“Comparison of SAW and Tandem Electrode Gas Shielded Processes for Productivity, and Distortion in Thin Panel Butt Joints for Thin Panel Structures”

August 17, 2010 Idaho Falls, Idaho

NSRP Subcontract Agreement No. 2010-305

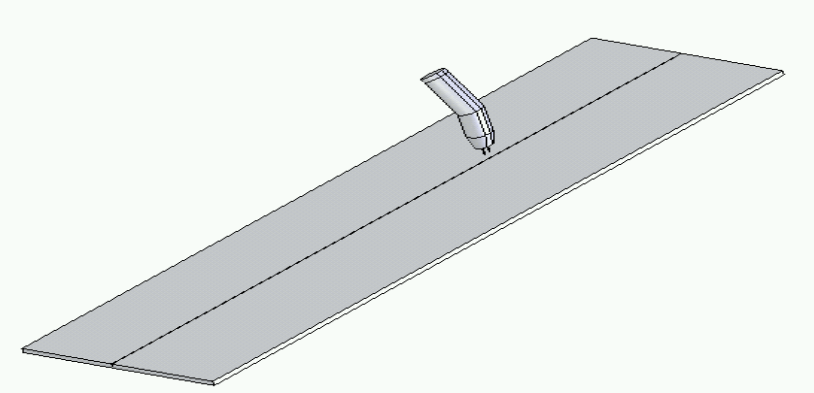
Prime Contractor: ***Todd Pacific Shipyard***

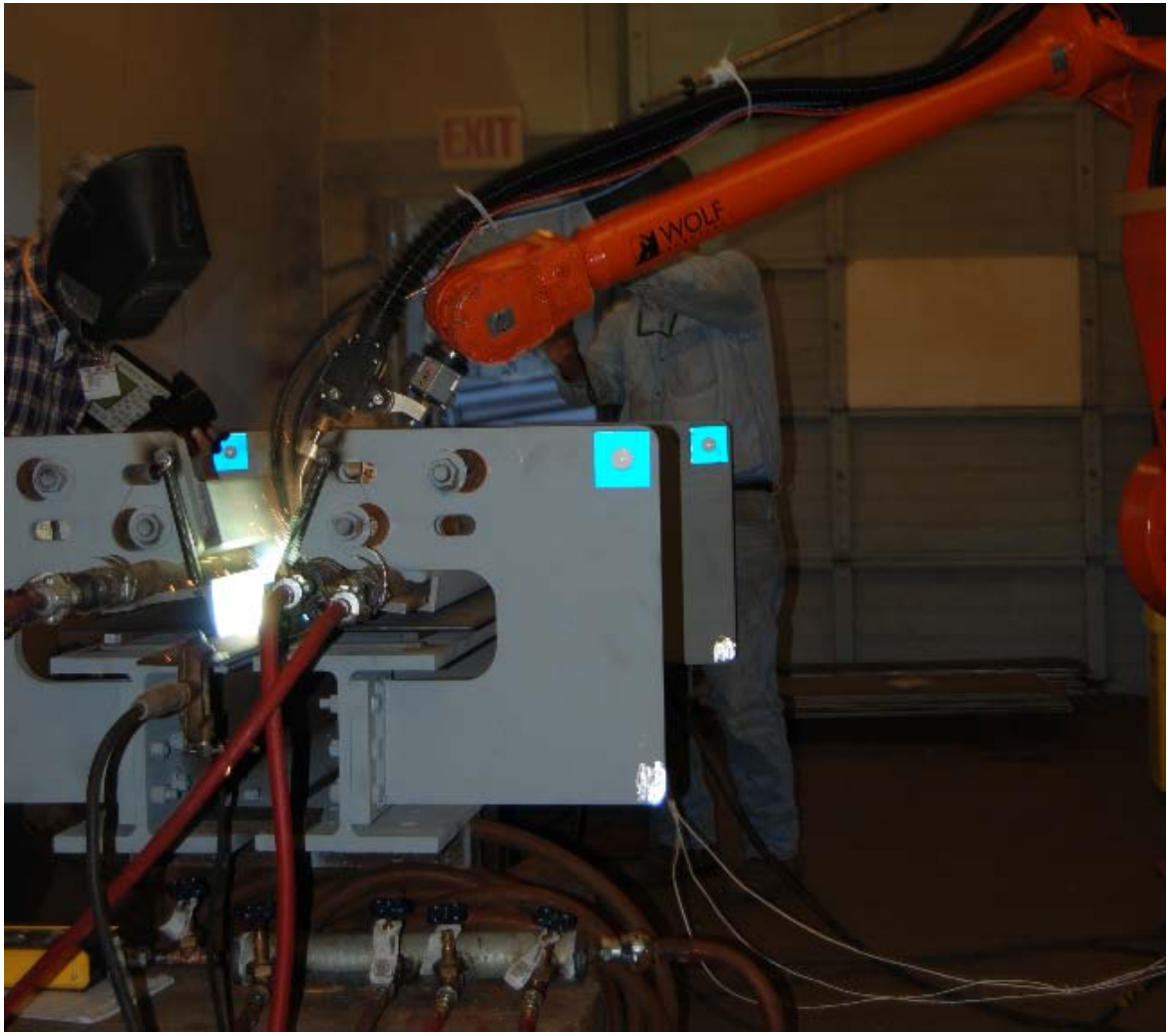
Sub-Contractors: ***NASSCO Shipbuilding, CD-adapco , Weaver Engineering, Dwight Laboratories, Machinists Inc.***

