of each plate. If there is noticeable scale, take scale samples and preserve in clean glass jar.
2. Inspect the failed section for isolated cracks or colonies of cracks using nondestructive testing techniques. Carbon steel surfaces surrounding the rupture should be cleaned with an appropriate non-abrasive cleaner and subsequently inspected using a wet fluorescent magnetic particle inspection (WFMT) method. The circumferential weld should be examined by dye penetrant (PT) and WFMT (this weld was backcladded with austenitic material and there will be a carbon steel heat affected zone on one side and austenitic cladding on the other side of the weld).
3. Visually examine the fracture surfaces in detail to identify the characteristics of the fracture, the presence of any defect or anomaly, and the failure initiation point(s). Utilize a suitable

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method to thoroughly document the fracture surface including dimensional documentation. Suitable methods to document the fracture surface include, but are not limited to, the following:

- Foil method
- Photographs of macroscopic examination

Marking and Sample Selection for Analysis

1. Examine each tagged sample for areas where sections will be removed for further detailed analysis. The laboratory metallurgist with concurrence of all parties should determine the areas to sample for all analyses. Include areas directly opposite of any fractured weld/area to get both sides of the fracture.
2. Mark all areas chosen for further examination and label ID and OD. Include specimen side to be exposed when mounted.
3. Document those areas with macrophotographs, showing areas to be removed, ID tag, and reference measurements.
4. Mark all remote areas to be sampled for general chemical analysis and mechanical tests, including base metal, welds, and Heat Affected Zones (HAZ).

Fractographic/Metallographic Examination

1. Saw cutout sections to be mounted or looked at with Macroscope / optical light stereoscope, maintaining tag traceability and side to be examined.
2. Examine specimens with Macroscope and take pictures. If sample fracture surface was corroded before spraying with clear lacquer, then cut in half and keep one half and then take other half and remove lacquer with acetone and clean surface with a cleaning solution such as Endox. Then, examine specimens with Macroscope and take pictures. Retain some of the fracture surface of interest and go to Step 3.
3. Examine un-mounted and unpolished fracture surfaces of interest in an SEM at 5, 50, 100, 500, 1000 and 5000X to look for possible / likely initiation sites and clearly describe the fracture surface morphology (intergranular, cleavage, microvoid coalescence). Any deposit areas should be analyzed with EDS analysis.
4. Cold mount sample pieces in areas of interest for metallography.
5. Etch control numbers on each mount corresponding to original tags.

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6. Grind and polish the surface of each sample using a series of progressively finer grit papers and polishing wheels to obtain a surface suitable for examination under a metallurgical microscope with magnification at 50X, 100X, 200X, 500X, 1000X, and 1500X.
7. Examine each mount in the unetched condition under a Macroscope at 5 to 50X magnification.
8. Take photomicrographs and document any areas of interest. Areas of interest may include:
 - At or near the fracture origin
 - Fracture surfaces
 - Weld seams and HAZs
 - Anomalies
 - Areas with indications of defects or cracks identified through visual and/or non-destructive testing
 - Areas exhibiting "typical" microstructures of the base metal, weld metal, and heat-affected zone.
9. Examine each mount under a metallurgical microscope for a higher magnification view of any areas on the sample.
10. Photograph any areas of interest.
11. Surface etch each mount with a Nital 5% etch solution (for A515-70) and reexamine using both the macro and microscopes.
12. Mounts that contain alloys other than carbon steel may require different etch solutions or techniques.
13. Photograph and document all areas of interest.
14. Decide if any mounts are to be further examined using a Scanning Electron Microscope (SEM) either in the etched or unetched condition in the case of the mounts.
15. Photograph and document all areas of interest.
16. Perform EDS analysis of any scale or weld/base metal zone as required on the polished mount samples.
17. All weld joint cross section specimens should be given a series of microhardness tests starting in base metal and traveling through the weld HAZ and weld metal using a protocol to be provided by the lag. If there is a fracture surface in cross section in a mount, take a microhardness reading adjacent to the fracture surface. Then take microhardness on the mounted specimen that came from the other side of the particular fracture location and perform a microhardness adjacent to the fracture surface.

