

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 1 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

CONTACT:	JIM McVAY
ISSUED BY:	JEFF BLOUGH
TELEPHONE EXTENSION:	440-604-9843
MAIL STOP:	A- BETA
REVIEWED BY :	DAVE KLESCH

REPORT ISSUED TO:

Jim McVay	Robert J. Hall	Robert Parker
-----------	----------------	---------------

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 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 interpretive report is a result of testing/analysis derived from material, information and/or specifications furnished by the customer and is confidential and is intended for the customer only. If you are receiving it in error, please advise immediately. Further, you are prohibited from disclosing, copying, distributing or using any of this information without written approval from Beta Lab. This report shall not be reproduced except in its entirety and, in any case, without prior written approval from Beta Lab. Except for such obligations as are set forth in the Agreement between Beta Lab and its customer for whom this work has been performed, neither the party preparing this report nor any person acting on its behalf: Makes any warranty or representation, express or implied, including merchantability or fitness for a particular purpose, with respect to the accuracy, completeness or usefulness of the information contained in this report, or that the use of any information, apparatus method or process disclosed from this report does not infringe upon privately owned rights or intellectual property; or Assumes any liability with respect to the use of, or for damages, including consequential or punitive damages, resulting from the use of, any information, apparatus, method or process disclosed in this report.

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 2 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

In this report the LS# and CS# refer to longitudinal and circumferential weld seams, respectively, while the part number refers to the chain of custody. This report is the sixth of a series on failed parts of 6600E heat exchanger. The following is a list of previous reports:

- | | |
|---|---|
| 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 | |

TEST PERFORMED: The tests on the exchanger parts included visual examination, chemical analysis via Vacuum Spectrometry and LECO carbon, macro hardness measurements, Magnetic particle inspection (by others), and mechanical property testing (by others). 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 pieces labeled part 16-1 and 16-2 (LS2-01/CS3-01) and part 17 (LS1-01/CS2-01) shown in Figures 2 & 3, were received at BETA Lab for testing. The part 16 was given two sub-part numbers because Halvorsen was requested to cut the piece in half for ease of handling and cutting at BETA. The ID surface of part 16-1& 2 and part 17 were magnetic particle inspected (by others, see attachment 3) and no reportable indications were found.

Samples of the can 1, can 2 and 3, and the ID and OD crowns of CS2, CS3, LS1 and LS2 were obtained and chemically analyzed. The results of those chemical analyses are detailed in Table 2.

Rockwell hardness testing was performed at approximately the mid wall on transverse section for can 1, can 2 and 3 and the results are reported in Table 3.

A test plan for mechanical testing containing the tests to perform and where to perform the tests was developed by a combination of the test protocol contained in attachment 1 and 2 and the signatory parties or their technical representatives that were present in the laboratory at the time. The test plan included room temperature tensile tests and impact test of base metal and weld metal. Additionally it included side bend testing of the welds. Since many of these tests are performed transverse to the rolling direction the first step was to remove two pieces of plate and mount them at right angles to each other to determine the rolling direction. In all cases the plate rolling direction was perpendicular to the axis of the long seams. The mechanical tests were performed, by others, and the results of the impact tests for the base metal and weld metal are contained in Table 4 and 5 and plotted in Figure 6, 7 and 8, 9 respectively. The results for the tensile tests of the weld and base metals are contained in Figure 10 and tables 6 and 7 respectively. Additionally weld side bends were performed and all passed a 180 degree bend except 16-1-CS3 which failed with a >1/8 inch crack at 90 degrees, see Table 8 for details. The test certifications and the details of all mechanical tests are contained in Attachment 4.

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
		PAGE 3 OF 54

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

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	J. BLOUGH	HALVORSEN & BETA, VARIOUS	TEST RESULTS & FIGURES 1-5
CHEMICAL ANALYSIS	THERMO ARL-3460 OE SPECTROMETER	M. TASCAR	BETA, 6/16,6/25, 7/23 & 8/13/2010	TABLE 2
Carbon Analysis	Leco Carbon/Sulfur Determination CS-444	M. Belviso	BETA, 7/26/2010 & 8/17/2010	Table 2
ROCKWELL HARDNESS	Wilson Rockwell 524THardness Tester	M, Tascar	BETA, 7/26 & 8/19/10	Table 3
MAGNETIC PARTICLE TESTING	FLUORESCENT	TEAM INDUSTRIAL SERVICE ,MICHAEL BUCKLEY	BETA, 6-15-2010	ATTACHMENT 3
MECHANICAL PROPERTY TESTING	IMPACT, TENSILE AND BENDING	TENSILE TESTING METALLURGICAL LABORATORY	TTML, 7/27 TO 8/25/2010	FIGURES 6-10 TABLES 4-8 AND ATTACHMENT 4

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 4 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

TABLE 2 CHEMICAL ANALYSIS FOR BASE METAL AND WELD DEPOSITS

SAMPLE IDENTIFICATION	CHEMICAL COMPOSITION, WT. %											
	C	SI	P	S	MN	NI	CR	MO	V	CU	CO	AL
17- CAN1	0.28	0.24	0.01	0.024	0.62	0.12	0.13	0.03	<0.001	0.18	0.01	0.005
14-3 CAN 2	0.259	0.23	0.008	0.019	0.59	0.12	0.12	0.02	<0.001	0.18	0.01	0.01
14-3 CAN 3	0.260	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	0.13-0.45	0.035 MAX	0.035 MAX	1.30 MAX	NS	NS	NS	NS	NS	NS	NS
17 LS1 ID WELD SURFACE	0.13	0.46	0.011	0.021	1.12	0.08	0.09	0.02	0.001	0.04	0.01	0.006
17 LS1 OD CROWN	0.07	0.59	0.012	0.017	1.18	0.05	0.07	0.01	0.002	0.14	0.01	0.005
17 CS2 ID WELD SURFACE	0.11	0.57	0.015	0.021	1.22	0.06	0.10	0.01	0.002	0.23	0.01	0.007
17 CS2 OD CROWN	0.08	0.57	0.011	0.017	1.16	0.05	0.07	0.01	0.002	0.15	0.01	0.007
16-1 LS2 ID WELD SURFACE	0.12	0.54	0.011	0.018	1.15	0.05	0.07	0.01	0.002	0.14	0.01	0.010
16-1 LS2 OD CROWN	0.08	0.49	0.011	0.021	1.12	0.07	0.08	0.02	0.001	0.04	0.01	0.005
14-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
14-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
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	0.025	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

NOTES: NS = NOT SPECIFIED, ND = NOT DETECTED

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

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 5 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

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

SAMPLE IDENTIFICATION	HARDNESS			
	MINIMUM	MAXIMUM	AVERAGE	NUMBER OF INDENTATIONS
17 CAN 1	81.4	84.4	82.7	7
14 CAN 2	82.3	83.5	83.1	7
14 CAN 3	82.5	83.7	83.1	7

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING PART: 6600-E HEAT EXCHANGER 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
		DATE: AUGUST 27, 2010
PAGE 6 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

TABLE 4 IMPACT TESTING ON BASE METAL

Sample ID	19ECS4			16-1 CS3			16-2 LS2			17 LS1		
	Ft- Lb	Lat. Exp.	% shear	Ft- Lb	Lat. Exp.	% shear	Ft- Lb	Lat. Exp.	% shear	Ft- Lb	Lat. Exp.	% shear
120	33	31	80	30	27	60	33	29	70	26	19	50
120	32	27	80	27	22	50	30	30	60	29	25	70
120	35	30	80	29	24	60	32	33	80	27	23	70
90	27	26	30	22	23	20	23	21	20	22	20	20
90	27	28	30	22	21	20	24	23	20	19	14	10
60	19	13	20	22	14	20	20	17	20	16	12	20
60	19	15	20	18	13	20	18	15	20	17	16	20
60	22	14	20	15	8	20	12	7	20	7	5	20
20	10	5	10	14	7	10	6	1	10	9	1	10
20	7	2	10	9	3	10	5	1	10	6	4	10
20	6	2	10	12	6	10	7	2	10	10	3	10
0	5	1	0	5	1	0	11	7	0	8	3	0
0	5	0	0	5	1	0	5	2	0	11	5	0
0	11	5	0	6	1	0	8	1	0	7	2	0
-20	5	0	0	8	1	0	7	1	0	6	0	0
-20	2	0	0	5	1	0	7	1	0	9	4	0
-20	6	1	0	5	2	0	5	1	0	8	2	0

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
		DATE: AUGUST 27, 2010
PAGE 7 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING
TABLE 5 IMPACT TESTING ON WELD METAL

Sample ID Temperature (F)	17 CS2			16-1 CS3			16-2 LS2			17 LS1		
	Ft- Lb	Lat. Exp.	% shear	Ft- Lb	Lat. Exp.	% shear	Ft- Lb	Lat. Exp.	% shear	Ft- Lb	Lat. Exp.	% shear
0	33	24	40	36	29	30	33	30	30	39	34	30
0	33	32	40	33	22	30	33	26	30	42	28	30
0	36	33	40	41	31	30	33	26	30	45	41	30

TABLE 6 ROOM TENSILE TESTING ON BASE METAL

Sample ID	19E CS4				16-1 CS3				16-2 LS2				17 LS1			
	Ten.	Yield	Elong.	RA	Ten.	Yield	Elong.	RA	Ten.	Yield	Elong.	RA	Ten.	Yield	Elong.	RA
1	74	42.4	26	49	75.5	45.2	26	52	72.5	41	29	55	77	42.6	27	51
2	73.5	41.6	27	52	75	45.7	28	52	72	38.9	29	54	76.5	41.9	27	52
SA 515 Grade 70	70- 90	38 Min.	17 Min.	21 Min.	NA	NA	NA		NA	NA	NA	NA	NA	NA	NA	NA

Ten. = Tensile, Elong. = Elongation, RA = Reduced Area

Test were performed with the extensometer on the test sample

SA-515 Specification for Pressure Vessel Plates, Carbon Steel, For Intermediate-And higher-Temperature Service – July 2003 Addendum

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
		DATE: AUGUST 27, 2010
PAGE 8 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

TABLE 7 ROOM TENSILE TESTING ON WELD METAL

Sample ID	17 CS2			16-1 CS3			16-2 LS2			17 LS1		
	Tensile	Yield	Elongation	Tensile	Yield	Elongation	Tensile	Yield	Elongation	Tensile	Yield	Elongation
1	76	47.1	29	66.5	58.5	12	68.5	56.5	7.5	77.5	55.5	20
2	76	42	29	65.5	58	12	74.5	55	15	78.5	55.5	22

Test were performed with the extensometer on the cross heads

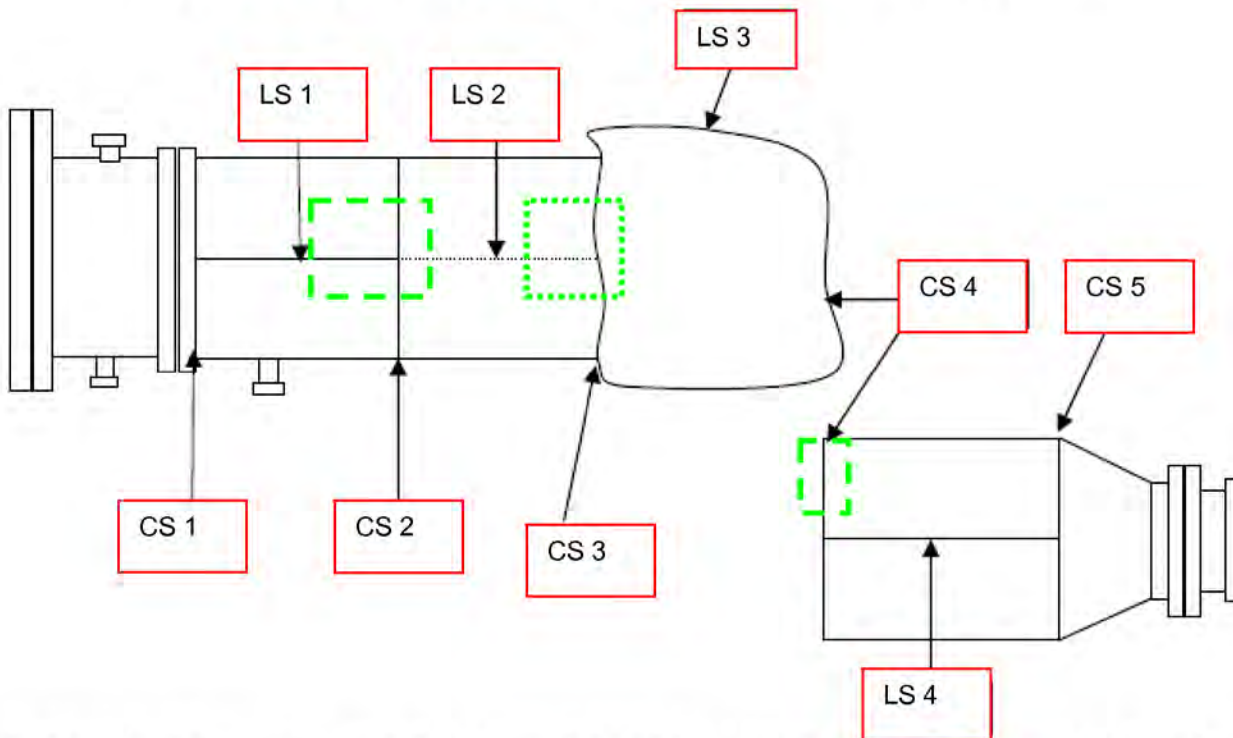
TABLE 8 BEND TESTS ON WELDS

Sample ID	17 CS2	16-1 CS3	16-2 LS2	17 LS1
1	Passed	*Failed >1/8 inch cracks @ 90 °	Passed	Passed
2	Passed	*Failed >1/8 inch cracks @ 90 °	Passed	Passed

