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Qualification of Submerged Arc Welding Consumables and Procedures to ABS Rules

Darren Begg

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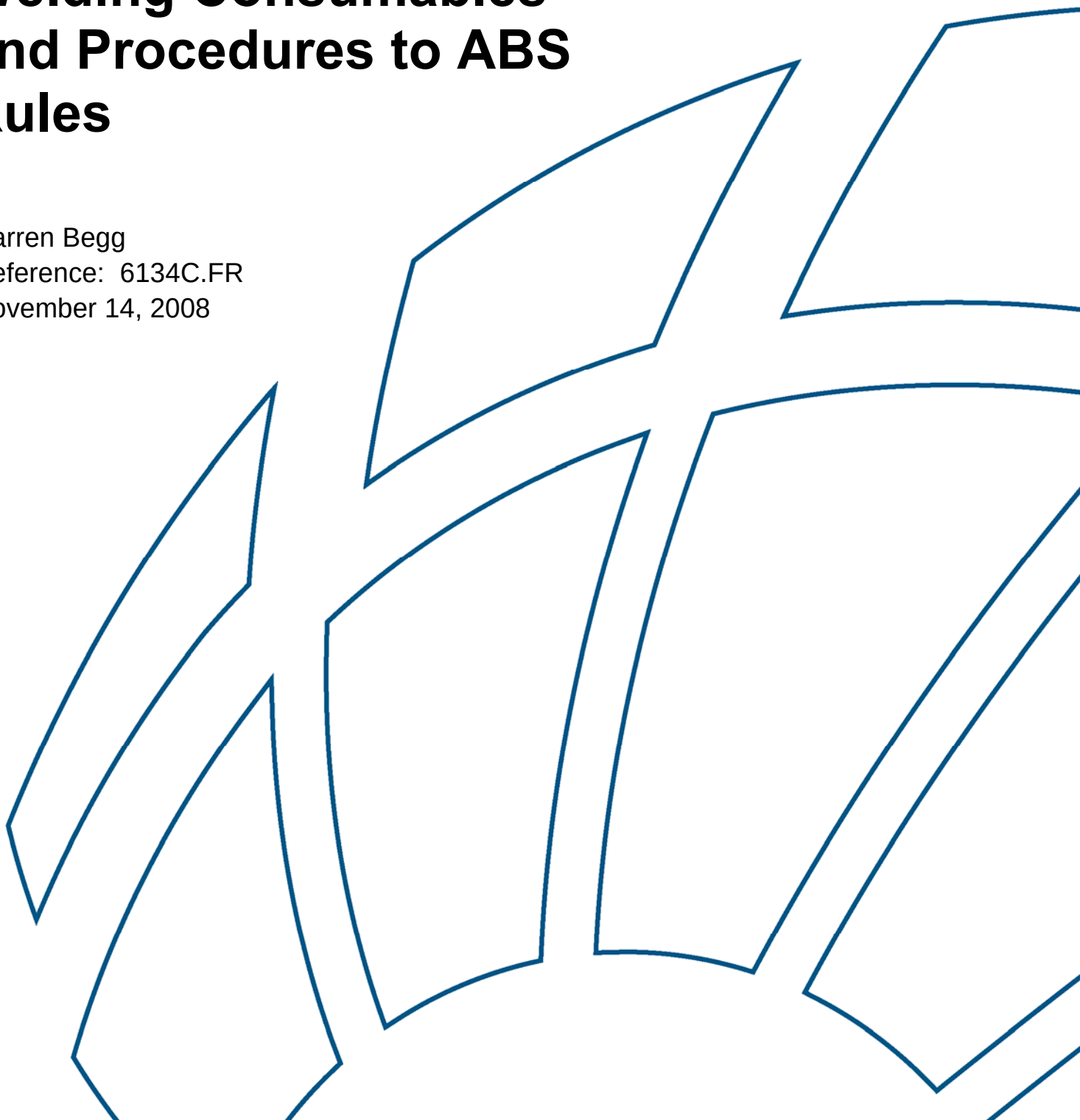
November 14, 2008



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QUALIFICATION OF SUBMERGED ARC WELDING CONSUMABLES AND PROCEDURES TO ABS RULES

FINAL REPORT

November 14, 2008

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REPORT: Qualification of Submerged Arc Welding Consumables and Procedures to ABS Rules

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ABBREVIATIONS

ABS	American Bureau of Shipping
ASTM	American Society for Testing Materials
AWMT	All Weld Metal Tensile
AWS	American Welding Society
CTWD	Contact Tip to Work Distance
ESO	Electrical Stick Out
FCB	Flux Copper Backing
HSLA	High Strength Low Alloy
IPM	Inches Per Minute
MPT	Magnetic Particle Testing
NSRP	National Ship Building Research Program
OSW	One Sided Welding
SAW	Submerged Arc Welding
UT	Ultrasonic Testing
UTS	Ultimate Tensile Strength
VBAC	Variable Balance Alternating Current
YS	Yield Strength
WFS	Wire Feed Speed

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1. BACKGROUND

The welding procedures developed under NSRP/ASE Project 2005-386 demonstrated significant productivity enhancements along with mechanical properties that comfortably met stringent NAVSEA requirements. Productivity enhancements as high as 1200% were identified with potential cost reductions approaching 65%, with weld metal deposition rates exceeded 110 lbs/hr, significantly higher compared to current practice. General Dynamics NASSCO requested that the results of this recently completed project be used to produce and qualify highly productive welding procedures under American Bureau of Shipping (ABS) Rules for HSLA-65 and EH36 steels, using variable balance AC (VBAC) submerged arc welding (SAW) and metal cored electrode technologies. The procedures included the single pass one-sided welding (OSW) onto flux copper backing (FCB) and one pass per side two sided welding no with backgouging techniques, both in a tandem arrangement.

2. SCOPE OF WORK

The main deliverables in this project are ABS qualified highly productive welding procedures for one-sided and two sided welding that will allow shipyards to readily adopt these techniques into practice. Each shipyard that implements these technologies will expect to significantly reduce their labor costs per foot of completed weld joint and also decrease their electrode and flux consumption requirements.

The following welding procedures were qualified and registered under ABS Rules:

- Single pass OSW of ½" and 1 inch thick EH36 and HSLA-65 steels onto a FCB
- Single pass per side two sided welding (no backgouging) of ½ and 1 inch thick EH36 and HSLA-65 steels

OSW procedures were developed and qualified with Kobelco PFI-50R backing flux to be aligned with the current production techniques used at GD NASSCO. The welding electrode/flux combination was also qualified under this testing matrix.

All developmental work, welding of test plates, and mechanical testing of specimens were performed by BMT FTL, with all welding of test plates and testing of mechanical property specimens being witnessed by an ABS representative.

3. TASKS

The objectives of this project were met with the completion of the following tasks:

3.1 Task 1: Welding Electrode Qualification

Prior to the welding procedure qualification phases of this project, the welding electrode and flux combination required qualification. The welding parameters selected resulted in the highest and lowest cooling rate that this combination would likely be used in during production welding. The target **deposited weld metal** properties are as follows:

- **EH36 Weld Metal Targets**
  - Min. 58ksi Yield Strength, 71 to 95ksi Ultimate Tensile Strength, and 20% Elongation
  - Charpy V-notch Impacts of 20ft-lbs @ -20°F
- **HSLA-65 Weld Metal Targets**
  - Min. 65ksi Yield Strength, 20% Elongation
  - Charpy V-notch Impacts of 30 ft-lbs @ -20°F

3.2 Task 2: Welding Procedure Qualification

The welding procedures were qualified under the requirements of NAVSEA Technical Publication 248 using the highest heat input that each plate thickness would be subjected to in production for each type of joint design.

Target mechanical properties for each welding procedure are as follows:

- **EH36 Weld Metal Targets**
  - Min. 58ksi Yield Strength Weld Metal, 71 to 95ksi Ultimate Tensile Strength (all weld metal and cross weld), and 20% Elongation (weld metal)
  - Charpy V-notch Impacts of 17ft-lbs @ -4°F and -40°F
    - 5 samples tested, highest and lowest values disregarded, average 3 remaining values
- **HSLA-65 Weld Metal Targets**
  - Min. 65ksi Yield Strength (all weld metal), 20% Elongation (all weld metal), 78-100 ksi Ultimate Tensile Strength (cross weld tensile)
  - Charpy V-notch Impacts of 30 ft-lbs @ -20°F
    - 5 samples tested, highest and lowest values disregarded, average 3 remaining values

4. RESULTS

4.1 Task 1: Welding Electrode Qualification

The objective of the welding electrode certification testing is to evaluate the properties of the deposited undiluted weld metal over a range of heat inputs (and resulting cooling rates).

The formulation of the welding electrode is provided in **Table 4.1**. The electrode is classified as AWS A5.23 ECM3, and the trade name is TriMark Metalloy M3S.

Table 4.1: Welding Electrode Formulation

	Compositions (%)																
	C	Mn	Si	S	P	Ni	Cr	Mo	Al	B	Cu	Zr	Nb	Ti	V	N	O
ELECTRODE Formulation	0.02000	1.60000	0.45000	0.00200	0.00200	2.00000	0.05000	0.50000	0.00400	0.00400	0.03000	0.00800	0.01000	0.03000	0.00400		

Prior to sending the electrodes to BMT, the electrode manufacture Hobart/Trimark produced a series of test welds on flat plate in accordance with AWS A5.23 to determine the undiluted chemistry of the weld deposit using two fluxes, i.e., Hobart/TriMark HN-511 and Lincoln MIL-800H. The result of this analysis is shown in **Table 4.2**.

Table 4.2: Test Weld Analysis

	Compositions (%)																
	C	Mn	Si	S	P	Ni	Cr	Mo	Al	B	Cu	Zr	Nb	Ti	V	N	O
ELECTRODE Formulation	0.02000	1.60000	0.45000	0.00200	0.00200	2.00000	0.05000	0.50000	0.00400	0.00400	0.03000	0.00800	0.01000	0.03000	0.00400		
299H-01-011 with Hobart flux	0.034	1.98	0.277	0.007	0.022	1.882	0.051	0.449	0.001	0.001	0.055	0.003	0.005	0.008	0.004		
299H-01-011 with Lincoln Mil 800H flux	0.045	1.413	0.21	0.009	0.015	2.044	0.044	0.507	0.001	0.0017	0.07	0.002	0.005	0.02	0.004		

In addition, Hobart conducted some preliminary testing of the electrode with TriMark HN-511 flux in accordance with AWS A5.23 to examine the resulting mechanical properties. The welding conditions used as well as the results of this testing is given as **Appendix A**. To summarize, the weld metal demonstrated the following:

- Yield Strength: 95.4 ksi
- Ultimate Tensile Strength: 104.2 ksi
- Elongation: 23.9%
- Charpy V-notch Impact @ -40°F: 93, 89, 71, 84, 70 ft-lbs
- Charpy V-notch Impact @ -76°F: 62, 61, 32, 52, 72 ft-lbs

Test plates for the electrode/flux qualification tests were made from 1-inch thick, 40-inch long HSLA-65 plate. The welds were manufactured using a single electrode with DCEP polarity. The 5/32” diameter Metalloy M3S electrode’s lot number was N812342301611. The Lincoln MIL-800H flux used for all welding had a stock and lot number of ED020925 and 11471002, respectively.

Each of the welds fabricated were subjected to 100% visual inspection, as well as Magnetic Particle Testing (MPT) and Ultrasonic Testing (UT). The welding conditions as witnessed by ABS were as follows:

4.1.1 High Cooling Rate Test (Low Heat Input)

The conditions and tests used for the high cooling rate test weld, identified as **65-CT-LH**, are summarized below:

- 5/32" diameter Single Electrode – DCEP
- 30° included angle, ½" root opening
- 30-40 kj/in heat input
    - Amperage: 475A
    - Voltage: 28V
    - Travel Speed: 20 ipm
    - Electrical Stick-out: 1-1/2"
    - Wire Feed Speed: 70 – 115 ipm
- Preheat and Interpass Temperature: 75-150°F
- Extract and test two (2) all weld metal tensile and five (5) weld metal Charpy V-notch impacts tested at -20^{o}F

The test weld required 13 passes to fill the joint, two passes per fill layer and three cap passes, as shown in **Figure 4.1**. The lab records of the parameters as witnessed and signed by ABS are provided as **Appendix B**.

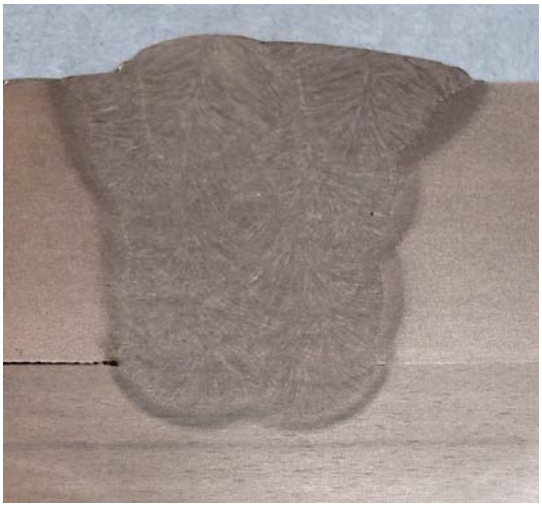


Figure 4.1: Macro, 65-CT-LH

4.1.2 Low Cooling Rate Test (High Heat Input)

The conditions and tests used for the low cooling rate test weld, identified as **65-CT-HH**, are summarized below:

- 5/32" diameter Single Electrode – DCEP
- 30° included angle, ½" root opening
- >75 kJ/in heat input
    - Amperage: 600A
    - Voltage: 32V
    - Travel Speed: 15ipm
    - Electrical Stick-out: 1-1/2"
    - Wire Feed Speed: 120-180 ipm
- Preheat and Interpass Temperatures: 275-325°F
- Extract and test two (2) all weld metal tensiles and five (5) weld metal charpy V-notch impacts tested at -20F

The test weld required 6 passes to fill the joint as shown in **Figure 4.2**. The lab records pf the parameters as witnessed and signed by ABS are provided as **Appendix C**.

Figure 4.2: Macro, 65-CT-HH

Visual inspection as well as MPT and UT revealed no flaws within the weld metal. From each of the test plates fabricated, 2 all weld metal tensile specimens and 5 weld metal notched Charpy V-notch impact specimens were extracted and tested. The specimens were extracted as per **Figure 4.3**, at the T/2 location.

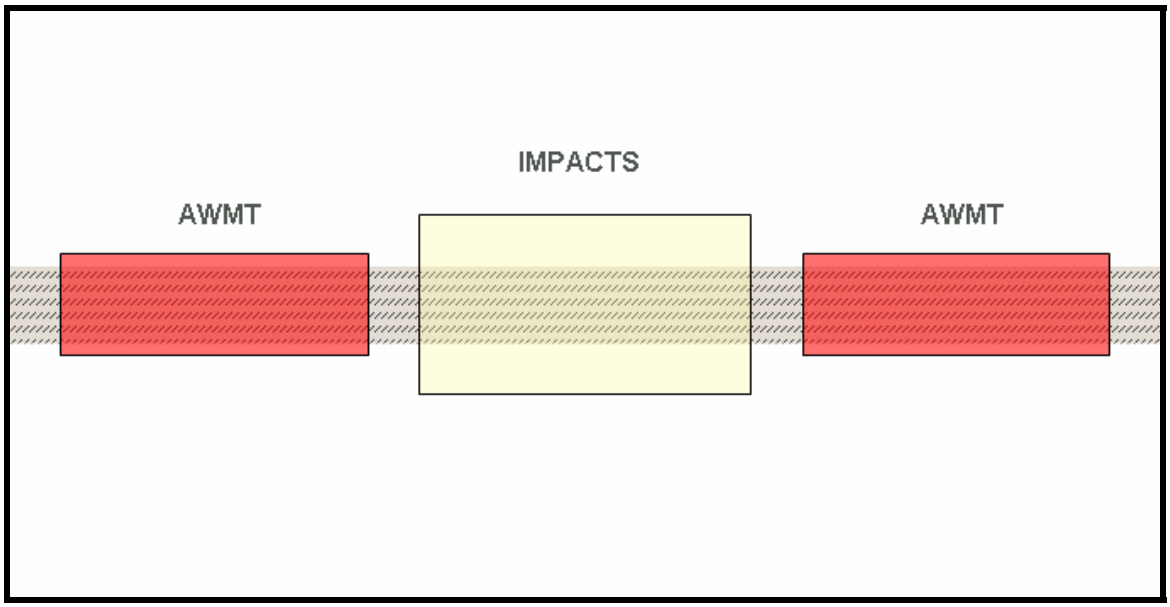


Figure 4.3: Location of Mechanical Test Specimens

The results of the tensile and impact testing are summarized in **Tables 4.3** and **4.4, respectively**, and the reports as signed and witnessed by ABS are given as **Appendix D**.

Table 4.3: Tensile Test Results

Tensile Test Results													
I.D.	**Elongation (%)**	Diameter		Area		Yield Load		Maximum Load		**Y.S.**		**U.T.S.**	
	(in 50 mm)	in.	(mm)	$in.^2$	(mm^2)	lbs.	(kN)	lbs.	(kN)	psi	(MPa)	psi	(MPa)
65-CT-HH T-1	6.1%	0.501	12.7	0.197	127.1	16,500	73	17,430	78	83,783	578	88,505	610
65-CT-HH T-2	15.1%	0.494	12.6	0.192	123.8	15,900	71	18,450	82	82,859	571	96,148	663
65-CT-LH T-1	25.4%	0.505	12.8	0.201	129.4	19,125	85	21,040	94	95,364	658	104,913	723
65-CT-LH T-2	24.7%	0.505	12.8	0.200	129.2	19,125	85	21,010	93	95,498	658	104,911	723

Table 4.4: High and Low Cooling Rate Weld Metal Impact Test Results

Procedure	Location	Specimen	Temperature	Absorbed Energy ft/lbs
65-CT-HH T/2	WM	1	-20°F	85
		2		105
		3		105
		4		108
		5		108
			Average	**106**
65-CT-LH T/2	WM	1	-20°F	68
		2		100
		3		75
		4		78
		5		95
			Average	**83**

The results show that the tensile, yield, and impact requirements are comfortably met over the entire heat input range, however the elongation on the high heat input welds were below minimum requirements. On the fracture surface of the high heat input tension specimens and throughout their gauge lengths, there appeared to be evidence of cracking. The surfaces were bright and had the characteristics of hydrogen embrittlement. None of this cracking was detected during NDT of the test plates and it is therefore believed the cracking occurred during the low strain rate tension testing. It is possible that a post weld aging treatment of the tension specimen would have released all traces of hydrogen in the specimen and thus enhanced the elongation properties achieved in the results. Regardless, the yield and ultimate tensile properties meet the minimum requirements.

In addition, diffusible hydrogen tests were conducted on the electrode flux combination using 75% of the highest amperage range used, i.e., 450A. The travel speed and voltage for each test specimen was held constant at 22ipm and 27V, respectively. Hydrogen analysis was conducted in accordance with AWS A4.3 using the under mercury method. The results of the hydrogen analysis in 4 specimens after being held at 45°C for 72 hrs were 2.2, 2.4, 2.4, and 2.5 ml/100g of weld metal deposited.

4.2 Task 2: Welding Procedure Qualification

Welding procedures were qualified in EH36 and HSLA-65 material using the Trimark Metalloy M3S and Lincoln MIL-800H flux combination. The mill test reports for these base materials are included as **Appendix E**.

The ABS signed lab work sheets along with welding procedure data sheets for each of the welds fabricated are provided as **Appendix F**.

The identification system used for each of the welding procedures was as follows:

½" Thickness

- 36-OSW-0.5 = EH36 Base Metal, One Sided Welded
- 36-DS-0.5 = EH36 Base Metal, Two Sided Weld, no backgouging
- 65-OSW-0.5 = HSLA-65 Base Metal, One Sided Weld
- 65-DS-0.5 = HSLA-65 Base Metal, Two Sided Weld, no backgouging

1" Thickness

- 36-OSW-1 = EH36 Base Metal, One Sided Weld
- 36-DS-1 = EH36 Base Metal, Two Sided Weld, no backgouging
- 65-OSW-1 = HSLA-65 Base Metal, One Sided Weld
- 65-DS-1 = HSLA-65 Base Metal, Two Sided Weld, no backgouging

All tandem SAW work was performed using Miller Summit Arc 1000 power sources and witnessed by ABS. Sample macrosections from ½" and 1" OSW and DS welds are shown in **Figures 4.4** to **4.7**.