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During the course of examination metallographic samples should be examined to characterize and validate any issues specific to the failure such as:

- *Material specification, grade, and heat treatment*
- *Weld seam in area of fracture*
- *Weld seam in un-affected area*
- *Degradation of microstructure from service conditions*
- *Corrosion*
- *Indications of outside force damage*
- *Differences in microstructure based on op. temperature (which varies along the length of the shell)*

Mechanical Properties

Testing should be performed to determine the mechanical properties of the heat exchanger and any appurtenances. Mechanical properties of test specimens should not be taken from areas of the heat exchanger that have been plastically deformed as a result of the failure but shall include tests from all components within 2 feet of the fracture surfaces. These mechanical tests should at least include the following:

- Tensile Testing
- Charpy V-notch Impact Testing
- Chemical Analysis

1. Tensile Testing

Tensile test specimens should be prepared and tested in accordance with ASTM A370 (Mechanical Testing of Steel Products) for the shell base metal and weld seams to measure yield strength, ultimate tensile strength, and elongation. The shell base metal should, at a minimum be tested in the transverse direction, and weld seam specimens should be taken across the weld seam.

2. Charpy V-notch Impact Testing

Charpy V-notch (CVN) specimens should be prepared and tested in accordance with ASTM E23 (Notched Bar Impact Testing of Metallic Materials) to determine the toughness characteristics of in the transverse direction. Transition curves shall be produced with three (3) specimens at each temperature. Results from CVN testing may be reported in some or all of the following forms depending on the testing results:

- Upper-Shelf Energy (in ft-lbs and SI units)
- Lower-Shelf Energy (in ft-lbs and SI)
- Ductile-to-Brittle Transition Temperature (50% in °F) determined from graphical representation of testing results
- Fracture Appearance Transition Temperature (in °F) corresponding to 50 % shear

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- Lateral expansion (to measure notch toughness)
 In some steels it may be difficult to measure percent shear because of "woody" fracture surfaces. In these cases it would be more appropriate to use lateral expansion and absorbed energy measurements to obtain a more accurate transition temperature.

Optional: If the Charpy transition curves or fracture appearance displays any deviation from normal A515-70 material behavior, fracture mechanics testing should be performed to determine both static and dynamic fracture toughness. There are several standards and specimens that could be used and the appropriate test(s) should be agreed upon by all parties.

3. Chemical Analysis

Chemistry samples representative of all components within two feet of the fracture surfaces shall be taken and analyzed in accordance with ASTM Specification A20 / A20M compared to ASME Section II material specifications. Perform Leco analysis for carbon. A determination of carbon equivalent for each test shall be made.

Energy dispersive spectroscopy (EDS) and either x-ray diffraction (XRD) or x-ray photoelectron spectroscopy (XPS) analyses may be used to determine elements and compounds present in surface deposits that were collected during the visual examination if considered germane to the investigation. Other suitable test methods may also be used.

High Temperature Hot Hydrogen Testing (OPTIONAL)

If the initial analysis appears to indicate HTHA, then have small specimens removed and analyzed per the Materials Property Council (MPC) Moly-Hy Joint Industry Program protocol at University of Tennessee. This protocol involves cryo-cracking (cryogenic induced fracture after immersing in liquid nitrogen) after machining a small notch in the material (probably close to fracture surface) and then examining the fracture surface with SEM at high magnification (5,000 – 15,000X). Another part of the protocol is to measure the non-diffusible hydrogen to infer the CH₄ content.

Laboratory Results Reporting/Sample Retention

1. All laboratory tests, including photographs or sketches, should be documented and summarized in a complete lab report. No analysis or conclusions shall be provided.
2. The Laboratory Report should be signed by a P.E from the laboratory.
3. An electronic version (e.g. pdf, jpg) report shall be distributed by the third party conducting these examinations to all parties simultaneously within 72 hours of completion. No party shall have the opportunity to review any results in advance of the other parties. Any part requesting clarification or correction of anything in the report shall submit their request to all parties

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4. All samples that are cut, whether used or not and all samples analyzed shall be saved and stored in a manner that minimizes corrosion, by retaining in a container filled with desiccant or wrapping in plastic, etc.
5. The chain of custody form should be signed at all stages where the samples are handled within the lab or removed from the lab for any reason. Any markings/tags should be visible and retained.

