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Evaluation of the Tip Tig Welding System, a Semi-automatic Hot Wire GTAW Process, Compared to Manual GTAW

Final Report

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Task Order 29

As Managed By
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TITLE

Evaluation of the Tip Tig Welding System, a Semi-automatic Hot Wire GTAW Process, Compared to Manual GTAW

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ABSTRACT

The purpose of this project was to evaluate the patented Tip Tig system in comparison with standard GTAW and to identify potential shipbuilding applications where it could be beneficial. This project was operated as a National Ship Research Program (NSRP) panel project through SCRA Applied R&D (ATI Agreement No. 2005-341).

The Tip Tig process is a semi-automatic, hot wire variant of manual GTAW. The continuously fed preheated filler metal very significantly improves the deposition rate. The equipment system includes a filler wire agitation mechanism that improves the dynamics of the molten weld puddle. The agitation appeared to improve fluidity of the puddle by breaking up impurities and it reportedly reduces the risk of inclusions and porosity.

Initially, two joints were welded in 0.50 inch thick vertically positioned carbon steel plate butt joints to compare manual GTAW and Tip Tig. This demonstrated that even with minimal Tip Tig experience, the welder was able to complete the joint in about one fifth of the arc time required for manual GTAW. The appearance of the reinforcement was almost indistinguishable from the manual weld and the transverse tensile properties were virtually the same. Potential applications were then identified and tried including Alloy 625 overlays on carbon steel, butt welding of a thick wall stainless steel pipe in the horizontal fixed position, welding of a carbon steel boss onto a pipe and stainless steel sheet metal welding. The process proved to be very versatile and easy to use for an experienced manual GTAW welder. It seemed to produce less distortion than manual GTAW and the base metal dilution in the overlay weld metal was very low compared to previous GMAW overlay qualifications on similar base material. Some limitations were found which related to the size of the torch and the fact that filler wire and torch cannot be operated independently as they are with manual GTAW. Shipboard operation in confined spaces and joints with limited accessibility are probably not good candidates for this process.

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REFERENCES

(a) MIL-STD-22D, Welded Joint Design

(b) MIL-E-23765/1E, Electrodes and Rods – Welding, Bare, Solid and Alloyed Cored, Ordinary Strength and Low Alloy Steel

(c) NAVSEA Technical Publication T9074-AS-GIB-010/271 (Tech Pub 271)- Requirements for Nondestructive Testing Methods

(d) MIL-STD-2035, Nondestructive Testing Acceptance Criteria

(e) AWS B4.0:2007, Standard Methods for Mechanical Testing of Welds

PURPOSE

The purpose of this project was to evaluate the patented Tip Tig system in comparison with standard GTAW and to identify potential shipbuilding applications where it could be beneficial. This project was operated as a National Ship Research Program (NSRP) panel project through SCRA Applied R&D (ATI Agreement No. 2005-341, Task Order 29, Modification 02; TIP TIG vs. TIG Panel Project).

BACKGROUND

The Tip Tig process is a semi-automatic, hot wire variant of manual Gas Tungsten Arc Welding (GTAW). The continuously fed, preheated filler metal very significantly improves the deposition rate. The equipment system includes a filler wire agitation mechanism that improves the dynamics of the molten weld puddle. The agitation appeared to increase fluidity of the puddle and help break up impurities and release evolving gases for reduced risk of inclusions and porosity. The basic equipment is shown in Figure 1 below. Figures 2 and 3 show the torch and wire feed oscillation device respectively.