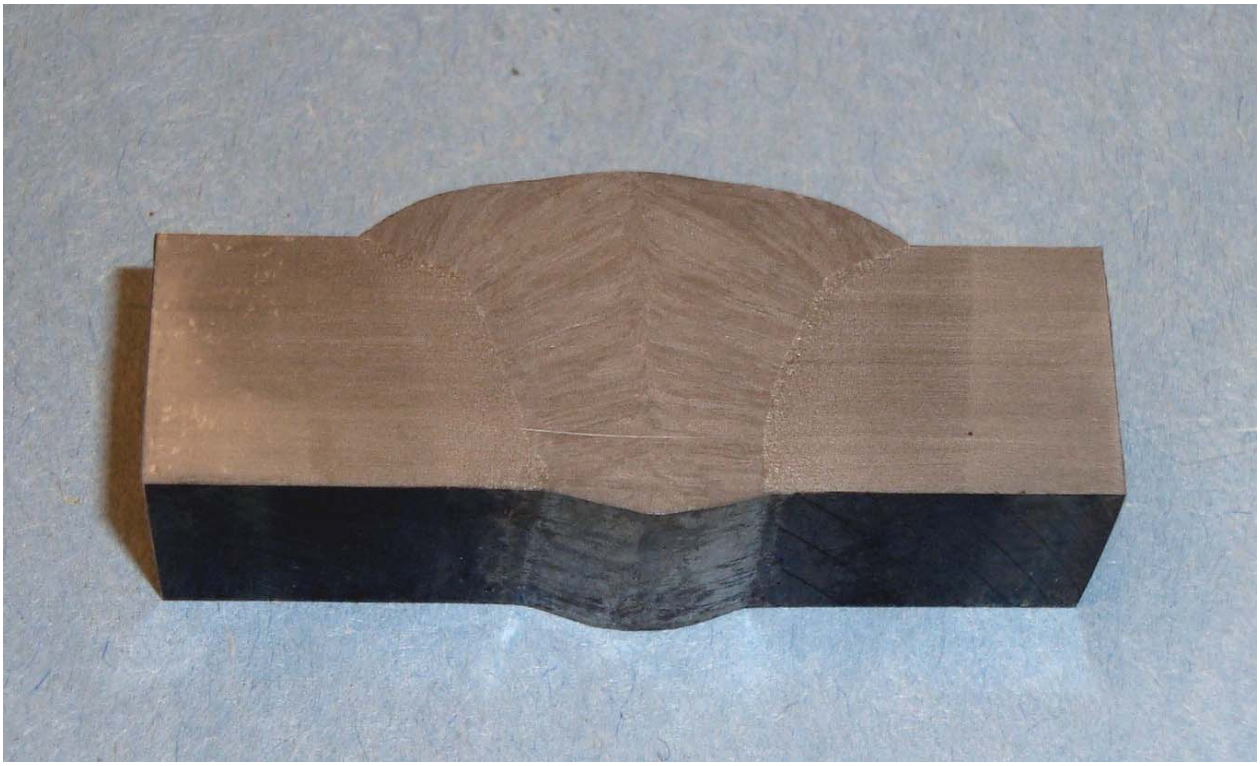


Figure 4.4: Sample Macro, ½" OS Weld Procedure

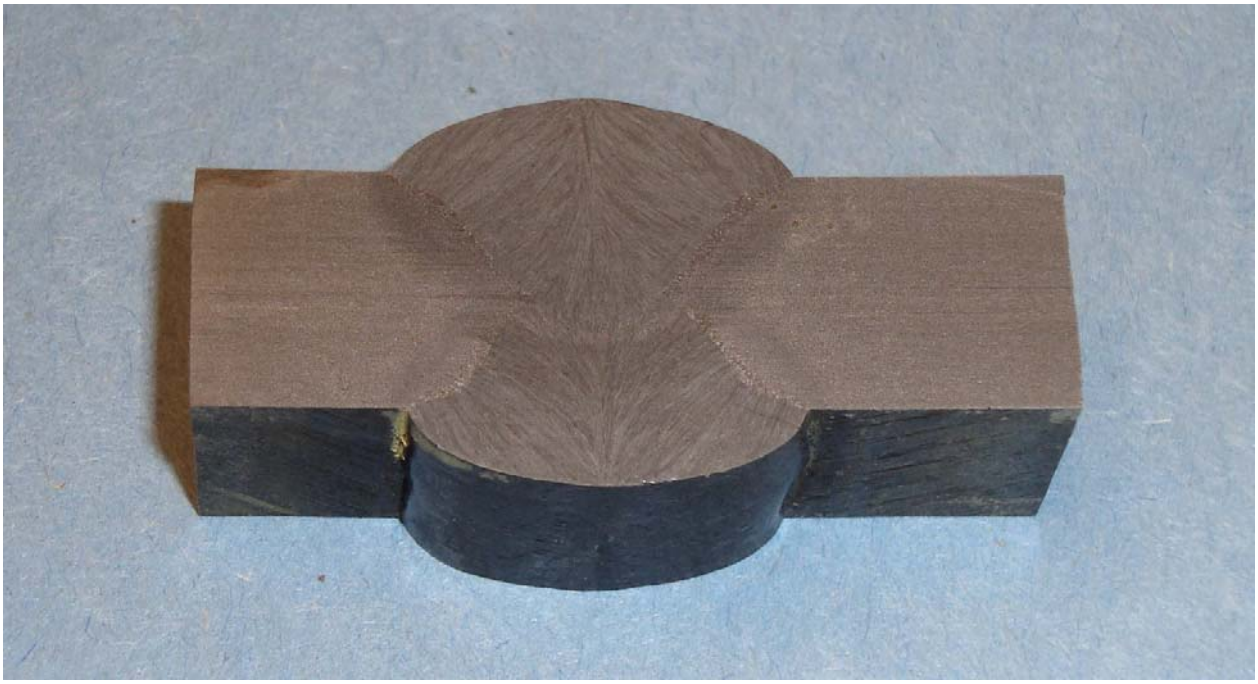


Figure 4.5: Sample Macro, ½" DS Weld Procedure

Figure 4.6: Sample Macro, 1" OS Weld Procedure

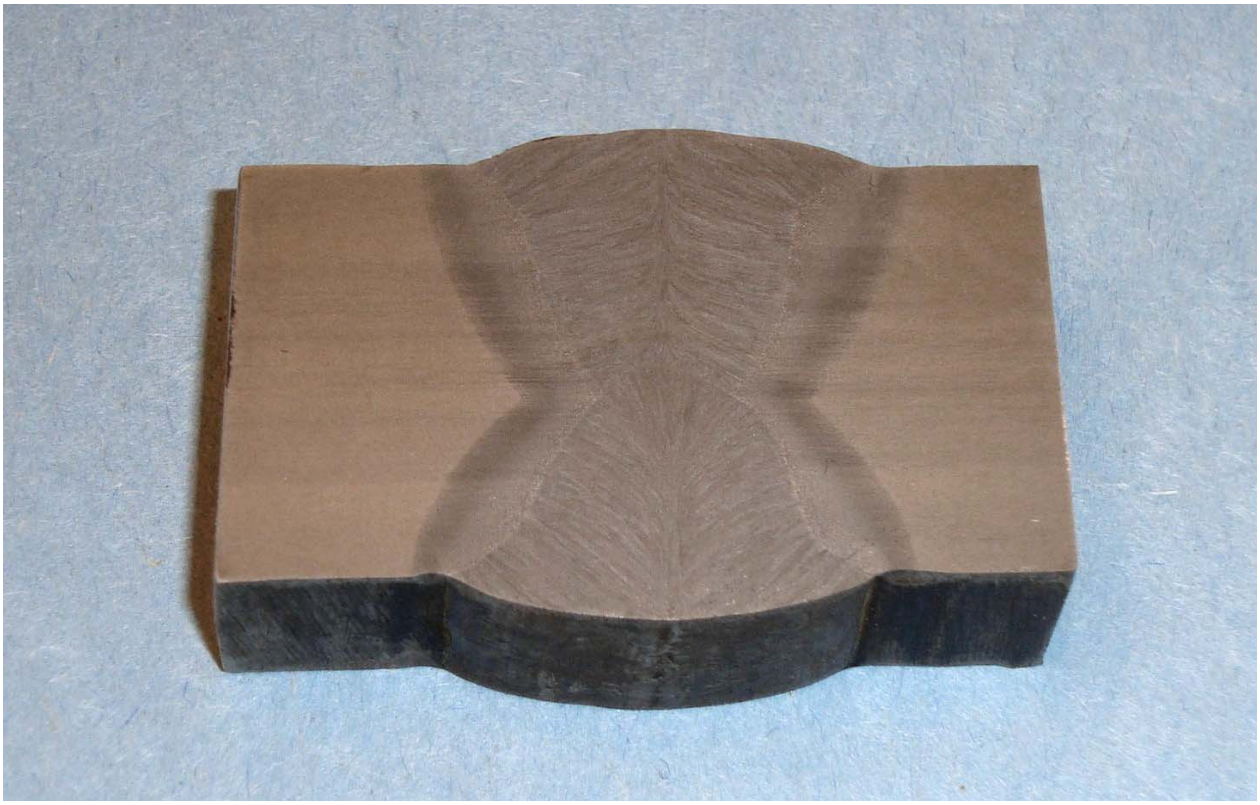


Figure 4.7: Sample Macro, 1" DS Weld Procedure

The mechanical test matrix is described following in Sections 4.2.1 and 4.2.2.

4.2.1 HSLA-65 (1 inch thickness only):

Each plate welded was subjected to 100% Visual, MPT, and UT. The procedures qualified include high heat input single pass OSW onto FCB with variable balance AC tandem SAW. The test matrix included:

- Two (2) all weld metal tensiles
- Two (2) cross weld tensiles
- Four (4) side bends
- Five (5) weld metal cvn's at -20°F
- Five (5) HAZ cvn's at -20°F

4.2.2 EH36 (1/2" and 1 inch Thicknesses):

Each plate welded was subjected to 100% Visual, MPT, and UT. The procedures qualified include high heat input single pass OSW onto FCB with variable balance tandem SAW, and, two sided tandem SAW (with no backgouging).

½" Plates

- Two (2) Cross Weld Tensiles
- One (1) Macro / Micro / Hardness
- Two (2) Root Bends and Two (2) Face Bends for One Sided Welds
- Four (4) Side Bends for Two (2) Sided Welds
- Charpy V-notch Impact @ T/2 location - *Ten (10) samples at each location (CL & FL) with Five (5) tested at -4°F and Five (5) at -40°F

1" Plates

- Two (2) Cross Weld Tensiles
- Two (2) All Weld Metal Tensile (centered at ¼" below Side #1 surface), except EH36 One Sided Weld Procedure, only One (1) specimen required.
- One (1) Macro / Micro / Hardness
- Four (4) Side Bends
- Charpy V-notch Impact @ 1/16" from Side #1 Surface - *Ten (10) samples at each location (CL & FL) with Five (5) tested at -4°F and Five (5) at -40°F

Weld metal chemical analysis samples were also extracted from each fractured all weld metal tensile specimens from the 1” thick test plates.

4.2.3 Welding Procedure Testing Results

The results of the visual and MPT revealed no surface flaws. The UT inspection reports are included as **Appendix G**.

The results of the mechanical testing are summarized below.

4.2.3.1 All Weld Metal Tension Test Results

Each all weld metal tension specimen was machined and tested in accordance with ASTM E8. The results are summarized following in **Table 4.5**, and the ABS witnessed signed test reports and stress strain curves are included as **Appendix H**.

Table 4.5: All Weld Metal Tension Test Results

Tensile Test Results													
I.D.	Elongation (%)	Diameter		Area		Yield Load		Maximum Load		Y.S.		U.T.S.	
	(in 25 mm)	in.	(mm)	$in.^2$	(mm^2)	lbs.	(kN)	lbs.	(kN)	psi	(MPa)	psi	(MPa)
36-DS-1 T1	24.3	0.249	6.316	0.049	31.3	4,566	20,311	5,039	22,415	94,022	648	103,762	715
36-DS-1 T2	22.8	0.249	6.318	0.049	31.4	4,486	19,957	4,970	22,106	92,316	636	102,256	705
65-DS-1 T1	25.0	0.250	6.352	0.049	31.7	4,448	19,786	4,865	21,641	90,557	624	99,047	683
65-DS-1 T2	24.1	0.250	6.346	0.049	31.6	4,443	19,763	4,926	21,912	90,626	625	100,478	693
36-OSW-1	23.9	0.249	6.319	0.049	31.4	3,486	15,508	4,722	21,002	71,715	494	97,121	670
65-OSW-1 T1	29.2	0.250	6.338	0.049	31.5	3,691	16,418	4,864	21,636	75,477	520	99,464	686
65-OSW-1 T2	25.8	0.249	6.316	0.049	31.3	3,514	15,633	4,598	20,455	72,359	499	94,681	653

4.2.3.2 Cross Weld Tension Test Results

Full thickness cross weld tension specimen were machined and tested in accordance with ASTM E8. The results are summarized below in **Table 4.6**, and the ABS witnessed signed test reports and stress strain curves are included as **Appendix I**.

Table 4.6: Cross Weld Tension Test Result Summary

Procedure	Specimen	Ultimate Tensile Strength (Psi)	Failure Location
36-OSW-1/2	1	50,279	Weld*
	2	42,257	Weld*
65-OSW-1/2	1	86,335	Weld
	2	88,172	Base Metal
36-DS-1/2	1	79,936	Base Metal
	2	79,216	Base Metal
65-DS-1/2	1	87,842	Base Metal
	2	88,907	Base Metal
36-OSW-1	1	82,420	Base Metal
	2	80,033	Base Metal
65-OSW-1	1	83,990	Base Metal
	2	79,790	Weld
36-DS-1	1	81,504	Base Metal
	2	80,422	Base Metal
65-DS-1	1	84,962	Base Metal
	2	84,899	Base Metal

** Specimens extracted from run on and run off tab locations and failed due to solidifcation cracks in specimens.*

4.2.3.3 Bend Test Results

Root, face and side bend tests were conducted in a bend test jig using a mandrel diameter of 1.5 inches. All of the test specimens were bent 180° using a pneumatic ram. Each of the specimens revealed no visible discontinuities to the surface that exceeded the maximum requirement of 1/8". The surfaces of each series of bend tests are shown in **Figures 4.8** to **4.15**.

Figure 4.8: Face and Root Bend Tests, 36-OSW-1/2

Figure 4.9: Face and Root Bend Tests, 65-OSW-1/2

Figure 4.10: Side Bend Tests, 65-DS-1/2

Figure 4.11: Side Bend Tests, 36-DS-1/2

Figure 4.12: Side Bend Tests, 36-OSW-1

Figure 4.13: Side Bend Tests, 65-OSW-1

Figure 4.14: Side Bend Tests, 36-DS-1

Figure 4.15: Side Bend Tests, 65-DS-1

4.2.3.4 Charpy V-notch Impact Test Results

Full size impact specimens were machined and tested in accordance with ASTM E23. The requirement for the EH36 impact testing is an average of 17 ft-lbs at -4°F and -40°F, and that only one sample of the averaged three specimens may be lower, but not lower than 70% of 17 ft-lbs (i.e. 11.9ft-lbs). The requirement for the HSLA-65 impact testing is an average of 30 ft-lbs at -20°F. The results of the impact testing are summarized in **Tables 4.7** to **4.13**, and the witnessed signed test reports are included as **Appendix J**.

Table 4.7: 36-OSW-1/2 Charpy V-notch Impact Test Results

Procedure	Location	Specimen	Temperature	Absorbed Energy ft/lbs
36 OSW ½"	WM	1	-4°F	111
		2		111
		3		114
		4		116
		5		112
			Average	**112**
			-40°F	90
		7		85
		8		83
		9		73
		10		85
			Average	**84**
36 OSW ½"	HAZ	1	-4°F	19
		2		21
		3		24
		4		22
		5		24
			Average	**22**
		6	-40°F	18
		7		18
		8		13
		9		16
		10		14
			Average	**16**

Table 4.8: 36-DS-1/2 Charpy V-notch Impact Test Results

Procedure	Location	Specimen	Temperature	Absorbed Energy ft/lbs
36 DS ½"	HAZ	1	-4°F	51
		2		50
		3		51
		4		60
		5		50
			Average	**51**
		6	-40°F	30
		7		47
		8		21
		9		23
		10		24
			Average	**26**
36 DS ½"	WM	1	-4°F	105
		2		113
		3		108
		4		117
		5		111
			Average	**114**
		6	-40°F	89
		7		100
		8		100
		9		100
		10		78
			Average	**96**

Table 4.9: 65-DS-1/2 Charpy V-notch Impact Test Results

Procedure	Location	Specimen	Temperature	Absorbed Energy ft/lbs
65 DS ½"	HAZ	1	-20°F	28
		2		39
		3		47
		4		30
		5		65
			Average	**38**
	WM	1	-20°F	81
		2		83
		3		89
		4		89
		5		89
			Average	**87**
65 OSW ½"	HAZ	1	-20°F	43
		2		41
		3		69
		4		44
		5		77
			Average	**51**
	WM	1	-20°F	91
		2		107
		3		97
		4		91
		5		107
			Average	**98**

Table 4.10: 36-OSW-1 Charpy V-notch Impact Test Results

Procedure	Location	Specimen	Temperature	Absorbed Energy ft/lbs
36 OSW 1”	HAZ	1	-4°F	28
		2		25
		3		30
			Average	**28**
		4	-40°F	26
		5		53
		6		19
			Average	**33**
36 OSW 1” 1/16” Below Cap	WM-1	1	-4°F	44
		2		44
		3		30
			Average	**39**
		4	-40°F	32
		5		24
		6		35
			Average	**30**
36 OSW 1” T/2	WM-2	1	-4°F	45
		2		38
		3		42
			Average	**42**
		4	-40°F	31
		5		31
		6		25
			Average	**29**
36 OSW 1” 1/16” above root	WM-3	1	-4°F	47
		2		43
		3		53
			Average	**48**
		4	-40°F	44
		5		47
		6		48
			Average	**46**

Table 4.11: 36-DS-1 Charpy V-notch Impact Test Results

Procedure	Location	Specimen	Temperature	Absorbed Energy ft/lbs
36 DS 1”	WM	1	-4°F	105
		2		111
		3		109
		4		118
		5		100
			Average	**108**
	HAZ	1	-4°F	169
		2		125
		3		77
		4		68
		5		48
			Average	**90**

Table 4.12: 65-DS-1 Charpy V-notch Impact Test Results

Procedure	Location	Specimen	Temperature	Absorbed Energy ft/lbs
65 DS 1”	WM	1	-20°F	142
		2		134
		3		125
		4		137
		5		130
			Average	**134**
	HAZ	1	-20°F	74
		2		92
		3		38
		4		92
		5		70
			Average	**79**

Table 4.13: 65-OSW-1 Charpy V-notch Impact Test Results

Procedure	Location	Specimen	Temperature	Absorbed Energy ft/lbs
65 OSW 1"	WM	1	-20°F	67
		2		78
		3		70
		4		65
		5		82
			Average	**72**
	HAZ	1	-20°F	20
		2		22
		3		13
		4		43
		5		32
			Average	**25**

4.2.3.5 Hardness Test Results

Hardness measurements were conducted on each of the welding procedures at the subsurface and T/2 locations, along with sample weld metal hardnesses along the weld centreline. Specimens were prepared to a 0.5 micron finish and tested with a 5kg load. The results are summarized in **Appendix K**.

4.2.3.6 Weld Metal Chemical Analysis Results

Samples were extracted form the gauge length of the fractured tension specimens. This method gives a correlation between the chemical analysis of the undiluted weld metal and the resulting tensile properties. The results are provided as **Appendix L**.

5. SUMMARY

A welding electrode formulation was manufactured by Hobart/Trimark as trade name Metalloy M3S under classification AWS A5.23 ECM3. The electrode was subjected to high and low cooling rate tests using Lincoln MIL-800H flux. Mechanical test specimens were extracted to determine all weld metal tension and impact properties under the two cooling rate conditions. The results show that the yield strength, ultimate tensile strength, and impact properties comfortably meet minimum requirements. The elongation of the high heat input weld however did not meet the requirements likely as the result of hydrogen embrittlement.

The electrode flux combination was then used to qualify welding procedures in EH36 and HSLA-65 steels of 0.5 and 1.0 inch thickness. The procedures consisted of single pass tandem one sided welding onto Kobelco backing flux as well as tandem two sided welding (one pass per side) without backgouging. The welds were subjected to cross weld and all weld metal tensile testing, weld metal and HAZ impact testing, and bend testing. All results met the minimum requirements for ultimate tensile and yield strength, impact toughness, and ductility. The 1.0 inch thick welds were further examined for hardness and all weld metal chemical analysis, and the results are reported.

All welding of test plates and testing of specimens was witnessed by ABS. A copy of ABS's Statement of Fact is included as **Appendix M**.