James Darnell
Vice President, Health and Safety
Tesoro Companies


Signature 5 May 2010
Date

Robert Parker
Compliance Manager
Division of Occupational Safety and Health


Signature 5-17-10
Date

Robert J. Hall
Investigator-in-Charge
U.S. Chemical Safety Board


Signature 5-15-10
Date

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**Tesoro Exchanger E Failure Examination Protocol
Addendum-1: Additional Work for Part 1 of Protocol**

Part 1. Field Visual and Nondestructive Examination

All field visual and nondestructive tests shall be appropriately documented indicating examinations performed, scope of examinations, test equipment used in examinations, results of testing and the qualifications of the examiner as appropriate. All reports will be signed and dated by the examiner(s). Data reports shall be distributed by the third party conducting these examinations to all parties simultaneously. No party shall have the opportunity to review any data results in advance of the other parties. Any party requesting clarification or correction of anything in the report shall submit their request to all parties. Data generated as a result of the execution of this protocol will be shared with all parties to the agreement simultaneously. Visual inspection reports, analysis or conclusion will not be shared.

Field Visual and Nondestructive Examination

Current work in the section:

3. Field Crack Detection Ultrasonic Testing

Conduct ultrasonic examination adjacent to all fracture surfaces using techniques suitable for stress corrosion cracking or other potential service cracking mechanisms. Phased array is preferred for macro-cracking and AUBT is preferred for fissuring due to HTHA.

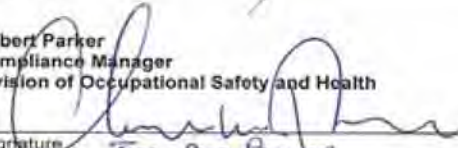
Additional work recommended for this section:

Exchanger E: Perform phased array ultrasonic inspection on all full penetration welds located between the point of failure and the shell to tubesheet flange weld with the exception of nozzle welds. Data reports for the additional work will be provided to all parties simultaneously within 24 hours of completion of the inspection.

James Darnell
Vice President, Health and Safety
Tesoro Companies


Signature _____ Date 18 MAY 2010

Robert Parker
Compliance Manager
Division of Occupational Safety and Health


Signature _____ Date 5-20-10
For Bob Parker

Robert J. Hall
Investigator-in-Charge
U.S. Chemical Safety Board


Signature _____ Date 5-20-10

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Tesoro Exchanger E Failure Examination Protocol Addendum – 3: Revisions/Lab Clarifications

This Addendum-3 to Exchanger E Failure Examination Protocol sets forth revisions to the original Inspection Protocol document.

1. The requirement to take caliper readings for thickness in the middle of the plate is deleted.
2. The requirement to take macro hardness readings on each plate will only apply to test plates supplied to the laboratory and not plates which remain attached to the heat exchanger.
3. The WFMT and PT shall be applied only to the ID surfaces in the vicinity of the fractures.
4. The fracture surfaces will be documented but the identification of the initiation point, the fracture mode and the interpretation of the fracture will be the responsibility of the signatory parties or their technical representatives.
5. Dimensional documentation of all fracture surfaces will be by inclusion of a scale in all photos.
6. The laboratory, acting as a referee laboratory, will be supplied the locations to take the test samples and the type of test and test parameters to be performed at each location on the test sample, i.e. magnification, hardness load/test method. The signatory parties or their technical representatives that are present in the laboratory at the time shall make those decisions and give that information directly to the laboratory. Comments from other technical experts will be considered and factored into the signatory parties or their technical representative's decisions but all decisions on protocol or samples shall remain as decisions of the signatory parties or their representatives.
7. The requirement for mounting samples on each side of any fractured weld /area will apply where convenient from the samples already cut out as of this date and will not apply to material still attached to the heat exchanger.
8. Since the fracture surfaces were not coated with any lacquer the requirement to cut each fracture sample in half, keeping one as is and cleaning only one half will not apply.
9. The acceptable cleaning methods for the SEM evaluation of the fracture surfaces are cathodic cleaning in mild alkaline or acid solution or alternatively Alconox and inhibited acid cycles. There is always a risk that extensive field corrosion has consumed the damage profile. One sample will be cleaned and evaluated in the SEM at any given time.
10. All magnifications listed in the test protocol are for equipment capability and the exact magnification and area of interest for all photomicrographs will be will be the responsibility of the signatory parties or their technical representatives present in the lab at the time.
11. A 2 % Nital etch solution is acceptable for use.
12. Because of all the deformation in the vicinity of the fractures the requirement to take the mechanical test specimens within 2 feet of the fractures is deleted.