* Acceptance criteria QW-163 ASME Section IX Qualification Standard for Welding and Brazing Procedures, Welders, Blazers, and Welding and Brazing Procedures- July 2003 Addendum

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 9 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



Sketch of main heat exchanger Cans 1-3 and separated back head Can 4- green dotted line are the items for this report. The box with the small dots is on the opposite side of the exchanger from the of the leak



Back Head

FIGURE 1 Un-packaged 6600E heat exchanger

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 10 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



Marking on shell- note tee at T2 location



Cut out of shell



Part 16-1 cut out ready for shipment



Part 16-2 cut out ready for shipment-curved edge is due to location where wood cribbing was located

FIGURE 2 Samples 16-1 & 16-2 (LS2/CS3) cut out at Halvorsen

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 11 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



Cut ready for removal



Cut out of shell



Part 17 cut out ready for shipment

FIGURE 3 Sample 17 (LS1/CS2) cut out at Halvorsen

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 12 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



Arrows denote the determined rolling direction for each can- the missing areas are where T2, T2C, T-2L mounts were taken and reported on in a previous report

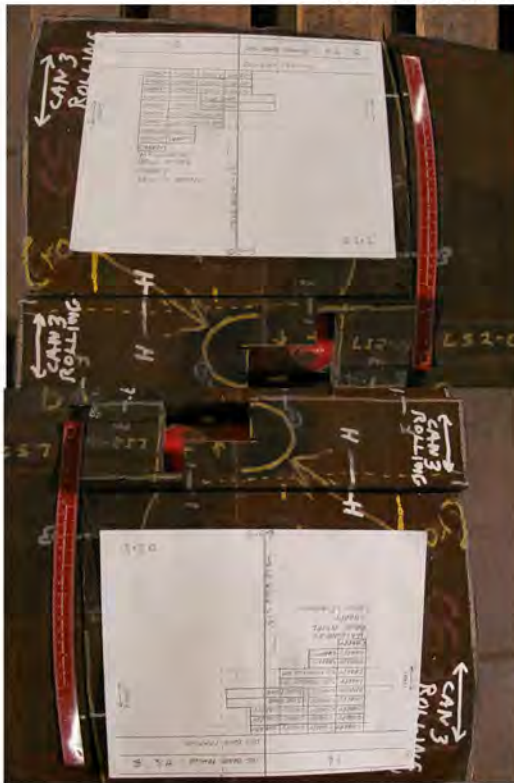


FIGURE 4 Sample 16-2 & 16-2 (LS2/CS3) with possible layout of base metal Charpy and tensile and weld metal Charpy, tensile, and bend tests. All specimens are transverse to plate rolling direction or weld.

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 13 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



Arrows denote the determined rolling direction for each can



17 LS1 weld



17 CS2 weld

FIGURE 5 Sample 17 (LS1/CS2) with possible layout of base metal Charpy and tensile and weld metal Charpy, tensile, and bend tests. All specimens are transverse to plate rolling direction or weld.

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING

PART: 6600-E HEAT EXCHANGER 17 (LS1-CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)

TESORO REFINING AND MARKETING COMPANY
ANACORTES REFINERY
10200 W. MARCH POINT ROAD T91WA4428
ANACORTES, WA 98221

CUSTOMER P.O. NO.: 4501667904

DATE: AUGUST 27, 2010

PAGE 14 OF 54

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

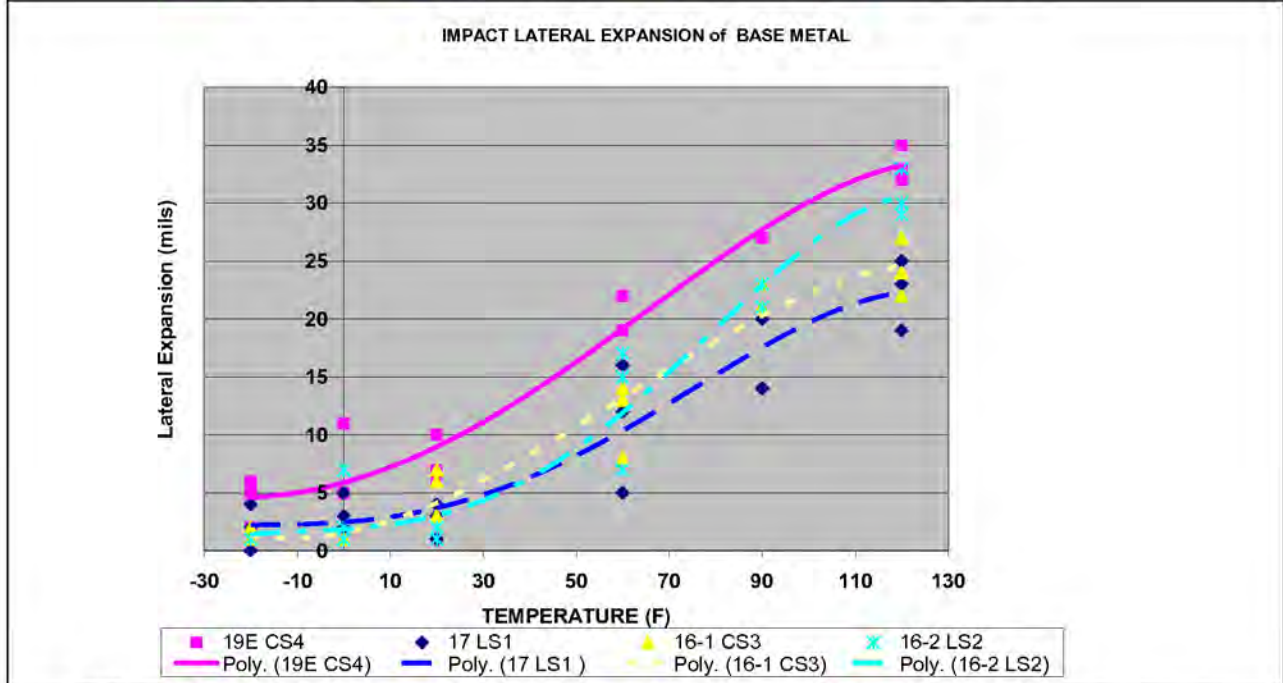
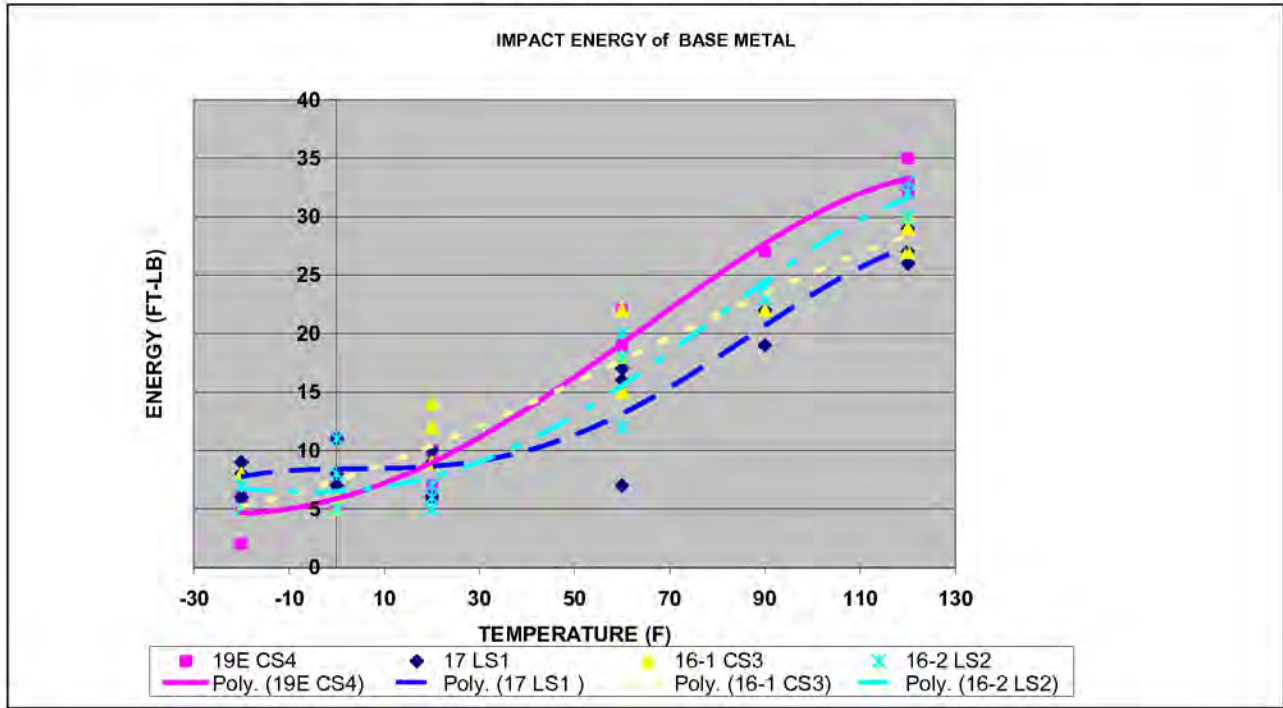
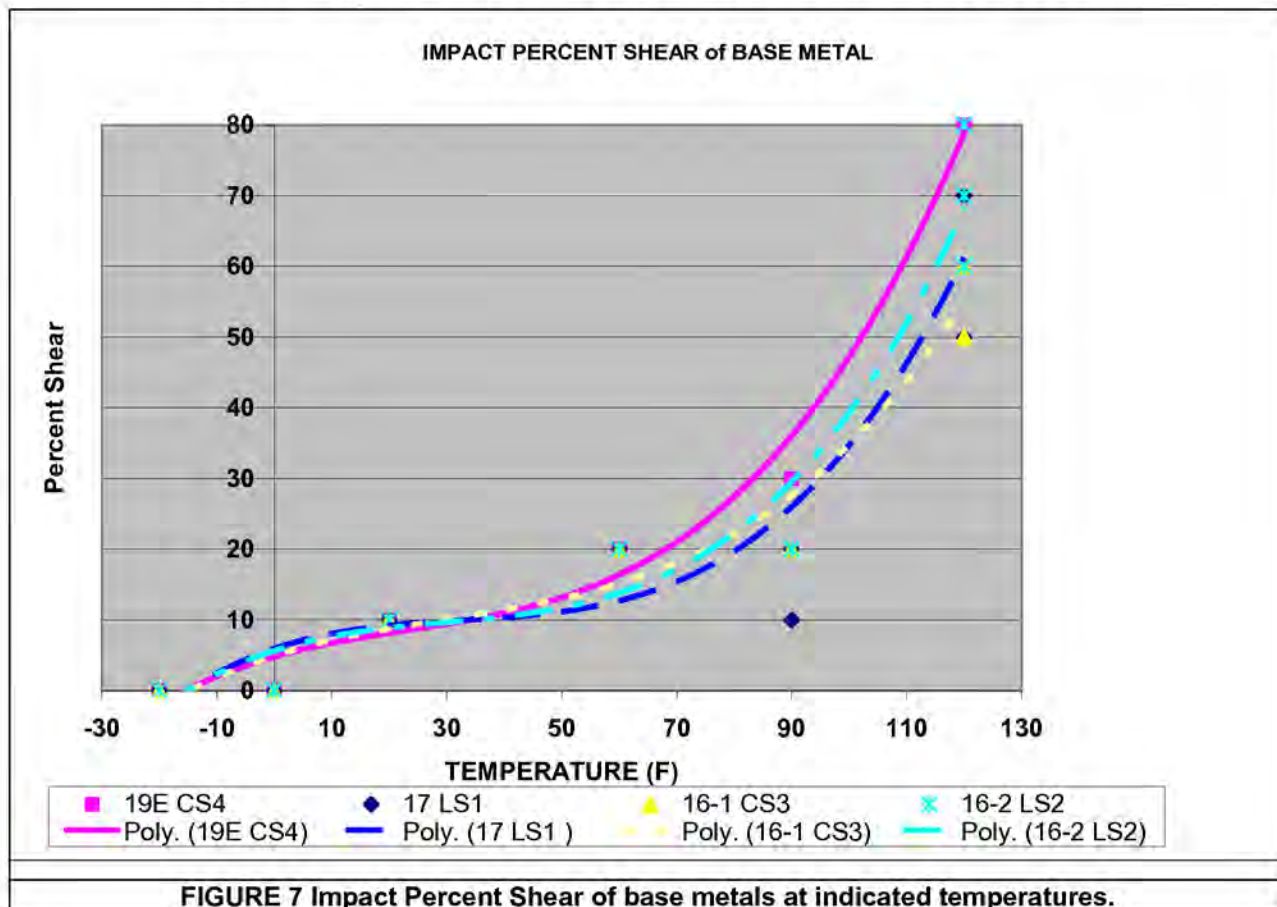


FIGURE 6 Impact Energy and Lateral Expansion of base metals at indicated temperatures.