APPENDIX A

HOBART PRELIMINARY TEST RESULTS

Hobart Brothers Filler Metals Testing Report

Product: **METALLOY EM13K-S** Item : **S280450** Size: **5/32**

Specification: **A5.23** Class:

Specimen No: **PA7901** Control No: **0299H-01-011** Tested No:

Plate: Material: **BUTTERED** Length: **12** Thickness: **1**

Included Angle: **30** Root Opening: **.5** Position: **1G**

Welding Parameters:

Amps: **500** Volts: **29** WFS (IPM): **63** Travel Speed (IPM): **15**

Gas Type: **HN-511** Current: **DCEP** Electrical Stickout (in): **1.25**

PreHeat (F): **300** Interpass (F): **300** Layers: **6** Pass Sequence: **1,2,2,2,2,3**

Welded By: **SUMMEKE** Date Welded: **5/22/2008** Joules/in: **58,000** Total Passes: **12**

Radiograph: Spec: **A5.23** **Conforms** By: **jbii**

Fillets: Flat: **None** Vertical: **None** Overhead: **None** Horizontal: **None**

Tensile: **1** Type: **.505** PWHT: **As Welded**

UTS(PSI): **104200** YS(PSI): **95400** Elong(%): **23.9** RA(%): **68.8**

Bend Tests:

Impacts:		Type	PWHT	Temp (C)	Temp (F)	Ft. Lbs.	Joules
1	1	**Charpy-V-Notch**	**As Welded**	**-40**	**-40**	**93**	**126**
1	2	**Charpy-V-Notch**	**As Welded**	**-40**	**-40**	**89**	**121**
1	3	**Charpy-V-Notch**	**As Welded**	**-40**	**-40**	**71**	**96**
1	4	**Charpy-V-Notch**	**As Welded**	**-40**	**-40**	**84**	**114**
1	5	**Charpy-V-Notch**	**As Welded**	**-40**	**-40**	**70**	**95**
2	1	**Charpy-V-Notch**	**As Welded**	**-60**	**-76**	**62**	**84**
2	2	**Charpy-V-Notch**	**As Welded**	**-60**	**-76**	**61**	**83**
2	3	**Charpy-V-Notch**	**As Welded**	**-60**	**-76**	**32**	**43**
2	4	**Charpy-V-Notch**	**As Welded**	**-60**	**-76**	**52**	**71**
2	5	**Charpy-V-Notch**	**As Welded**	**-60**	**-76**	**72**	**98**

Chemistry: Specimen No: **PA7901** Amps: **500** Volts: **29** WFS: **63** Item No: **S280450**

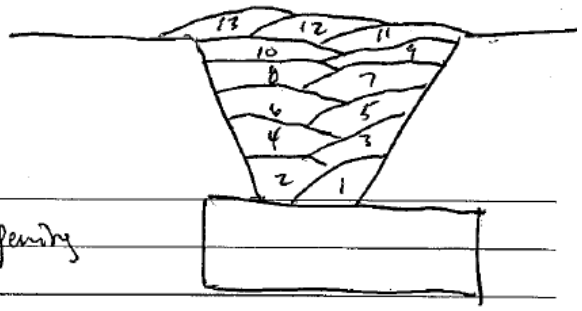
Gas Type: **HN-511** Current: **DCEP** Welded By: **SUMMEKE** Weld Date: **5/22/2008**

C:	**0.025**	Mn:	**1.901**	P:	**0.014**	S:	**0.009**	Si:	**0.379**	Cu:	**0.056**
Cr:	**0.059**	V:	**0.005**	Ni:	**2.067**	Mo:	**0.463**	Al:	**0.001**	Ti:	**0.018**
Nb:	**0.005**	Co:	**0.0060**	B:	**0.00192**	W:	**0.005**	Sn:	**0.00900**		
Zr:	**0.00300**			As:	**0.00353**						

APPENDIX B

WELDING ELECTRODE LOW HEAT INPUT CERTIFICATION LAB RECORDS

Consumable Certification
Low Heat Input
HSLA-65 Base Metal – 1" Thickness
- 30° Incl
- ½" root opening
- DCEP
- 1¼" ESO



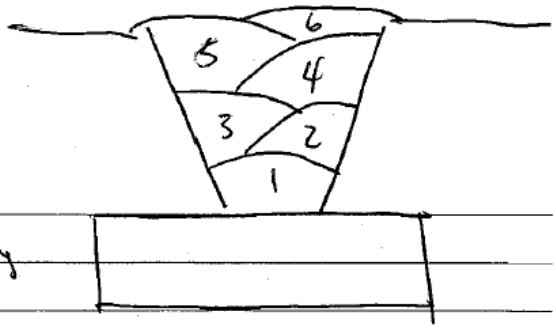
Pass (#)	A	V	WFS (IPM)	TS (IPM)	INT TEMP (°F)
1	475	28	90	20	85 (Room Temp)
2	"	"	80	20	
3	"	"	"	"	
4	"	"	"	"	
5	"	"	72	"	
6	"	"	82	"	
7	"	"	73	"	
8	"	"	75	"	
9	"	"	90-107	"	
10	"	"	63-100	"	
11	"	"	68-96	"	
12	"	"	80-100	"	
13	"	"	105-115	"	

John Duffy
9 July 2008

APPENDIX C

WELDING ELECTRODE HIGH HEAT INPUT CERTIFICATION LAB RECORDS

Consumable Certification
High Heat Input
HSLA-65 Base Metal - 1" Thickness
- 30° Incl
- ½" root opening DEEP
- 1¼" ESO



Pass	A	V	WFS (IPM)	INT TEMP (°F)	TS (IPM)
1	650	33	175	275 FPH	14
2	650	34	175	300	15
3	650	34	120	300	15
4	650	34	125	275	15
5	650	34	120	275	15
6	650	34	180	275	15

9 July 2008

APPENDIX D

WELDING ELECTRODE CERTIFICATION TEST RESULTS

BMT Fleet Technology

Welding Electrode Certification Report

Form 600-007
2-040628

Client's Name		Applicable Standard:	CSA W48-01
Date:	18-Aug-08	Engineer:	Alex Jodoin
Contract Number:	6134	Witnessed By:	

WELDING ELECTRODE CERTIFICATION REPORT

Tensile Test Results

I.D.	Elongation (%) (in 50 mm)	Diameter in.	Diameter (mm)	Area $in.^2$	Area (mm^2)	Yield Load lbs.	Yield Load (kN)	Maximum Load lbs.	Maximum Load (kN)	Y.S. psi	Y.S. (MPa)	U.T.S. psi	U.T.S. (MPa)
65-CT-HH T-1	6.1%	0.501	12.7	0.197	127.1	16,500	73	17,430	78	83,783	578	88,505	610
65-CT-HH T-2	15.1%	0.494	12.6	0.192	123.8	15,900	71	18,450	82	82,859	571	96,148	663
65-CT-LH T-1	25.4%	0.505	12.8	0.201	129.4	19,125	85	21,040	94	95,364	658	104,913	723
65-CT-LH T-2	24.7%	0.505	12.8	0.200	129.2	19,125	85	21,010	93	95,498	658	104,911	723

19 Aug 2008

BMT Fleet Technology

Impact Test Report

Form F600-011
3-040914

CONTRACT NO.:	
TECH:	
SPECIMEN SIZE:	
DATE:	

☐ Set at Zero

Ian Corbett
19 Aug 2008

SPECIMEN No.	TEMP.	FT. LBS	LAT. EXP	%SHEAR
65-CT-HI				
1	-20° F	85		
12		105		
2		105		
3		108		
5		108		
65-CT-LH				
1	-20° F	68		
2		100		
3		75		
4		78		
5		95		

F600-011 Impact Test Report

APPENDIX E

MILL TEST REPORTS

ISG PLATE INC.

SHIP TO:
METALS USA PLATES&SHAPES NE LP
50 CABOT BLVD
LANGHORNE PA 19047

TEST CERTIFICATE

PAGE NO: 01 OF 04
FILE NO: 5201-03-04
MILL ORDER NO: 53806-001
MELT NO: U7686
SLAB NO: 4CB
DATE: 05/25/06

SOLD TO:
METALS USA PLATES&SHAPES NE LP
INC
50 CABOT BOULEVARD EAST
LANGHORNE PA 19047

SEND TO:

01-0

PLATE DIMENSIONS / DESCRIPTION

TOTAL QTY	GAUGE	WIDTH	LENGTH	DESCRIPTION	PIECE WEIGHT
1	.5" 12.7MM	96" 2438.4MM	360" 9144MM	RECTANGLE RECTANGLE	4901# 2223KG

CUSTOMER INFORMATION

CUSTOMER PO: PHI-7300

SPECIFICATION(S)

THIS MATERIAL HAS BEEN MANUFACTURED AND TESTED IN ACCORDANCE WITH PURCHASE ORDER REQUIREMENTS AND SPECIFICATION(S).

ASTM A945 YR 05 GR 65 ←
SPEC. MODIFIED FOR GAUGE AND CHROME
MATERIAL PRODUCED UNDER A CERTIFIED QUALITY MGMT SYSTEM COMPLYING WITH ISO 9001 ABS-QE CERT. NO. 30130

CHEMICAL COMPOSITION

	C	MN	P	S	CU	SI	NI	CR	MO
MELT:U7686	.10	1.41	.011	.003	.26	.22	.36	.15	.07

	V	TI	AL	CB	N
MELT:U7686	.064	.011	.013	.022	.0066

MANUFACTURE

FINELINE - VACUUM DEGASSED - FINE GRAIN PRACTICE

WE HEREBY CERTIFY THE ABOVE INFORMATION IS CORRECT:

QUALITY ASSURANCE LABORATORY
COATESVILLE, PA 19320

Elinore Zaplitny
SUPERVISOR - TEST REPORTING
ELINORE ZAPLITNY

BMT FLEET TECH. LTD.
PO# VERBAL-DARREN
WO# 167141

Noted as Part of ABS report# TO1022213

Apr 02 07 12:20p Steel Yard 7783 p.2

OREGON STEEL MILLS

P.O. BOX 2760, Portland, Oregon 97208 • (503) 286-9651 Fax (503) 240-5268

REPORT OF CHEMICAL/PHYSICAL TESTS

CERTIFICATE NO.	DATE	PAGE
811627	Jun 29, 2004	1

MILL ORDER NO: 168614
CUSTOMER ORDER NO.: 5039360-C TK
JOB/REQ. NO.: T-AKE
SHIPPING NO: 811627 DATE: 06/29/2004
CARRIER: BURLINGTON NORTHERN
CAR/TRUCK NO.: CRLE8587

THE FIRST ISO9002 REGISTERED U.S. PLATE PRODUCER

SOLD TO:
NATIONAL STEEL & SHIPBUILDING
ATTN: ACCOUNTS PAYABLE
PO BOX 85278
SAN DIEGO, CA 92186-5278

NATIONAL STEEL & SHIPBUILDING
ATTN: DAVE POWERS
2798 HARBCR DRIVE, PO BOX 85278
MAIL STOP 17
SAN DIEGO, CA 92113

THIS MATERIAL HAS BEEN MANUFACTURED, TESTED AND FOUND TO MEET THE SPECIFICATIONS AND PURCHASE ORDER REQUIREMENTS
OSM HSLA STRUCTURAL QUALITY PLATE ABS GRADE EH36 PRIORITY RATING DO-A3.

PHYSICAL PROPERTIES

QSU	DESCRIPTION	HEAT NO.	SLAB	YIELD PSI X 100	TENSILE PSI X 100	% ELONG 8"	% ELONG 2"	% RA	HARDNESS BHN	BEND TEST	IMPACTS

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN MANUFACTURED TO THE APPLICABLE SPECIFICATION AND TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF THE AMERICAN BUREAU OF SHIPPING RULES WITH SATISFACTORY RESULTS.

3 0.9843 X 48.228 X 120.079
25MM X 1225MM X 3050MM
MARK: 82-86159-014

M00159 560 755 28
SIZE SUBSTITUTION M00159 D24 @ 0.9843 X 48.228 X 114.000 (1 PC ONLY)
SIZE SUBSTITUTION M00159 D24 @ 0.9843 X 48.228 X 114.000 (1 PC ONLY)
THE FOLLOWING PLATES WERE NORMALIZED AT 1680 DEGS F FOR 46 MINUTES AND AIR COOLED
2 PCS 3070 LBS M00159 D24 LCVN @ -40 DEG F 10.0mm 90 90 120/100 ft/lbs

2 PCS 3070 LBS TOTALS

ABS EH-36 P0545390

CHEMICAL ANALYSIS

HEAT NO.	C	Mn	P	S	Si	Cu	Ni	V	Cb	Al	Cr	Mo	Ti	B	N	Ca	CE	McQuaid Ehn Grain Size
M00159	.18	1.36	.012	.002	.30	<.02	<.02	.046	.002	.031	<.02	<.02	.003					

HEATS INDICATED WITH (+) WERE MELTED & MANUFACTURED IN THE USA. ALL OTHER HEATS WERE ROLLED IN THE USA.

.... END OF REPORT ....

AMERICAN BUREAU OF SHIPPING SURVEYOR JUN 29 2004 PORTLAND, OREGON

I certify the above to be correct as contained in the records of OREGON STEEL MILLS By CHRISTINE WRINKLE Q.C. RECORDS ADMINISTRATOR

Mittal Steel USA Burns Harbor Plate
QUALITY ASSURANCE
REPORT OF TEST AND ANALYSES

SHIPMENT NO 803-20082 | DATE SHIPPED 12-14-06 | CAR OR VEHICLE NO LANDSTAR RANGER TRLR 112211 | PAGE 2

SOLD TO: NATIONAL STEEL & SHIPBUILDING CO
PO BOX 85278
SAN DIEGO CA 92186-5278

SHIP TO: NATIONAL STEEL & SHIPBUILDING CO
28TH ST & HARBOR DR
SAN DIEGO CA 92113

NOTE	SERIAL NUMBER	PAT NO	HEAT NUMBER	NO. PCS	SIZE AND QUANTITY: THICKNESS	WIDTH OR DIA	LENGTH	WEIGHT	YIELD POINT	TENSILE STRENGTH	ELONG	RED
					MM	MM	MM	KILO	MPA	MPA	MM	% %

QUALITY STEEL MELTED & MANUFACTURED IN THE U. S. A.
PLATES - ABS GR EH36 KLD FINE GRAIN PRAC REV 2006, CH-V A673 FREQ (P) L 25/18 FTLBS AT -40F --- PLT NORMALIZED & COOLED IN STILL AIR
NO WELD REPAIR WAS PERFORMED ON BELOW PLATE(S)
MFST - MFST T-AKE CONTRACT MFST MILL SERIAL# LENGTH PLUS 1 MINUS 0 LIFT MAX 10 TON UNLDG OH-CHAIN SLING
CO# MUS494106-C GH 816-1981A
PLATES HEAT TREATED WITH TEST SPECIMENS ATTACHED.
OUTSIDE INSPECTION BY AMERICAN BUREAU OF SHIPPING

CH784319

S032644 821V00670 1 13.0 1400 12727 1818 378 519203 27
N 1650 DEG F - 38 MIN
4009 LBS 54,924 ksi 75,304 ksi
(M55)MFST REF#:003 82-85969

S032870 823V61970 1 13.0 1400 12727 1818 413 550203 24
N 1650 DEG F - 44 MIN
4009 LBS 79,800 ksi 59,900 ksi
(M55)MFST REF#:003 82-85969

Q-QUENCH TEMPERATURE T-TEMPER TEMPERATURE N-NORMALIZE TEMPERATURE

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN MADE BY THE MITTAL BRN HRB PLT . TO THE APPLICABLE SPECIFICATION BY AN APPROVED PROCESS AND HAS BEEN TESTED IN ACCORDANCE WITH THE REQUIREMENTS OF THE AMERICAN BUREAU OF SHIPPING RULES FOR THE INSPECTION AND TESTING OF MATERIALS TO THE SATISFACTION OF THE SURVEYORS.

SERIAL NUMBER	PAT NO	HEAT NUMBER	HARD	BEND	THICKNESS MM	TYPE	SIZE	DIR	TEST TEMP C	CHARPY IMPACT ENERGY JOULES 1	2	3	SHEAR % 1	2	3	LAT. EXP MM 1	2	3
S032644		821V00670			13.0	V	FULL	L	-40	384	391	399						
S032870		823V61970			13.0	V	FULL	L	-40	(209)	(290)	(339)						
										155	214	251						
										Avg. 206.7								

J. M. KELLY

CHEMICAL ANALYSIS

HEAT NUMBER	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Ti	Al	B	Ca	N	Sn	MOLD GRAIN SIZE
821V00670	.12	1.41	.017	.004	.295	.022	.01	.10	.056	.001	.003	.038	.0002		.033	.005	
IIW	.39	PCM	.21														
823V61970	.13	1.38	.017	.003	.321	.015	.01	.11	.056	.001	.002	.027	.0002		.031	.009	
IIW	.40	PCM	.22														

I certify that the above results are a true and correct copy of actual results contained in records maintained by Mittal Steel Inc. and are in full compliance with the requirements of the specification cited above. This test report cannot be altered and must be substantiated in full with any subsequent third party test reports, if required.
"PRODUCED UNDER A CERTIFIED QMS COMPLYING WITH ISO 9002 ABS-QE CERT #00477"

D. W. ELWOOD PER WNK

SUPV QUALITY ASSURANCE

BHPLTRPT.F

Apr 02 07 12:20p Steel Yard 7783 p.4

ISG Burns Harbor Plate, Inc.
QUALITY ASSURANCE
REPORT OF TESTS AND ANALYSES

SHIPMENT NO.	DATE SHIPPED	CAR OR VEHICLE NO.	PAGE
803-16184	00-00-00	TRLR	1

SOLD TO: METALS USA PLATES & SHAPES NE L P
50 CABOT BLVD EAST
LANGHORNE PA 19047

SHIP TO: METALS USA PLATES & SHAPES NE L P
50 CABOT BLVD
LANGHORNE PA 19047

NOTE	SERIAL NUMBER	PAT NO.	HEAT NUMBER	NO. PCS	SIZE AND QUANTITY THICKNESS INCHES	WIDTH OR DIA. INCHES	LENGTH INCHES	WEIGHT POUNDS	YIELD POINT PSI	TENSILE STRENGTH PSI	ELONG. IN	RED.
	QUALITY STEEL MELTED & MANUFACTURED IN THE U. S. A.											
	PLATES - ASTM A945-00 GR 65 MOD N.012 MAX											
	TI.005/.02 KLD FINE GRAIN PRAC,											
	CH-V A673 FREQ (P) T 70 FTLB AT											
	-40F --- PLT CONTROL ROLL											
	NO WELD REPAIR WAS PERFORMED ON BELOW PLATE(S)											
	MFST - LIFT MAX 10 TON-SIZES & GAUGES SEP UNLDG											
	OH-HOOK-CHAIN											
	CO# PHI-8079 GH 366-5318											
	S257039	832P38690	1	40.84 LB 96		360		9801	77100	90100	8	25
	S257040	832P38690	1	40.84 LB 96		360		9801	74700	89300	8	25

Q-QUENCH TEMPERATURE T-TEMPER TEMPERATURE NORMALIZE TEMPERATURE

SERIAL NUMBER	PAT NO.	HEAT NUMBER	HARD	BEND	THICKNESS INCHES	TYPE	SIZE	DIR	CHARPY IMPACT TEST TEMP F	ENERGY FT. LBS. 1	2	3	SHEAR(%) 1	2	3	LAT.EXP 1	2	3	MIL
S257039		832P38690			1.000	V	FULL	T	-40	90	126	104							
S257040		832P38690			1.000	V	FULL	T	-40	129	127	120							

HEAT NUMBER	CHEMICAL ANALYSIS C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Ti	Al	B	Cb	N	Sn	MCQUAID GRAIN SIZE
832P38690	.09	1.45	.021	.005	.283	.025	.01	.04	.008	.068	.017	.028	.0002		.028	.006	

I certify that the above results are a true and correct copy of the actual results contained in records maintained by International Steel Group and are in full compliance with the requirements of the specification cited above. This test report cannot be altered and must be transmitted intact with any subsequent third party test reports, if required.
PRODUCED UNDER A CERTIFIED QMS COMPLYING WITH ISO 9002 ABS-QE CERT #30477

SUPV. QUALITY ASSURANCE D.W. ELWOOD WNK

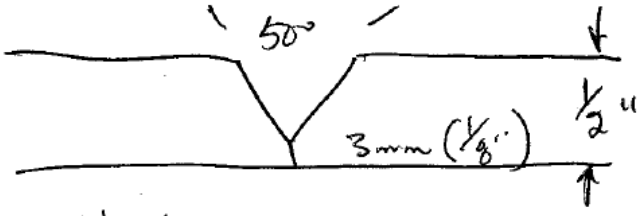
PMTSTRPT.MDF

BMT FLEET TECH. LTD.
PO# VERBAL-DARREN
WO# 167141

APPENDIX F

LAB RECORDS AND WELDING PROCEDURE DATA SHEETS

½" EH36
OSW



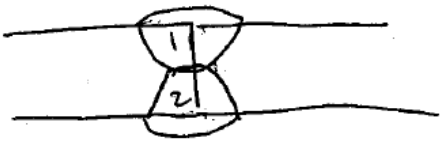
MIL 800- H flux
KOBE Backing flux
Copper Backing Bar