Contributing Team Members: ***ESAB Welding and Cutting Products, Wolf robotics, Abicor Binzel Corporation, Northrop Grumman Ship Systems***

“Comparison of SAW and Tandem Electrode Gas Shielded Processes for Productivity, and Distortion in Thin Panel Butt Joints for Thin Panel Structures”

Presented to
SP-7 Panel
Idaho Falls, Id
August 17, 2010





Fully Configured Weld Cell Welding a Butt Joint

Project Status Report

August 17, 2010

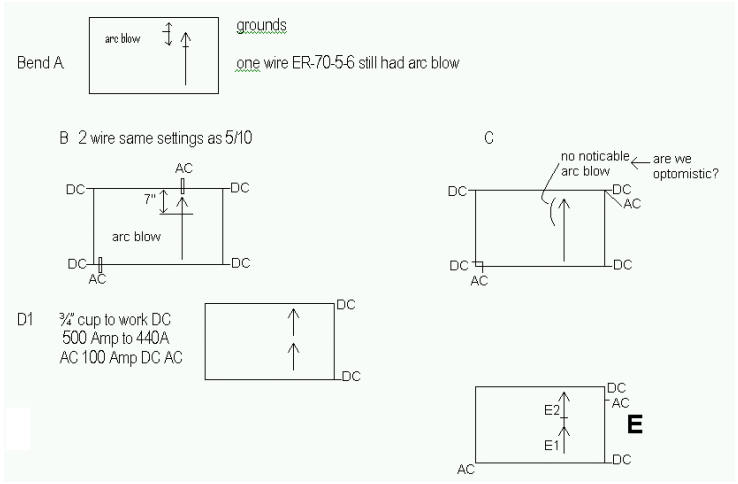
- Delays in first and second quarter making weld cell operational previously reported have set the schedule back.
- Effort for Quarter
  - Effort regarding successful mitigation of arc blow are discussed.
  - Welding Procedure Development Variations Assessed.
- Results
  - We are near a successful procedure for 6 mm plate. The current procedure with results and favorable comparisons to SAW are shown in this presentation.

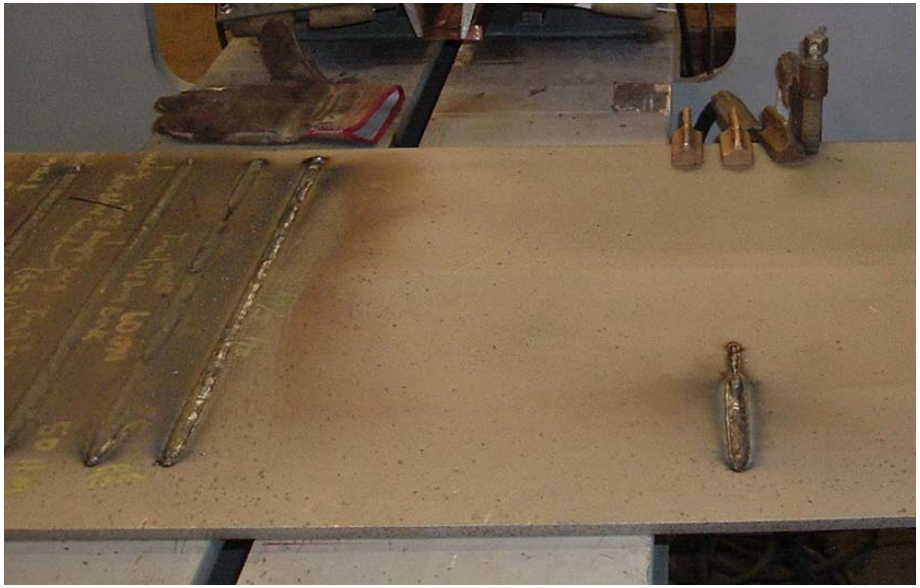
Arc Blow

- **The baseline procedure uses DC Electrode Positive for both electrodes.**

- **The total current through the tandem electrode is over 950 amps. Initially, we were experiencing intolerable levels of arc blow and tried several techniques to eliminate it:**
  - **Ground Locations and Configurations. We tried two grounds per machine - four grounds total on the weld plate.**
  - **With an additional power supply, superimposing 75 - 100 Amps AC current into the weld plate. This resulted in some improvement, but did not eliminate the problem. See Figure 7.**
  - ***Adding large (12 inch x 12 inch minimum) run-out tabs at the ends of the weld joint. This was a successful idea and has eliminated the arc blow problem.***