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**Tesoro Exchanger E Failure Examination Protocol
Addendum – 3: Revisions/Lab Clarifications**

13. The tensile and impact testing in the transverse direction is interpreted as transverse to the original plate rolling direction.

14. The requirement to simultaneously distribute the report within 72 hours of completion is deleted and the parties agree to a level 2 report, which contains descriptive text and captioned photos with the resultant assembly time being a function of the amount of data obtained but is typically 2-3 weeks. Any signatory party, its representative, or other party permitted to witness the laboratory testing may have the opportunity to see the data so long as there is no disruption to lab work but no one can have or make any copies of the laboratory work product prior to the Laboratory issuing the test report to the signatory parties.

James Darnell
Vice President, Health and Safety
Tesoro Companies


Signature _____ Date 7-6-10

Robert Parker
Compliance Manager
Division of Occupational Safety and Health


Signature _____ Date 7-6-10

Robert J. Hall
Investigator-in-Charge
U.S. Chemical Safety Board


Signature _____ Date 7-6-10

BETA LAB NO. M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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LABORATORY REPORT-LS3 TOP

Attachment2

TEST EQUIPMENT and PROCEDURES

TEST	INSTRUMENT & MODEL	CALIBRATION DUE DATE	BETA NO.	LSS PROCEDURE	
				NUMBER & TITLE	REV NO.
Failure Analysis	N/A	N/A	N/A	B0069 Failure Analysis	0
Chemical Analysis	Thermo ARL 3460 Optical Emission Spectrometer	Performance check prior to use	BETA 665	B0068 ARL 3460 Optical Emission Spectrometer Analysis	2
SEM/EDS	Amray Scanning Electron Microscope, Model: 1830T4, S/N: 18321002, with IXRF Energy Dispersive X-ray Spectrometer	*	BETA 386 BETA 755	B0064	*
SEM/EDS	Camscan Scanning Electron Microscope, Model: MV2300U, S/N: US0187039/VG0540181U with IXRF Energy Dispersive X-ray Spectrometer and x-ray Optics/AAT Detector	Sept. 3, 2010	BETA 602 BETA 756	B0047 CAMSCAN/IXRF SEM/EDS System	8
Rockwell Hardness	Wilson Rockwell 524T Hardness Tester, Model 83259910	Performance check prior to use	BETA 400	D0027 Wilson Rockwell Model 524T Hardness Tester	5
Rockwell Hardness	NewAge NI300-C Hardness Tester, Model 8150 S/N 951480	Performance check prior to use	BETA 897	D0052	*
Knoop/Vickers Hardness	Buehler Micromet II Digital Microhardness Tester, Model B-D58222	Performance check prior to use	BETA 401	D0028	*
Knoop/Vickers Hardness by Image Analysis	Buehler Micromet II Digital Microhardness Tester, Model B-D58222 with Buehler OmniMet Analysis System Program Version 9.0 Rev 3	Performance check prior to use	BETA 401 BETA 977	D0028	*
Field Hardness	Proceq Equotip Hardness Tester, Model 25-819	Performance check prior to use	BETA 428	D0016	*
Knoop/Vickers, Semi-Macro Vickers Hardness	Instron Tukon 2100B Hardness Tester, Model T2100BR1942	Performance check prior to use	BETA 2006	D0068 Instron Tukon 2100B Hardness Tester	0
Reagent Preparation [▲]	N/A	N/A	N/A	C0005 Metallurgical Reagents ▲	1
Linear Measurements by Optical Methods	LECO PMG-3 Inverted Metallograph with Buehler OmniMet Analysis System Program Version 9.0 Rev 3	*	BETA 419 BETA 977	D0065	*
Average Grain Size	LECO PMG-3 Inverted Metallograph with Buehler OmniMet Analysis System Program Version 9.0 Rev 3	*	BETA 419 BETA 977	D0066	*
Dimensional	Starrett Micrometer Number 222	9/09/2010	BETA DLC-C-094	NA	NA
Dimensional	Starrett Vernier S/N 120 A	*	BETA 2005	NA	NA
Dimensional	Mitutoyo Digital Micrometer 342-361	*	BETA 884	NA	NA
Mass	Mettler AE-100 S/N C-31383	*	BETA 113	NA	NA
Mass	Sartorius LP-6200S	*	MLL 0009	NA	NA