¼" ESO LEAD
½" 1" TRAIL

Amps		Volts		WFS		T.S.
L	T	L	T	L	T	
900	660	30.5	33	140-145	120-130	30
HSLA65						
925	660	29.5	35	150-160	125-140	30

18 July 2006

1/2" EH36 + HSLA65



AC-AC
66/34 (EP/EN)

ROOT - 0

Square Butt TANDEM SAW 5/32" Ø LEAD + TRAIL 7/8" SPACING

TRAVEL ANGLE 0° L 15° PUSH TRAIL

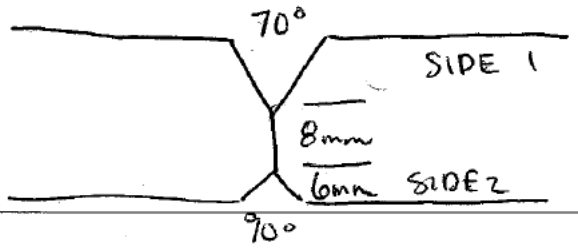
ESO 3/4" L 1 1/4" T

Pass #	A		V		WFS		TS
	L	T	L	T	L	T	
1	950	600	30	35	150	124	45
2	950	600	30	35	140-145	140-145	45

150°F (66°C) INT PASS TEMP

John Ockfen
9 July 2008

AC-AC
66/34 (EP/EN)



1" HSLA65 TANDEM 5/32" Ø LEAD + TRAIL
TRAVEL ANGLE 0° L 15° PUSH T
ESO 1¾" L 1½" T INT TEMP 150°F

	A		V		WFS		TS
PASS	L	T	L	T	L	T	
1	~~1000~~	~~850~~	~~32.5~~	~~36~~	~~160~~ - 180	~~210~~ - 220	~~38~~
2	950	725	32.5	35	145 - 155	150 - 155	45

1" EH36

1	1000	850	32.5	36	180	220	38
2	950	725	32.5	35	140 - 145	150 - 155	45

9 July 2008

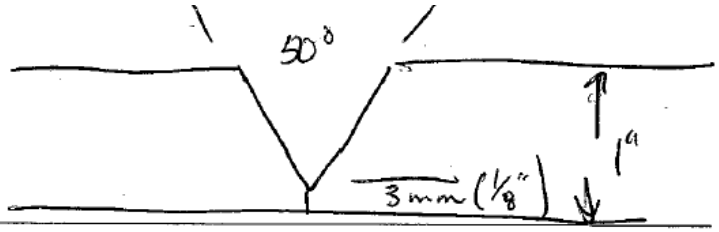
HSLA-65 1" T

OSW

MIL 800-H flux

Kobe Backing Flux

Copper Backing Bar



1/2" CTWD L – 15° Lag

2" " T – 0°

	Amps		Volts		WFS		TS
	L	T	L	T	L	T	(1PM)
	1150	950	~~200-230~~ 32.5	42.5	200-230	280-300	17
EH36	1050	950	33.5	42.5	200-215	250-265	17

Jim Gilfoyle
18 July 2004

BMT Fleet Technology

Welding Procedure Data Sheet

WPS No.:

WPDS No.: 36-OSW-0.5

Welding Process: SAW **Electrode Type:** Metal Cored **Flux:** Lincoln MIL-800H

Filler Metal Identification: AWS A5.23 ECM3

Material Specification: EH36

Preheat Temperature (°C): 66

Interpass Temperature (°C): N/A

Preheat Method: Torch

Position of Welding: Flat

Travel Direction Lead Wire: 0°Drag **Travel Direction Trail Wire:** 15°Push Angle

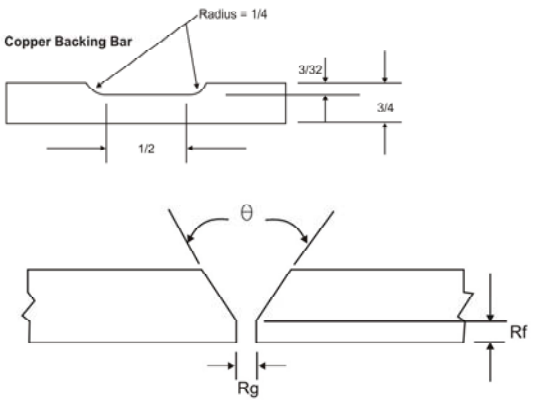
Current: CV **Polarity:** AC (66% DCEP 34%DCEN)

Manual, Semi-Auto, Auto,Machine: Machine

Single or Multiple Arc: Multiple (Tandem Arc)

Single or Multipass: Single

Cleaning Method: Grind to remove scale 2" in all directions of joint



Θ = 50° Included Angle **Rg = 0** **Rf = 1/8**

Material Thickness	Tandem Process	Weld Sequence			Electrode Size	Wire Feed Speed	Flux Depth	Amps	Volts	Contact Tip to Plate	Travel Speed	Electrode Spacing
In.	Wire	Side	Layer	Pass	In's	ipm	In.	A	V	In.	ipm	In.
1	Lead	1	1	1	5/32	140-145	1	900	30.5	1-1/4	30	7/8
	Trail	1	1	1	5/32	120-130	1 1/2	660	35	1-1/2		

Procedure Qualification Record No.:

Date:

FTL:

Procedure Notes:

Fill groove in copper backing bar flush with flux. Copper backing bar shall fit tight to back of plate.

Flux shall be baked and held in a holding oven at temperatures within manufacturer's specified range.

Approval:

BMT Fleet Technology

Welding Procedure Data Sheet

WPS No.:

WPDS No.: 36-DS-0.5

Welding Process: SAW **Electrode Type:** Metal Cored **Flux:** Lincoln MIL-800H

Filler Metal Identification: AWS A5.23 ECM3

Material Specification: EH36

Preheat Temperature (°C): 66

Interpass Temperature (°C): 66

Preheat Method: Torch

Position of Welding: Flat

Travel Direction Lead Wire: 0°Drag **Travel Direction Trail Wire:** 15°Push Angle

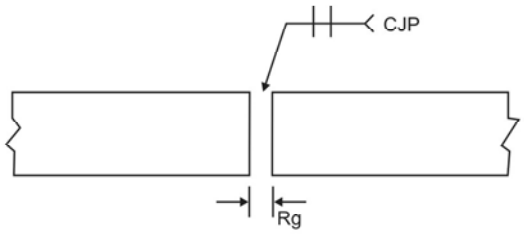
Current: CV **Polarity:** AC (66% DCEP 34%DCEN)

Manual, Semi-Auto, Auto,Machine: Machine

Single or Multiple Arc: Multiple (Tandem Arc)

Single or Multipass: Single

Cleaning Method: Grind to remove scale 2" in all directions of joint



Weld first side of joint, flip plate and weld side 2.
Rg = 0

Material Thickness	Tandem Process	Weld Sequence			Electrode Size	Wire Feed Speed	Flux Depth	Amps	Volts	Contact Tip to Plate	Travel Speed	Electrode Spacing
In.	Wire	Side	Layer	Pass	In's	ipm	In.	A	V	In.	ipm	In.
1	Lead	1	1	1	5/32	150	1/2	950	30	3/4	45	7/8
	Trail	1	1	1	5/32	125	1 1/2	600	35	1-1/4		
	Lead	2	1	2	5/32	140-145	1/2	950	30	3/4	45	7/8
	Trail	2	1	2	5/32	140-145	1 1/2	600	35	1-1/2		

Procedure Qualification Record No.:

Date:

FTL:

Procedure Notes:

Flux shall be baked and held in a holding oven at temperatures within manufacturer's specified range.

Approval:

BMT Fleet Technology

Welding Procedure Data Sheet

WPS No.:

WPDS No.: 36-OSW-1

Welding Process: SAW **Electrode Type:** Metal Cored **Flux:** Lincoln MIL-800H

Filler Metal Identification: AWS A5.23 ECM3

Material Specification: EH36

Preheat Temperature (°C): Ambient

Interpass Temperature (°C): N/A

Preheat Method: N/A

Position of Welding: Flat

Travel Direction Lead Wire: 15°Drag **Travel Direction Trail Wire:** 0°Angle

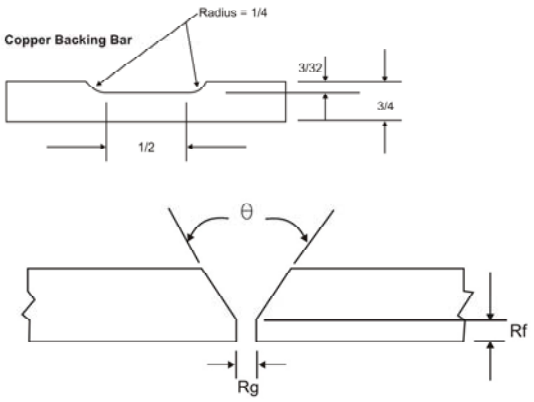
Current: CV **Polarity:** AC (66% DCEP 34%DCEN)

Manual, Semi-Auto, Auto,Machine: Machine

Single or Multiple Arc: Multiple (Tandem Arc)

Single or Multipass: Single

Cleaning Method: Grind to remove scale 2" in all directions of joint



Θ = 50° Included Angle **Rg = 0** **Rf = 1/8**

Material Thickness	Tandem Process	Weld Sequence			Electrode Size	Wire Feed Speed	Flux Depth	Amps	Volts	Contact Tip to Plate	Travel Speed	Electrode Spacing
In.	Wire	Side	Layer	Pass	In's	ipm	In.	A	V	In.	ipm	In.
1	Lead	1	1	1	5/32	200-215	1	1150	32.5	1/2	17	4
	Trail	1	1	1	5/32	250-265	1 3/4	950	42.5	2		

Procedure Qualification Record No.:

Date:

FTL:

Procedure Notes:

Fill groove in copper backing bar flush with flux. Copper backing bar shall fit tight to back of plate.

Flux shall be baked and held in a holding oven at temperatures within manufacturer's specified range.

Approval:

BMT Fleet Technology

Welding Procedure Data Sheet

WPS No.:

WPDS No.: 36-DS-1

Welding Process: SAW **Electrode Type:** Metal Cored **Flux:** Lincoln MIL-800H

Filler Metal Identification: AWS A5.23 ECM3

Material Specification: EH36

Preheat Temperature (°C): 66

Interpass Temperature (°C): 66

Preheat Method: Torch

Position of Welding: Flat

Travel Direction Lead Wire: 0°Drag **Travel Direction Trail Wire:** 15°Push Angle

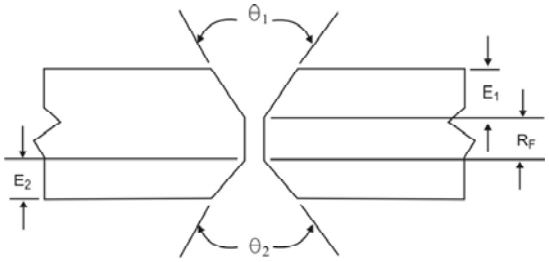
Current: CV **Polarity:** AC (66% DCEP 34%DCEN)

Manual, Semi-Auto, Auto,Machine: Machine

Single or Multiple Arc: Multiple (Tandem Arc)

Single or Multipass: Single

Cleaning Method: Grind to remove scale 2" in all directions of joint



Θ_1=70° Included Angle, Θ_2=90° Included Angle, Rg = 0, Rf = 5/16, E_1=7/16, E_2=1/4

Material Thickness	Tandem Process	Weld Sequence			Electrode Size	Wire Feed Speed	Flux Depth	Amps	Volts	Contact Tip to Plate	Travel Speed	Electrode Spacing
In.	Wire	Side	Layer	Pass	In's	ipm	In.	A	V	In.	ipm	In.
1	Lead	1	1	1	5/32	160-180	1/2	1000	32.5	1-1/4	38	7/8
	Trail	1	1	1	5/32	210-220	1 1/2	850	36	1-1/2		
	Lead	2	1	2	5/32	140-145	1/2	950	32.5	1-1/4	45	7/8
	Trail	2	1	2	5/32	150-155	1 1/2	725	35	1-1/2		

Procedure Qualification Record No.:

Date:

FTL:

Procedure Notes:

Flux shall be baked and held in a holding oven at temperatures within manufacturer's specified range.

Approval:

BMT Fleet Technology

Welding Procedure Data Sheet

WPS No.:

WPDS No.: 65-OSW-0.5

Welding Process: SAW **Electrode Type:** Metal Cored **Flux:** Lincoln MIL-800H

Filler Metal Identification: AWS A5.23 ECM3

Material Specification: HSLA-65

Preheat Temperature (°C): 66

Interpass Temperature (°C): N/A

Preheat Method: Torch

Position of Welding: Flat

Travel Direction Lead Wire: 0°Drag **Travel Direction Trail Wire:** 15°Push Angle

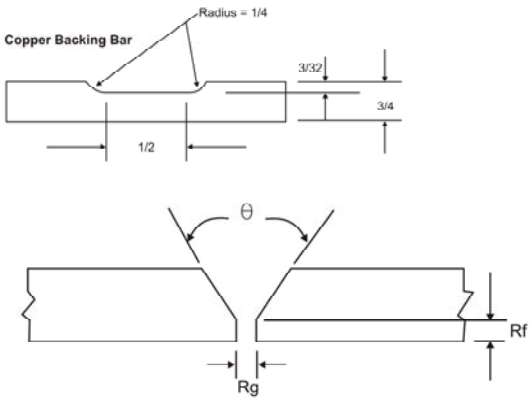
Current: CV **Polarity:** AC (66% DCEP 34%DCEN)

Manual, Semi-Auto, Auto,Machine: Machine

Single or Multiple Arc: Multiple (Tandem Arc)

Single or Multipass: Single

Cleaning Method: Grind to remove scale 2" in all directions of joint



Θ = 50° Included Angle **Rg = 0** **Rf = 1/8**

Material Thickness	Tandem Process	Weld Sequence			Electrode Size	Wire Feed Speed	Flux Depth	Amps	Volts	Contact Tip to Plate	Travel Speed	Electrode Spacing
In.	Wire	Side	Layer	Pass	In's	ipm	In.	A	V	In.	ipm	In.
1	Lead	1	1	1	5/32	150-160	1	925	29.5	1-1/4	30	7/8
	Trail	1	1	1	5/32	125-140	1 1/2	660	35	1-1/2		

Procedure Qualification Record No.:

Date:

FTL:

Procedure Notes:

Fill groove in copper backing bar flush with flux. Copper backing bar shall fit tight to back of plate.

Flux shall be baked and held in a holding oven at temperatures within manufacturer's specified range.

Approval:

BMT Fleet Technology

Welding Procedure Data Sheet

WPS No.:

WPDS No.: 65-DS-0.5

Welding Process: SAW **Electrode Type:** Metal Cored **Flux:** Lincoln MIL-800H

Filler Metal Identification: AWS A5.23 ECM3

Material Specification: HSLA-65

Preheat Temperature (°C): 66

Interpass Temperature (°C): 66

Preheat Method: Torch

Position of Welding: Flat

Travel Direction Lead Wire: 0°Drag **Travel Direction Trail Wire:** 15°Push Angle

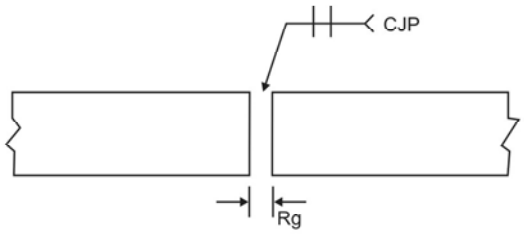
Current: CV **Polarity:** AC (66% DCEP 34%DCEN)

Manual, Semi-Auto, Auto,Machine: Machine

Single or Multiple Arc: Multiple (Tandem Arc)

Single or Multipass: Single

Cleaning Method: Grind to remove scale 2" in all directions of joint



Weld first side of joint, flip plate and weld side 2.
Rg = 0

Material Thickness	Tandem Process	Weld Sequence			Electrode Size	Wire Feed Speed	Flux Depth	Amps	Volts	Contact Tip to Plate	Travel Speed	Electrode Spacing
In.	Wire	Side	Layer	Pass	In's	ipm	In.	A	V	In.	ipm	In.
1	Lead	1	1	1	5/32	150	1/2	950	30	3/4	45	7/8
	Trail	1	1	1	5/32	125	1 1/2	600	35	1-1/4		
	Lead	2	1	2	5/32	140-145	1/2	950	30	3/4	45	7/8
	Trail	2	1	2	5/32	140-145	1 1/2	600	35	1-1/2		

Procedure Qualification Record No.:

Date:

FTL:

Procedure Notes:

Flux shall be baked and held in a holding oven at temperatures within manufacturer's specified range.

Approval:

BMT Fleet Technology

Welding Procedure Data Sheet

WPS No.:

WPDS No.: 65-OSW-1

Welding Process: SAW **Electrode Type:** Metal Cored **Flux:** Lincoln MIL-800H

Filler Metal Identification: AWS A5.23 ECM3

Material Specification: HSLA-65

Preheat Temperature (°C): Ambient

Interpass Temperature (°C): N/A

Preheat Method: N/A

Position of Welding: Flat

Travel Direction Lead Wire: 15°Drag **Travel Direction Trail Wire:** 0°Angle

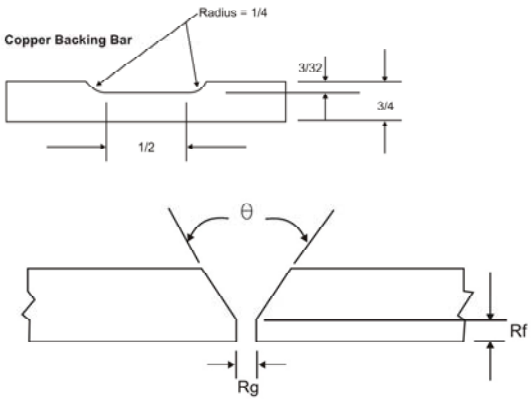
Current: CV **Polarity:** AC (66% DCEP 34%DCEN)

Manual, Semi-Auto, Auto,Machine: Machine

Single or Multiple Arc: Multiple (Tandem Arc)

Single or Multipass: Single

Cleaning Method: Grind to remove scale 2" in all directions of joint



Θ = 50° Included Angle **Rg = 0** **Rf = 1/8**

Material Thickness	Tandem Process	Weld Sequence			Electrode Size	Wire Feed Speed	Flux Depth	Amps	Volts	Contact Tip to Plate	Travel Speed	Electrode Spacing
In.	Wire	Side	Layer	Pass	In's	ipm	In.	A	V	In.	ipm	In.
1	Lead	1	1	1	5/32	200-230	1	1150	32.5	1/2	17	4
	Trail	1	1	1	5/32	280-300	1 3/4	950	42.5	2		

Procedure Qualification Record No.:

Date:

FTL:

Procedure Notes:

Fill groove in copper backing bar flush with flux. Copper backing bar shall fit tight to back of plate.

Flux shall be baked and held in a holding oven at temperatures within manufacturer's specified range.

Approval:

BMT Fleet Technology

Welding Procedure Data Sheet

WPS No.:

WPDS No.: 65-DS-1

Welding Process: SAW **Electrode Type:** Metal Cored **Flux:** Lincoln MIL-800H

Filler Metal Identification: AWS A5.23 ECM3

Material Specification: HSLA-65

Preheat Temperature (°C): 66

Interpass Temperature (°C): 66

Preheat Method: Torch

Position of Welding: Flat

Travel Direction Lead Wire: 0°Drag **Travel Direction Trail Wire:** 15°Push Angle

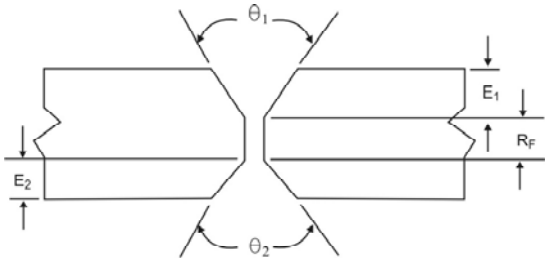
Current: CV **Polarity:** AC (66% DCEP 34%DCEN)

Manual, Semi-Auto, Auto,Machine: Machine

Single or Multiple Arc: Multiple (Tandem Arc)

Single or Multipass: Single

Cleaning Method: Grind to remove scale 2" in all directions of joint



Θ_1=70° Included Angle, Θ_2=90° Included Angle, Rg = 0, Rf = 5/16, E_1=7/16, E_2=1/4

Material Thickness	Tandem Process	Weld Sequence			Electrode Size	Wire Feed Speed	Flux Depth	Amps	Volts	Contact Tip to Plate	Travel Speed	Electrode Spacing
In.	Wire	Side	Layer	Pass	In's	ipm	In.	A	V	In.	ipm	In.
1	Lead	1	1	1	5/32	160-180	1/2	1000	32.5	1-1/4	38	7/8
	Trail	1	1	1	5/32	210-220	1 1/2	850	36	1-1/2		
	Lead	2	1	2	5/32	140-145	1/2	950	32.5	1-1/4	45	7/8
	Trail	2	1	2	5/32	150-155	1 1/2	725	35	1-1/2		

Procedure Qualification Record No.:

Date:

FTL:

Procedure Notes:

Flux shall be baked and held in a holding oven at temperatures within manufacturer's specified range.