Arc Blow


arc blow
Bend A
grounds
one wire ER-70-5-6 still had arc blow
B 2 wire same settings as 5/10
AC
DC
DC
7"
arc blow
DC
DC
AC
C
no noticable arc blow
are we optomistic?
DC
DC
AC
DC
DC
AC
D1
¾" cup to work DC
500 Amp to 440A
AC 100 Amp DC AC
DC
DC
DC
AC
E2
E1
E
DC
AC



Welding Procedure Development

Issues

- **Penetration.**
  - **Lead Wire Current :**
  - **Joint Design : Gap, Bevel**
  - **Shielding Gas**
- **Bead Profile Front side: Reinforcement Height**
  - **Gap Size : zero to .09**
  - **I^2R Heating : .045 vs. .062**
- **Bead Profile Back side : Reentrant Angle at Bead Toe**
  - **Chill effect : Copper; Ceramic tape**
  - **Gap below Plate**
  - **Slag**

Welding Procedure Development

- **Power Supply Current :=> ESAB Provided a 6502C, 650 amp, inverter/chopper power supply when it became apparent 500 amps was not enough to drive the lead wire.**
- **Direct welding into the copper backing bar. See Figure 1.**
- **Pouring Flux into a large groove on one side of the backing bar. See Figure 2. Difficulty controlling Gap between Plate and Flux.**
- **Ceramic tape. This is one possibility that we are still assessing. The results are encouraging but the chill effect is a key variable. Our fixture needs to be re-configured to use ceramic backing well. See Figure 3**
- **Fiberglass Tape has proved to be very effective.**
- **Shielding Gas and Root Opening Variations.**
- **Fluxcored Wire for lead arc**

Welding Procedure Development

Direct welding into copper backing bar

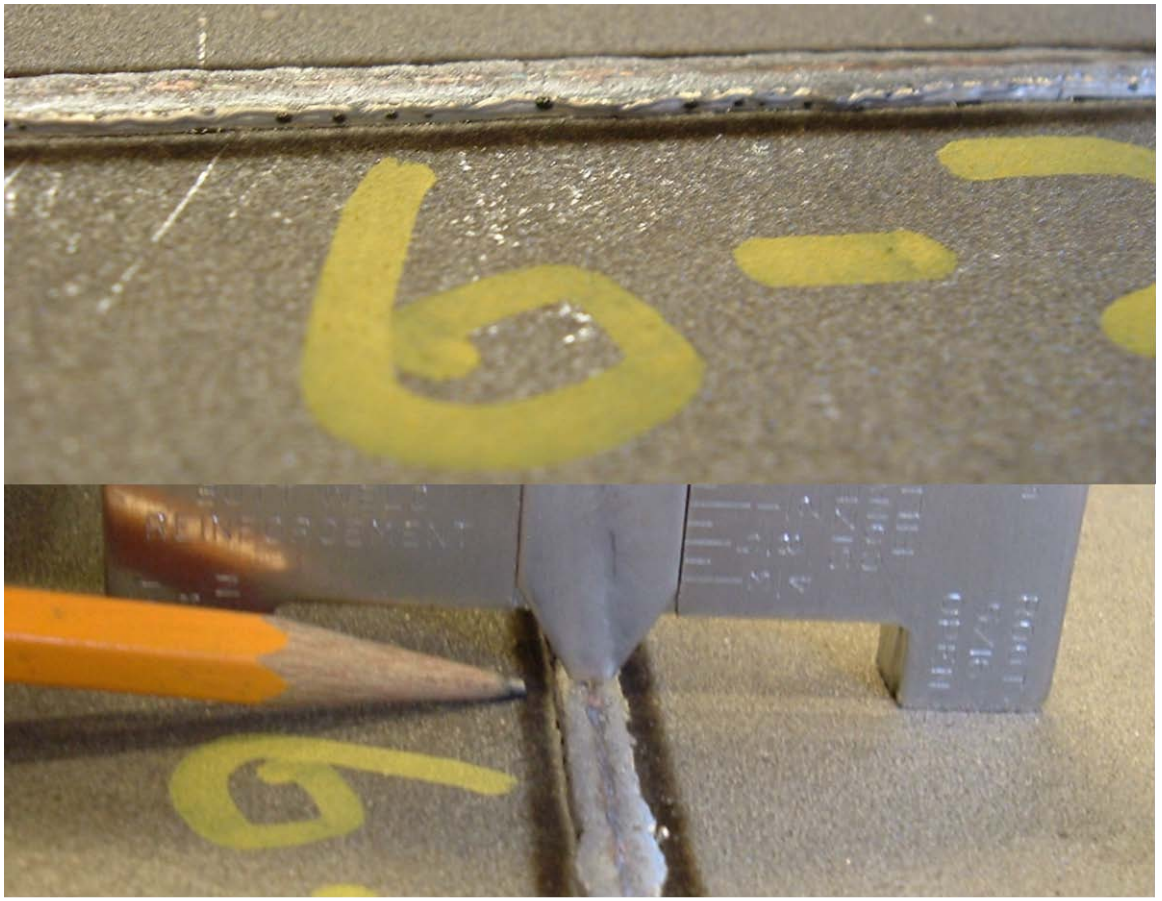


Figure 1 June 23, Weld C. Root. Copper Backing Bar.