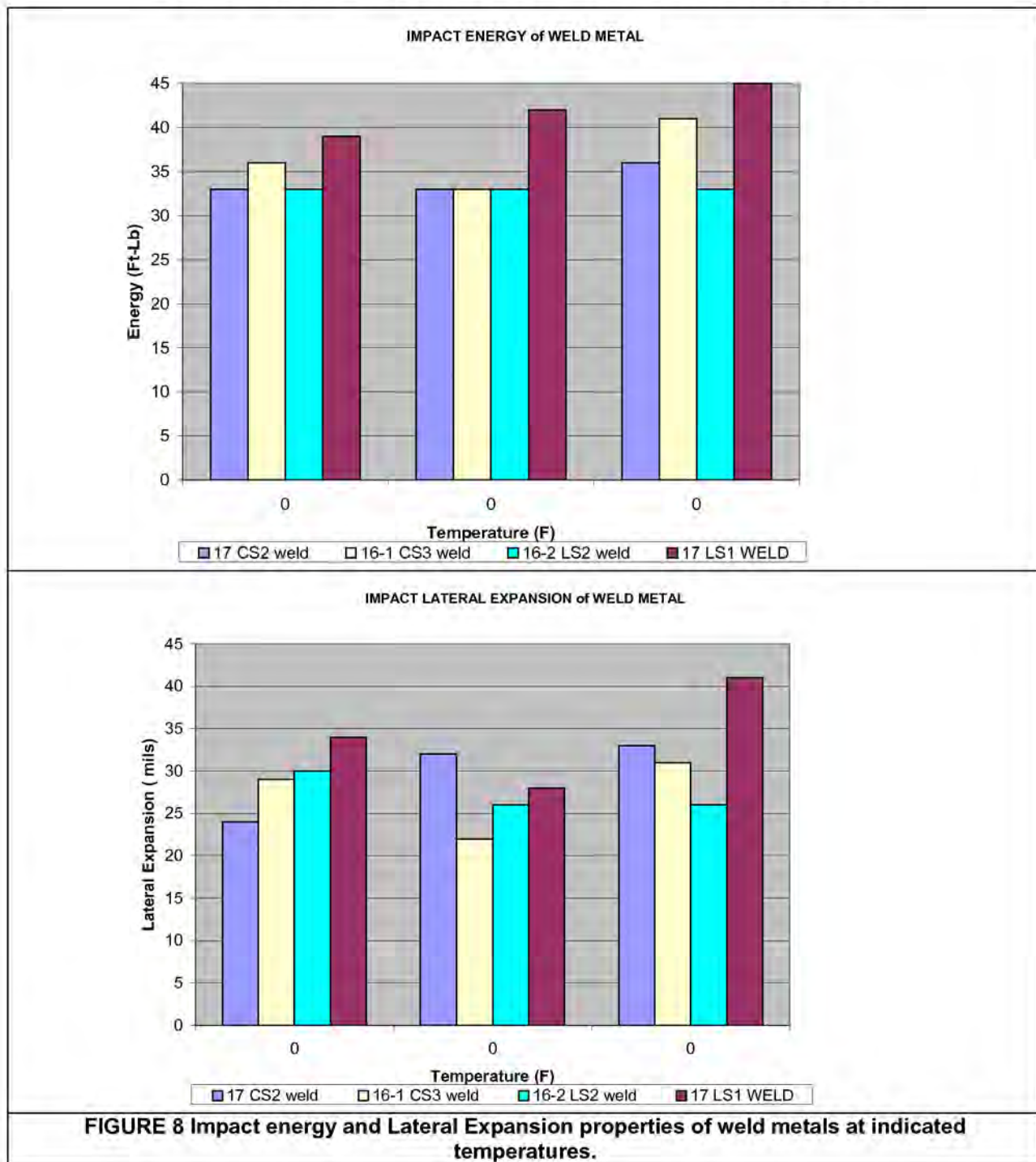
BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
PART: 6600-E HEAT EXCHANGER 17 (LS1-CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 15 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



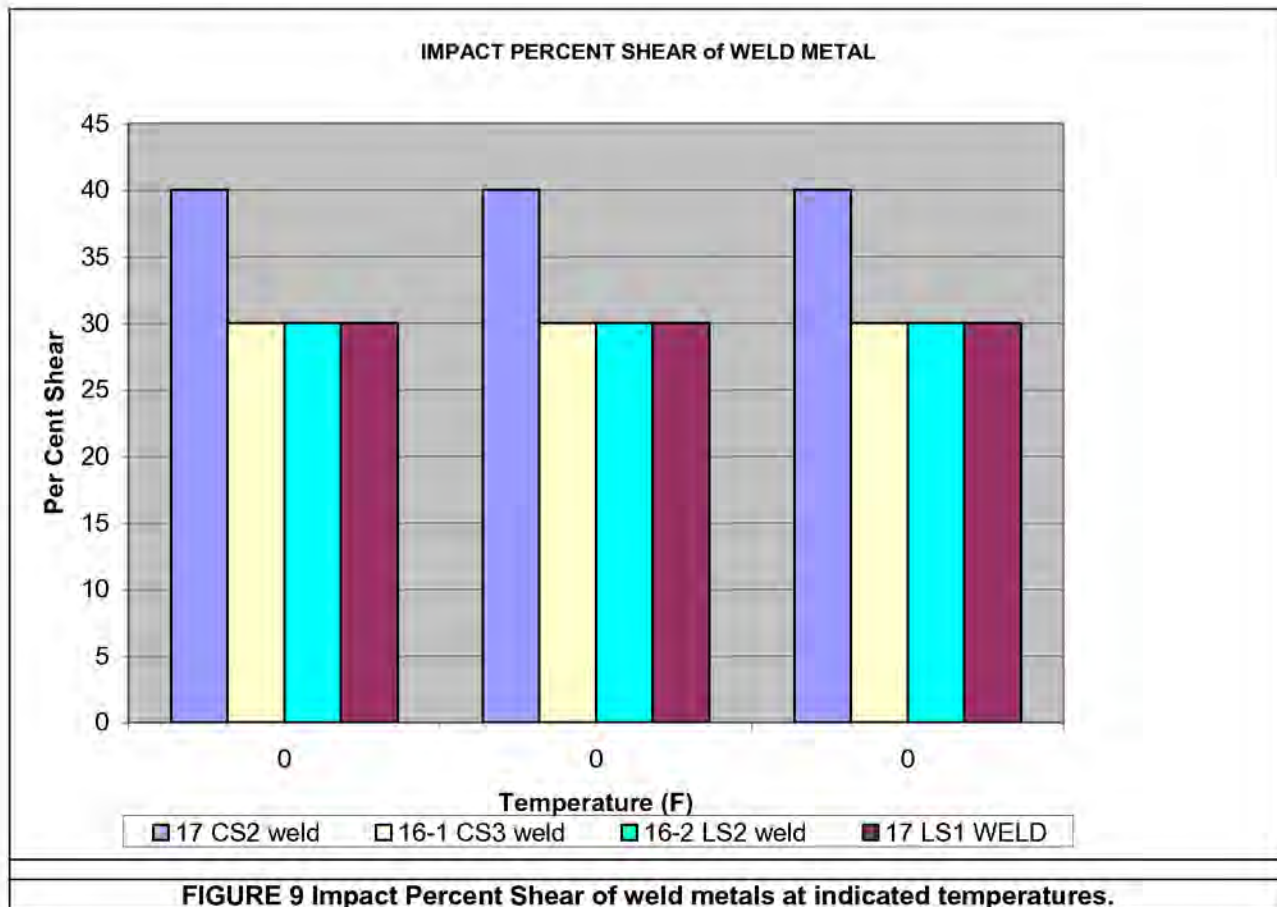
BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
PART: 6600-E HEAT EXCHANGER 17 (LS1-CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 16 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 17 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 18 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

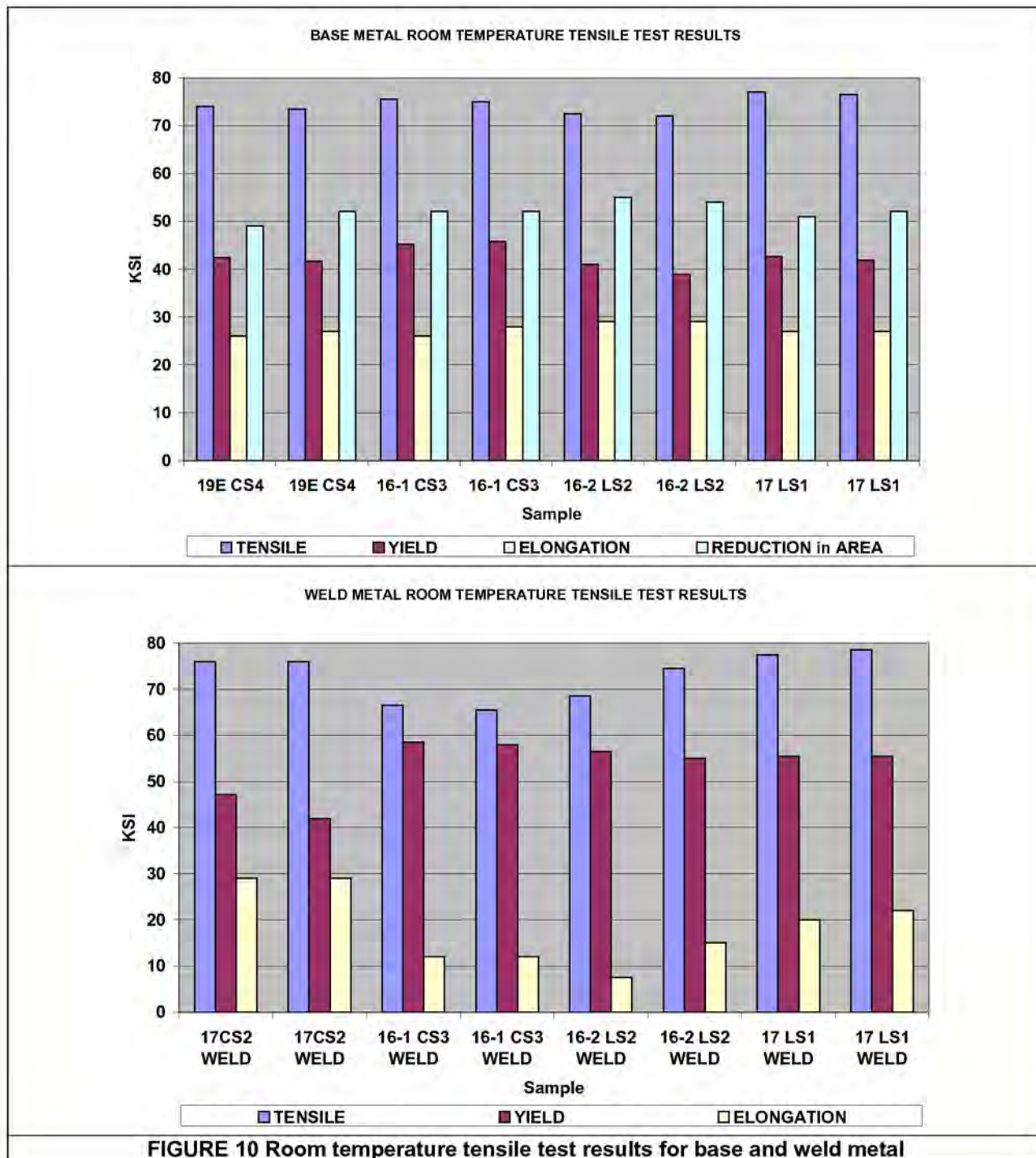


FIGURE 10 Room temperature tensile test results for base and weld metal

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
		PAGE 19 OF 54

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

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 of these 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

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 20 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

Tesoro Exchanger E Failure Examination Protocol

- 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.