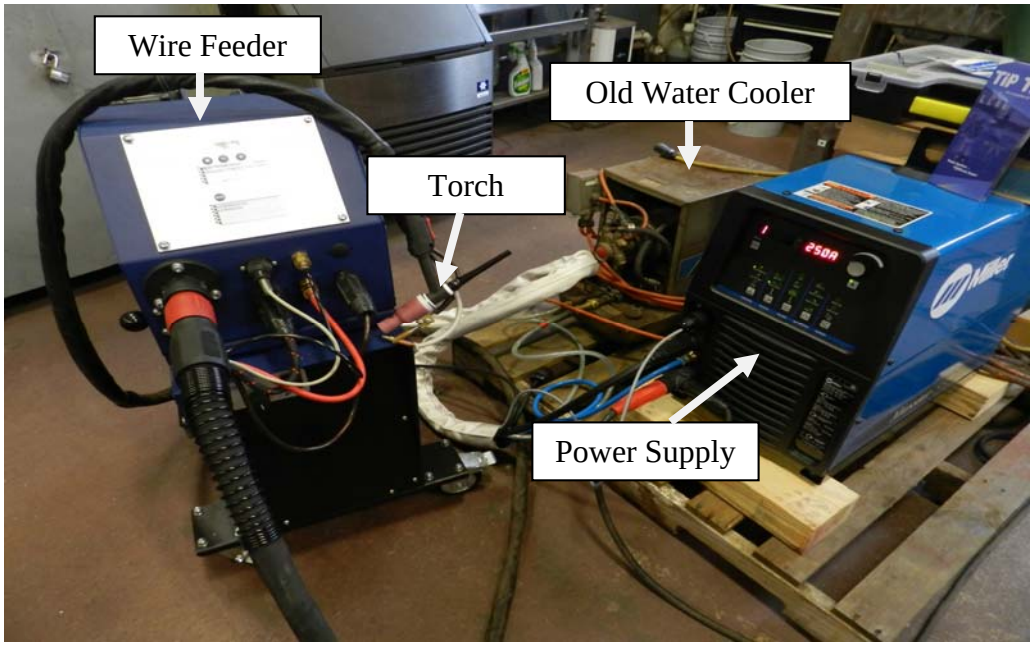


Figure 1 – Basic Tip Tig Equipment

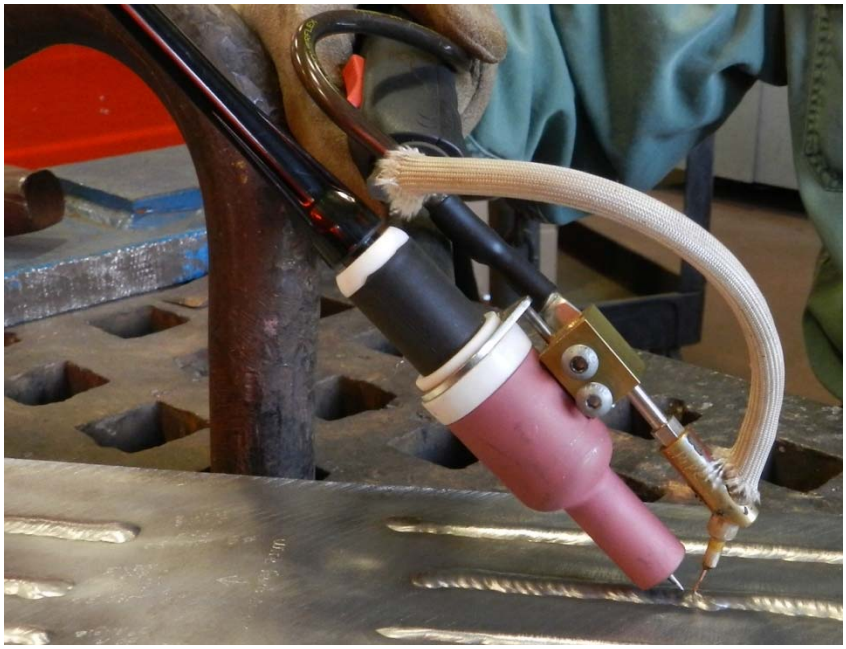


Figure 2 – Tip Tig Torch

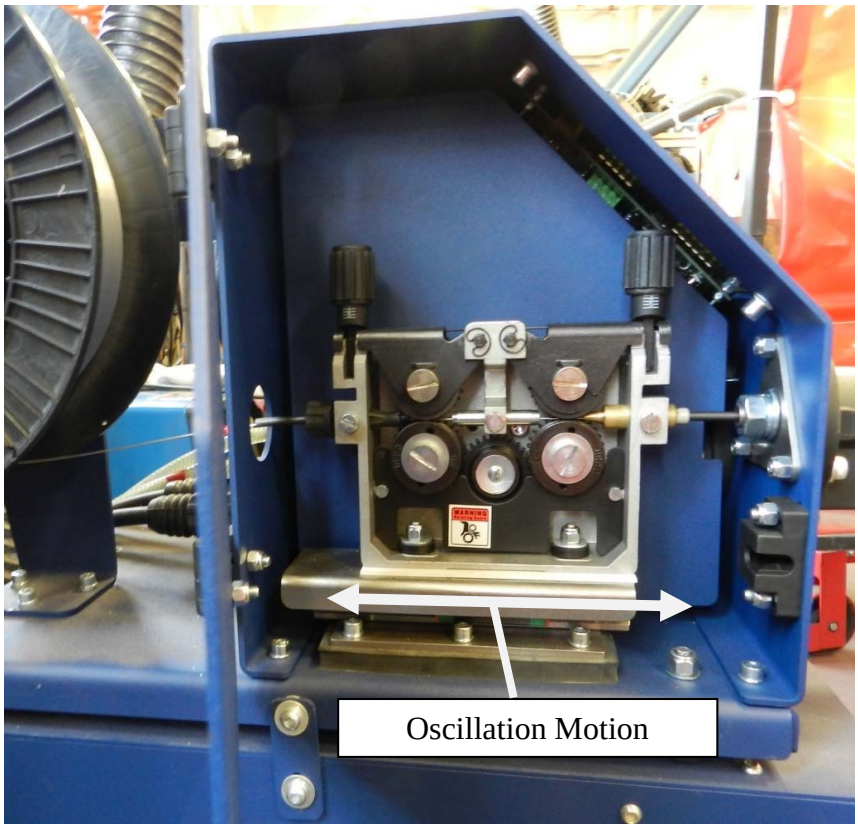


Figure 3 – Wire Feeder

METHOD

One day of training on the equipment was provided by a Tip Tig company representative. Training consisted of equipment set-up and familiarization, bead on plate welding, and fillet welding demonstration and practice. The most noticeable differences compared with manual GTAW were hand placement on the torch, learning the sequence for switching on the welding electrode circuit then the filler wire activation circuit and a more generous torch angle. Another prominent difference was the fact that the filler wire position and movement relative to the molten puddle were not independent of the torch as it is for manual GTAW. The location and angle of the filler wire relative to the torch can be adjusted only between weld segments. As a starting point, it is best for the wire to be directed into the puddle in approximately the same position as it would be for manual GTAW. However, as experience was gained, it was observed that the torch angle and wire feed angle could be adjusted fairly liberally without grossly impacting the placement, appearance or penetration profile of the weld. The most important technique related item is to maintain observation of the arc and weld puddle, especially where the filler wire is being fed in. This is more difficult for Tip Tig because of the relatively large torch and the hot filler metal components connected to it. The trainer indicated that the voltage control knob for the hot wire circuit did not seem to be working properly. He recommended that it be left on the maximum setting of 12 Volts for this project.

After the training and a few additional hours of practice with the Tip Tig equipment, two identical butt joints in 0.50 inch thick carbon steel plate were prepared for a direct comparison of manual GTAW with Tip Tig. The joints were type B1V.5 in accordance with reference (a) with a backing bar, 3/8 inch root gap and a 45 degree included bevel angle. They were welded in the vertical position (3G) with upward progression using MIL-70S-3 filler metal in accordance with reference (b). Joint 01 used a 3/32 inch tungsten electrode and 1/16 inch diameter filler metal. This would be typical for this type of manually welded joint. Joint 02 used a 1/8 inch diameter tungsten electrode and 0.035 inch diameter wire as recommended in the training session (0.045 inch wire can also be used but the smaller wire was indicated by the training to be preferred for most applications). For the manual GTAW Joint 01, the average heat input was 46.3 kJ/in (range from 34 to 62 kJ/in). The semi-automatic Tip Tig Joint 02, had an average heat input of 40.2 kJ/in (range from 31 to 53 kJ/in). This does not take into account the preheat provided by the 12 volt maximum hot wire system. Testing of these two joints included visual inspection (VT), magnetic particle inspection (MT) and radiographic inspection (RT) in accordance with reference (c) and with Level I acceptance criteria of reference (d). Destructive testing included transverse bend and tensile tests which were done in accordance with reference (e). See Figures 4 and 5 for further details about welding these joints.

At the onset of the first two weld joints, it became evident that the high frequency arc starting system of both power supplies was causing the normal parameter data collection device, a Miller Digi-Meter 600, to malfunction. Therefore, amperage and voltage readings were taken from the power supply digital displays and time was measured by use of a stop watch. It is understood that these measurement methods may not be as accurate as using the calibrated Digi-Meter, but they are typically considered sufficient for the GTAW process. Capturing the full range of welding parameters, particularly voltage and time, required a second person to assist the welder.

A data collection helper was necessary on the first two joints because they were designed to be a comparison of manual GTAW and semi-automatic GTAW (Tip Tig). The remaining weld joints for this project had the assistance of a helper when one was readily available. Reduced documentation was also used to ensure that the project stayed within budget while potential applications emerged and were explored.

The third weldment (Joint 03) was a two layer Alloy 625 overlay on one inch thick carbon steel plate in the flat position. The filler wire used was 0.045 inch diameter because no 0.035 inch wire was available. Alloy 625 wire is typically stiff but the feeder and torch were able to be adjusted to accommodate it. After welding the first layer, adjustments of the power supply "final slope" settings had to be made to avoid crater cracks at the end of each bead. See Figure 6 for details about this weldment.

Joint 04 was a thicker wall (0.718 inch) type 304 CRES pipe in the horizontal fixed (5G) position. The consumable insert was welded with the Tip Tig torch but without the addition of the hot wire filler metal. The torch shielding gas was 100% argon. An internal argon gas purge was used until weld bead number 6 was completed. This joint was challenging because the included bevel angle of 55 degrees and the thicker pipe wall made it difficult to get the torch tip into the root. With the welding position progression of overhead to vertical up to flat, repositioning and adaptation were required. When filler metal was applied, the entry angle was limited by the hot wire tip and mounting block components to either just in front of the torch or just behind the torch. Even using the ceramic coated hot wire tip, other bare energized parts can come in contact with the side wall of the joint. The side of the copper alloy tip holder grounded out on the first fill pass. This required light grinding to remove the residue. Heat resistant fiberglass tape was then applied to the tip holder to prevent a recurrence of this problem. See Figure 7 for further details about welding this joint.

The fifth weldment (Joint 05) was an Alloy 625 overlay on carbon steel pipe in the flat position. A horizontal pipe was horizontally rotated with manual positioning of a hand held torch. This was to provide a comparison to an overlay with Shielded Metal Arc Welding (SMAW), a process with a similar deposition rate. The Tip Tig deposit was performed in a continuous manner while making only minor torch position adjustments. An excessive heat build-up in the welding torch became evident even though the current was fairly low at 225 amps. Additional high duty cycle testing showed that the torch handle temperatures reached around 150°F. The equipment had been purchased without a water cooler so a Bernard 350SS unit was installed. A Miller Coolmate 3.5 water cooler later replaced the less effective Bernard. See Figure 8 for further details about welding this joint.

Joint 06 was a CuNi pipe butt joint welded in the vertical fixed (horizontal 2G) position. The joint was similar to Joint 04, except no consumable insert or internal gas purge was used for root welding. The main purpose of this joint was to explore the welding of CuNi pipe in the 2G position. The filler metal was 0.035 inch diameter MIL-EN67. The shielding gas was 100% argon. Manual GTAW is usually used with a small push travel angle technique. It was decided to see what travel angle limits could be used with Tip Tig. Therefore, half of the joint was welded with a push angle of 25° $\pm$ 10°, and the other half was welded with a drag angle of 25° $\pm$ 10°. See Figure 9 for further details about welding this joint.