Welding Procedure Development

Using flux in weld root

Figure 2 Test of May 19 with 3/32 Root Opening, Flux Root

5/19/2010 B

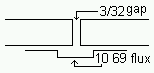
Lead 1/16 705 C pulse	trail .045 CW 70		top edge a little UC on 1 edge
307 in/min 36.3 V (-1.5)	488 in/min		Lead voltage a bit high
30.8 V	353 A 28 V (-1.0)		back side with flux toes not
449 A	29.8 V		Reentrant angle but profile is consistent

Figure 2 May 19 Procedure B.

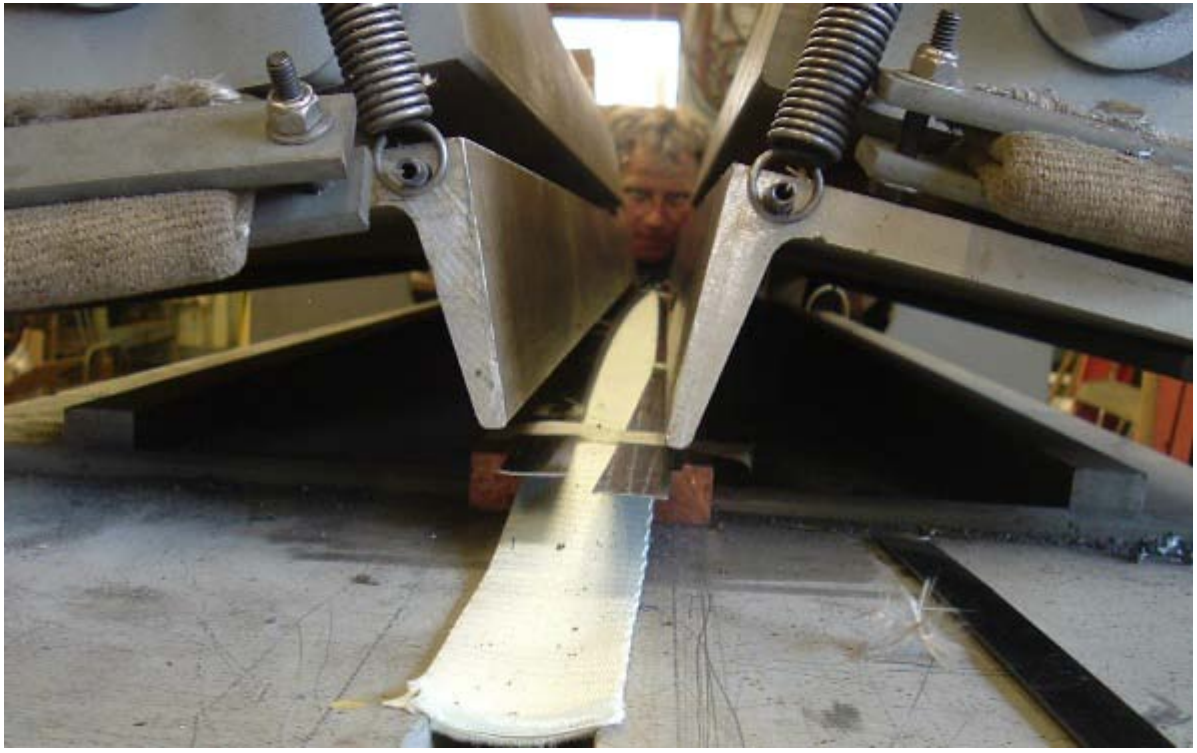
Welding Procedure Development

Using Ceramic Backing

Figure 3 Weld Setup and Root and Face With Ceramic Backing

Welding Procedure Development

Using Fiberglass Tape with Shims for Gap Control



Welding Procedure Development

Melt-through Contour with Fiberglass Tape

Welding Procedure Development

- Shielding Gas Variations :
  - (1) 75% CO2, 25% Argon: Not enough heat, Spatter
  - (2) 95% CO2, 5% Oxygen: Porosity issues
  - (3) 90% CO2, 25% Argon: Acceptable. See Figure 4
  - (4) 100% CO2: Unacceptable Spatter. See Figure 12

- Root Opening. In the shipbuilding industry, welding a square butt joint with a tight root is desirable. Through the procedure development, 3/32 inch, 1/16 inch, and tight fit roots were assessed. In order to penetrate through a square, tight fit root with the lead wire, we obtained a higher amperage welding power supply and were successful with repeatable penetration of tight fit roots on the welding procedures of June 23 and earlier.