*Denotes procedures or instruments not used in this report

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BETA LAB No. M10198- LS3 TOP	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. No.: 4501667904
PART: 6600-E HEAT EXCHANGER LS 3 TOP PART 15		DATE: SEPTEMBER 20, 2010
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LABORATORY REPORT-LS3 TOP
Attachment 3 TEAM Industrial Service NDE Report

TEAM® Industrial Services, Inc.

5901 Harper Road
Solon, OH 44139
(440) 498-9494

MT-FORM-05 Lab and Field Technique Sheets
MAGNETIC PARTICLE EXAMINATION TECHNIQUE SHEET

Client: <u>FIRST ENERGY</u> Facility: <u>6670 BETA DRIVE, MAYFIELD VILLAGE OH450</u> Client PO#: <u>45342412</u> Project Description: <u>WET MAGNETIC PARTICAL TESTING</u>	Technician: <u>MICHAEL RUCKLEY</u> Date: <u>6-15-10</u> Technique #: <u>1</u> Job #: <u>13103168</u>
---	---

Item Data		
<input checked="" type="checkbox"/> Weld	<input type="checkbox"/> Non-Weld	<input type="checkbox"/> Structural
<input type="checkbox"/> Other:	<input checked="" type="checkbox"/> Initial Inspection	<input type="checkbox"/> Repair
<input type="checkbox"/> Final Inspection		
# of Parts: <u>60</u>	Base Metal: <u>S/A</u>	Filler Metal: <u>S/A</u>
Part Description: <u>WELDS ON PLATES</u>		

Inspection Data		
<input type="checkbox"/> Dry	<input checked="" type="checkbox"/> Wet	<input type="checkbox"/> Visible
<input checked="" type="checkbox"/> Fluorescent	<input type="checkbox"/> Circular	<input checked="" type="checkbox"/> Longitudinal
<input checked="" type="checkbox"/> AC	<input type="checkbox"/> DC	<input type="checkbox"/> Prods
<input checked="" type="checkbox"/> Yoke	Prod Spacing: <u>3.5"</u>	Amperage: <u>FIXED</u>
Equipment Type/Model: <u>CONTOUR PROBE B 300</u>	Serial No.: <u>17867</u>	Color: <u>14AM</u> Batch / Lot #: <u>109612K</u>
Cal. Due Date: <u>12-1-10</u>	Examination Preparation Method: <u>AS RECEIVED</u>	
Black Light S/N: <u>1693129</u>	Intensity: <u>N/A</u> (uv/cm ²)	Light Meter: <u>N/A</u> Type: <u>N/A</u> Serial No.:
Demagnetization Required? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Method:	

Inspection Results	
Procedure: <u>MT ASME N2</u> Rev. _____	Acceptance Criteria: <u>ASME SECTION III</u>
Inspection Results Summary: <u>INSPECTED 6 PLATES WITH WELDS. 3 PLATE PIECES WERE FOUND TO BE NONCONFORMING DUE TO LINEAR INDICATIONS THOSE PART NUMBERS ARE AS FOLLOVED L53-01 BOTTOM, L63-01 TOP, AND L54-01. 3 PLATE PIECES WERE FOUND TO BE CONFORMING, PART NUMBERS ARE AS FOLLOVED L51-01 CS2-01 TEE, AND PART# L52-01 CS3-01 WENT TO 2 PIECES ANY INDICATION MARKED ON PIECES</u>	
<input type="checkbox"/> Accept	<input type="checkbox"/> Reject
<input type="checkbox"/> See Attachments	

Reported by: [Signature] Reviewed by: _____

Supervisor: _____ Contact: _____

NOTICE: This examination report reflects the actual NDT procedure which was conducted by TEAM personnel. Submission of this report is for informational purposes and does not reflect any guarantee of the part, inspection procedures, or standards and is subject to the limitations of each.

MT-FORM-05 Lab and Field Technique Sheet