In addition to the first six joints, other potential applications were explored. These included:

1. Thin Wall (0.120 inch) type 304 CRES pipe socket joints welded in the 2F and 5F positions with 0.035 inch diameter MIL-308L filler metal.
2. Type 304 CRES sheet metal butt and corner joints. Two thicknesses, 0.030 inch and 0.060 inch, were welded.
3. Three inch diameter carbon steel bosses on a large diameter carbon steel pipe. The filler metal was 0.035 inch diameter MIL-70S-3.

During this phase of the evaluation, welding trades and management from several areas were invited to participate in hands-on demonstrations of the Tip Tig process.

RESULTS

Both the Joint 01 manual GTAW weld and the Joint 02 Tip Tig weld passed VT, MT and RT with no discernible indications of any type. Both passed three bend test specimens each with no visible fissures. Their transverse tensile results were very similar. All four tensile specimens broke in the base metal. The Joint 01 specimens had ultimate tensile strengths of 73.4 and 73.8 ksi and the Joint 02 specimens had ultimate tensile strengths of 74.2 and 74.8 ksi. Given the similar calculated heat inputs of these two carbon steel welds, it appears that the net affect of additional heat from the wire preheating system was negligible. Figure 10 below shows how similar the appearance of the weld reinforcement was. The most remarkable difference between the two joints was the cumulative arc time that it took for each weld. The manual GTAW weld took almost 5 hours of arc time with a total of 29 beads deposited. The Tip Tig weld took less than one hour of arc time with only 11 beads deposited. Based on the constant wire feed speed used, the deposition rate of the Tip Tig process was over 2.8 lbs per arc hour verses about 0.5 lbs per arc hour for manual GTAW. The NDT results for Joints 01 and 02 are recorded in Figures 4 and 5 respectively. The destructive testing results are recorded in Figures 11 and 12 respectively.

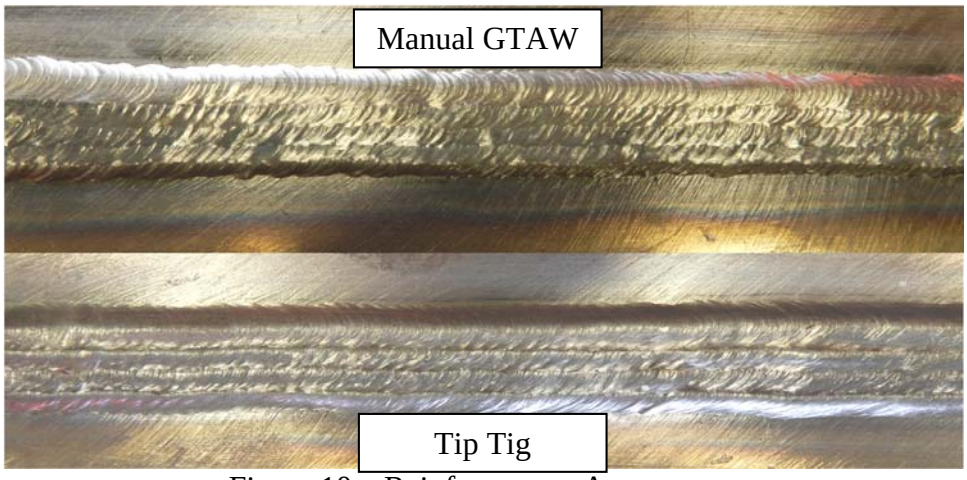


Figure 10 – Reinforcement Appearance

The Alloy 625 overlay on carbon steel plate (Joint 03) seemed to wet out much better than normal for a high nickel alloy filler metal. Sluggish oxide film floating on the surface of the molten weld can normally be observed with manual GTAW welding of Alloy 625, especially

when cleaning is not rigorous. The oxide film seemed to be absent with Tip Tig. This is attributed to the patented filler metal oscillation agitating the weld metal. The weld deposit composition was measured at a distance of 1/16 inch from the plate surface and 1/8 inch from the plate surface to determine the amount of iron dilution from the base metal. The 1/16 inch sample, representing the first weld layer, contained 9.0 percent iron while the 1/8 inch sample, representing the second weld layer, contained only 2.2 percent iron. GMAW, in the spray and pulsed modes, is normally used for making such overlays at NNS. The closest comparison during qualification testing was 17.0 percent iron at 1/16 inch, 6.7 percent iron at 1/8 inch and 3.5 percent iron at 3/16 inch of overlay thickness. Looking at a weld cross section, GMAW typically has a finger-like penetration profile that is associated with high argon content shielding gas. However, the Tip Tig penetration showed a shallower, more consistent profile. Tip Tig has a much lower deposition rate compared to GMAW, but it appears to be able to provide thinner overlays with the benefit of less distortion. See Figure 13 below for the Tip Tig overlay appearance.

Figure 13 – Alloy 625 Overlay on CS Plate

The Joint 04 horizontal CRES pipe weld showed that the Tip Tig torch has limitations when it comes to welding joints that are relatively deep and narrow. Based on this experience, fusion of consumable insert joints with this equipment is not recommended, even when no additional filler metal is added. It was learned that use of heat resistant tape on the bare hot wire system torch components is recommended to prevent electrical short-circuiting to the side wall of the joint. Radiography was not conducted because the root face failed visual inspection due to excessive reinforcement. However, cross sectioning and etching of the weld in each of the four quadrants showed no internal defects. See Figure 14. An informal dye penetrant inspection of the outside surface was satisfactory.

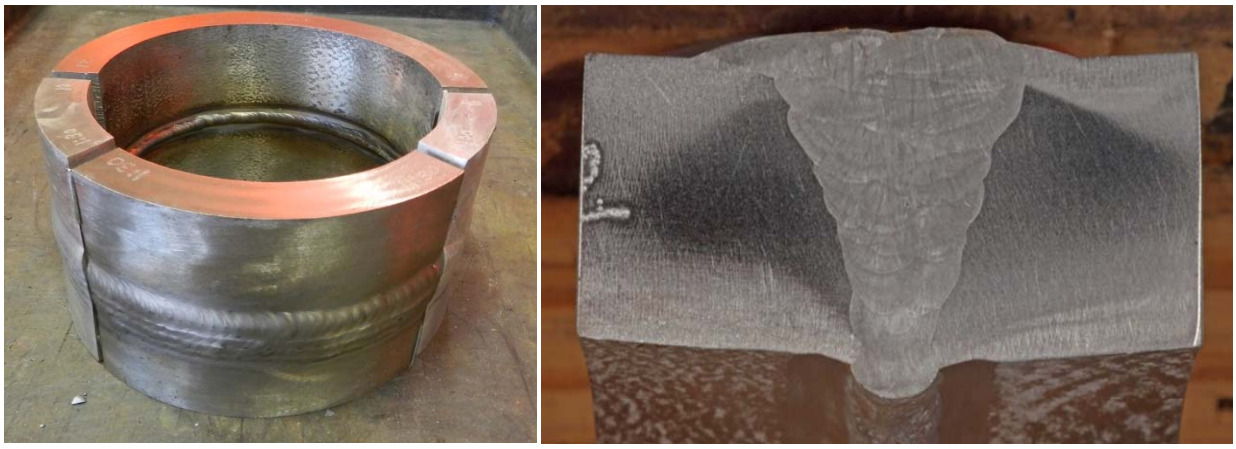


Figure 14 - Cross Section and Etch of CRES Pipe Weld

The second Alloy 625 overlay, Joint 05, which was done on pipe, welded very similarly to Joint 03 which was welded on plate. The main benefit of this weld was revealing the issue of the initial water cooler not being adequate for higher duty cycle welding. Also, it verified that adjusting the down slope parameters on the Miller power supply eliminated the initial problem with crater cracking.