Welding Procedure Development

Shielding Gas Variations

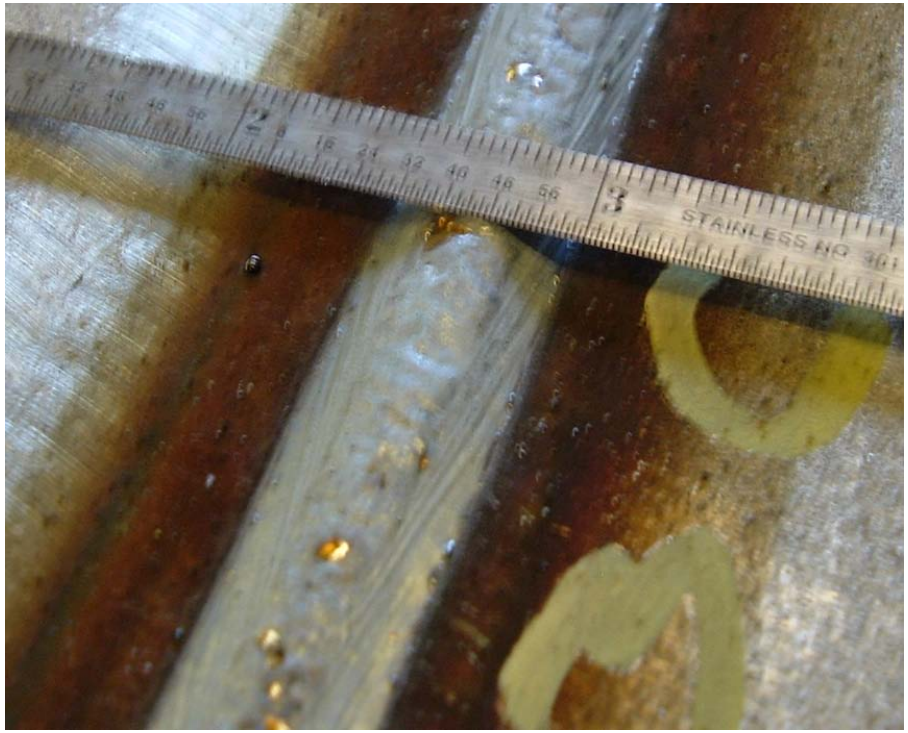


Figure 4 June 23, Procedure 5 Weld Face, 90% CO2, 10% Argon

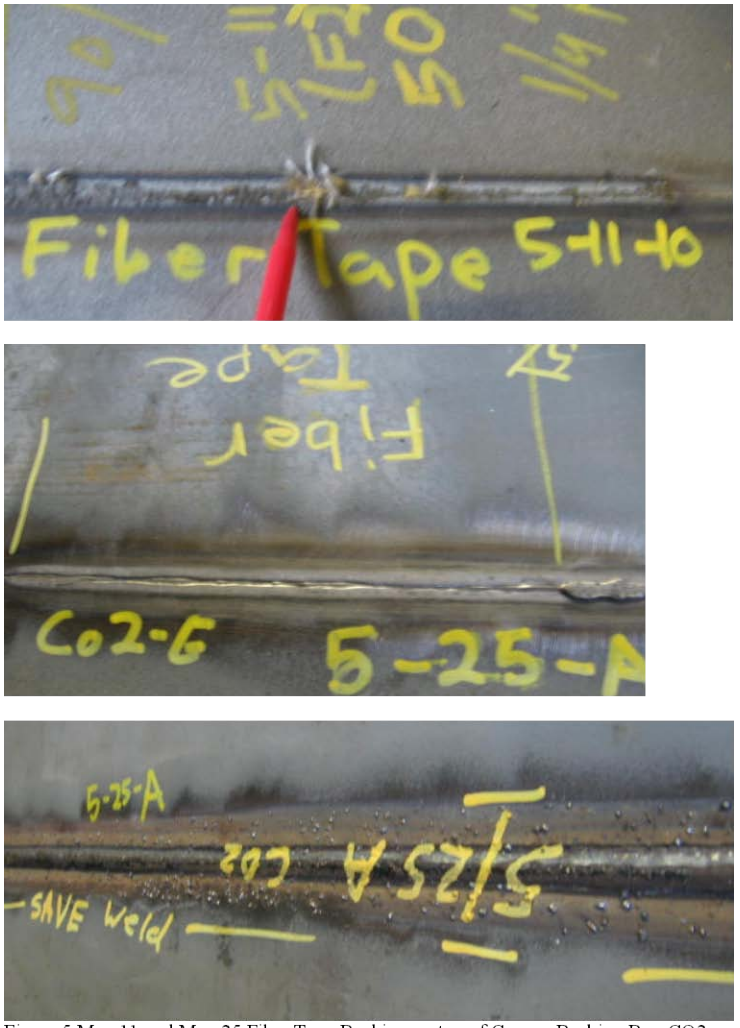


Figure 5 May 11 and May 25 Fiber Tape Backing on top of Copper Backing Bar, CO2 Gas.