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 21 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

Tesoro Exchanger E Failure Examination Protocol

- 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.

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 22 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

Tesoro Exchanger E Failure Examination Protocol

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

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 23 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

Tesoro Exchanger E Failure Examination Protocol

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

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 24 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

Tesoro Exchanger E Failure Examination Protocol

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.

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 25 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

Tesoro Exchanger E Failure Examination Protocol

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.

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 26 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

Tesoro Exchanger E Failure Examination Protocol

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

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 27 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

Tesoro Exchanger E Failure Examination Protocol

- 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


BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 28 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

Tesoro Exchanger E Failure Examination Protocol

- 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

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 29 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

**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 20 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

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 30 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

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.

BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 31 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

**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

 7-6-10
Signature Date

Robert Parker
Compliance Manager
Division of Occupational Safety and Health

 7-6-10
Signature Date

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

 7-6-10
Signature Date

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
		DATE: AUGUST 27, 2010
PART: 6600-E HEAT EXCHANGER 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		PAGE 32 OF 54

LABORATORY REPORT- MECHANICAL PROPERTY TESTING
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	•	BETA 602 BETA 756	B0047	•
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	*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	•	BETA DLC-C-094	NA	NA
Dimensional	Starrett Micrometer S/N 120 A	•	BETA 2005	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

▲ Etchant 5-1 2% Nital

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 34 OF 54		

**LABORATORY REPORT- MECHANICAL PROPERTY TESTING
Attachment 4 TTML Mechanical Test Results**



A DIVISION OF J.T. ADAMS CO., INC.
4520 WILLOW PARKWAY
CLEVELAND, OHIO 44125
PHONE (216) 641-3290
FAX (216) 641-1223
www.tensile.com

CERTIFIED TEST REPORT

First Energy
6670 Beta
Mayfield OH 44143

Amended Copy: 8-20-10
Job No.: B0-210-992
Date: 8-12-10
Cust. PO#: 55102614

Attn: Jeff Blough

Description: 1 Welded Plate Lab# M10198 (NHT E-6600E) Receiving Order# 3271001
ID: 17 CS2 Partial

Temp: Charpy Test Temperature@ 0°F

----- TEST RESULTS -----

<u>Width</u>	<u>Thickness</u>	<u>Area</u>	<u>Tensile, ksi</u>	<u>Yield, .2% ksi</u>	<u>Elong., % in 2"</u>	<u>Type of Failure & Location</u>
0.750	0.847	0.6353	76.0	42.0	29	Ductile/ Base Metal
0.750	0.847	0.6353	76.0	47.1	29	Ductile/ Base Metal

Test Method: ASME Section IX, Weld, Transverse
(Sec Attached Charts)

<u>Item</u>	<u>Charpy, ft-lbs</u>	<u>Lateral Exp. Mils</u>	<u>% Shear</u>
1	33.0	24.0	40
2	33.0	32.0	40
3	<u>36.0</u>	33.0	40
Avg.	34.0		

Test Method: ASTM E23-07ae1, Weld, Transverse

(2) 180° Side Bends

Both Passed

Tracy Waugaman
Authorized Agent



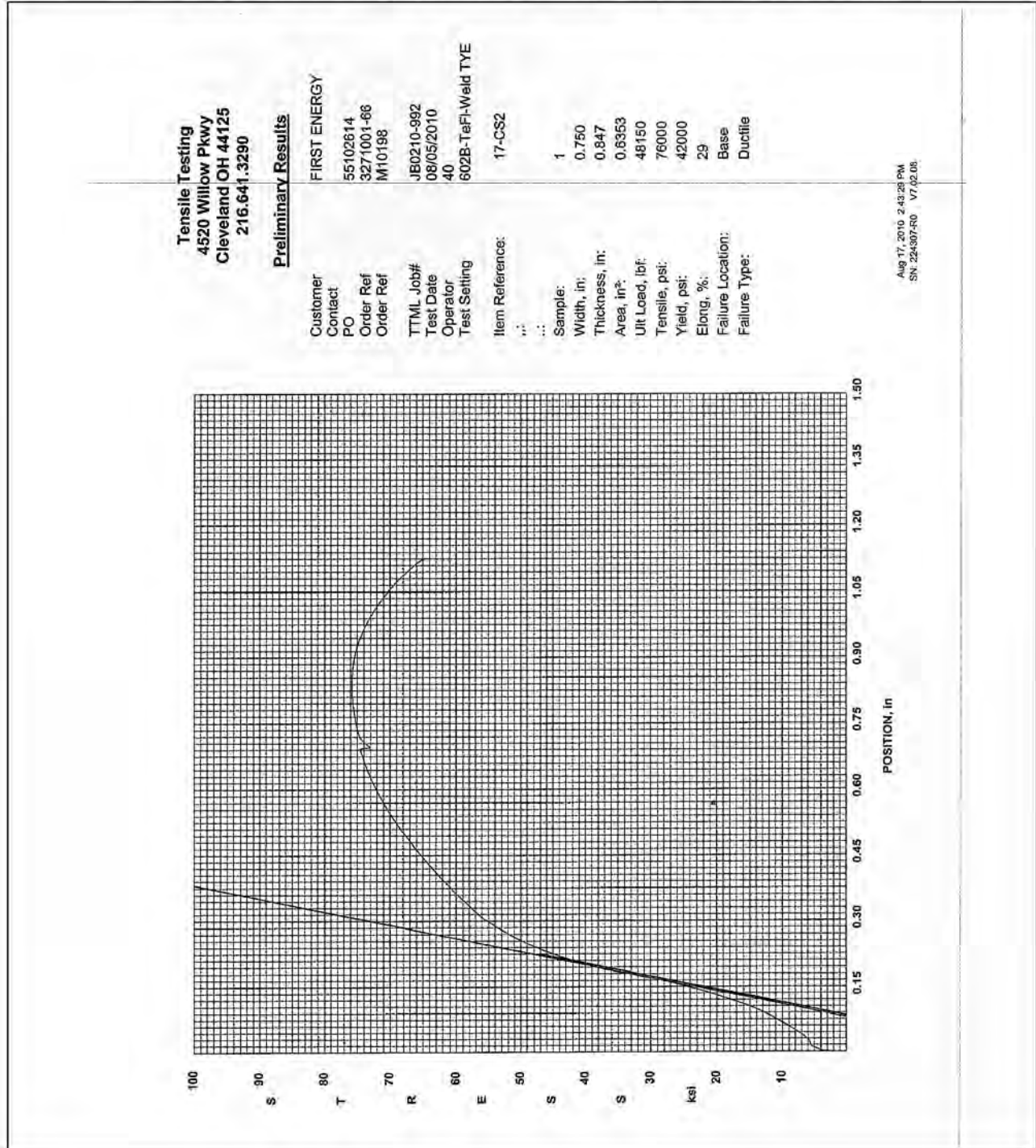
Page 1 of 1

This Report May Not Be Reproduced Except in Full

This report represents Tensile Testing interpretation of the results obtained from the test and is not to be construed as a Guaranty or Warranty of the condition of the materials tested. Tensile Testing shall not be held liable for misinterpretation of conditions, loss, damage, injury or death arising from or attributable to delay preceding a test or subsequent to performance of a test.

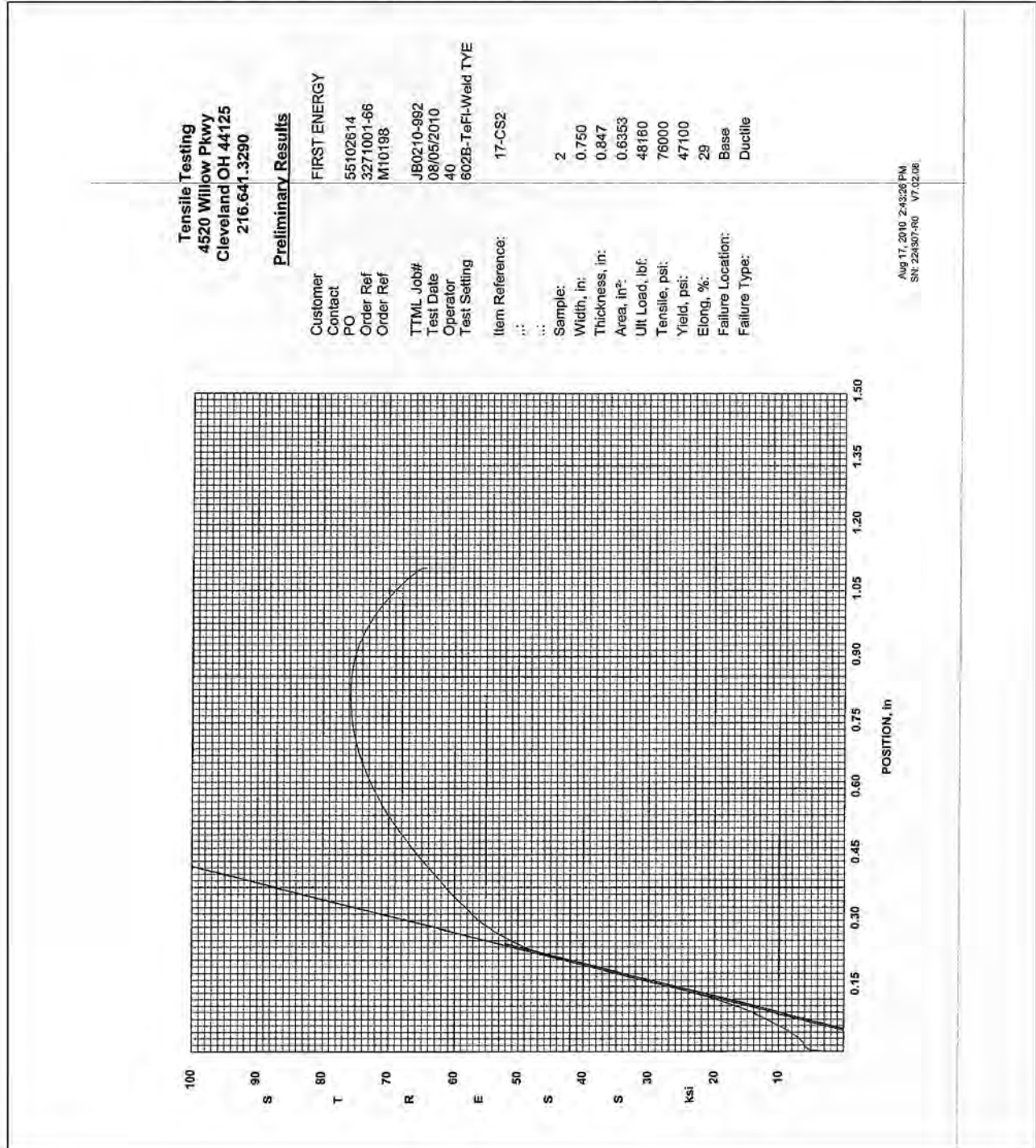
BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
PART: 6600-E HEAT EXCHANGER 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 35 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 36 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO.M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
		DATE: AUGUST 27, 2010
PART: 6600-E HEAT EXCHANGER 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		PAGE 37 OF 54

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



A DIVISION OF J.T. ADAMS CO., INC.
 4520 WILLOW PARKWAY
 CLEVELAND, OHIO 44125
 PHONE (216) 641-3290
 FAX (216) 641-1223
 www.tensile.com

CERTIFIED TEST REPORT

First Energy
 6670 Beta
 Mayfield OH 44143

Amended Copy: 8-20-10
 Job No.: B0-210-993
 Date: 8-12-10
 Cust. PO#: 55102614

Attn: Jeff Blough

Description: I Welded Plate Lab# M10198 (NHT E-6600E) Receiving Order# 3271001
 ID: 17 LS1 Partial

Base Metal Spec: ASTM A515-03 Gr. 70

TEST RESULTS

<u>Dia.</u>	<u>Tensile, ksi</u>	<u>Yield, .2% ksi</u>	<u>Elong., % in 4D</u>	<u>Red. Of Area, %</u>
Requirements (Min.):	70-90	38	21	—
.502"	77.0	42.6	27	51
.502"	76.5	41.9	27	52

Test Method: ASTM A370-09a, Base Metal, Transverse

<u>Width</u>	<u>Thickness</u>	<u>Area</u>	<u>Tensile, ksi</u>	<u>Yield, .2% ksi</u>	<u>Elong., % in 2"</u>	<u>Type of Failure & Location</u>
0.750	0.879	0.6593	77.5	55.5	20	Ductile/ Base Metal
0.752	0.872	0.6557	78.5	54.0	22	Ductile/ Base Metal