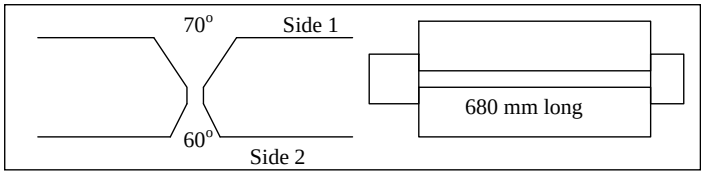
Approval:

APPENDIX G

UT REPORTS

Ultrasonic Examination of Welds Transducer: AWS0256 2.25 MHz **70°** July 24 2008

Project: ____6134_____
Weld Identification: 36-DS-1_____
Material & Thickness: ____1 inch**_____**
Weld Joint Identification:_____
Weld Process: ___SAW**_____**
Quality Requirements: Section # ABS Guide for NDT_



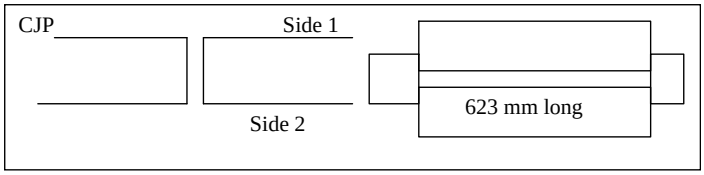
Remarks: Calibration on DSC block, inspected as AWS D1.1 cyclically loaded non-tubular structural weld. Scanned at +20 dB from both sides of weld, only rejectable reflectors reported.

Line Number	Indication Number	Transducer Angle	Half Skip Number	Indication Level	Reference Level	Attenuation Factor	Indication Rating	Length	Angular Distance Sound Path	Depth from Surface "A"	Distance From		Discontinuity Evaluation	Remarks (All distances are in millimetres)
				a	b	c	d				X	Y		
1														No rejectable reflectors found
2														
3														
4														
5														
6														
7														
8														
9														

Attenuation Factor "c": *subtract 25.4 mm from the sound path distance and divide the remainder by 12.7*

Ultrasonic Examination of Welds Transducer: AWS0256 2.25 MHz **70°** July 24 2008

Project: ____6134_____
Weld Identification: 36-DS-1/2_____
Material & Thickness: ____1/2 inch_____
Weld Joint Identification:_____
Weld Process: ___SAW_____
Quality Requirements: Section # ABS Guide for NDT_
Remarks: Calibration on DSC block, inspected as AWS D1.1 cyclically loaded non-tubular structural weld. Scanned at +20 dB from both sides of weld, only rejectable reflectors reported.

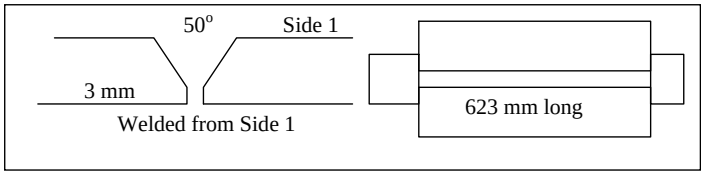


Line Number	Indication Number	Transducer Angle	Half Skip Number	Indication Level	Reference Level	Attenuation Factor	Indication Rating	Length	Angular Distance Sound Path	Depth from Surface "A"	Distance From		Discontinuity Evaluation	Remarks (All distances are in millimetres)
				a	b	c	d				X	Y		
1														No reportable reflectors found
2														
3														
4														
5														
6														
7														
8														
9														

Attenuation Factor "c": *subtract 25.4 mm from the sound path distance and divide the remainder by 12.7*

Ultrasonic Examination of Welds Transducer: AWS0256 2.25 MHz **70°** July 24 2008

Project: ___6134_____
Weld Identification: 65-OSW-1/2_____
Material & Thickness: ____1/2 inch**_____**
Weld Joint Identification:_____
Weld Process: ___SAW**_____**
Quality Requirements: Section # ABS Guide for NDT_
Remarks: Calibration on DSC block, inspected as AWS D1.1 cyclically loaded non-tubular structural weld. Scanned at +20 dB from both sides of the weld, only rejectable reflectors reported.

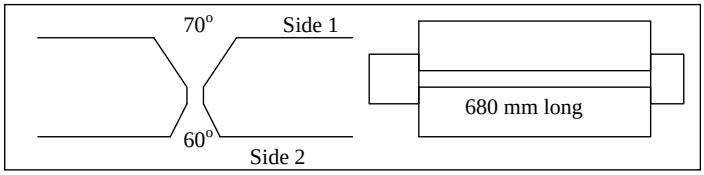


Line Number	Indication Number	Transducer Angle	Half Skip Number	Indication Level	Reference Level	Attenuation Factor	Indication Rating	Length	Angular Distance Sound Path	Depth from Surface "A"	Distance From		Discontinuity Evaluation	Remarks (All distances are in millimetres)
				a	b	c	d				X	Y		
1	1	70	2	+3.7	57.0	2	+2	28	53	7.3	320	-19		This reflector is 8 mm outside weld zone in base metal.
2														
3														
4														
5														
6														
7														
8														
9														

Attenuation Factor "c": *subtract 25.4 mm from the sound path distance and divide the remainder by 12.7*

Ultrasonic Examination of Welds Transducer: AWS0256 2.25 MHz **70°** July 24 2008

Project: ___6134_____
Weld Identification: 65-DS-1_____
Material & Thickness: ____1 inch**_____**
Weld Joint Identification:_____
Weld Process: ___SAW**_____**
Quality Requirements: Section # ABS Guide for NDT_
Remarks: Calibration on DSC block, inspected as AWS D1.1 cyclically loaded non-tubular structural weld. Scanned at +20 dB from both sides of weld, only rejectable reflectors reported.

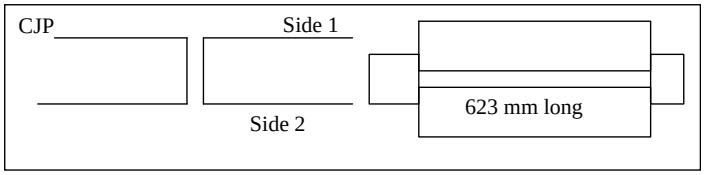


Line Number	Indication Number	Transducer Angle	Half Skip Number	Indication Level	Reference Level	Attenuation Factor	Indication Rating	Length	Angular Distance Sound Path	Depth from Surface "A"	Distance From		Discontinuity Evaluation	Remarks (All distances are in millimetres)
				a	b	c	d				X	Y		
1														No rejectable reflectors found
2														
3														
4														
5														
6														
7														
8														
9														

Attenuation Factor "c": *subtract 25.4 mm from the sound path distance and divide the remainder by 12.7*

Ultrasonic Examination of Welds Transducer: AWS0256 2.25 MHz **70°** July 24 2008

Project: ___6134_____
Weld Identification: 65-DS-1/2_____
Material & Thickness: ____1/2 inch**_____**
Weld Joint Identification:_____
Weld Process: ___SAW**_____**
Quality Requirements: Section # ABS Guide for NDT_
Remarks: Calibration on DSC block, inspected as AWS D1.1 cyclically loaded non-tubular structural weld. Scanned at +20 dB from both sides of the weld, only rejectable reflectors reported.



Line Number	Indication Number	Transducer Angle	Half Skip Number	Indication Level	Reference Level	Attenuation Factor	Indication Rating	Length	Angular Distance Sound Path	Depth from Surface "A"	Distance From		Discontinuity Evaluation	Remarks (All distances are in millimetres)
				a	b	c	d				X	Y		
1														No reportable reflectors found
2														
3														
4														
5														
6														
7														
8														
9														

Attenuation Factor "c": *subtract 25.4 mm from the sound path distance and divide the remainder by 12.7*

APPENDIX H

ALL WELD METAL TENSILE TEST REPORTS

BMT Fleet Technology

Welding Electrode Certification Report

Form 600-007
2-040628

Client's Name		Applicable Standard:	CSA W48-01
Date:	18-Aug-08	Engineer:	Alex Jodoin
Contract Number:	6134	Witnessed By:	

WELDING ELECTRODE CERTIFICATION REPORT

Tensile Test Results

I.D.	Elongation (%) (in 25 mm)	Diameter in.	Diameter (mm)	Area in.^{2}	Area (mm^2)	Yield Load lbs.	Yield Load (kN)	Maximum Load lbs.	Maximum Load (kN)	Y.S. psi	Y.S. (MPa)	U.T.S. psi	U.T.S. (MPa)
36-DS-1 T1	24.3	0.249	6.316	0.049	31.3	4,566	20,311	5,039	22,415	94,022	648	103,762	715
36-DS-1 T2	22.8	0.249	6.318	0.049	31.4	4,486	19,957	4,970	22,106	92,316	636	102,256	705
65-DS-1 T1	25.0	0.250	6.352	0.049	31.7	4,448	19,786	4,865	21,641	90,557	624	99,047	683
65-DS-1 T2	24.1	0.250	6.346	0.049	31.6	4,443	19,763	4,926	21,912	90,626	625	100,478	693
35-OSW-1	23.9	0.249	6.319	0.049	31.4	3,486	15,508	4,722	21,002	71,715	494	97,121	670
65-OSW-1 T1	29.2	0.250	6.338	0.049	31.5	3,691	16,418	4,864	21,636	75,477	520	99,464	686
65-OSW-1 T2	25.8	0.249	6.316	0.049	31.3	3,514	15,633	4,598	20,455	72,359	499	94,681	653

19 Aug 2008

36DS1T1

Created using the Tensile Automation Tool

Date: 8/19/2008 2308

Created by AJ

Disp. Conv.	Disp. Units	Load Conv.	Load Units	Gauge Len	GL Units	Shape
1	mm	4.448222	kN	25	mm	

Round Tensile

PRESS (Cntrl + q) to REDO regression calculations.

Diameter 6.316 mm

Area 31.33099 mm^2

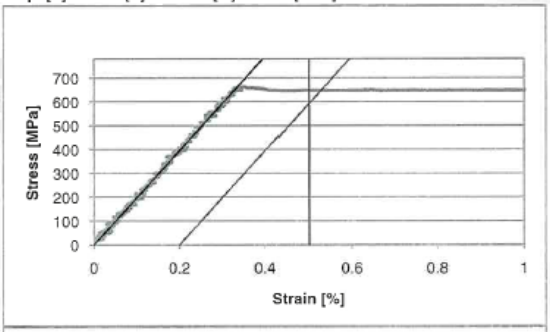
Slope Load Values

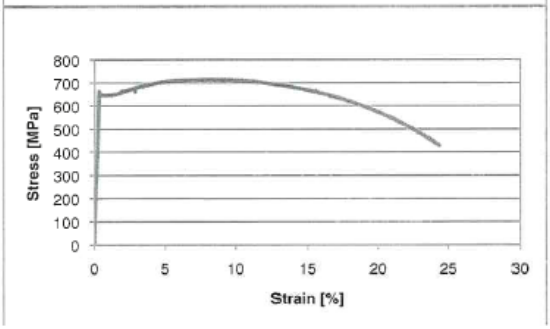
Load 1 200

Load 2 400

Load 1 row	109
Load 2 row	181
Slope	1979.255
Intercept	3.98E-13

Displ.[V] Load [V] Strain [%] Stress [MPa]





Linear Regression

Strain [%]	Stress [MP	0.2% Offset	0.5% EUL	Stress	
0	3.98E-13	0.2	0.5	0	
-2E-16	0	0.2	0.5	890.6648	0.075073
0.05	98.96276	0.25			
0.1	197.9255	0.3			
0.15	296.8883	0.35			
0.2	395.851	0.4			
0.4	791.7021	0.6			
0.45	890.6648	0.65			

(Optional editing to define height of regression lines)

Results:	E (Mod.)	YS(0.2%)	YS(0.5%)	UTS	EUL (%)	I Elongation (%)
	197926	648.3	648.0	715.4	8.06	24.34

19 Aug 2008

36DS1T2

Created using the Tensile Automation Tool

Date: ######## 2201

Created by AJ

Disp. Conv.	Disp. Units	Load Conv.	Load Units	Gauge Len	GL Units	Shape
1	mm	4.448222	kN	25	mm	

Round Tensile

Diameter 6.318 mm

Area 31.35084 mm^2

PRESS (Cntrl + q) to REDO regression calculations.

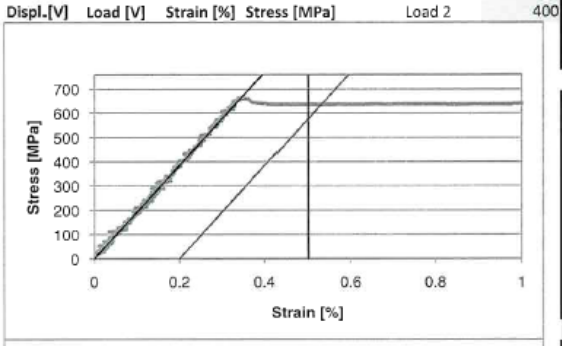
Slope Load Values

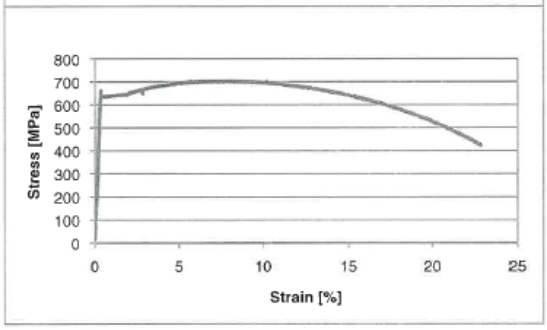
Load 1 200

Load 2 400

Load 1 row	113
Load 2 row	187
Slope	1922.116
Intercept	1.14E-13

Displ.[V]	**Load [V]**	**Strain [%]**	**Stress [MPa]**





Linear Regression

Strain [%]	Stress [MP	0.2% Offse	0.5% EUL	Stress	
0	1.14E-13	0.2	0.5	0	
-5.9E-17	0	0.2	0.5	768.8465	0.005172
0.05	96.10582	0.25			
0.1	192.2116	0.3			
0.15	288.3175	0.35			
0.2	384.4233	0.4			
0.35	672.7407	0.55			
0.4	768.8465	0.6			

(Optional editing to define height of regression lines)

Results:	E (Mod.)	YS(0.2%)	YS(0.5%)	UTS	EUL (%)	I Elongation (%)
	192212	636.5	636.9	705.0	8.11	22.85

19 Aug 2008

65DS1T1

Created using the Tensile Automation Tool

Date: ######## 2333

Created by AJ

Disp. Conv.	Disp. Units	Load Conv.	Load Units	Gauge Len	GL Units	Shape
1	mm	4.448222	kN	25	mm	

Round Tensile

Diameter 6.352 mm

Area 31.68917 mm^2

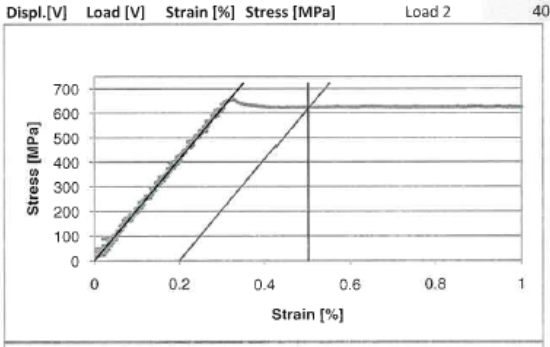
Displ.[V] Load [V] Strain [%] Stress [MPa]

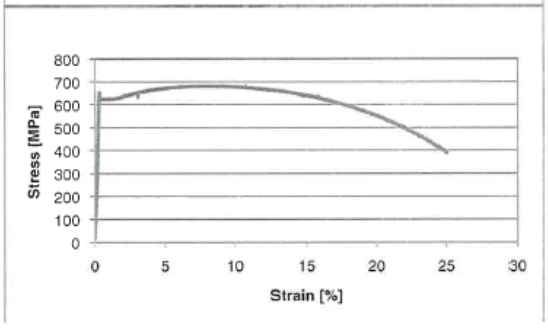
PRESS (Cntrl + q) to REDO regression calculations.

Slope Load Values

Load 1	200
Load 2	400

Load 1 row	108
Load 2 row	178
Slope	2062.913
Intercept	2.27E-13





Linear Regression

Strain [%]	Stress [MP	0.2% Offse	0.5% EUL	Stress	
0	2.27E-13	0.2	0.5	0	
-1.1E-16	0	0.2	0.5	722.0195	-0.00039
0.05	103.1456	0.25			
0.1	206.2913	0.3			
0.15	309.4369	0.35			
0.2	412.5826	0.4			
0.3	618.8739	0.5			
0.35	722.0195	0.55			

(Optional editing to define height of regression lines)

Results:	E (Mod.)	YS(0.2%)	YS(0.5%)	UTS	EUL (%)	l Elongation (%)
	206291	624.4	624.6	682.9	8.71	24.99

Jan Clifford
19 Aug 2008

65DS1T2

Created using the Tensile Automation Tool Date: ######## 2206

Disp. Conv.	Disp. Units	Load Conv.	Load Units	Gauge Leng	GL Units	Shape
1	mm	4.448222	kN	25	mm	

Created by AJ

Round Tensile

PRESS (Cntrl + q) to REDO regression calculations.

Diameter 6.346 mm

Area 31.62933 mm^2

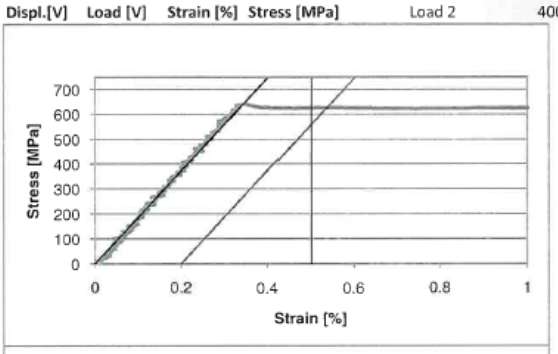
Slope Load Values

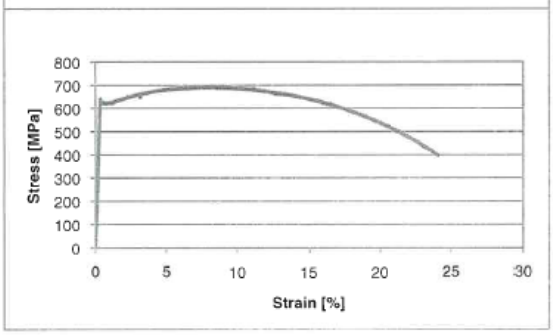
Load 1 200

Load 2 400

Load 1 row	102
Load 2 row	167
Slope	1860.8
Intercept	-2.3E-13

Displ.[V] Load [V] Strain [%] Stress [MPa]





Linear Regression

Strain [%]	Stress [MP	0.2% Offse	0.5% EUL	Stress	
0	-2.3E-13	0.2	0.5	0	
1.22E-16	0	0.2	0.5	744.3201	-0.00739
0.05	93.04001	0.25			
0.1	186.08	0.3			
0.15	279.12	0.35			
0.2	372.16	0.4			
0.35	651.2801	0.55			
0.4	744.3201	0.6			

(Optional editing to define height of regression lines)

Results:	E (Mod.)	YS(0.2%)	YS(0.5%)	UTS	EUL (%)	I Elongation (%)
	186080	624.8	624.3	692.8	8.88	24.07

19 Aug 2008

36OSW1

Created using the Tensile Automation Tool

Date: ######## 2247

Created by AJ

Disp. Conv.	Disp. Units	Load Conv.	Load Units	Gauge Len	GL Units	Shape
1	mm	4.448222	kN	25	mm	

Round Tensile

Diameter 6.319 mm

Area 31.36076 mm^2

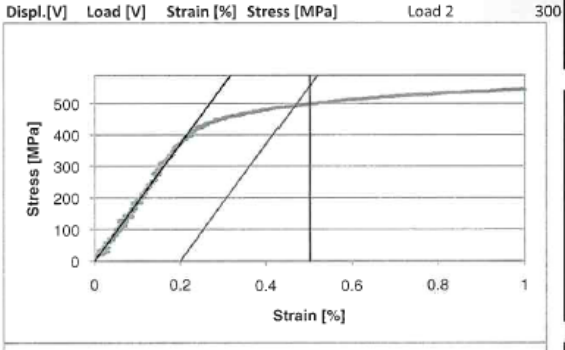
Displ.[V]	Load [V]	Strain [%]	Stress [MPa]

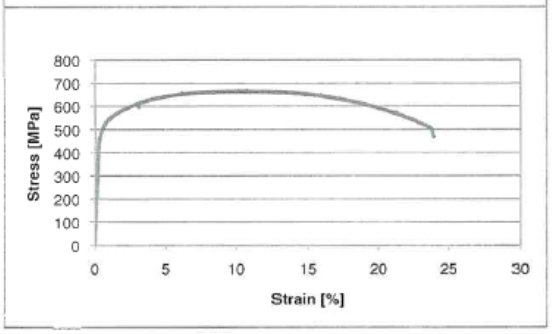
PRESS (Cntrl + q) to REDO regression calculations.