Results

Current Welding Procedure (as of 7/15 report) And Heat Input Comparison

6/23/2010 (C)			
LEAD	50 IPM Travel	Trail	Notes: Lead Volts up 26.5
1/16" ER-70S6		.045 CW-70	Lead WF up 26.5
26.5 Volts		374 IPM	Lead WF up 445 to 450
449 IPM		25.8 Volts Set	Trail WF up 375
655 Brown Out		25.5 Act.	Nice weld best back side
9 Volts		305 AMPS	Brown out at end
440 IPM 26.5 Volts		Root Opening:	0 - Tight

June 23, Weld C Procedure

Heat Input Calculation, June 23, Procedure C

Lead			
	Volts	26.5	V
	Amps	655	Amperes
	Travel Spd	50	in/min
	Heat	20.829	V*A/(Spd/(60 sec/min))(1 kJ/1000 J) = kJ/inch
Trail			
	Volts	25.5	
	Amps	305	
	Travel Spd	50	
	Heat	9.333	
	Total	**30.2**	**kJ per Inch**

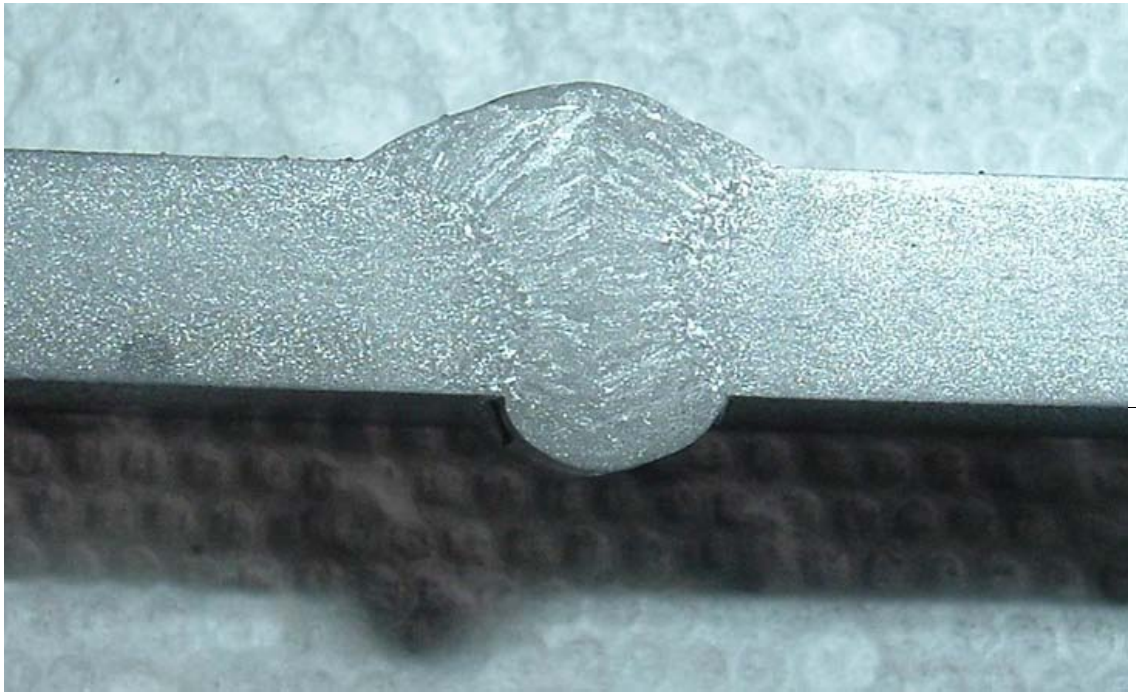
Heat Input Calculation.

Procedure	Thickness	Heat Input kJ/in	kJ adjusted for thickness
Current TGS Procedure (June 23, Procedure C)	6.35 mm	30.2	**30.2**
EWI High Speed Narrow Groove SAW, Ref [1],	5.00 mm	41.4	**52.6**
Shipyard One Sided Welding Flux Copper Backing Technique Sheet	6.35 mm	63.0	**63.0**

Table 1 Comparison of Heat Inputs

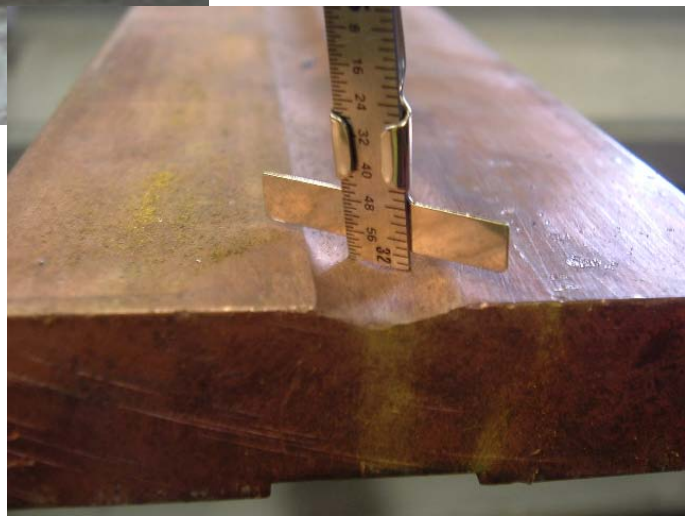
Results

- Macro With Fiberglass Tape Backing - .060 Standoff Distance to Tape.
  Tight Root Joint.