Joint 06 verified that CuNi pipe can be welded with the Tip Tig process. It proved that the Tip Tig process can be used with a relatively wide range of travel angles. This indicates that the location that the wire is introduced into the molten weld pool is not critical, probably because the preheated wire is nearly molten. The result is that the wire location relative to the torch does not have to be adjusted as frequently as would be done for manual welding.

The socket joints in thin wall type 304 CRES steel were visually inspected for melt through or excessive oxidation on the inside surface of the pipe. All were acceptable to the requirements of reference (d). Several were cross sectioned to verify adequate penetration with satisfactory results. This indicates that Tip Tig may be able to help prevent backside conditions that could lead to corrosion problems. The high deposition rate for a given heat input is the probable reason.

The sheet metal results indicate that butt welding of the 0.030 inch material with Tip Tig is unlikely with the maximum hot wire voltage that was being used. However, the unit has been verified to be working properly and further work at a lower filler metal voltage should be explored. Any typical joint configuration and root gap with the 0.060 inch material produced excellent results for skilled sheet metal welders. They also remarked that the Tip Tig torch is much less bulky than another competing process with a patented wire oscillation mechanism.

The small carbon steel boss welded up quickly with a very good ease of use and weld appearance. The only issue for this commercial boss joint was the lack of root penetration. This was revealed by cross sectioning and etching the weld. The root may need to be completed by manual GTAW or another appropriate welding process rather than Tip Tig if deeper penetration is required. See Figure 15 below. Additional work with larger bosses can determine if there is less distortion compared with manual GTAW.

Figure 15 – Carbon Steel Boss Weld

CONCLUSION

For Joints 01 and 02, the hand held Tip Tig system had an approximate 5 to 1 weld deposition rate advantage when compared to GTAW. Distortion should be significantly lower for the Tip Tig process. Data showed that the cumulative heat input for the Tip Tig joint was much lower than for the manual GTAW. NDT and destructive testing verified that there was no difference in weld metal quality or mechanical properties.

Cleanliness and fluidity of the weld puddle during use of high nickel Alloy 625 filler metal was readily apparent. The Tip Tig process was also shown to have very low base metal dilution rates for Alloy 625 weld overlay deposits. It had flatter penetration profiles when compared to the data for GMAW in NNS procedure qualification records. The process also seemed relatively easy to learn.

There are several disadvantages of Tip Tig verses manual GTAW. The size of the Tip Tig torch is larger and the location of the switch to energize the welding and wire feeding circuits essentially make it a two handed torch, similar to other semi-automatic welding processes. The hot wire feeding system attached to the torch makes it more cumbersome than a manual GTAW torch. The tip holder and mounting block are a risk for shorting out if contact is made with the base material, especially when the joint is deep and narrow. Copper contamination of the CRES weld could be a risk if the welder had such a short and did not remove possible copper alloy residue. This risk can be mitigated somewhat by the use of heat resistant fiberglass tape as an insulator. However, visibility of the root while welding and proper placement of the torch and filler wire angle are inherently limited. Therefore, Tip Tig is not well suited for deep and narrow joints. It cannot access joints with limited accessibility like manual GTAW routinely does. The equipment is not portable enough to reach many below deck shipboard applications. The deposition rate of Tip Tig is not high enough to directly compete with pulsed GMAW for most applications. It may be comparable with SMAW where higher quality deposits or lower distortion are needed. It is also not known at this point how durable the equipment will be in a shop environment.

There are several candidate shipyard applications that could benefit from Tip Tig welding. However, more work is needed to develop a business case to justify the cost of equipment, welding procedure qualifications and welder training/qualification. These include, but are not limited to:

1. Sheet metal welding.
2. Thin wall CRES socket joints.
3. Distortion control for larger bosses on large diameter thinner wall pipe.
4. Various overlays and claddings.

Overall, the Tip Tig process is very promising for all position welding. Its use should be further developed for shipbuilding. It will not replace manual GTAW, SMAW or pulsed GMAW, especially shipboard. However, it will be a good compliment to these more standard processes, primarily in the shops. In certain applications, it is much more efficient than manual GTAW and provides a great amount of operator appeal.

Instructions for filling out form O37-4A

11/1/05

1) This form to be filled out by engineer
2) All blocks should be filled in; if a block is not applicable use "N/A"; if an entire section is not applicable, draw a diagonal line thru that area.
3) Engineer should put technical report # under "W. E. Technical Report" in header
4) This form to be used for outside-funded projects where a report goes outside the Company.

W.E. Technical Report
E.66-7
Figure 4

Form # O37-17A, Rev. 6

Procedure Qualification Record

PQR Number: N/A | Qualification Standard: N/A | Fabrication Document: N/A

Process: X GTAW
Manual/Auto: X Manual
Position: 3G
Vertical prog.: Up
Preheat (min/max): 32°F/NC
Interpass (min/max): 32°F/NC
Preheat Method: Ambient

Equipment

	A	B
	Closed loop / X Open loop	Closed loop / Open loop
Power Supply/Model	MILLER MAXSTAR 200 DX	
Carriage Type (if required)	N/A	
Torch/Gas Cup/Wire Feeder	Weldcraft HW24 / 5&6 / N/A	
Current	AC / DCEP / X DCEN	AC / DCEP / DCEN

Measured by: Thermocouple
Max. interpass reached? Yes X No

Tungsten: Type: EWTh-2; Diameter: 3/32"; Point prep/shape: Pointed; 3:1 Taper

Torch Angle: Work angle: 0° to 10°; Travel angle (+push/-drag): 0° - 10° push

Filler Material

	A	B
A#:	A-2B	
Form/shape:	Bare Wire	
Size/Brand/Type	1/16" Lincoln MIL-70S-3	
PO/Heat/Lot	4300069593 / NA / 834B	
Specification	MiL-E-23765/1E	

Shielding Method: Shielding gas type: 100%Ar; Flow rate (cfh): 25; Purge gas type: N/A; Purge flow rate (cfh): N/A; Flux brand/Lot#: N/A; Flux type: N/A; Flux specification: N/A; Flux size: N/A

Base Material

	A	B
S#:	S-1	S-1
Form:	Plate	Metallic Backing
Pre-weld cleaning	Method: Grind / Sanded; Distance: 2"	Method: Grind & Sanded; Distance: 2"
Interpass cleaning	Method: Grinding	Method: Grinding
Type/Dimensions	HTS 1/2"(T) x 9 1/2"x 18"	Carbon Steel 2" x 22" x 3/8"(T)
PO/Heat/Lot	4500300893-68-9 / NA / NA	Project Stock
Specification	MIL-S-22698	MIL-S-22698

Backside Prep/NDT: MT: Satisfactory; As welded: Ground: PT: Unsat
NNS Procedure:
Procedure std.:
Acceptance std.:
Initial and Date:

Final Visual Inspection: X Satisfactory; X As welded: Ground: Unsat
NNS Procedure: QAI 612.1 / QAI 612.10
Procedure std.: T9074-AS-GIB-010/271
Acceptance std.: MIL-STD-2035 Class 1
Initial and Date: CGE / 03/ 11 /2013

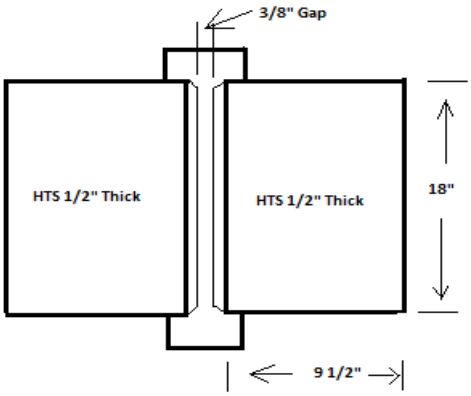
Final MT/PT: X MT; X Satisfactory; PT: Unsat
NNS Procedure: SSP N-21/121
Procedure std.: T9074-AS-GIB-010/271
Acceptance std.: MIL-STD-2035 Class 1
Initial and Date: CGE / 03/ 13 /2013