Test Method: ASME Section IX, Weld, Transverse

(See attached charts)



BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 38 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



A DIVISION OF J.T. ADAMS CO., INC.
4520 WILLOW PARKWAY
CLEVELAND, OHIO 44125
PHONE (216) 641-3290
FAX (216) 641-1223
www.tensile.com

CERTIFIED TEST REPORT

Job No.: B0-210-993

<u>Base Metal</u>						
<u>Temp.</u>	<u>Item</u>	<u>Charpy, ft-lbs</u>	<u>Lateral Exp. Mils</u>	<u>% Shear</u>	<u>Avg. ft-lbs</u>	
+120°F	1	26.0	19.0	50	27.3	
	2	29.0	25.0	70		
	3	27.0	23.0	70		
+90°F	1	22.0	20.0	20	20.5	
	2	19.0	14.0	10		
+60°F	1	16.0	12.0	20	13.3	
	2	17.0	16.0	20		
	3	7.0	5.0	20		
+20°F	1	9.0	1.0	10	8.3	
	2	6.0	4.0	10		
	3	10.0	3.0	10		
0°F	1	8.0	3.0	0	8.7	
	2	11.0	5.0	0		
	3	7.0	2.0	0		
-20°F	1	6.0	0	0	7.7	
	2	9.0	4.0	0		
	3	8.0	2.0	0		
<u>Weld</u>						
0°F	1	39.0	34.0	30	42.0	
	2	42.0	28.0	30		
	3	45.0	41.0	30		

Test Method: ASTM E23-07a¹

(2) 180° Side Bends

Both Passed

Tracy J. Kuyperman
Authorized Agent



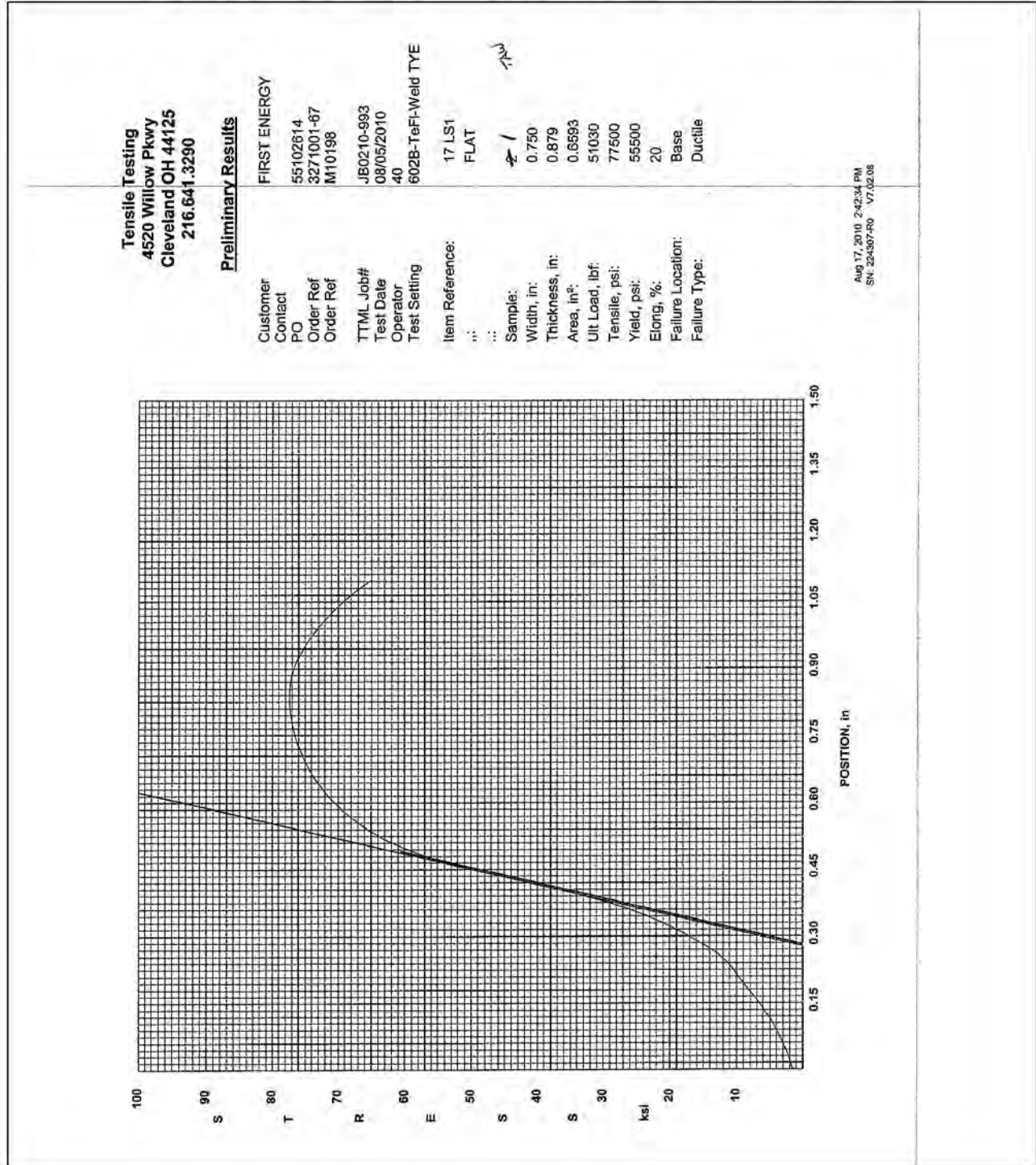
Page 2 of 2

This Report May Not Be Reproduced Except In Full

This report represents Tensile Testing interpretation of the results obtained from the test and is not to be construed as a Guaranty or Warranty of the condition of the materials tested. Tensile Testing shall not be held liable for misinterpretation of conditions, loss, damage, injury or death arising from or attributable to delay preceding a test or subsequent to performance of a test.

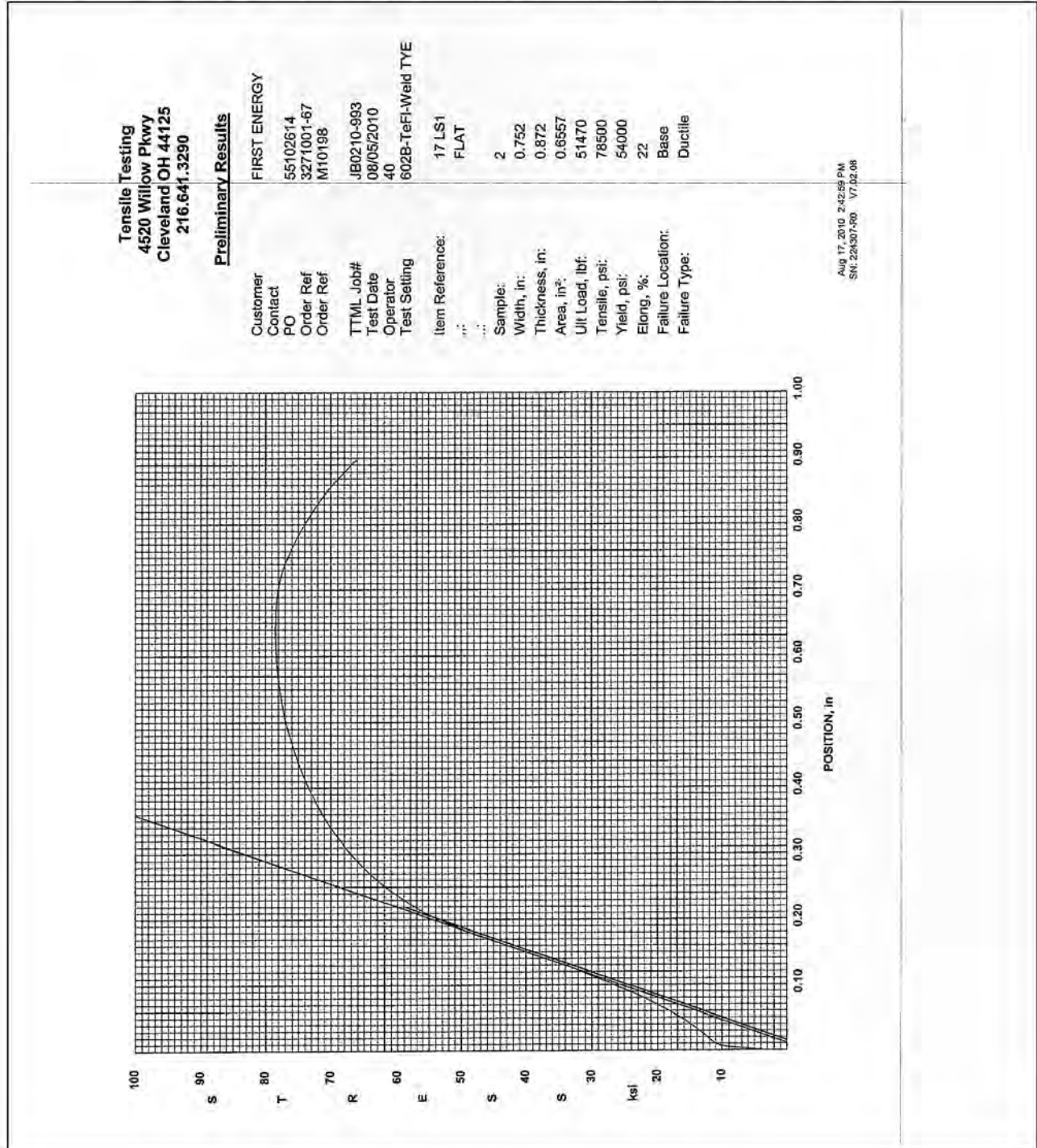
BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
PART: 6600-E HEAT EXCHANGER 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 39 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



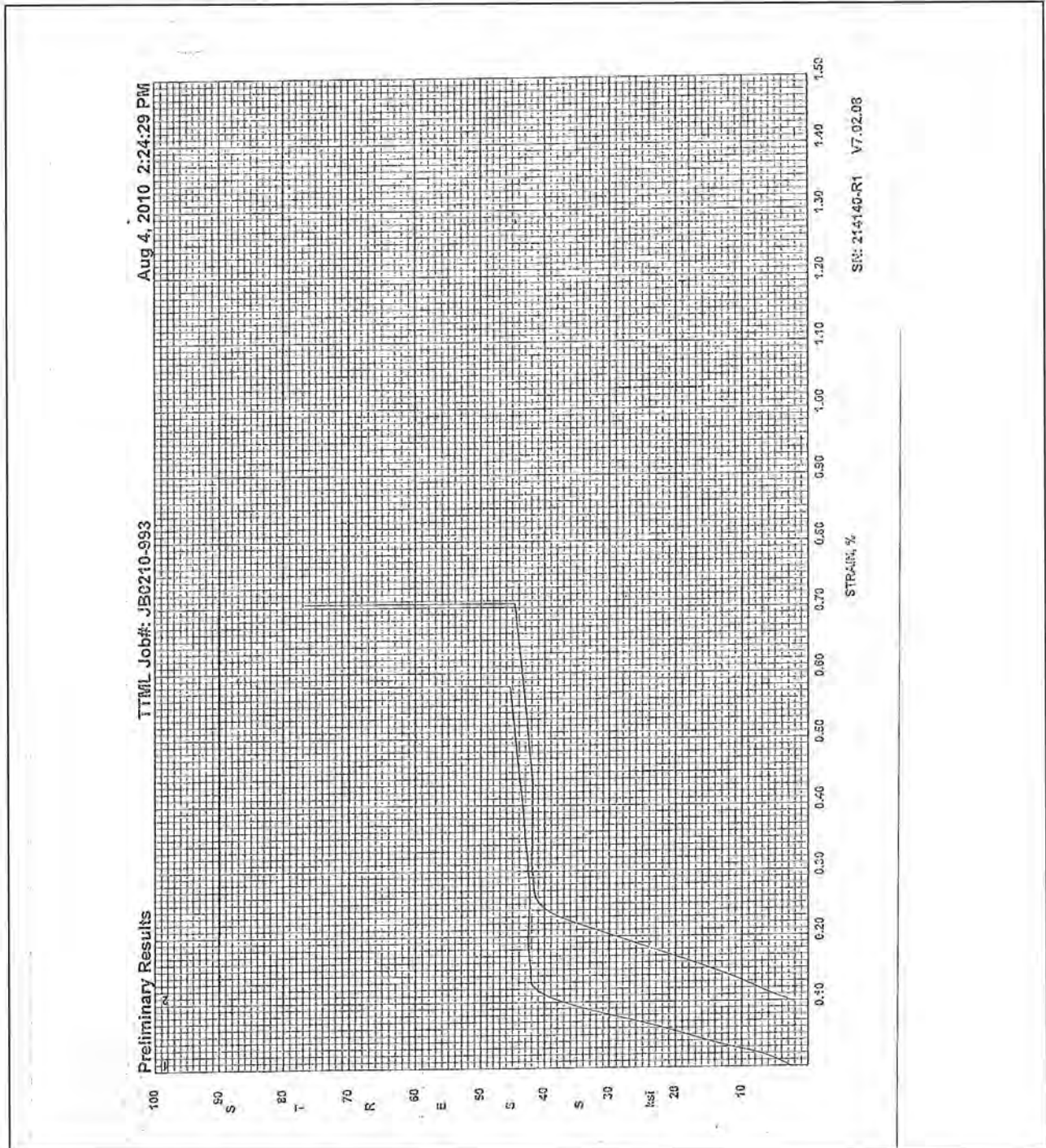
BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
PART: 6600-E HEAT EXCHANGER 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 40 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 41 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 42 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