Slope Load Values

Load 1	100
Load 2	300

Load 1 row	65
Load 2 row	141
Slope	1857.476
Intercept	2.84E-14





Linear Regression

Strain [%]	Stress [MP	0.2% Offse	0.5% EUL	Stress	
0	2.84E-14	0.2	0.5	0	
-1.5E-17	0	0.2	0.5	650.1165	0.035501
0.05	92.87379	0.25			
0.1	185.7476	0.3			
0.15	278.6214	0.35			
0.2	371.4952	0.4			
0.3	557.2428	0.5			
0.35	650.1165	0.55			

(Optional editing to define height of regression lines)

Results:	E (Mod.)	YS(0.2%)	YS(0.5%)	UTS	EUL (%)	l Elongation (%)
	185748	494.5	499.1	669.6	10.74	23.90

19 Aug 2008

650SW1[illegible]-TT

Created using the Tensile Automation Tool Date: ######## 2719

Disp. Conv.	Disp. Units	Load Conv.	Load Units	Gauge Len	GL Units	Shape
1	mm	4.448222	kN	25	mm	

Created by AJ

Round Tensile

PRESS (Cntrl + q) to REDO regression calculations.

Diameter 6.338 mm

Area 31.54964 mm^2

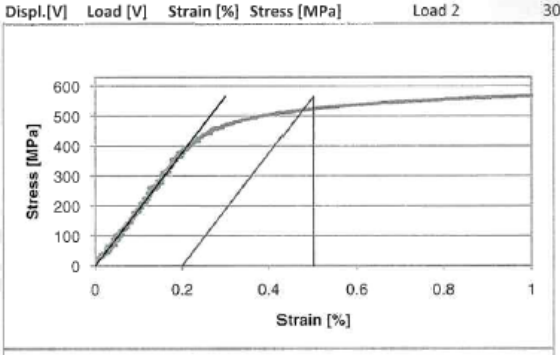
Slope Load Values

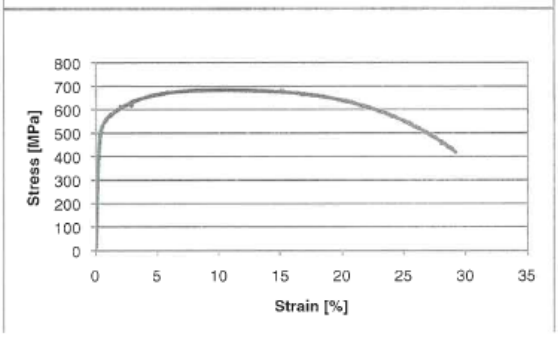
Load 1 100

Load 2 300

Load 1 row	62
Load 2 row	145
Slope	1886.916
Intercept	-2.8E-14

Displ.[V] Load [V] Strain [%] Stress [MPa]





Linear Regression

Strain [%]	Stress [MP	0.2% Offse	0.5% EUL	Stress	
0	-2.8E-14	0.2	0.5	0	
1.51E-17	0	0.2	0.5	566.0749	0.004307
0.05	94.34581	0.25			
0.1	188.6916	0.3			
0.15	283.0374	0.35			
0.2	377.3833	0.4			
0.25	471.7291	0.45			
0.3	566.0749	0.5			

(Optional editing to define height of regression lines)

Results:	E (Mod.)	YS(0.2%)	YS(0.5%)	UTS	EUL (%)	l Elongation (%)
	188692	520.4	522.9	685.8	9.58	29.21

Jan Clifford
19 Aug 2008

650SW1 - T2

Created using the Tensile Automation Tool

Date: ######## 2405

Created by AJ

Disp. Conv.	Disp. Units	Load Conv.	Load Units	Gauge Len	GL Units	Shape
1	mm	4.448222	kN	25	mm	

Round Tensile

Diameter 6.316 mm

Area 31.33099 mm^2

Displ.[V] Load [V] Strain [%] Stress [MPa]

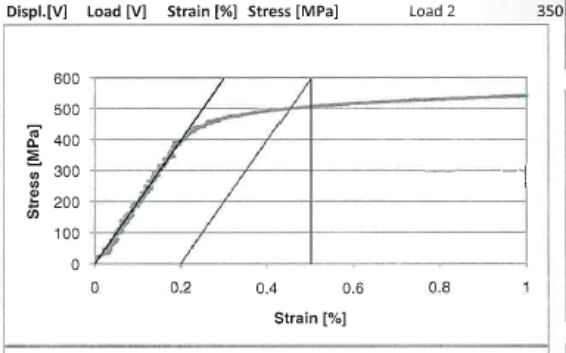
PRESS (Cntrl + q) to REDO regression calculations.

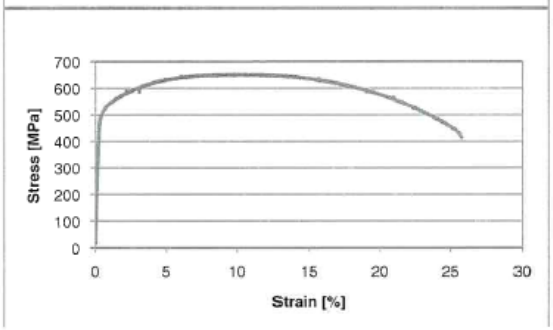
Slope Load Values

Load 1 150

Load 2 350

Load 1 row	82
Load 2 row	159
Slope	1988.352
Intercept	0





Linear Regression

Strain [%]	Stress [MP	0.2% Offse	0.5% EUL	Stress	
0	0	0.2	0.5	0	
0	0	0.2	0.5	596.5055	-0.00447
0.05	99.41758	0.25			
0.1	198.8352	0.3			
0.15	298.2528	0.35			
0.2	397.6703	0.4			
0.25	497.0879	0.45			
0.3	596.5055	0.5			

(Optional editing to define height of regression lines)

Results:	E (Mod.)	YS(0.2%)	YS(0.5%)	UTS	EUL (%)	l Elongation (%)
	198835	498.9	505.4	652.8	10.66	25.76

Ian Jeffrey
19 Aug 2008

APPENDIX I

CROSS WELD TENSILE TEST REPORTS

BMT Fleet Technology	**TENSILE TESTS RESULTS**	Form F600-006 2-040629

CONTRACT NO.:

TENSILE TESTS							
SAMPLE NO.		36-05-.5 1	36-05-.5 2		36-05-.5 1	36-05-.5 2	
DIMENSIONS	ins	.512 x .738	.519 x .737		.487 x .735	.490 x .763	
CROSS SEC. AREA	sq in	.3753	.3825		.3580	.3739	
GAUGE LENGTH	ins	2	2		2	2	
YIELD LOAD							
YIELD STRENGTH							
MAXIMUM LOAD	lbs.	30,000	30,300		18,000	15,800	
U.T.S.	PSI	79,936	79,216		50,279	42,257	
% ELONGATION							
~~FRACTURE LOCATION~~ REDUCTION OF AREA		BM	BM		WELD	WELD	
CROSSHEAD SPEED		.125"/min	-		-	-	

BEND TESTS						
SAMPLE NO.						
SAMPLE THICKNESS						
MANDRELL SIZE						
DEGREE OF BEND						
RESULTS						

DATE: SUPERVISOR:

TECHNICIAN: LT INSPECTOR: 19 Aug 06

A DIVISION OF FLEET TECHNOLOGY LIMITED

Noted as Part of ABS report# TO1022213

F600-006 Test Results Form

BMT Fleet Technology	**TENSILE TESTS RESULTS**	Form F600-006 2-040629

CONTRACT NO.:

TENSILE TESTS						
SAMPLE NO.	36-05W-1 CWT-1	36-05W-1 CWT-2		36-DS-1 CWT-1	36-DS-1 CWT-2	
DIMENSIONS ins	.952x.757	.966x.758		.964x.742	.968X.74[illegible]	
CROSS SEC. AREA sq. ins.	.7207	.7322		.7153	.7212	
GAUGE LENGTH ins	2	2		2	2	
YIELD LOAD						
YIELD STRENGTH						
MAXIMUM LOAD lbs	59,400	58,600		58,300	58,000	
U.T.S. PSI	82,420	80,033		81,504	80,422	
% ELONGATION ~~FRACTURE LOCATION~~						
~~REDUCTION OF AREA~~	Base Met.	Base Met.		B.M.	BM	
CROSSHEAD SPEED	.125"/min					

BEND TESTS						
SAMPLE NO.						
SAMPLE THICKNESS						
MANDRELL SIZE						
DEGREE OF BEND						
RESULTS						

DATE: Aug. 19/08 SUPERVISOR:

TECHNICIAN: LT INSPECTOR: 19 Aug 08

A DIVISION OF FLEET TECHNOLOGY LIMITED

Noted as Part of ABS report# TO1022213

F600-006 Test Results Form

BMT Fleet Technology

TENSILE TESTS RESULTS

Form F600-006
2-040629

CONTRACT NO.:

TENSILE TESTS						
SAMPLE NO.	65-05-1-1	65-05-1-2		65-05-1-1	65-05-1-1	65-05-1 R
DIMENSIONS ins	.985 x .741	.984 x .741		.993 x .741	.985 x .742	.987 x .753
CROSS SEC. AREA SQ ins.	.7368	.7291		.7358	.7309	.7432
GAUGE LENGTH ins	2	2		2	2	2
YIELD LOAD						
YIELD STRENGTH						
MAXIMUM LOAD lbs	62,600	61,900		61,800	49,000	59,300
U.T.S. PSI	84,962	84,899		83,990	67,041	79,790
% ELONGATION						
~~REDUCTION OF AREA~~ FRACTURE LOCATION	BM	BM		BM	WELD	WELD
CROSSHEAD SPEED	.125"/min					
BEND TESTS						
SAMPLE NO.						
SAMPLE THICKNESS						
MANDRELL SIZE						
DEGREE OF BEND						
RESULTS						

DATE: SUPERVISOR:

TECHNICIAN: LT INSPECTOR: 19 Aug 04

A DIVISION OF FLEET TECHNOLOGY LIMITED

Noted as Part of ABS report# TO1022213

F600-006 Test Results Form

BMT Fleet Technology

TENSILE TESTS RESULTS

Form F600-006
2-040629

CONTRACT NO.:

½" Material

TENSILE TESTS

SAMPLE NO.		65-05-.5 1	65-05-.5 2		65-05-.5 1	65-05-.5 2	
DIMENSIONS	ins	.492 x .759	.484 x .760		.476 x .759	.485 x .760	
CROSS SEC. AREA	Sq. ins	.3734	.3678		.3613	.3686	
GAUGE LENGTH	ins	2	2		2	2	
YIELD LOAD							
YIELD STRENGTH							
MAXIMUM LOAD	lbs.	32,800	32,706		31,200	32,500	
U.T.S.	PSI	87,842	88,907		86,355	88,172	
% ELONGATION							
~~REDUCTION OF AREA~~ FRACTURE LOCATION		BM	BM		WELD	BM	
CROSSHEAD SPEED		.125"/min					

BEND TESTS

SAMPLE NO.						
SAMPLE THICKNESS						
MANDRELL SIZE						
DEGREE OF BEND						
RESULTS						

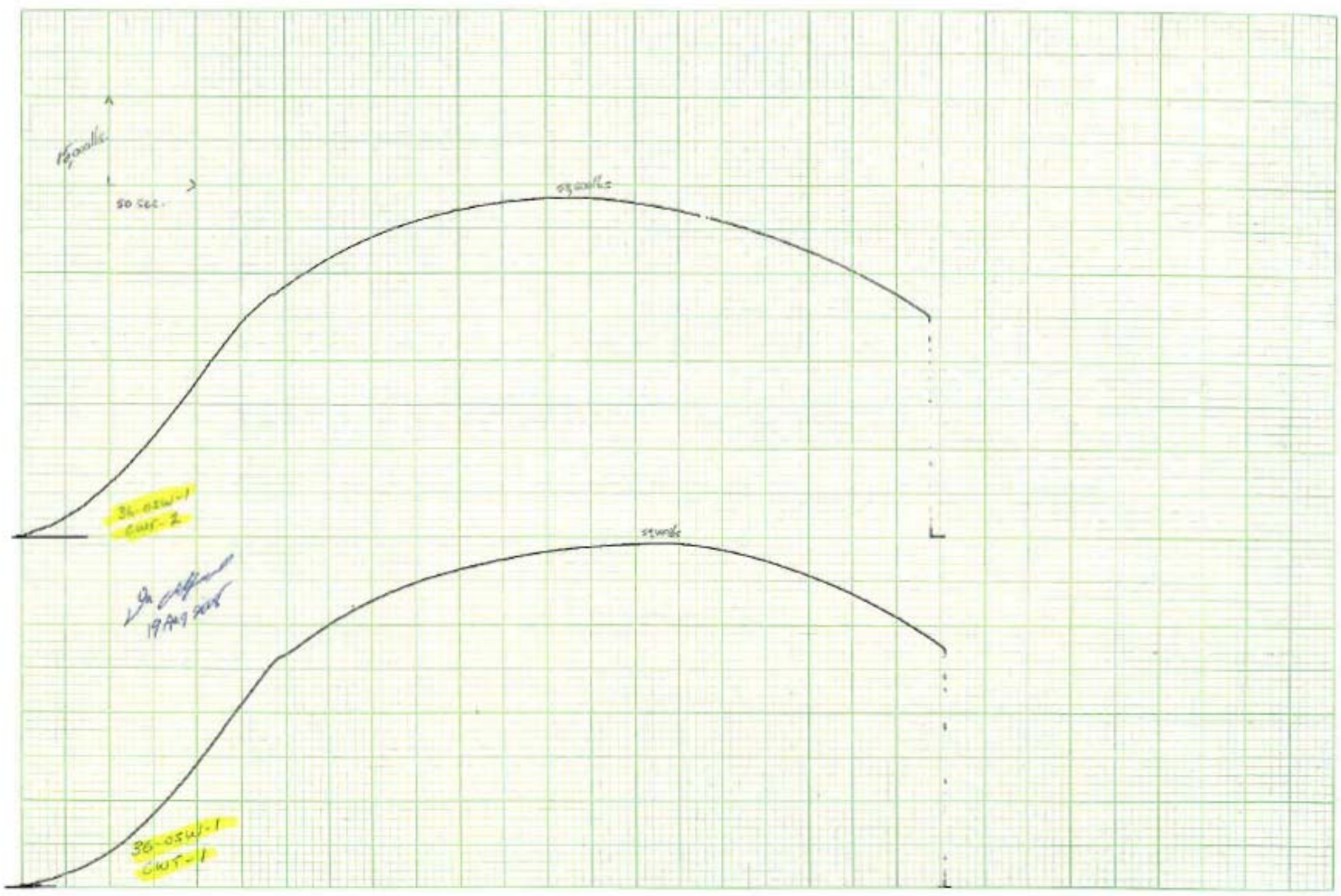
DATE: Aug. 19/08 SUPERVISOR:

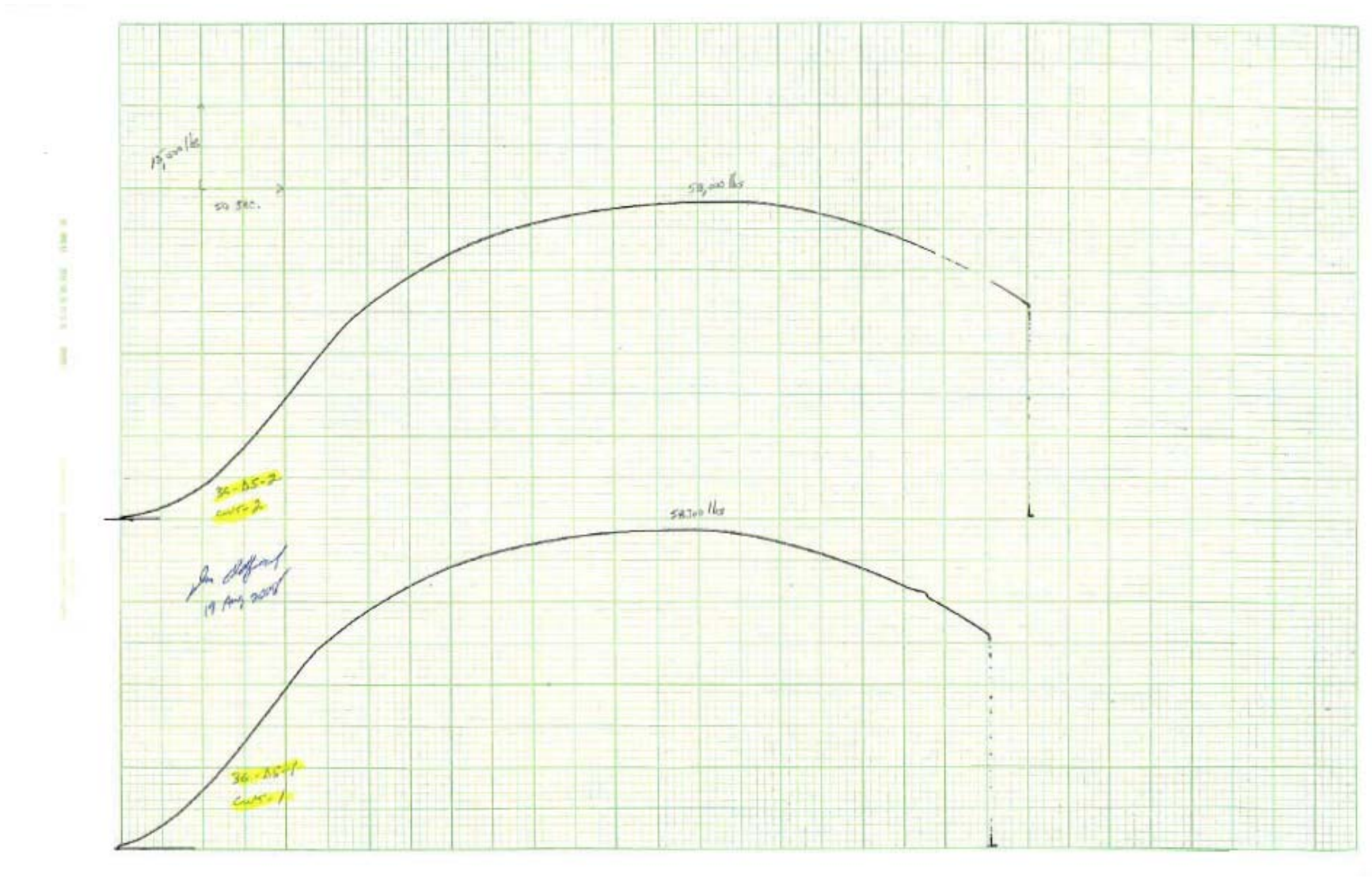
TECHNICIAN: LS INSPECTOR: [signature] 19 Aug 08