Final RT: X Satisfactory: Unsat
NNS Procedure: SSP N-41/141
Procedure std.: T9074-AS-GIB-010/271
Acceptance std.: MIL-STD-2035 Class 1
Initial and Date: MCT 03/ 14 /2013

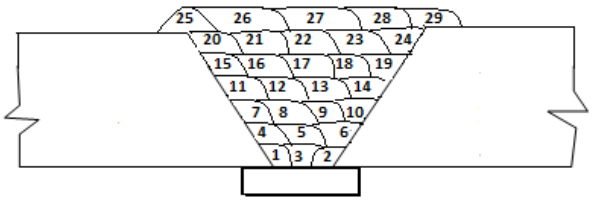
Final UT: Satisfactory: Unsat
NNS Procedure:
Procedure std.:
Acceptance std.:
Initial and Date:

Post Weld Heat Treatment: Temp. Range:; Holding Time:; Heat rate:; Cooling rate:

Joint Sketch



Bead Placement



Joint type: B1V.5 | Land (in): 0"
Root gap (in): 3/8" | Bevel angle (included): 45°
Backgouge depth (in): N/A
Backgouge radius & bevel angle: N/A N/A

Ceramic backing manufacturer: N/A
Ceramic backing designation: N/A
Ceramic backing configuration: N/A
Pass size <1/2" thick? X Yes No

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	2-21-2013 to 3-11-2013

Welding Engineer/Signature/Date	Joint Number
Greg Pike /	2012-57-01

Welding Data - Manual, Semiauto, Mechanized, Automatic Welding

Pass No	Filler Mat'l.	Electrode Stickout Distance (in)	Gas Cup-to-Work Distance (in)	Wire Feed Speed (ipm)	Current (A)	Voltage (V)	Arc Time		Bead Length (in)	Travel Speed (ipm)	Heat Input (kJ/inch)	Oscilation Parameters		
							Min.	Sec.				Amplitude (in)	Frequency (cpm)	Dwell Time (s)
1	A	5/16	3/8	N/A	103	10.7	12	52	18.0	1.4	47.2	N/A	N/A	N/A
2	A	5/16	3/8	N/A	105	11.0	12	29	18.0	1.4	49.5	N/A	N/A	N/A
3	A	5/16	3/8	N/A	111	10.2	16	2	18.0	1.1	61.8	N/A	N/A	N/A
4	A	5/16	3/8	N/A	119	10.4	14	23	18.0	1.3	57.1	N/A	N/A	N/A
5	A	5/16	3/8	N/A	118	10.3	10	52	18.0	1.7	42.9	N/A	N/A	N/A
6	A	5/16	3/8	N/A	123	10.8	13	46	18.0	1.3	61.3	N/A	N/A	N/A
7	A	5/16	3/8	N/A	124	10.3	12	37	18.0	1.4	54.7	N/A	N/A	N/A
8	A	5/16	3/8	N/A	124	10.5	10	11	18.0	1.8	43.4	N/A	N/A	N/A
9	A	5/16	3/8	N/A	124	10.6	8	16	18.0	2.2	35.8	N/A	N/A	N/A
10	A	5/16	3/8	N/A	123	11.1	10	36	18.0	1.7	48.2	N/A	N/A	N/A
11	A	5/16	3/8	N/A	128	10.5	9	42	18.0	1.9	42.4	N/A	N/A	N/A
12	A	5/16	3/8	N/A	129	10.3	9	54	18.0	1.8	44.3	N/A	N/A	N/A
13	A	5/16	3/8	N/A	128	11.3	9	3	18.0	2.0	43.4	N/A	N/A	N/A
14	A	5/16	3/8	N/A	133	11.0	10	14	18.0	1.8	48.8	N/A	N/A	N/A
15	A	5/16	3/8	N/A	133	10.4	9	25	18.0	1.9	43.7	N/A	N/A	N/A
16	A	5/16	3/8	N/A	131	11.0	8	18	18.0	2.2	39.3	N/A	N/A	N/A
17	A	5/16	3/8	N/A	135	11.4	6	51	18.0	2.6	35.5	N/A	N/A	N/A
18	A	5/16	3/8	N/A	135	11.0	6	54	18.0	2.6	34.3	N/A	N/A	N/A
19	A	5/16	3/8	N/A	135	11.1	7	38	18.0	2.4	37.5	N/A	N/A	N/A
20	A	5/16	3/8	N/A	135	10.7	7	44	18.0	2.3	37.7	N/A	N/A	N/A

Notes:

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	2-21-2013 to 3-11-2013
Welding Engineer/Signature/Date		**Joint Number**
Greg Pike / /		2012-57-01

Welding Data - Manual, Semiauto, Mechanized, Automatic Welding

Pass No	Filler Mat'l.	Electrode Stickout Distance (in)	Gas Cup-to-Work Distance (in)	Wire Feed Speed (ipm)	Current (A)	Voltage (V)	Arc Time		Bead Length (in)	Travel Speed (ipm)	Heat Input (kJ/inch)	Oscilation Parameters		
							Min.	Sec.				Amplitude (in)	Frequency (cpm)	Dwell Time (s)
21	A	5/16	3/8	N/A	135	10.9	8	28	18.0	2.1	42.0	N/A	N/A	N/A
22	A	5/16	3/8	N/A	135	11.1	9	45	18.0	1.8	50.0	N/A	N/A	N/A
23	A	5/16	3/8	N/A	135	10.9	10	36	18.0	1.7	51.9	N/A	N/A	N/A
24	A	5/16	3/8	N/A	135	11.4	10	4	18.0	1.8	51.3	N/A	N/A	N/A
25	A	5/16	3/8	N/A	135	11.5	7	42	18.0	2.3	40.5	N/A	N/A	N/A
26	A	5/16	3/8	N/A	135	11.2	10	26	18.0	1.7	53.4	N/A	N/A	N/A
27	A	5/16	3/8	N/A	135	11.1	10	52	18.0	1.7	52.9	N/A	N/A	N/A
28	A	5/16	3/8	N/A	135	11.7	8	19	18.0	2.2	43.1	N/A	N/A	N/A
29	A	5/16	3/8	N/A	135	11.7	9	11	18.0	2.0	47.4	N/A	N/A	N/A

Notes:

Total arc on welding time of 4 hrs. 53 min. and 10 sec.

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	2-21-2013 to 3-11-2013
Welding Engineer/Signature/Date		Joint Number
Greg Pike / /		2012-57-01

W.E. Technical Report
E.66-7
Figure 5

Form # O37-17, Rev. 9

Procedure Qualification Record

PQR Number: N/A | Qualification Standard: N/A | Fabrication Document: N/A

Process: SMAW | GMAW | GMAW-P | SAW | X GTAW | FCAW | X OTHER hot wire (Tip Tig)

Manual | Auto | X Semiauto | Mechanized

Position: 3G | Vertical prog.: Up

Preheat (min/max): 32°F/NC
Interpass (min/max): 32°F/NC
Preheat Method: Ambient
Measured by: Thermocouple
Max. interpass reached? Yes | X No

Equipment

	A	B
	Closed loop / X Open loop	Closed loop / Open loop
Power Supply/Model	Miller Maxstar 350	
Carriage Type (if required)	N/A	
Torch/Gas Cup/Wire Feeder	Tip Tig Torch 18 SC #6 A-4600	
Current	AC DCEP X DCEN	AC DCEP DCEN

Tungsten: Type: EWTh-2 | Diameter: 1/8" | Point prep/shape: Blunt | 3:1 Taper

Torch Angle: Work angle: 0° to 10° | Travel angle (+push/-drag): ± 20° push

Filler Material

	A	B
A#:	A-2B	
Form/shape:	Spooled	
Size/Brand/Type	.035" Lincoln MIL-70S-3	
PO/Heat/Lot	NA / NA / 360E	
Specification	MiL-E-23765/1E	