A DIVISION OF J.T. ADAMS CO., INC.
4520 WILLOW PARKWAY
CLEVELAND, OHIO 44125
PHONE (216) 641-3290
FAX (216) 641-1223
www.tensile.com

CERTIFIED TEST REPORT

First Energy
6670 Beta
Mayfield OH 44143

Amended Copy: 8-20-10
Job No.: B0-210-977
Date: 8-11-10
Cust. PO#: 55102614

Attn: Jeff Blough

Description: 1 Welded Plate Lab# M10198 (NHT E-6600E) Receiving Order# 3271001
ID: 16-2 LS2 Partial

Base Metal Spec: ASTM A515-03 Gr. 70

TEST RESULTS

<u>Dia.</u>	<u>Tensile, ksi</u>	<u>Yield, .2% ksi</u>	<u>Elong., % in 4D</u>	<u>Red. Of Area, %</u>
Requirements (Min.):	70-90	38	21	—
.503"	72.5	41.0	29	55
.496"	72.0	38.9	29	54

Test Method: ASTM A370-09a, Base Metal, Transverse

<u>Width</u>	<u>Thickness</u>	<u>Area</u>	<u>Tensile, ksi</u>	<u>Yield, .2% ksi</u>	<u>Elong., % in 2"</u>	<u>Type of Failure & Location</u>
0.753	0.839	0.6318	68.5	56.5	7.5	Ductile/ Weld
0.749	0.860	0.6441	74.5	55.0	15	Ductile/ HAZ

Test Method: ASME Section IX, Weld, Transverse

(See attached charts)



Page 1 of 2

This Report May Not Be Reproduced Except In Full

This report represents Tensile Testing interpretation of the results obtained from the test and is not to be construed as a Guaranty or Warranty of the condition of the materials tested. Tensile Testing shall not be held liable for misinterpretation of conditions, loss, damage, injury or death arising from or attributable to delay preceding a test or subsequent to performance of a test.

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 43 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



A DIVISION OF J.T. ADAMS CO., INC.
4520 WILLOW PARKWAY
CLEVELAND, OHIO 44125
PHONE (216) 641-3290
FAX (216) 641-1223
www.tensile.com

CERTIFIED TEST REPORT

Job No.: B0-210-977

<u>Base Metal</u>					
<u>Temp.</u>	<u>Item</u>	<u>Charpy, ft-lbs</u>	<u>Lateral Exp. Mils</u>	<u>% Shear</u>	<u>Avg. ft-lbs</u>
+120°F	1	33.0	29.0	70	31.7
	2	30.0	30.0	60	
	3	32.0	33.0	80	
+90°F	1	23.0	21.0	20	23.5
	2	24.0	23.0	20	
+60°F	1	20.0	17.0	20	16.7
	2	18.0	15.0	20	
	3	12.0	7.0	20	
+20°F	1	6.0	1.0	10	6.0
	2	5.0	1.0	10	
	3	7.0	2.0	10	
0°F	1	11.0	7.0	0	8.0
	2	5.0	2.0	0	
	3	8.0	1.0	0	
-20°F	1	7.0	1.0	0	6.3
	2	7.0	1.0	0	
	3	5.0	1.0	0	
<u>Weld</u>					
0°F	1	33.0	30.0	30	33.7
	2	33.0	26.0	30	
	3	35.0	26.0	30	

Test Method: ASTM E23-07ae1

(2) 180° Side Bends

Both Passed

Tracy Wargaman
Authorized Agent



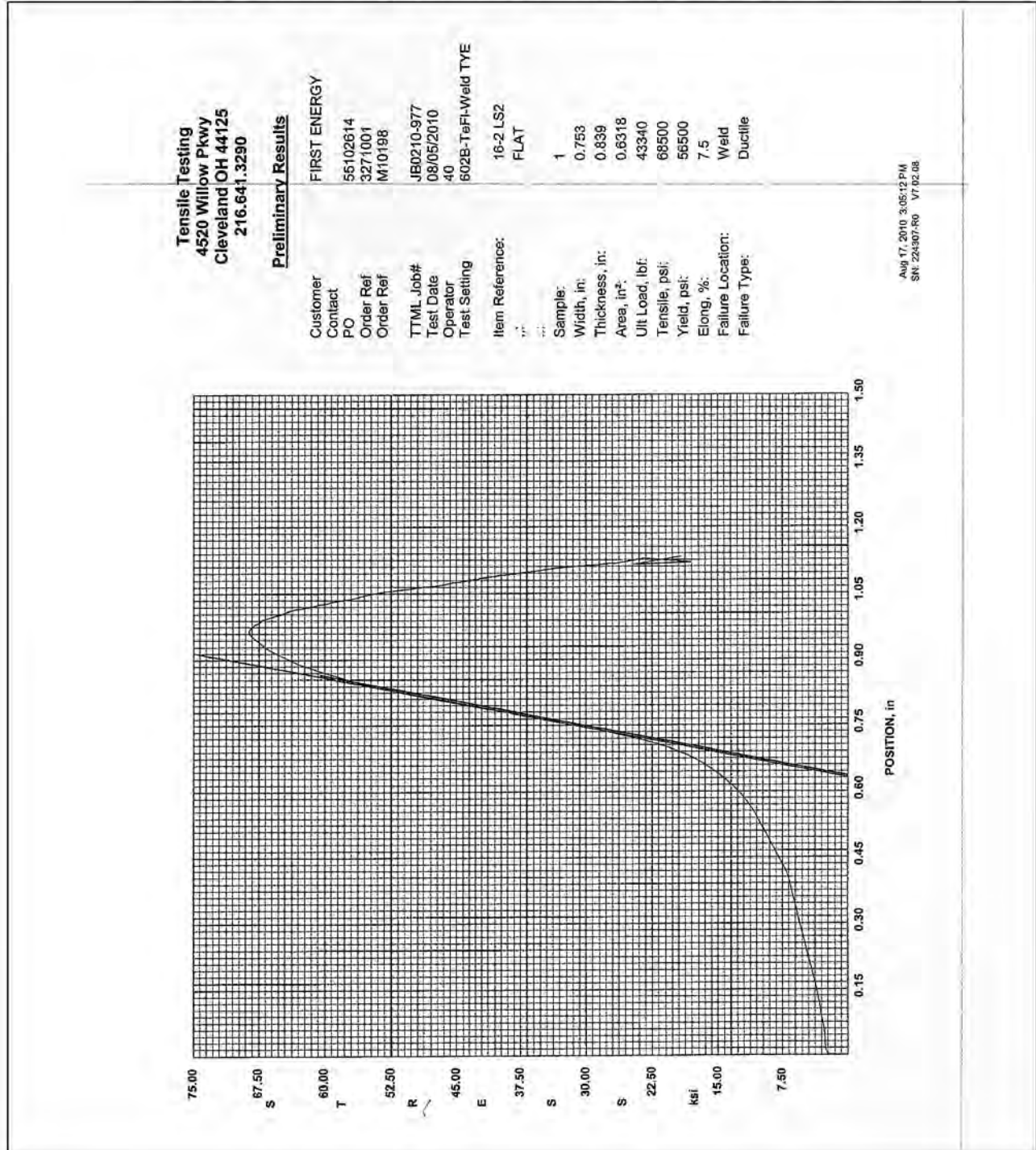
Page 2 of 2

This Report May Not Be Reproduced Except In Full

This report represents Tensile Testing interpretation of the results obtained from the test and is not to be construed as a Guaranty or Warranty of the condition of the materials tested. Tensile Testing shall not be held liable for misinterpretation of conditions, loss, damage, injury or death arising from or attributable to delay preceding a test or subsequent to performance of a test.

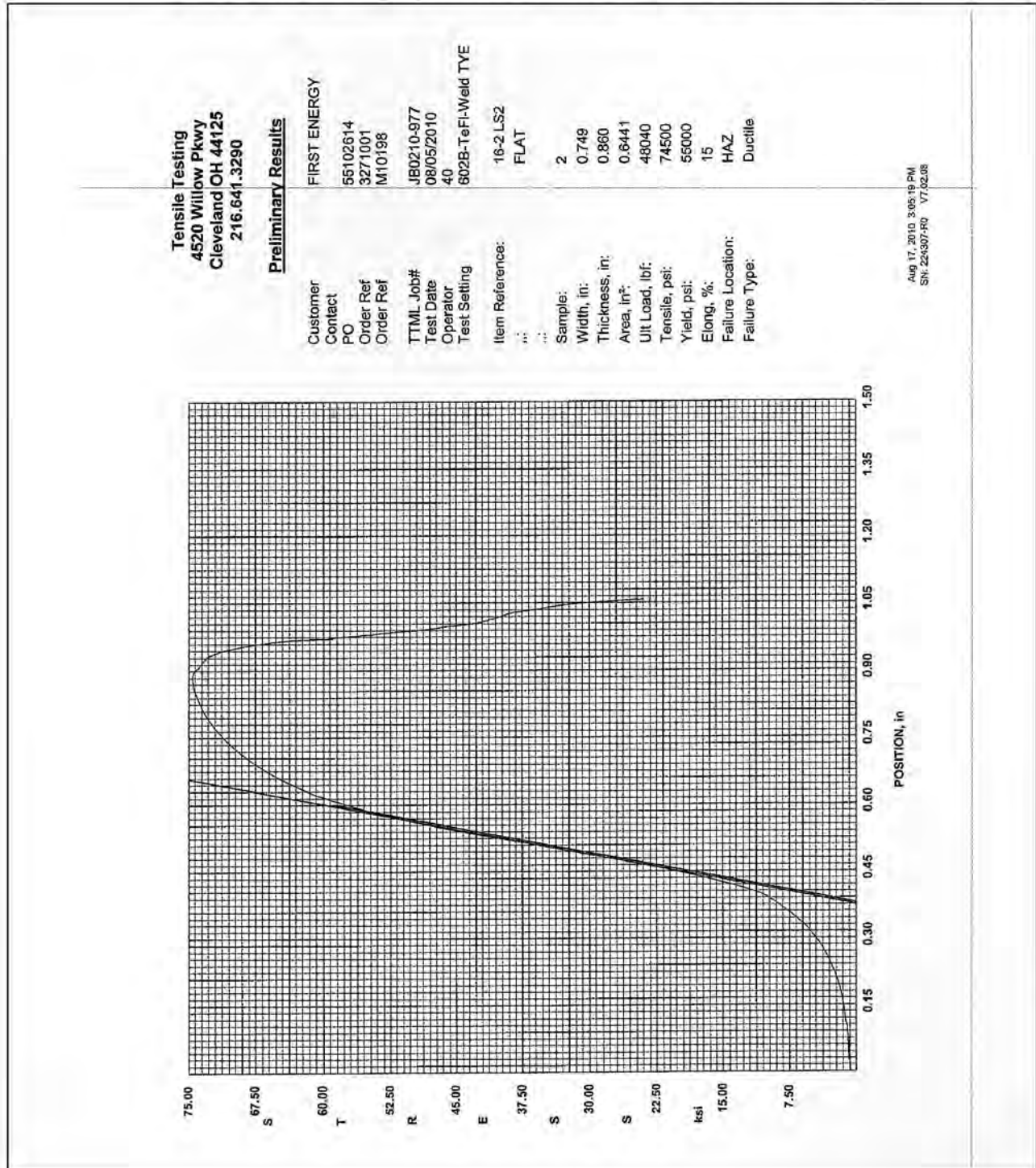
BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
PART: 6600-E HEAT EXCHANGER 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 44 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