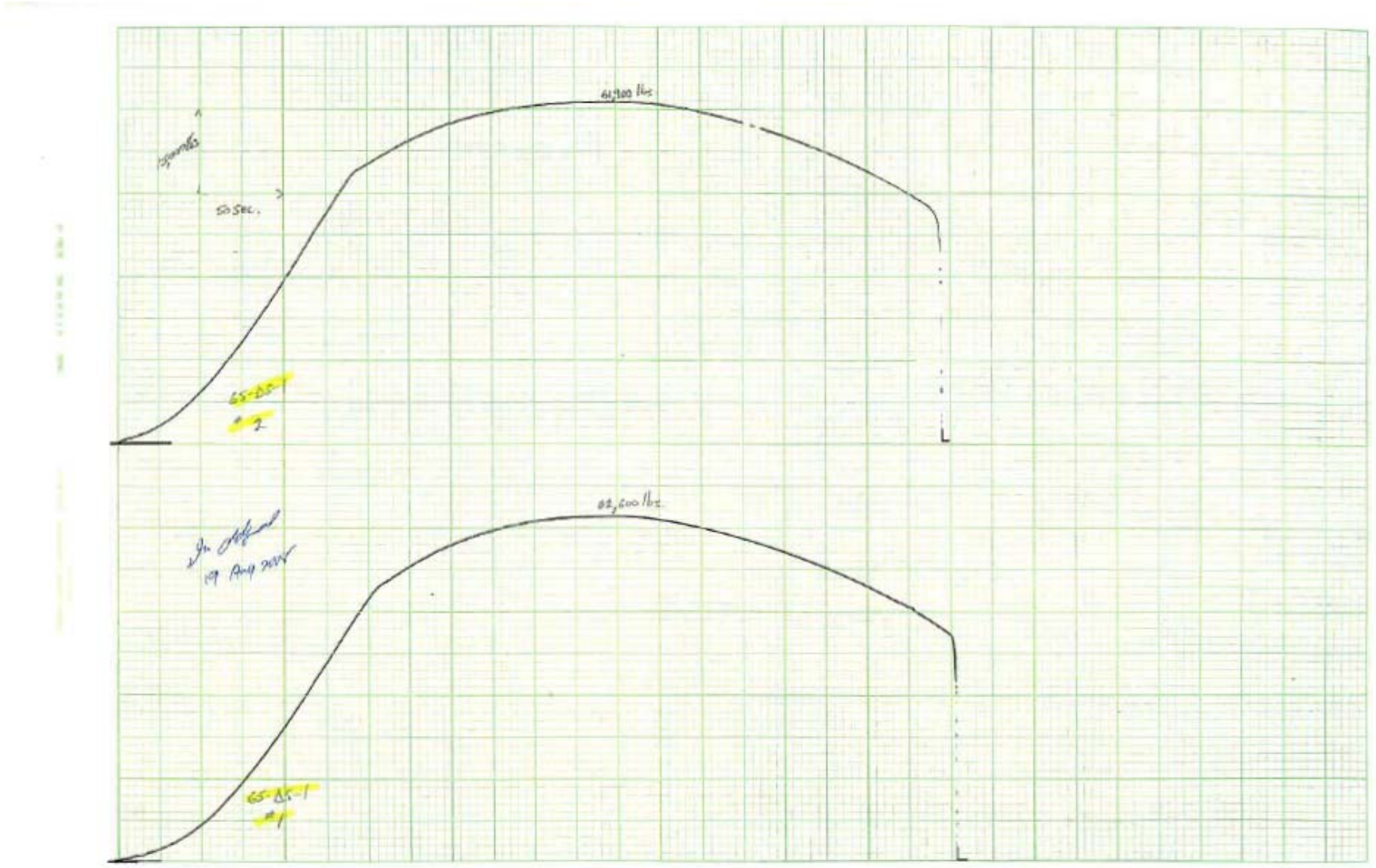
A DIVISION OF FLEET TECHNOLOGY LIMITED

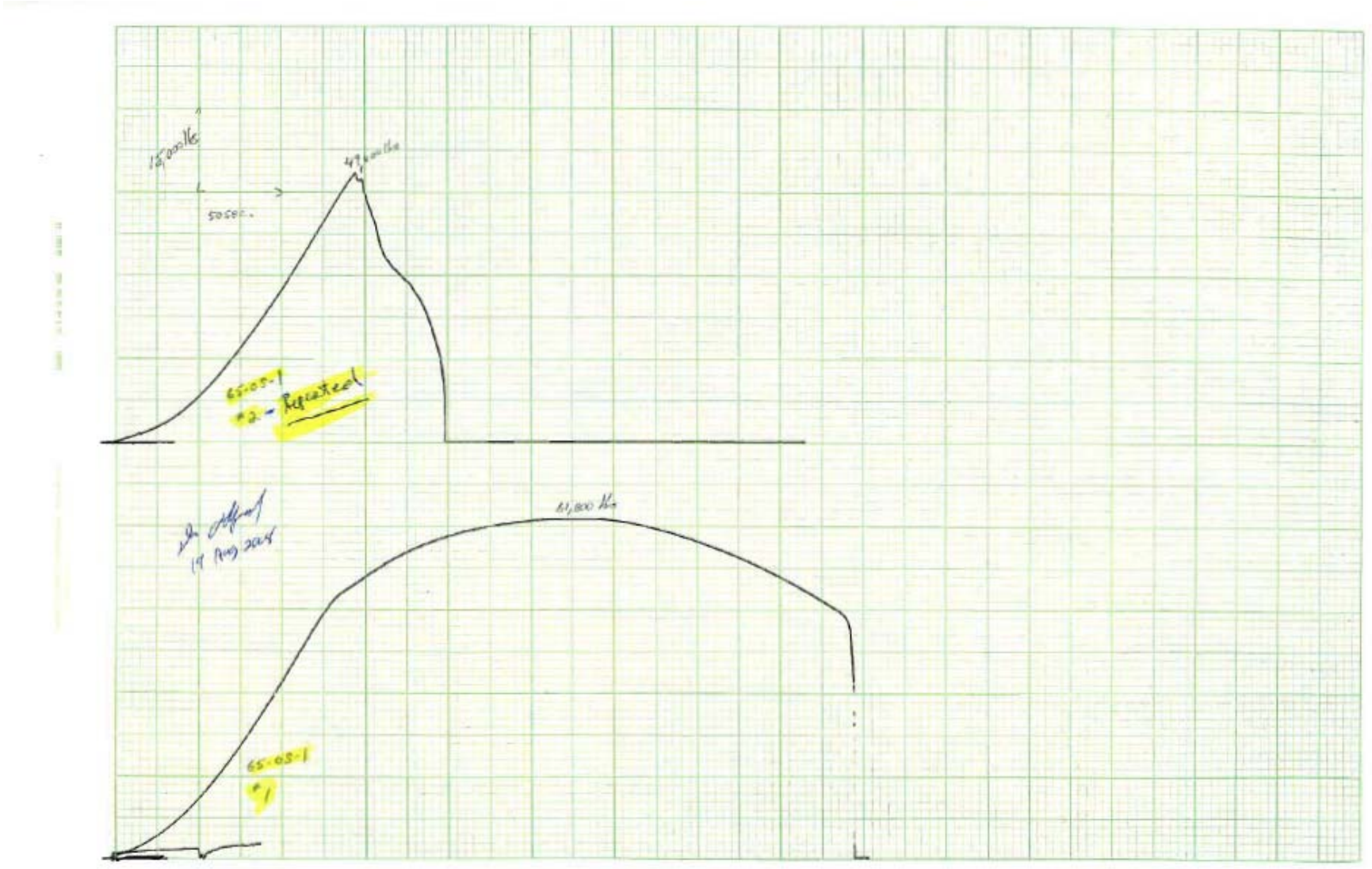
Noted as Part of ABS report# TO1022213

F600-006 Test Results Form


50 sec.
SAW-1
CWT-2
SAW-1
CWT-1


50 sec.
36-AS-2
CURVE-2
36-AS-1
CURVE-1


50 SEC.
65-AS-1
#2
65-AS-1
#1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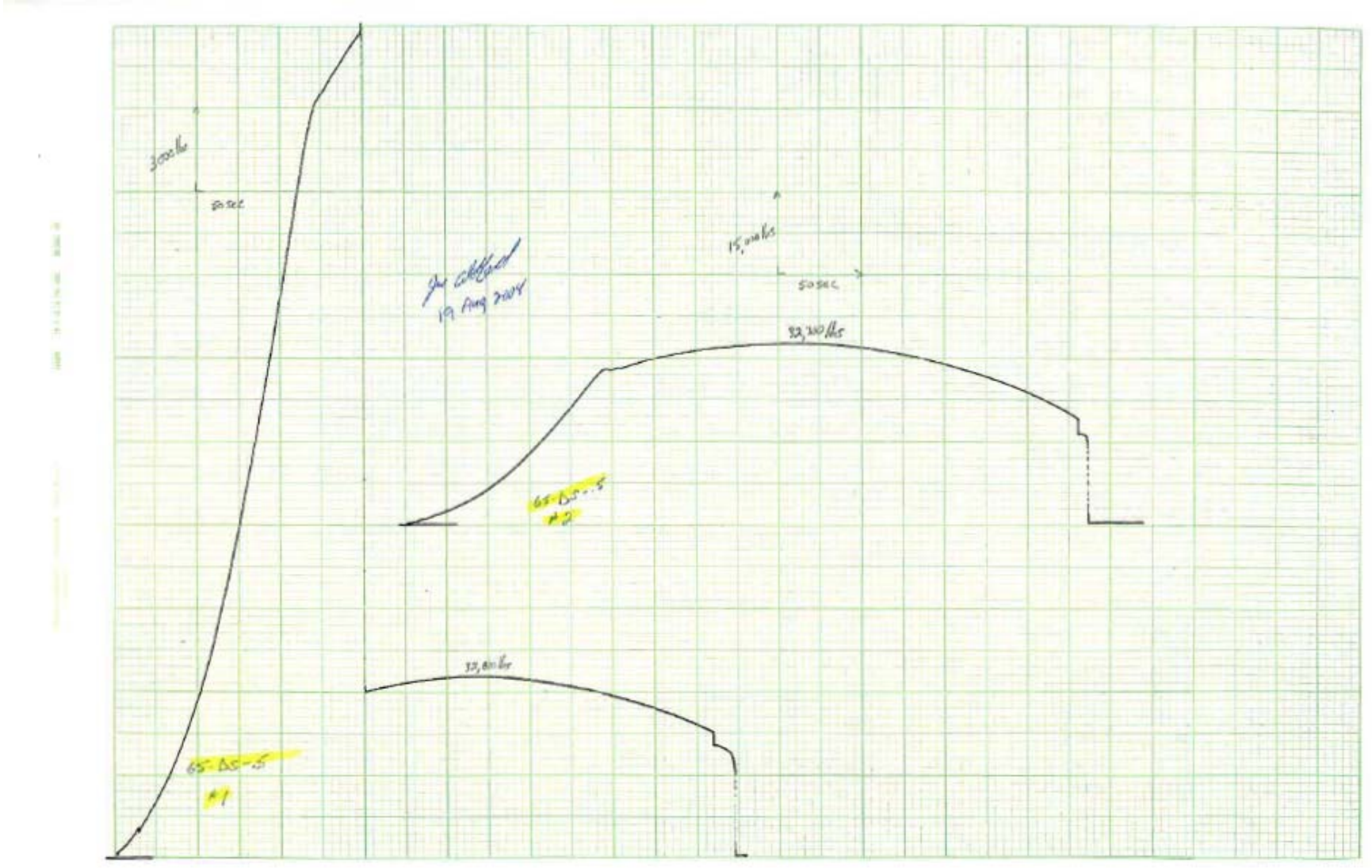
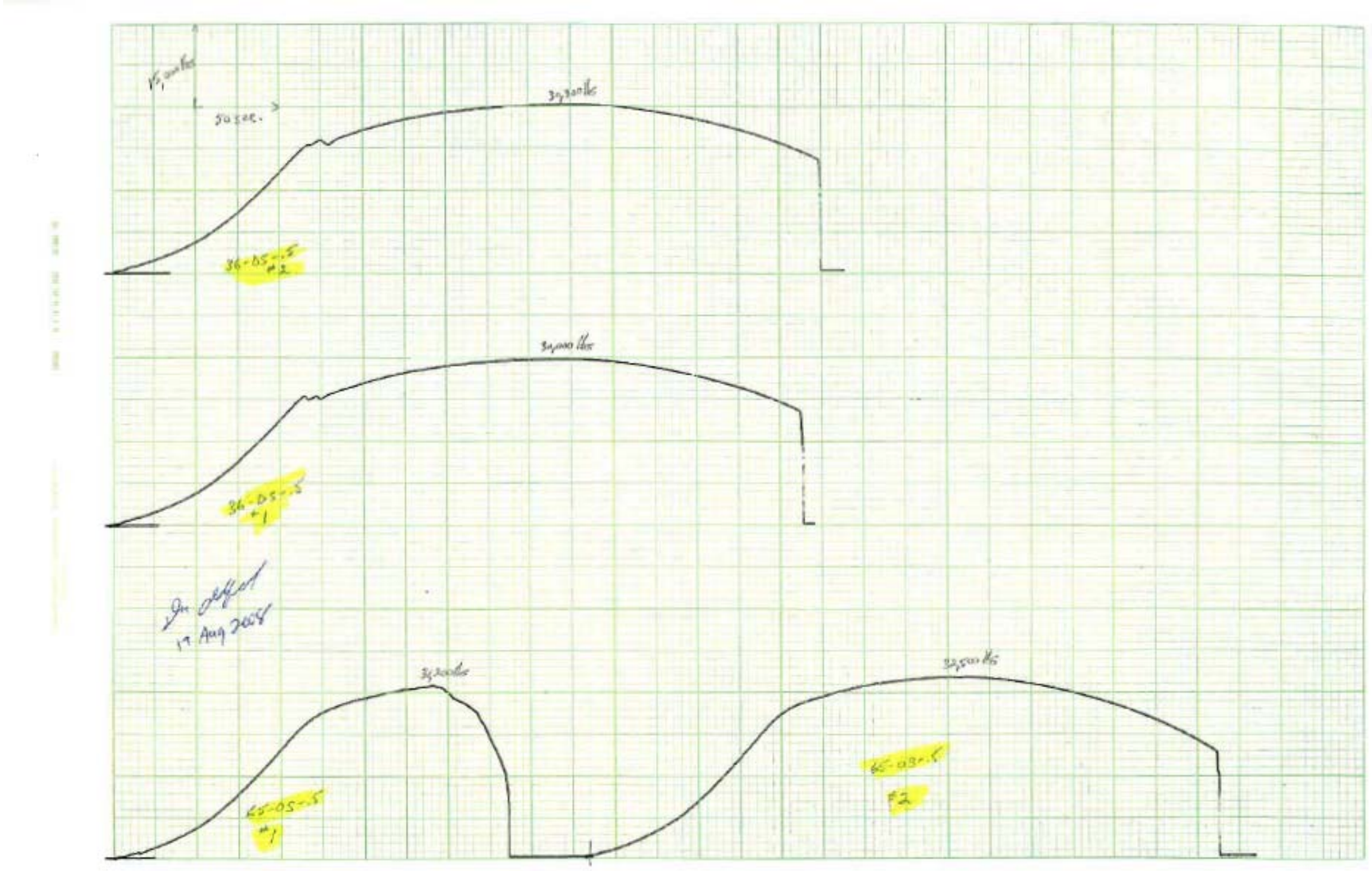
#2 - Repeated
65-05-1
#1


3000 lbs
50 sec
15,000 lbs
50 sec
33,300 lbs
65-Δs-5
#2
33,800 lbs
65-Δs-5
#1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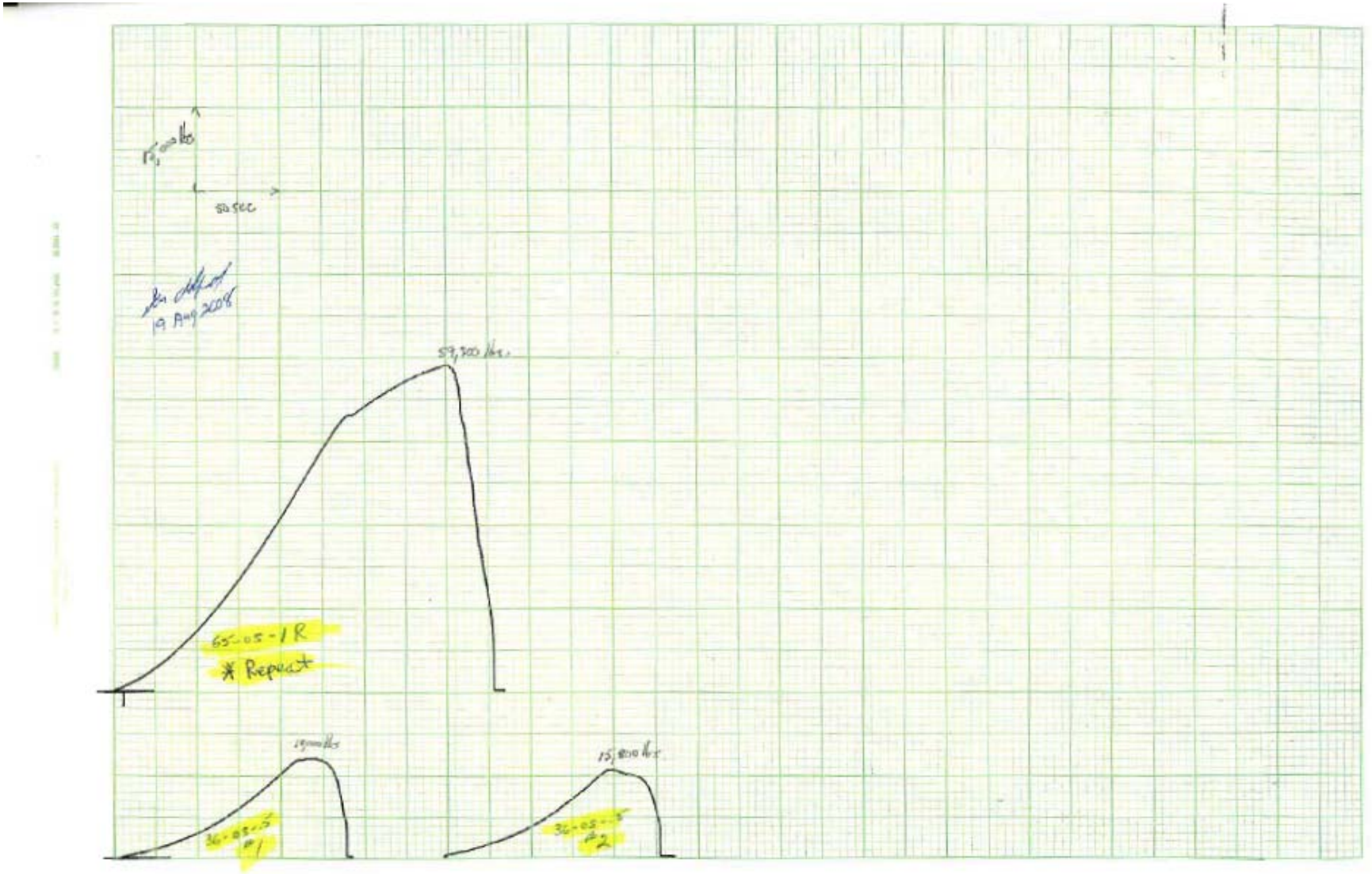
36-05-.5 #1
19 Aug 2008
65-05-.5 #1
65-05-.5 #2


50 sec
19 Aug 2008
65-05-1R
* Repeat
36-05-5
#1
36-05-5
#2

APPENDIX J

CHARPY IMPACT TEST REPORTS

BMT Fleet Technology

Impact Test Report

Form F600-011
3-040914

CONTRACT NO.:	
TECH:	
SPECIMEN SIZE:	
DATE:	

☐ Set at Zero

19 Aug 2008

	SPECIMEN No.	TEMP.	FT. LBS	LAT. EXP	%SHEAR
65 DS ½" HAZ	1	-20°F	28		
	2		39		
	3		47		
	4		30		
	5		65		
65 DS ½" WM	1	-20°F	81		
	2		83		
	3		89		
	4		89		
	5		89		
65 DSW ½" HAZ	1	-80°F	43		
	2		41		
	3		69		
	4		44		
	5		77		
65 DSW ½" WM	1	-20°F	91		
	2		107		
	3		97		
	4		91		
	5		107		

F600-011 Impact Test Report

BMT Fleet Technology

Impact Test Report

Form F600-011
3-040914

CONTRACT NO.:	
TECH:	
SPECIMEN SIZE:	
DATE:	

☐ Set at Zero

1st Qualified 19 Aug 2008

	SPECIMEN No.	TEMP.	FT. LBS	LAT. EXP	%SHEAR
65DS-1 WM	1	-20°F	142		
	2		134		
	3		125		
	4		137		
	5		130		
65DS-1 HAZ	1	-20°F	74		
	2		92		
	3		38		
	4		92		
	5		70		
65OSW1 WM	1	-20°F	67		
	2		78		
	3		70		
	4		65		
	5		82		
65OSW1 HAZ	1	-20°F	20		
	2		22		
	3		13		
	4		43		
	5		32		

F600-011 Impact Test Report

BMT Fleet Technology	**Impact Test Report**	Form F600-011 3-040914

CONTRACT NO.:	
TECH:	
SPECIMEN SIZE:	
DATE:	

☐ Set at Zero

Jim Clifford
19 Aug 2008

SPECIMEN No.	TEMP.	FT. LBS	LAT. EXP	%SHEAR
36DS				
½" HAZ				
1	-4°F	51		
2		50		
3		51		
4		60		
5		50		
6	-40°F	30		
7		47		
8		21		
9		23		
10		24		

F600-011 Impact Test Report

BMT Fleet Technology

Impact Test Report

Form F600-011
3-040914

CONTRACT NO.:	
TECH:	
SPECIMEN SIZE:	
DATE:	