Results

- Macro: Weld with Copper Backing Bar: .060 Standoff Distance to Copper Backing, Root Gap .062, (Old) 500 Amp Lead Wire Power Supply.



Results

- Just a pretty picture

DWIGHT COMPANY, Inc.

WELDING LABORATORY SERVICE

414 HEWITT RD, CHEHALIS, WASHINGTON, 98532 Voice; 360 - 262 - 9844, FAX ; 360 - 262 - 9624

TODD PACIFIC SHIPYARDS CORP.
OHD: CSR; MP
1801 16th Avenue SW
Seattle, WA 98134
ATTENTION : Ms. MARLENE WRIGHT, Subcontracts Mgr.
ATTENTION : Mr. KEN JOHNSON
PO # 57895

13-Aug-10
DH-32 (81) to DH-32 (81)
Square Butt Joint, Plasma Cut No Grind
S9074-AQ-GIB-010/248
Ref (10) TEST PLATE using Tandem Arc
WELDER: Ken Johnson, Steve Pollard
TEST PLATE = 1/4" THICK
PQR NUMBER To be assigned

CERTIFIED TEST REPORT

Spec. for DH - 32

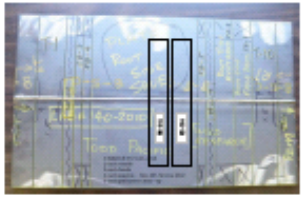
TENSILE RESULTS	Rectangular coupon T-1 Thk.	Width	Rectangular coupon T-10 Thk.	Width
Coupon Dimension	0.226	1.4996	0.2255	1.497
Area square inches:		0.339		0.338
Yield Strength, Lbs:		16963		16862
Yield Strength, PSI:		50054		49952
				46,000 Psi Minimum
Ultimate Load, Lbs:		23166		23085
Tensile PSI:		68358		68386
				64,000 to 85,000 Psi
Elongation in 2 In:		0.6436		0.6846
Elongation %:		32.2		34.2
				22% Minimum
Reduction of Area, %:		51.7		55.3
		Ductile Break in DH-32		Ductile Break in DH-32
				NR

MACRO OF WELD TO JOINT USING TANDEM WIRE

BOTH COUPONS WERE ACCEPTABLE DUCTILE BREAKS IN THE S1 BASE METAL.

NAVSEA S9074-AQ-GIB-010/248 PROCEDURE QUALIFICATION

DIGITAL RECORD



AS RECEIVED TEST COUPON W/ TANDEM ARC

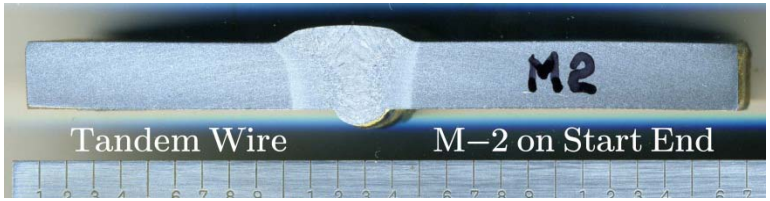
SIDE BENDS, ROOT & FACE BENDS TRANSVERSE TENSILES, MACROS

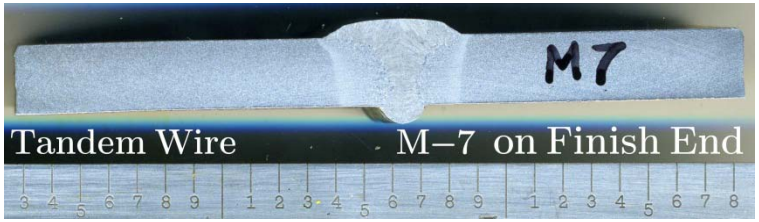
BENDS 7 EACH BENDS TESTED ON A 1.5 INCH DIAMETER.
Side Bends SB3, SB4, & SB5 , Root Bends RB-8, RB-8A, FB-9 & FB-9A are Acceptable in Accordance with 010/248.

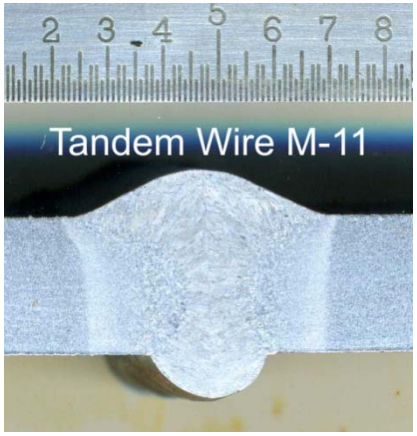
We certify that the material covered by this report has been inspected and / or tested in accordance with the applicable requirement described herein, and that test reports are on file subject to examination by qualified auditors.