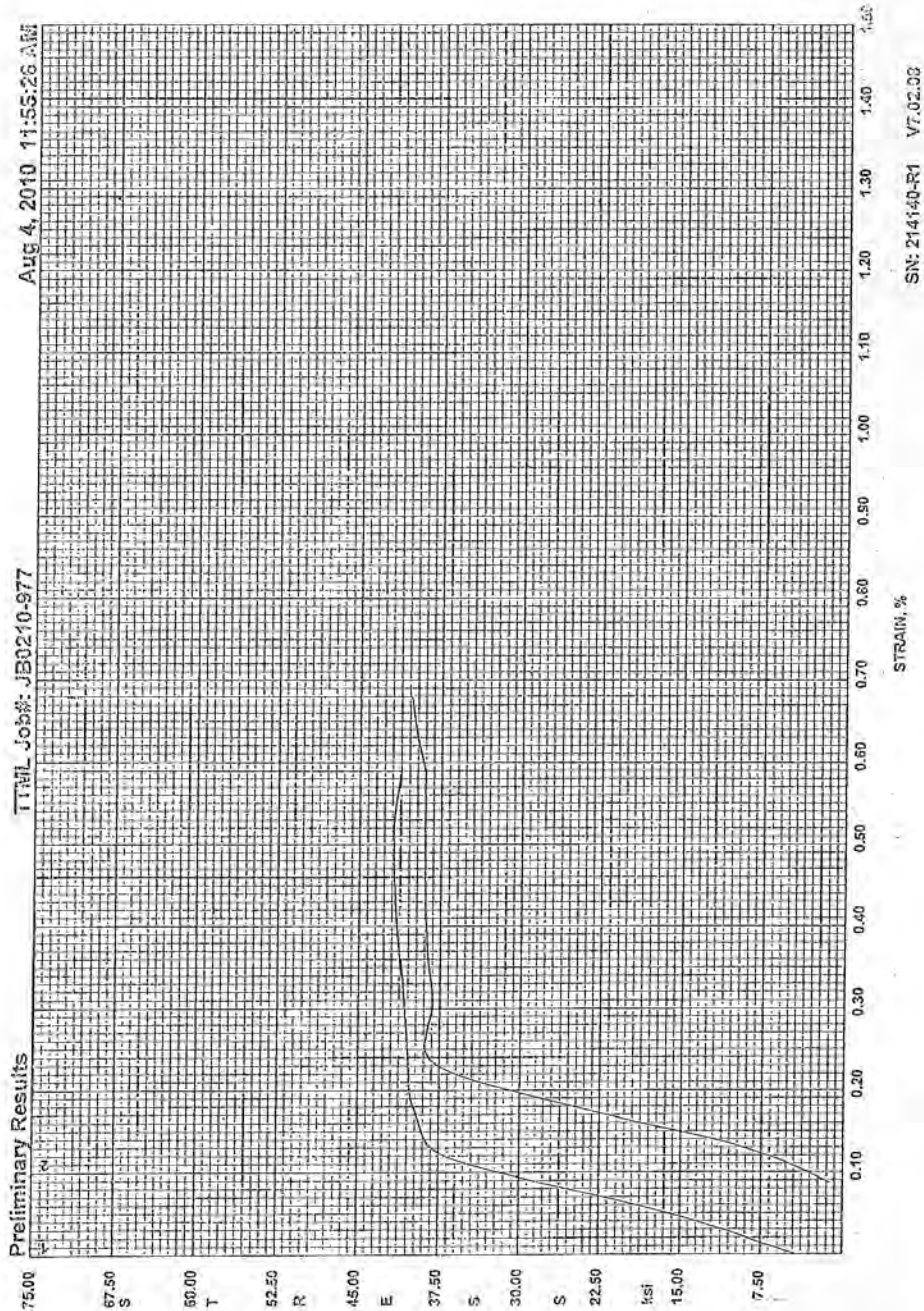
BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
PART: 6600-E HEAT EXCHANGER 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 45 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 46 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 47 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



A DIVISION OF J.T. ADAMS CO., INC.
4520 WILLOW PARKWAY
CLEVELAND, OHIO 44125
PHONE (216) 641-3290
FAX (216) 641-1223
www.tensile.com

CERTIFIED TEST REPORT

First Energy
6670 Beta
Mayfield OH 44143

Amended Copy: 8-20-10
Job No.: B0-210-978
Date: 8-12-10
Cust. PO#: 55102614

Attn: Jeff Blough

Description: 1 Welded Plate Lab# M10198 (NHT E-6600E) Receiving Order# 3271001
ID: 16-1 CS3 Partial

Base Metal Spec: ASTM A515-03 Gr. 70

TEST RESULTS

<u>Dia.</u>	<u>Tensile, ksi</u>	<u>Yield, .2% ksi</u>	<u>Elong., % in 4D</u>	<u>Red. Of Area, %</u>
Requirements (Min.):	70-90	38	21	—
.503"	75.5	45.2	26	52
.502"	75.0	45.7	28	52

Test Method: ASTM A370-09a, Base Metal, Transverse

<u>Width</u>	<u>Thickness</u>	<u>Area</u>	<u>Tensile, ksi</u>	<u>Yield, .2% ksi</u>	<u>Elong., % in 2"</u>	<u>Type of Failure & Location</u>
0.751	0.850	0.6384	65.5	58.0	12	Ductile/ Weld
0.751	0.850	0.6384	66.5	58.5	12	Ductile/ Weld

Test Method: ASME Section IX, Weld, Transverse

(See attached charts)



Page 1 of 2

This Report May Not Be Reproduced Except In Full

This report represents Tensile Testing interpretation of the results obtained from the test and is not to be construed as a Guaranty or Warranty of the condition of the materials tested. Tensile Testing shall not be held liable for misinterpretation of conditions, loss, damage, injury or death arising from or attributable to delay preceding a test or subsequent to performance of a test.

BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 48 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



A DIVISION OF J.T. ADAMS CO., INC.
4520 WILLOW PARKWAY
CLEVELAND, OHIO 44125
PHONE (216) 641-3290
FAX (216) 641-1223
www.tensile.com

CERTIFIED TEST REPORT

Job No.: B0-210-978

<u>Base Metal</u>						
<u>Temp.</u>	<u>Item</u>	<u>Charpy, ft-lbs</u>	<u>Lateral Exp. Mils</u>	<u>% Shear</u>	<u>Avg. ft-lbs</u>	
+120°F	1	30.0	27.0	60	28.7	
	2	27.0	22.0	50		
	3	29.0	24.0	60		
+90°F	1	22.0	23.0	20	22.0	
	2	22.0	21.0	20		
+60°F	1	22.0	14.0	20	18.3	
	2	18.0	13.0	20		
	3	15.0	8.0	20		
+20°F	1	14.0	7.0	10	11.7	
	2	9.0	3.0	10		
	3	12.0	6.0	10		
0°F	1	5.0	1.0	0	5.3	
	2	5.0	1.0	0		
	3	6.0	1.0	0		
-20°F	1	8.0	1.0	0	6.0	
	2	5.0	1.0	0		
	3	5.0	2.0	0		
<u>Weld</u>						
0°F	1	36.0	29.0	30	36.7	
	2	33.0	22.0	30		
	3	41.0	31.0	30		

Test Method: ASTM E23-07a¹

(2) 180° Side Bends

Both failed (cracks >1/8" at 90°)

Tracy Waugaman
Authorized Agent



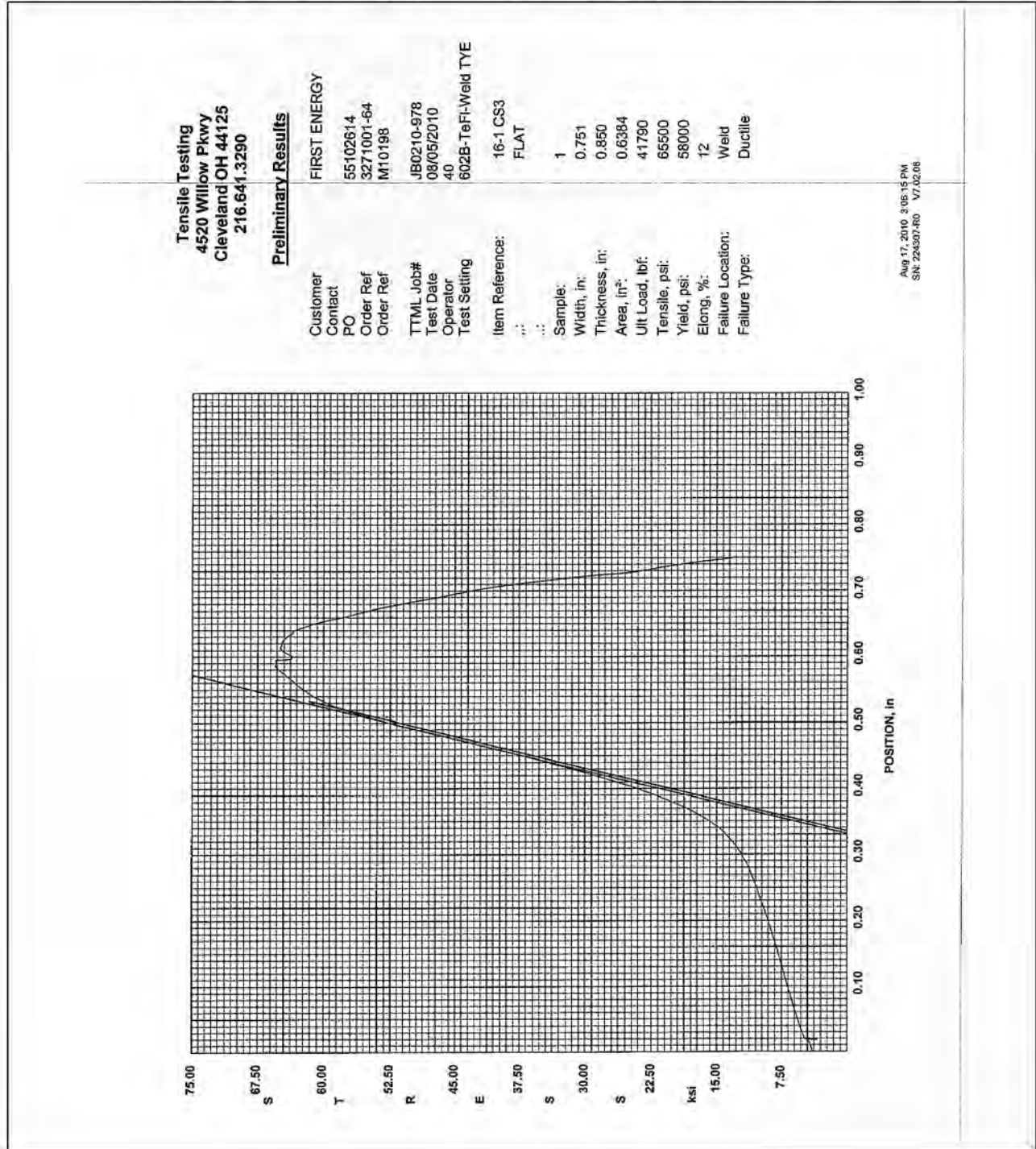
Page 2 of 2

This Report May Not Be Reproduced Except In Full

This report represents Tensile Testing interpretation of the results obtained from the test and is not to be construed as a Warranty or Warranty of the condition of the materials tested. Tensile Testing shall not be held liable for misinterpretation of conditions, loss, damage, injury or death arising from or attributable to delay preceding a test or subsequent to performance of a test.