☐ Set at Zero

Jw added 19 Aug 2008

SPECIMEN No.	TEMP.	FT. LBS	LAT. EXP	%SHEAR
36 OSW1" WM-3 1/16" BELOW SIDE #2 (root) 1	-40°F	47		
2		43		
3		57		
4	-40°F	44		
5		47		
6		48		
36 DS 1/2" WM 1	-40°F	105		
2		113		
3		108		
4		117		
5		111		
6	-40°F	89		
7		100		
8		108		
9		108		
10		78		

F600-011 Impact Test Report

BMT Fleet Technology

Impact Test Report

Form F600-011
3-040914

CONTRACT NO.:	
TECH:	
SPECIMEN SIZE:	
DATE:	

☐ Set at Zero

Machine calibrated 19 Aug 2014

SPECIMEN No.	TEMP.	FT. LBS	LAT. EXP	%SHEAR
36 OSW ½" WM 1	-40°F	111		
2		111		
3		114		
4		116		
5		112		
6	-40°F	90		
7		85		
8		83		
9		73		
10		85		
36 OSW ½ HAZ 1	-40°F	19		
2		21		
3		24		
4		22		
5		24		
6	-40°F	18		
7		18		
8		13		
9		16		
10		14		

F600-011 Impact Test Report

BMT Fleet Technology

Impact Test Report

Form F600-011
3-040914

CONTRACT NO.:	6134C
TECH:	D. Beese
SPECIMEN SIZE:	10x10 mm
DATE:	Aug 18/08

☑ Set at Zero

Impact Offset 14 Aug 2008

SPECIMEN No.	TEMP.	FT. LBS	LAT. EXP	%SHEAR
360SW 1" HAZ 1	-4°F	28		
2	"	25		
3	"	30		
4	-40°F	26		
5	-40°F	53		
6	-40°F	19		
360SW1" WM-1 1/16" Below Side #1 (cap) 1	-40F	44		
2		44		
3		30		
4	-40°F	32		
5		24		
6		35		
360SW1" WM-2 T/2 1	-40F	45		
2		38		
3		42		
4	-40°F	31		
5		31		
6		25		

F600-011 Impact Test Report

BMT Fleet Technology

Impact Test Report

Form F600-011
3-040914

CONTRACT NO.:	
TECH:	
SPECIMEN SIZE:	
DATE:	

☐ Set at Zero

In diffusible
19 Aug 2008

SPECIMEN No.	TEMP.	FT. LBS	LAT. EXP	%SHEAR
1	-4°F	105		
2		111		
3		109		
4		118		
5		107		
1	-4°F	169		
2		125		
3		77		
4		68		
5		48		

36 DS 1 WM

36 DS 1 HAZ

F600-011 Impact Test Report

APPENDIX K

HARDNESS RESULTS

BMT Fleet Technology

HARDNESS TEST REPORT

Form F600-012A
0-040705

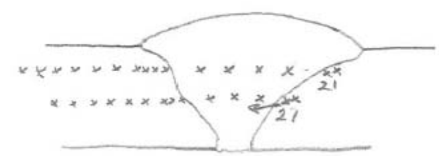
Procedure:		Applicable Standard:	
Date:	Nov. 13/08	Technician:	LT
Report Number:	36-OSW - ½	Checked by:	

Hardness Test Report

Hardness Test — Load (kg) 5

Location 2mm SS		Ocular Reading	Hardness	Location MID		Ocular Reading	Hardness
HAZ	1	208	214	HAZ	1	207	216
"	2	207	216	"	2	207	216
Weld	3	201	229	Weld	3	200	232
"	4	202	227	"	4	200	232
"	5	202	227	"	5	200	232
"	6	202	227	HAZ	6	206	219
HAZ	7	207	216	"	7	203	225
"	8	206	219	"	8	206	219
"	9	206	219	"	9	207	216
"	10	209	212	"	10	211	208
"	11	215	201	"	11	221	190
"	12	231	174	"	12	223	187
BM	13	236	167	BM	13	235	168
"	14	236	167	"	14	236	167
"	15	237	165	"	15	235	168
"	16	236	167	"	16	236	167
Average				Average			

Macrophoto



Comments:

	ACCEPT
	REJECT

F600-012A Hardness Test Report

BMT Fleet Technology

HARDNESS TEST REPORT

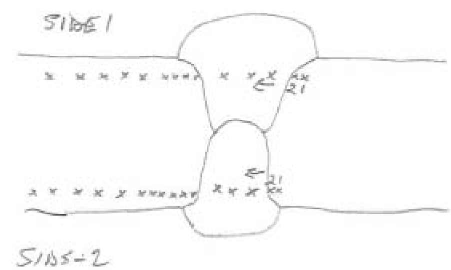
Form F600-012A
0-040705

Procedure:		Applicable Standard:	
Date:	Nov. 13/08	Technician:	LT
Report Number:	36-DS-1/2	Checked by:	

Hardness Test Report

Hardness Test			Load (kg) 5		
Location SIDE - 1	Ocular Reading	Hardness	Location SIDE - 2	Ocular Reading	Hardness
2mm SS-HAZ 1	200	232	2mm SS HAZ 1	201	229
HAZ 2	201	229	HAZ 2	202	227
Weld 3	187	265	Weld 3	197	239
" 4	187	265	" 4	197	239
" 5	190	257	" 5	198	236
HAZ 6	201	229	HAZ 6	204	223
" 7	202	227	" 7	204	223
" 8	205	221	" 8	209	212
" 9	212	206	" 9	214	203
" 10	218	195	" 10	220	192
" 11	224	185	" 11	224	185
BM 12	227	180	" 12	226	182
" 13	229	177	BM 13	231	174
" 14	230	175	" 14	230	175
" 15	230	175	" 15	230	175
			" 16	230	175
Average			Average		

Macrophoto



Comments:

	ACCEPT
	REJECT

F600-012A Hardness Test Report

BMT Fleet Technology

HARDNESS TEST REPORT

Form F600-012A
0-040705

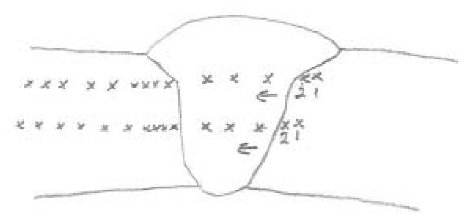
Procedure:		Applicable Standard:	
Date:	Nov. 13/08	Technician:	LS
Report Number:	65-0SW-½	Checked by:	

Hardness Test Report

Hardness Test — Load (kg) 5

Location SS 2mm		Ocular Reading	Hardness	Location MID		Ocular Reading	Hardness
HAZ	1	209	212	HAZ	1	207	216
"	2	208	214	"	2	207	216
Weld	3	201	229	Weld	3	201	229
"	4	202	227	"	4	201	229
"	5	202	227	"	5	202	227
HAZ	6	209	212	HAZ	6	209	212
"	7	209	212		7	208	214
"	8	209	212		8	209	212
"	9	212	206		9	210	210
"	10	215	201		10	210	210
"	11	231	174		11	215	201
"	12	223	187		12	226	182
BM	13	217	197	BM	13	219	193
"	14	217	197	"	14	219	193
				"	15	220	192
Average				Average			

Macrophoto



Comments:

	ACCEPT
	REJECT

F600-012A Hardness Test Report

BMT Fleet Technology

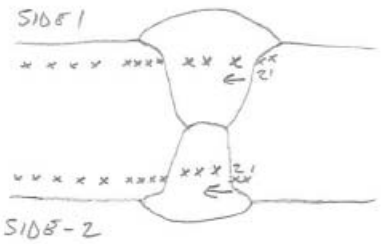
HARDNESS TEST REPORT

Form F600-012A
0-040705

Procedure:		Applicable Standard:	
Date:	Nov. 13/08	Technician:	L.T
Report Number:	65-DS-½	Checked by:	

Hardness Test Report

Hardness Test				Load (kg) 5			Macrophoto
Location	Ocular Reading	Hardness		Location	Ocular Reading	Hardness	
SIDE-1				SIDE-2			
SS HAZ 1	201	229		SS HAZ 1	204	223	
" 2	197	239		" 2	202	227	
Weld 3	190	257		Weld 3	201	229	
" 4	191	254		" 4	201	229	
" 5	195	244		" 5	200	232	
HAZ 6	203	225		HAZ 6	205	221	
" 7	205	221		" 7	206	219	
" 8	205	221		" 8	204	223	
" 9	208	214		" 9	207	216	
" 10	221	190		" 10	216	199	
" 11	222	188		" 11	219	193	
BM 12	216	199		BM 12	216	199	
" 13	215	201		" 13	216	199	
" 14	216	199		" 14	215	201	
" 15	217	197		" 15	216	199	
Average				Average			



Comments:

	ACCEPT
	REJECT

F600-012A Hardness Test Report

BMT Fleet Technology

HARDNESS TEST REPORT

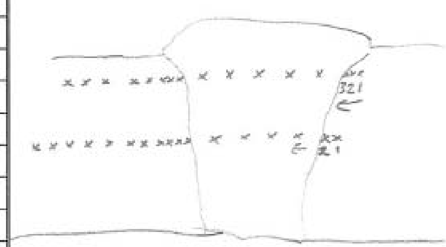
Form F600-012A
0-040705

Procedure:		Applicable Standard:	
Date:	Nov. 13/08	Technician:	LT
Report Number:	36-05W-1	Checked by:	

Hardness Test Report

Hardness Test				Load (kg) 5			
Location 2mm SS	#	Ocular Reading	Hardness	Location	#	Ocular Reading	Hardness
HAZ	1	213	204	MID-HAZ	1	207	216
"	2	212	206	"	2	207	216
"	3	211	208	Weld	3	206	219
Weld	4	203	225	"	4	203	225
"	5	206	219	"	5	203	225
"	6	206	219	"	6	204	223
"	7	204	223	HAZ	7	208	214
"	8	203	225	"	8	208	214
HAZ	9	213	204	"	9	211	208
"	10	213	204	"	10	212	206
"	11	218	195	"	11	220	192
"	12	222	188	"	12	227	180
"	13	236	167	"	13	234	169
"	14	238	164	"	14	236	167
BM	15	241	160	"	15	229	177
"	16	241	160	BM	16	233	171
				BM	17	222	188
Average				Average			

Macrophoto



Comments:

	ACCEPT
	REJECT

F600-012A Hardness Test Report

BMT Fleet Technology

HARDNESS TEST REPORT

Form F600-012A
0-040705

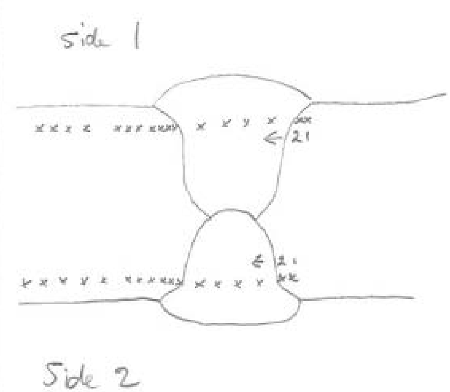
Procedure:		Applicable Standard:	
Date:	Nov. 13/08	Technician:	LJ
Report Number:	36-DS-1	Checked by:	

Hardness Test Report

Hardness Test — Load (kg) 5

Location SIDE 1	No.	Ocular Reading	Hardness	Location SIDE 2	No.	Ocular Reading	Hardness
HAZ	1	205	221	HAZ	1	200	232
"	2	203	225	"	2	194	246
Weld	3	197	239	Weld	3	196	241
"	4	197	239	"	4	196	241
"	5	196	241	"	5	195	244
"	6	196	241	"	6	196	241
HAZ	7	203	225	HAZ	7	201	229
"	8	204	223	"	8	203	225
"	9	206	219	"	9	211	208
"	10	214	203	"	10	221	190
"	11	226	182	"	11	224	185
"	12	230	175	BM	12	237	165
BM	13	239	162	"	13	236	167
"	14	239	162	"	14	241	160
"	15	240	161	"	15	241	160
"	16	241	160	"	16	241	160
"	17	241	160	"	17	241	160
Average				Average			

Macrophoto



Comments:

	ACCEPT
	REJECT

F600-012A Hardness Test Report

BMT Fleet Technology

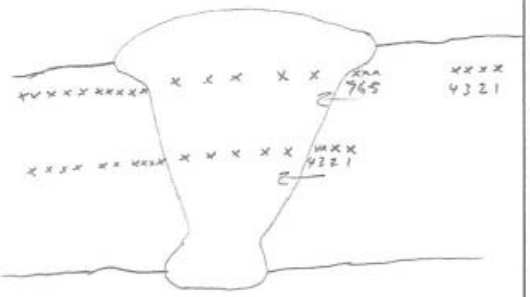
HARDNESS TEST REPORT

Form F600-012A
0-040705

Procedure:		Applicable Standard:	
Date:	Nov. 13/08	Technician:	LT
Report Number:	65-05W-1	Checked by:	

Hardness Test Report

Hardness Test			Load (kg) 5			Macrophoto
Location	Ocular Reading	Hardness	Location	Ocular Reading	Hardness	
2mm BM 1	219	193	" 21	235	168	
SS " 2	218	195	" 22	236	167	
" 3	219	193	BM 23	231	174	
" 4	219	193	" 24	228	178	
HAZ 5	207	216	MID → HAZ 1	214	203	
" 6	208	214	" 2	214	203	
" 7	206	219	" 3	212	206	
weld 8	199	234	" 4	207	216	
" 9	199	234	weld 5	202	227	
" 10	201	229	" 6	201	229	
" 11	203	225	" 7	202	227	
" 12	201	229	" 8	202	227	
HAZ 13	206	219	" 9	203	225	
" 14	207	216	HAZ 10	210	210	
" 15	207	216	" 11	211	208	
" 16	208	214	" 12	211	208	
" 17	211	208	" 13	211	208	
" 18	214	203	" 14	212	206	
" 19	213	204	" 15	215	201	
" 20	222	188	" 16	231	174	
Average			" Average			
			" 17 - 230		175	
			BM 18 - 227		180	
			" 19 - 224		185	



Comments:

	ACCEPT
	REJECT

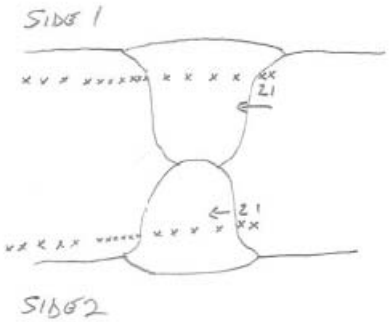
F600-012A Hardness Test Report

BMT Fleet Technology	HARDNESS TEST REPORT	Form F600-012A 0-040705

Procedure:		Applicable Standard:	
Date:	Nov. 13/08	Technician:	KT
Report Number:	65-DS-1	Checked by:	

Hardness Test Report

Hardness Test				Load (kg) 5				Macrophoto
Location		Ocular Reading	Hardness	Location		Ocular Reading	Hardness	
SIDE 1				SIDE 2				
HAZ	1	204	223	HAZ	1	207	216	
"	2	207	216	"	2	205	221	
Weld	3	198	236	Weld	3	198	236	
"	4	198	236	"	4	200	232	
"	5	198	236	"	5	198	236	
"	6	200	232	"	6	198	236	
HAZ	7	207	216	HAZ	7	207	216	
"	8	209	212	"	8	206	219	
"	9	209	212	"	9	206	219	
"	10	212	206	"	10	208	214	
"	11	215	201	"	11	211	208	
"	12	216	199	"	12	213	204	
"	13	216	199	BM	13	218	195	
BM	14	217	197	"	14	218	195	
"	15	217	197	"	15	219	193	
"	16	220	192	"	16	222	188	
"	17	220	192	"	17	221	190	
Average				Average				



Comments:

	ACCEPT
	REJECT

F600-012A Hardness Test Report

APPENDIX L

WELD METAL CHEMICAL ANALSYS RESULTS

Bodycote

Accredited Nadcap Materials Testing Laboratory

ACCREDITED TESTING CERT# 0104.01 & 0104.02

Bodycote Testing Group, Chicago Laboratory, 7530 Frontage Road, Skokie, Illinois, 60077-3213
Tel: 847 676 2100, Fax: 847 676 2132

Test Certificate

BMT Fleet Technology Ltd
311 Leggett Drive
Kanata, Ontario
Canada

K2K 1Z8

Attn: Darren Begg

REF No T810271 : Issue 1
Ord No 0240DB

Date Tested 09/09/08
Date Printed 09/09/08
Date Received 08/27/08

Item - CHEMICAL ANALYSIS OF 6 WELD SAMPLES

Specification - Not Applicable

Chemical Analysis

	C [%]	Mn [%]	P [%]	S [%]	Si [%]	Ni [%]	Cr [%]	Mo [%]	Cu [%]	Al [%]	V [%]	Comments
001:	.06	1.59	.020	.006	.32	1.24	.06	.29	.05	<.02	.04	65-05W-1 T1
002:	.09	1.47	.012	.006	.31	1.07	.03	.26	.04	<.02	.02	36-05W-1
003:	.10	1.46	.012	.006	.32	.96	.03	.23	.03	<.02	.03	36-DS-1 T1
004:	.06	1.49	.017	.007	.30	.97	.04	.23	.04	<.02	.04	65-DS-1 T1
005:	.05	1.53	.015	.007	.30	1.34	.05	.33	.06	<.02	.03	65-CT-HH T1
006:	.04	1.54	.013	.008	.33	1.88	.04	.45	.05	<.02	.01	65-CT-LH-T1

	Nb [%]	B [%]	Ti [%]	Zr [%]	N2 [%]	O2 [%]	Comments
001:	<.02	.0009	.03	<.01	.004	.021	65-05W-1 T1
002:	<.02	.0008	.02	<.01	.007	.022	36-05W-1
003:	<.02	.0012	.03	<.01	.007	.028	36-DS-1 T1
004:	.02	.0014	.03	<.01	.004	.031	65-DS-1 T1
005:	<.02	.0013	.03	<.01	.004	.033	65-CT-HH T1
006:	<.02	.0017	.03	<.01	.004	.042	65-CT-LH-T1

Analysis by ICP, OES, Combustion and/or Gravimetric Methods. Details available upon request.

Michael C Fec
Section Manager/Metallurgist
For and on behalf of
Bodycote Testing Group

APPENDIX M

ABS STATEMENT OF FACT

AMERICAN BUREAU OF SHIPPING
MISCELLANEOUS SURVEY REPORT

Customer Name	**BMT FLEET TECHNOLOGY LIMITED**	Purchase Order No.	
Attending Office	**Toronto**	Report Number	**TO1022213**
First Visit Date	**08-Jul-2008**	Last Visit Date	**19-Aug-2008**

Statement of Fact

Survey Location : Ottawa, Ontario

Surveyor(s) to The American Bureau of Shipping
Attending Surveyors

Oldford Dan — Electronically Signed on 28-Aug-2008

Reviewed By
Labrie, Michel — Electronically Signed on 28-Aug-2008, Halifax Port

AB Report Vendor

AMERICAN BUREAU OF SHIPPING
ABS Plaza – 16855 Northchase Drive
Houston, TX 77060-6008

Report No.: TO1022213 Date: 19-AUG-2008 Port: TORONTO

STATEMENT OF FACT
Welding

At the request of BMT Fleet Technology Limited the undersigned surveyor attended their facility located in Kanata, Ontario, Canada in order to witness welding and the subsequent testing of the herein described procedures and reports as follows:

Material used for the welding:

Mill	Grade	Heat#	Gauge
ISG Plate Inc.	ASTM A945 YR 05 GR 65	U7686	12.7 mm (1/2")
Oregon Steel Mills	ABS EH-36	M00159	25 mm (0.9843")
Mittal Steel USA Burns Harbour Plate	ABS EH-36	823V61970	13 mm
ISG Burns Harbor Plate Inc.	ASTM A945-00 GR 65	832P38690	1"

Joints used:

The details of the joints are included on the attached pages, the particulars are as follows:

Base Metal	Thickness	ID	Feeders	Passes	Sides
GR-65	1"	65-CT-LH	Single	13	1
GR-65	½"	65-DS-.5	Tandem	2	2
EH-36	½"	36-DS-.5	Tandem	2	2
GR-65	1"	65-DS-1	Tandem	2	2
EH-36	1"	36-DS-1	Tandem	2	2
GR-65	1"	65-CT-HH	Single	6	1
EH-36	½"	36-OSW-.5	Tandem	1	1
GR-65	½"	65-OSW-.5	Tandem	1	1
EH-36	1"	36-OSW-1	Tandem	1	1
GR-65	1"	65-OSW-1	Tandem	1	1

Test Results:

The test results are fully detailed on the attached reports, it is noted that there are thirty-one (31) pages attached to this report, including four (4) pages of steel mill test reports, six (6) pages of rough notes on welding parameters, six (6) pages of tensile test reports, seven (7) graphs of cross weld tension tests, and eight (8) pages of impact results.

OWS = One sided weld
DS = Double sided weld
LH = Low Heat Input
HH = High Heat input
CWT = Cross weld test

Dan Oldford – Surveyor
ABS Toronto

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