Shielding Method
Shielding gas type: 100%Ar
Flow rate (cfh): 35
Purge gas type: N/A
Purge flow rate (cfh): N/A
Flux brand/Lot#: N/A
Flux type: N/A
Flux specification: N/A
Flux size: N/A

Base Material

	A	B
S#:	S-1	S-1
Form:	Plate	Metallic Backing
Pre-weld cleaning Method	Grind / Sanded Distance 2"	Grind & Sanded Distance 2"
Interpass cleaning Method	Grinding	Grinding
Type/Dimensions	HTS 1/2"(T) x 9 1/2"x 18"	Carbon Steel 2" x 22" x 3/8"(T)
PO/Heat/Lot	4500300893-68-9 / NA / NA	Project Stock
Specification	MIL-S-22698	MIL-S-22698

Backside Prep/NDT: MT | Satisfactory | As welded | Ground | PT | Unsat
NNS Procedure:
Procedure std.:
Acceptance std.:
Initial and Date:

Final Visual Inspection: X Satisfactory | X As welded | Ground | Unsat
NNS Procedure: QAI 612.1 / QAI 612.10
Procedure std.: T9074-AS-GIB-010/271
Acceptance std.: MIL-STD-2035 Class 1
Initial and Date: CGE / 03/ 12 /2013

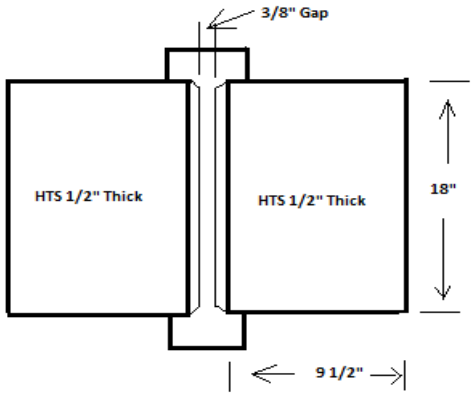
Final MT/PT: X MT | X Satisfactory | PT | Unsat
NNS Procedure: SSP N-21/121
Procedure std.: T9074-AS-GIB-010/271
Acceptance std.: MIL-STD-2035 Class 1
Initial and Date: CGE / 03/ 13 /2013

Final RT: X Satisfactory | Unsat
NNS Procedure: SSP N-41/141
Procedure std.: T9074-AS-GIB-010/271
Acceptance std.: MIL-STD-2035 Class 1
Initial and Date: MCT 03/ 14 /2013

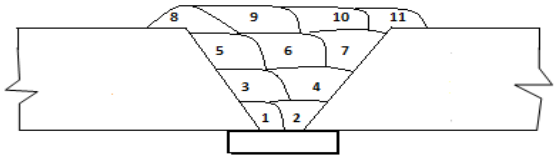
Final UT: Satisfactory | Unsat
NNS Procedure:
Procedure std.:
Acceptance std.:
Initial and Date:

Post Weld Heat Treatment
Temp. Range:
Holding Time:
Heat rate:
Cooling rate:

Joint Sketch



Bead Placement



Joint type: B1V.5 | Land (in): 0"
Root gap (in): 3/8" | Bevel angle (included): 45°
Backgouge depth (in): N/A
Backgouge radius & bevel angle: N/A N/A

Ceramic backing manufacturer: N/A
Ceramic backing designation: N/A
Ceramic backing configuration: N/A
Pass size <1/2" thick? X Yes | No

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	3/12/2013

Welding Engineer/Signature/Date	Joint Number
Greg Pike /	2012-57-02

Welding Data - Manual, Semiauto, Mechanized, Automatic Welding

Pass No	Filler Mat'l.	Electrode Stickout Distance (in)	Gas Cup-to-Work Distance (in)	Wire Feed Speed (ipm)	Current (A)	Voltage (V)	Arc Time		Bead Length (in)	Travel Speed (ipm)	Heat Input (kJ/inch)	Oscilation Parameters		
							Min.	Sec.				Amplitude (in)	Frequency (cpm)	Dwell Time (s)
1	A	3/8	1/2	105	201	12.3	4	24	18.0	4.1	36.2	N/A	N/A	N/A
2	A	3/8	1/2	105	201	11.8	6	36	18.0	2.7	52.7	N/A	N/A	N/A
3	A	3/8	1/2	105	201	11.5	6	16	18.0	2.9	47.8	N/A	N/A	N/A
4	A	3/8	1/2	105	210	11.7	6	25	18.0	2.8	52.7	N/A	N/A	N/A
5	A	3/8	1/2	105	220	11.5	5	30	18.0	3.3	46.0	N/A	N/A	N/A
6	A	3/8	1/2	105	220	11.8	3	34	18.0	5.0	31.2	N/A	N/A	N/A
7	A	3/8	1/2	105	220	12.1	3	57	18.0	4.6	34.7	N/A	N/A	N/A
8	A	3/8	1/2	105	215	12.7	3	58	18.0	4.5	36.4	N/A	N/A	N/A
9	A	3/8	1/2	105	215	12.4	4	37	18.0	3.9	41.0	N/A	N/A	N/A
10	A	3/8	1/2	105	215	12.4	3	32	18.0	5.1	31.4	N/A	N/A	N/A
11	A	3/8	1/2	105	215	12.7	3	30	18.0	5.1	32.1	N/A	N/A	N/A

Notes:

Total arc on welding time of 53 min. and 19 sec.

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	3/12/2013
Welding Engineer/Signature/Date		Joint Number
Greg Pike / /		2012-57-02

W.E. Technical Report
E.66-7
Figure 6

Form # O37-17A, Rev. 6

Procedure Qualification Record

PQR Number: N/A | Qualification Standard: N/A | Fabrication Document: N/A

Process: X GTAW | X OTHER hot wire (Tip Tig)
Manual | X Semiauto | Mechanized
Position: 1G | Vertical prog.: N/A
Preheat (min/max): 60°F/350°F | Interpass (min/max): 60°F/350°F | Preheat Method: Ambient

Equipment:
Power Supply/Model: A: Miller Maxstar 350
Carriage Type (if required): N/A
Torch/Gas Cup/Wire Feeder: A: Tip Tig Torch 18 SC #6 A-4600
Current: A: X DCEN
Measured by: Thermocouple
Max. interpass reached? X Yes No

Tungsten: Type: Lanthanated | Diameter: 1/8" | Point prep/shape: Blunt

Torch Angle: Work angle: 0° to 10° | Travel angle (+push/-drag): 10° to 20° Drag

Filler Material:
Size/Brand/Type: A: .045" Arcos MIL-EN625
PO/Heat/Lot: A: 4500286454 / QH553 / YM8938
Specification: A: MiL-E-21562 E

Shielding Method:
Shielding gas type: 100%Ar
Flow rate (cfh): 35
Purge gas type: N/A
Purge flow rate (cfh): N/A
Flux brand/Lot#: N/A
Flux type: N/A
Flux specification: N/A
Flux size: N/A

Base Material:
Pre-weld cleaning: Method: Grind / Sanded | Distance: ALL
Interpass cleaning: Method: S/S Wirebrush
Type/Dimensions: A: OSS 1"(T) x 10"x 36"
PO/Heat/Lot: A: 4500312900-1-4 / 842J31610 / NA
Specification: A: MIL-S-22698

Backside Prep/NDT: MT | Satisfactory
As welded | Ground | PT | Unsat
NNS Procedure
Procedure std.
Acceptance std.
Initial and Date

Final Visual Inspection: X Satisfactory
X As welded | Ground | Unsat
NNS Procedure: QAI 612.1 / QAI 612.10
Procedure std.: T9074-AS-GIB-010/271
Acceptance std.: MIL-STD-2035 Class 1
Initial and Date: CGE / 04/ 02 /2013