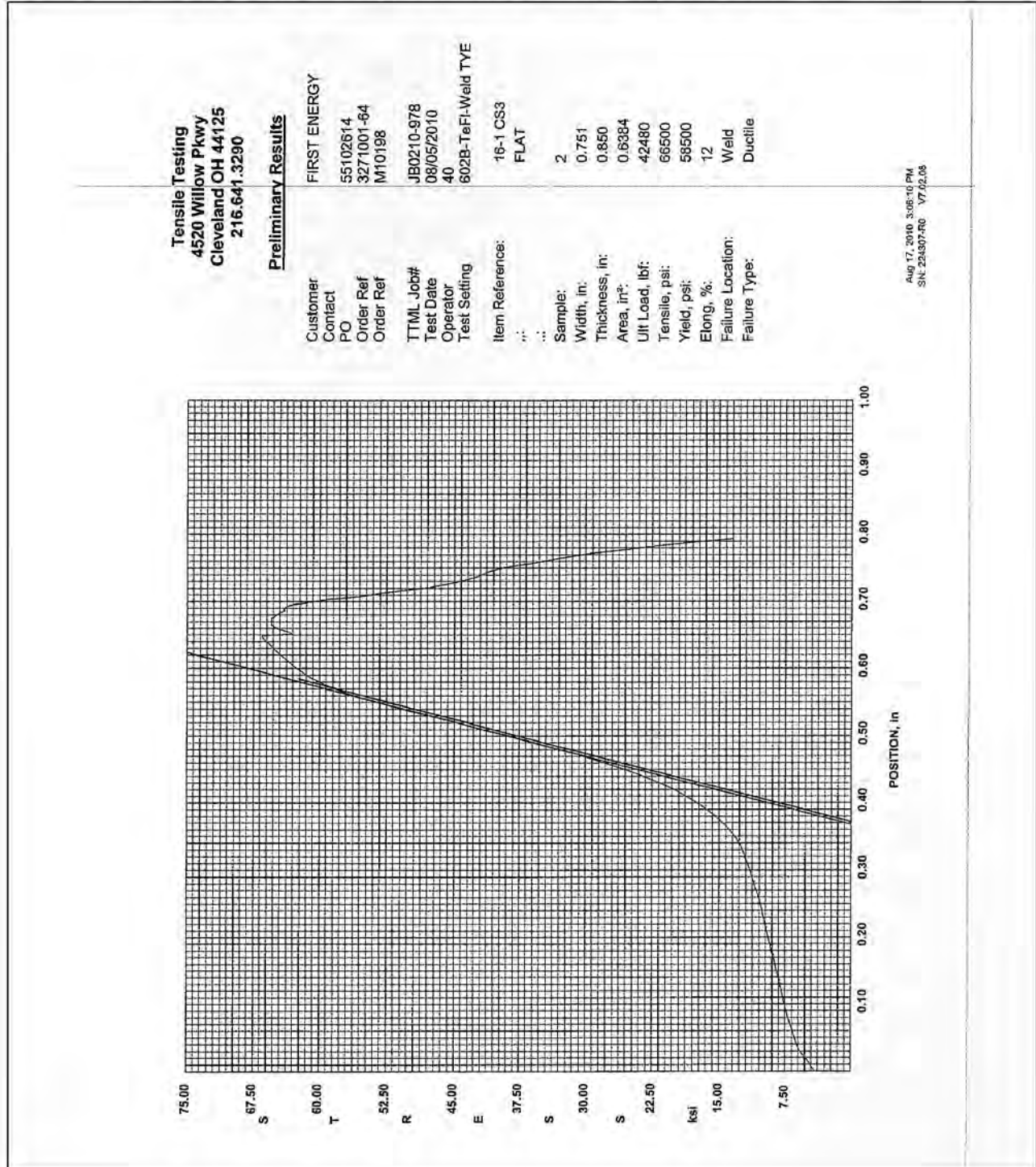
BETA LAB No.M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
PART: 6600-E HEAT EXCHANGER 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 49 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



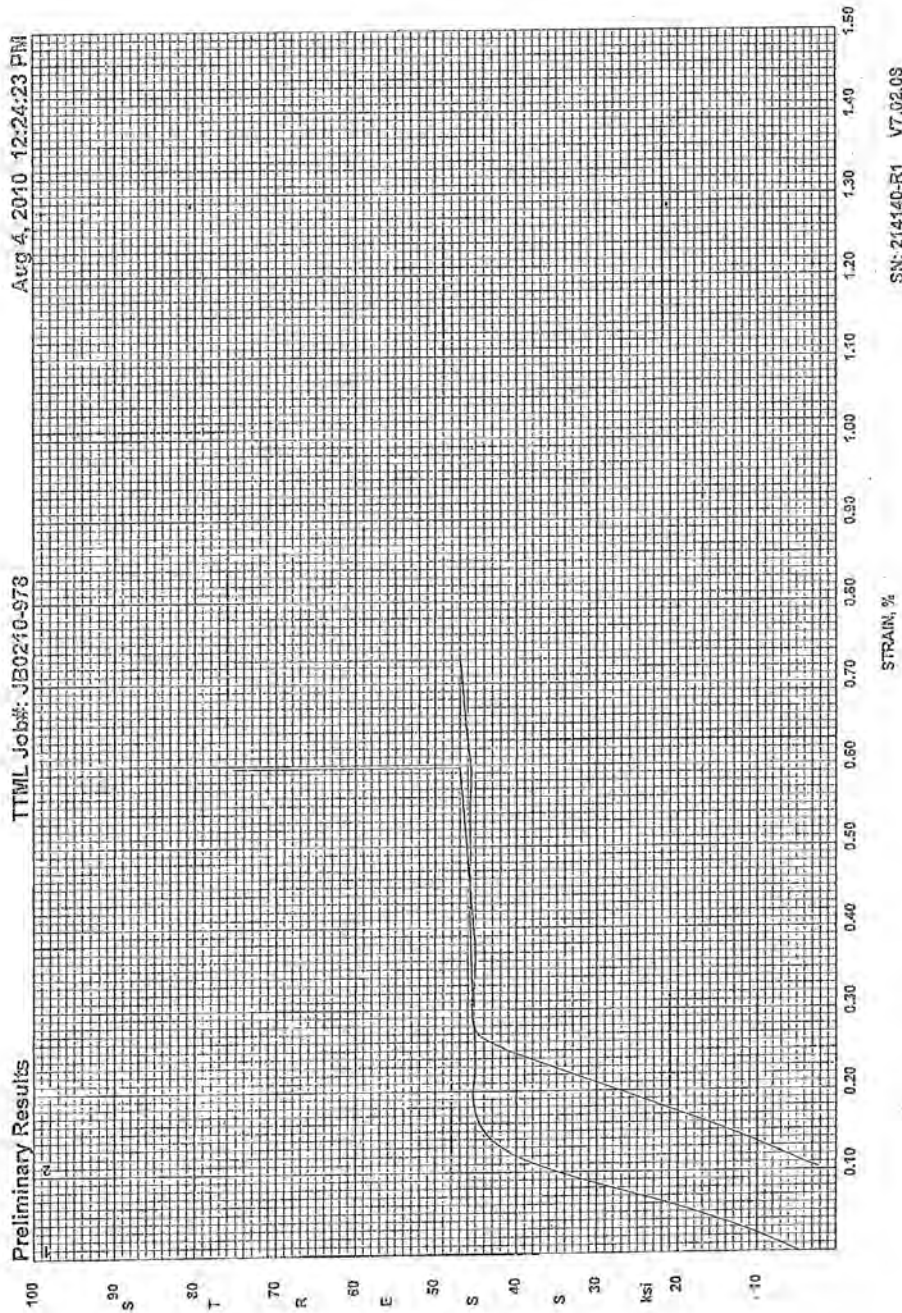
BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	TESORO REFINING AND MARKETING COMPANY ANACORTES REFINERY 10200 W. MARCH POINT ROAD T91WA4428 ANACORTES, WA 98221	CUSTOMER P.O. NO.: 4501667904
PART: 6600-E HEAT EXCHANGER 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 50 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 51 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 52 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



A DIVISION OF J.T. ADAMS CO., INC.
4520 WILLOW PARKWAY
CLEVELAND, OHIO 44125
PHONE (216) 641-3290
FAX (216) 641-1223
www.tensile.com

CERTIFIED TEST REPORT

First Energy
6670 Beta
Mayfield OH 44143

Amended Copy: 8-20-10
Job No.: B0-210-979
Date: 8-12-10
Cust. PO#: 55102614

Attn: Jeff Blough

Description: 1 Plate Lab# M10198 (NHT E-6600E) Receiving Order# 3271001 ID: 19E CS4 Partial
Base Metal Spec: ASTM A515-03 Gr. 70

TEST RESULTS

<u>Dia.</u>	<u>Tensile, ksi</u>	<u>Yield, .2% ksi</u>	<u>Elong., % in 4D</u>	<u>Red. Of Area, %</u>
Requirements (Min.):	70-90	38	21	—
.504"	74.0	42.4	26	49
.498"	73.5	41.6	27	52

Test Method: ASTM A370-09a, Base Metal, Transverse (See attached charts)

<u>Temp.</u>	<u>Item</u>	<u>Charpy, ft-lbs</u>	<u>Lateral Exp. Mils</u>	<u>% Shear</u>	<u>Avg. ft-lbs</u>
+120°F	1	33.0	31.0	80	33.0
	2	32.0	27.0	80	
	3	35.0	30.0	80	
+90°F	1	27.0	26.0	30	27.0
	2	27.0	28.0	30	
+60°F	1	19.0	13.0	20	20.0
	2	19.0	15.0	20	
	3	22.0	14.0	20	
+20°F	1	10.0	5.0	10	8.0
	2	7.0	2.0	10	
	3	6.0	2.0	10	
0°F	1	5.0	1.0	0	7.0
	2	5.0	0	0	
	3	11.0	5.0	0	
-20°F	1	5.0	0	0	5.0
	2	4.0	0	0	
	3	6.0	1.0	0	

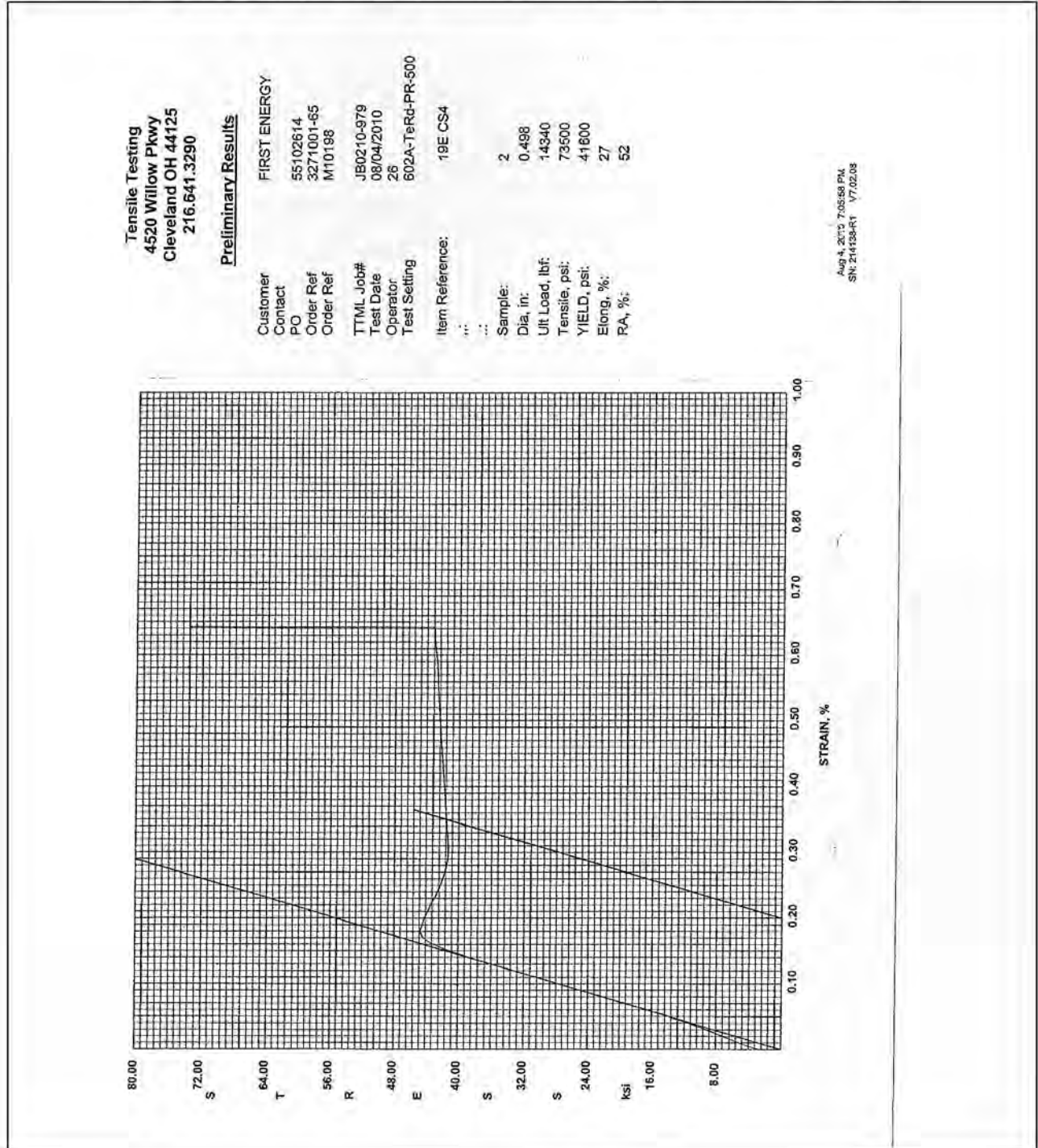
Test Method: ASTM E23-07a1, Base Metal, Transverse

Tracy Whigham
Authorized Agent



BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1- CS2), 16-1 & 2 (LS2- CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 53 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING



BETA LAB NO. M10198- MECHANICAL PROPERTY TESTING	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 17 (LS1-CS2), 16-1 & 2 (LS2-CS3) AND 19 (CS4)		DATE: AUGUST 27, 2010
PAGE 54 OF 54		

LABORATORY REPORT- MECHANICAL PROPERTY TESTING