LAB NO. 140-2010 (Notarized if Required) | J. M. Dwight (Signature) | WELDING ENGINEER (Title)

FILE: NAVSEA S9074-AQ-GIB-10/248 AUTOMATIC TANDEM ARC-1-4 Inch THICK PLATE-61 to S1-*Excel Format Rev-0* XLS

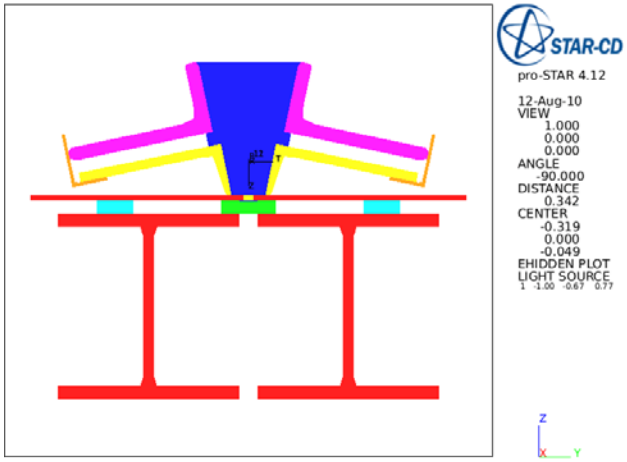


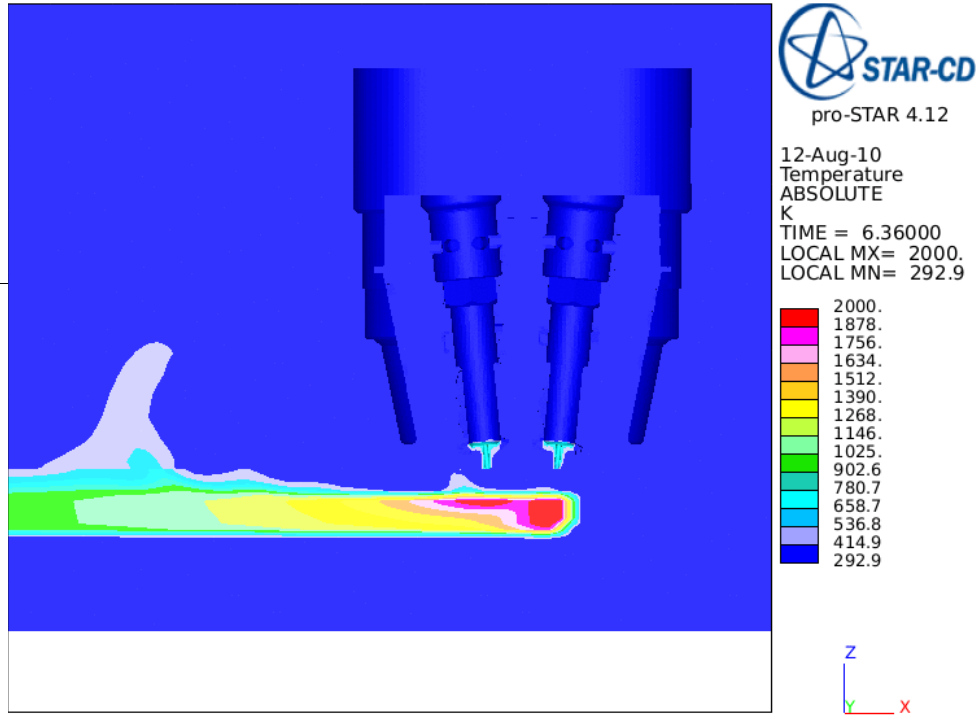




Distortion Measurement and Simulation

- Simulation Development Work is proceeding and awaiting a finalized welding procedure. Full Simulaiton and Distortion Measurements will be performed on the finalized weldment.
- Preliminary Simulation - validation of model fluid flow looking at convection without arc radiation.





Conclusion

We are aware that we are behind schedule but we believe the completed TGS 6 mm weld procedure has extremely low heat input and is a viable alternative to Submerged Arc Welding for thin panel shipbuilding production.

We intend to complete both 6 mm and 12 mm procedure development in the fourth quarter.

Conclusion

This project at Todd Pacific Shipyard would not be possible without the significant equipment and support of the contributing team members:

Especially -
Wolf Robotics and ESAB Welding and Cutting Equipment.

Also the effort and support of the subcontractors:
NASSCO Shipbuilding, CD-adapco , Weaver Engineering, Dwight Laboratories, Machinists Inc. and friends from industry

Abicor Binzel Tandem Gun

Thank You for your Support

Wolf Robotics

Abicor Binzel

ESAB NA Welding & Cutting Products