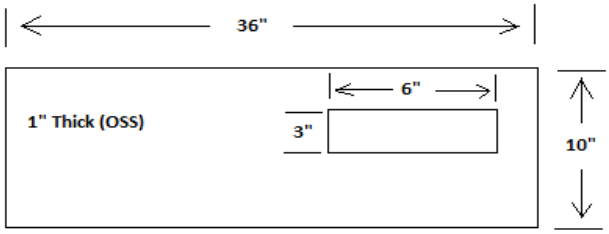
Final MT/PT: MT | X Satisfactory
X PT | Unsat
NNS Procedure: SSP N-21/121
Procedure std.: T9074-AS-GIB-010/271
Acceptance std.: MIL-STD-2035 Class 1
Initial and Date: CGE / 04/ 02 /2013

Final RT: Satisfactory | Unsat
NNS Procedure
Procedure std.
Acceptance std.
Initial and Date

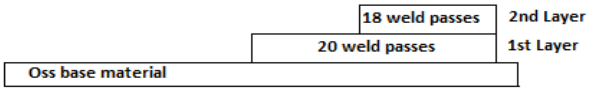
Final UT: Satisfactory | Unsat
NNS Procedure
Procedure std.
Acceptance std.
Initial and Date

Post Weld Heat Treatment:
Temp. Range
Holding Time
Heat rate
Cooling rate

Joint Sketch



Bead Placement



Joint type: Cladding | Land (in): N/A
Root gap (in): N/A | Bevel angle (included): N/A
Backgouge depth (in): N/A
Backgouge radius & bevel angle: N/A N/A

Ceramic backing manufacturer: N/A
Ceramic backing designation: N/A
Ceramic backing configuration: N/A
Pass size <1/2" thick? X Yes No

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	4-01-2013 to 4-02-2013

Welding Engineer/Signature/Date	Joint Number
Greg Pike /	2012-57-03

Welding Data - Manual, Semiauto, Mechanized, Automatic Welding

Pass No	Filler Mat'l.	Electrode Stickout Distance (in)	Gas Cup-to-Work Distance (in)	Wire Feed Speed (ipm)	Current (A)	Voltage (V)	Arc Time		Bead Length (in)	Travel Speed (ipm)	Heat Input (kJ/inch)	Oscilation Parameters		
							Min.	Sec.				Amplitude (in)	Frequency (cpm)	Dwell Time (s)
1	A	23/32	27/32	75	200	*	*	*	6.0	*	*	N/A	N/A	N/A
2	A	23/32	27/32	75	200	*	*	*	6.0	*	*	N/A	N/A	N/A
3	A	23/32	27/32	75	200	*	*	*	6.0	*	*	N/A	N/A	N/A
4	A	23/32	27/32	75	200	*	*	*	6.0	*	*	N/A	N/A	N/A
5	A	23/32	27/32	75	200	11.7	*	*	6.0	*	*	N/A	N/A	N/A
6	A	23/32	27/32	75	200	11.6	0	49	6.0	7.3	19.1	N/A	N/A	N/A
7	A	23/32	27/32	75	200	11.2	0	47	6.0	7.7	17.5	N/A	N/A	N/A
8	A	23/32	27/32	75	200	11.3	0	46	6.0	7.8	17.4	N/A	N/A	N/A
9	A	23/32	27/32	75	200	11.0	0	46	6.0	7.8	16.9	N/A	N/A	N/A
10	A	23/32	27/32	75	200	11.1	0	55	6.0	6.5	20.5	N/A	N/A	N/A
11	A	23/32	27/32	75	200	11.2	0	49	6.0	7.3	18.4	N/A	N/A	N/A
12	A	23/32	27/32	75	200	11.4	0	47	6.0	7.7	17.8	N/A	N/A	N/A
13	A	23/32	27/32	75	200	11.3	0	51	6.0	7.1	19.1	N/A	N/A	N/A
14	A	23/32	27/32	75	200	11.3	0	49	6.0	7.3	18.6	N/A	N/A	N/A
15	A	23/32	27/32	75	200	11.3	0	50	6.0	7.2	18.8	N/A	N/A	N/A
16	A	23/32	27/32	75	200	11.4	0	49	6.0	7.3	18.7	N/A	N/A	N/A
17	A	23/32	27/32	75	200	11.4	0	46	6.0	7.8	17.5	N/A	N/A	N/A
18	A	23/32	27/32	75	200	11.4	0	50	6.0	7.2	19.0	N/A	N/A	N/A
19	A	23/32	27/32	75	200	11.3	0	47	6.0	7.7	17.6	N/A	N/A	N/A
20	A	23/32	27/32	75	200	11.5	0	51	6.0	7.1	19.4	N/A	N/A	N/A

Notes:

This was an infomal PT (inspector not currently qualified).
The first layer was 6" (L) x 3" (W) x 3/32" (T). The second layer was 3" (L) x 3" (W) x 3/16 (T).
Needed to work with the machine to get rid of the crater pits. Adjusted the "final slope" to a longer time setting.
Used the 39° tip holder mark with blue (plate) for this job.

* Parameter not considered essential for evaluation and was not captured.

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	4-01-2013 to 4-02-2013
Welding Engineer/Signature/Date		**Joint Number**
Greg Pike / /		2012-57-03

Welding Data - Manual, Semiauto, Mechanized, Automatic Welding

Pass No	Filler Mat'l.	Electrode Stickout Distance (in)	Gas Cup-to-Work Distance (in)	Wire Feed Speed (ipm)	Current (A)	Voltage (V)	Arc Time		Bead Length (in)	Travel Speed (ipm)	Heat Input (kJ/inch)	Oscilation Parameters		
							Min.	Sec.				Amplitude (in)	Frequency (cpm)	Dwell Time (s)
21	A	23/32	27/32	75	200	12.3	0	26	3.0	6.9	21.4	N/A	N/A	N/A
22	A	23/32	27/32	75	200	11.9	0	25	3.0	7.2	19.8	N/A	N/A	N/A
23	A	23/32	27/32	75	200	11.4	0	26	3.0	6.9	19.8	N/A	N/A	N/A
24	A	23/32	27/32	75	200	11.0	0	28	3.0	6.4	20.6	N/A	N/A	N/A
25	A	23/32	27/32	75	200	11.2	0	28	3.0	6.4	21.0	N/A	N/A	N/A
26	A	23/32	27/32	75	200	10.9	0	30	3.0	6.0	21.8	N/A	N/A	N/A
27	A	23/32	27/32	75	200	11.0	0	32	3.0	5.6	23.6	N/A	N/A	N/A
28	A	23/32	27/32	75	200	10.9	0	31	3.0	5.8	22.6	N/A	N/A	N/A
29	A	23/32	27/32	75	200	10.9	0	30	3.0	6.0	21.8	N/A	N/A	N/A
30	A	23/32	27/32	75	200	10.9	0	28	3.0	6.4	20.4	N/A	N/A	N/A
31	A	23/32	27/32	75	200	10.8	0	29	3.0	6.2	20.9	N/A	N/A	N/A
32	A	23/32	27/32	75	200	10.7	0	29	3.0	6.2	20.7	N/A	N/A	N/A
33	A	23/32	27/32	75	200	10.7	0	29	3.0	6.2	20.7	N/A	N/A	N/A
34	A	23/32	27/32	75	200	10.9	0	30	3.0	6.0	21.8	N/A	N/A	N/A
35	A	23/32	27/32	75	200	10.9	0	30	3.0	6.0	21.8	N/A	N/A	N/A
36	A	23/32	27/32	75	200	10.8	0	28	3.0	6.4	20.3	N/A	N/A	N/A
37	A	23/32	27/32	75	200	10.9	0	22	3.0	8.2	16.0	N/A	N/A	N/A
38	A	23/32	27/32	75	200	10.8	0	20	3.0	9.0	14.4	N/A	N/A	N/A

Notes:

* Parameter not considered essential for evaluation and was not captured.

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	4-01-2013 to 4-02-2013
Welding Engineer/Signature/Date		**Joint Number**
Greg Pike / /		2012-57-03

W.E. Technical Report
E.66-7
Figure 7

Form # O37-17A, Rev. 6

Procedure Qualification Record

PQR Number: N/A | Qualification Standard: N/A | Fabrication Document: N/A

Process

	SMAW		GMAW		GMAW-P		SAW
X	GTAW		FCAW	X	OTHER	hot wire (Tip Tig)	

	Manual
	Auto
X	Semiauto
	Mechanized

Position	5G
Vertical prog.	Up

Preheat (min/max)	NC/350°F
Interpass (min/max)	NC/350°F
Preheat Method	Ambient
Measured by	Thermocouple
Max. interpass reached?	Yes X No

Equipment

	A	B
	Closed loop / X Open loop	Closed loop / Open loop
Power Supply/Model	Miller Maxstar 350	
Carriage Type (if required)	N/A	
Torch/Gas Cup/Wire Feeder	Tip Tig Torch 18 SC / 6 & # / A-4600	
Current	AC / DCEP / X DCEN	AC / DCEP / DCEN

Tungsten

Type	Lanthanated
Diameter	1/8"
Point prep/shape	Blunt
	3:1 Taper

Torch Angle

Work angle: 0° to 10° | Travel angle (+push/-drag): 25° ± 10° Push

Filler Material

	A	B
A#:	A-8B	A-8B
Form/shape:	Insert (Class 1)	Spooled
Size/Brand/Type	5/32" Arcos MIL-308-L	.035" Arcos MIL-308-L
PO/Heat/Lot	Q0600901	4500240398 / NA / XT8600
Specification	MIL-I-23413	MIL-E-19933 E

Shielding Method

Shielding gas type	100%Ar
Flow rate (cfh)	35
Purge gas type	100%Ar
Purge flow rate (cfh)	20
Flux brand/Lot#	N/A
Flux type	N/A
Flux specification	N/A
Flux size	N/A

Base Material

	A	B
S#:	S-8	
Form:	Pipe	
Pre-weld cleaning	Method: Sanded & Acetone / Distance: ALL	Method / Distance
Interpass cleaning	Method: S/S Wirebrush	Method
Type/Dimensions	S/S 304L / 6" x 12" x 0.718 (T)	
PO/Heat/Lot	Project Stock	
Specification		

Backside Prep/NDT

	MT		Satisfactory
As welded	Ground	PT	Unsat
NNS Procedure			
Procedure std.			
Acceptance std.			
Initial and Date			

Final Visual Inspection

	Satisfactory		
As welded	X Ground	X	Unsat
NNS Procedure	QAI 612.1 / QAI 612.10		
Procedure std.	T9074-AS-GIB-010/271		
Acceptance std.	MIL-STD-2035 Class 1		
Initial and Date	CGE / 04/ 08 /2013		

Final MT/PT

	MT	X	Satisfactory
X	PT		Unsat
NNS Procedure	SSP N-21/121		
Procedure std.	T9074-AS-GIB-010/271		
Acceptance std.	MIL-STD-2035 Class 1		
Initial and Date	CGE / 04/ 09 /2013		

Final RT

	Satisfactory	Unsat
NNS Procedure		
Procedure std.		
Acceptance std.		
Initial and Date		

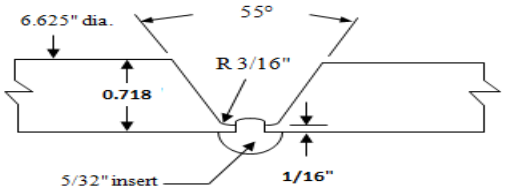
Final UT

	Satisfactory	Unsat
NNS Procedure		
Procedure std.		
Acceptance std.		
Initial and Date		

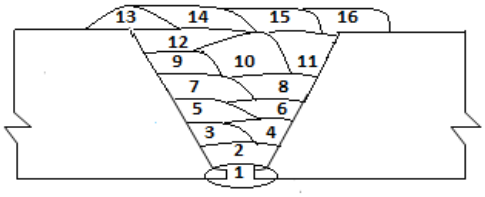
Post Weld Heat Treatment

Temp. Range
Holding Time
Heat rate
Cooling rate

Joint Sketch



Bead Placement



Joint type:	PN-2	Land (in):	1/16"
Root gap (in):	N/A	Bevel angle (included):	55°
Backgouge depth (in):	N/A		
Backgouge radius & bevel angle:	N/A	N/A	

Ceramic backing manufacturer:	N/A
Ceramic backing designation:	N/A
Ceramic backing configuration:	N/A
Pass size <1/2" thick?	X Yes No

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	4-03-2013 to 4-05-2013

Welding Engineer/Signature/Date	Joint Number
Greg Pike /	2012-57-04

Welding Data - Manual, Semiauto, Mechanized, Automatic Welding

Pass No	Filler Mat'l.	Electrode Stickout Distance (in)	Gas Cup-to-Work Distance (in)	Wire Feed Speed (ipm)	Current (A)	Voltage (V)	Arc Time		Bead Length (in)	Travel Speed (ipm)	Heat Input (kJ/inch)	Oscilation Parameters		
							Min.	Sec.				Amplitude (in)	Frequency (cpm)	Dwell Time (s)
1	A	5/16	5/16	*	*	*	*	*	*	*	*	N/A	N/A	N/A
2	B	3/8	1/2	69	150	*	6	51	21.3	3.1	*	N/A	N/A	N/A
3	B	3/8	1/2	66	130	*	*	*	*	*	*	N/A	N/A	N/A
4	B	3/8	1/2	66	150	*	*	*	*	*	*	N/A	N/A	N/A
5	B	3/8	1/2	66	170	*	*	*	*	*	*	N/A	N/A	N/A
6	B	3/8	1/2	66	180	*	*	*	*	*	*	N/A	N/A	N/A
7	B	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
8	B	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
9	B	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
10	B	3/8	1/2	105	190	*	*	*	*	*	*	N/A	N/A	N/A
11	B	3/8	1/2	105	190	*	*	*	*	*	*	N/A	N/A	N/A
12	B	3/8	1/2	105	190	*	*	*	*	*	*	N/A	N/A	N/A
13	B	3/8	1/2	75	180	*	*	*	*	*	*	N/A	N/A	N/A
14	B	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
15	B	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
16	B	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A

Notes:

Weld pass # 1 is the 5/32" insert.

The tip grounded to the joint on the first weld fill pass. Putting fiber glass tape on the tip prevented this from happening again.

A # 6 shielding gas cup was used through pass # 6 then a # 8 cup for the remainder of weld passes.

The purge gas was turned off after weld pass # 6.

The VT was "unsat" due to the ID pushing in as the remainder of the joint was completed.

Weld cross sections were taken at the 12:00, 6:00, 4:30 and 11:30 o'clock positions. No indications noted.

* Parameter not considered essential for evaluation and was not captured.

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	4-03-2013 to 4-05-2013
Welding Engineer/Signature/Date		**Joint Number**
Greg Pike / /		2012-57-04

W.E. Technical Report
E.66-7
Figure 8

Form # O37-17, Rev. 9

Procedure Qualification Record

PQR Number: N/A | Qualification Standard: N/A | Fabrication Document: N/A

Process

	SMAW		GMAW		GMAW-P		SAW
X	GTAW		FCAW	X	OTHER	hot wire (Tip Tig)	

Manual | Auto | X Semiauto | Mechanized

Position: 1G | Vertical prog.: N/A

Preheat (min/max): 60°F/350°F | Interpass (min/max): 60°F/350°F | Preheat Method: Ambient | Measured by: Thermocouple | Max. interpass reached? X Yes No

Equipment

	A	B
	Closed loop / X Open loop	Closed loop / Open loop
Power Supply/Model	Miller Maxstar 350	
Carriage Type (if required)	N/A	
Torch/Gas Cup/Wire Feeder	Tip Tig Torch 18 SC #6 A-4600	
Current	AC DCEP X DCEN	AC DCEP DCEN

Tungsten: Type: Lanthanated | Diameter: 1/8" | Point prep/shape: Blunt 3:1 Taper

Torch Angle: Work angle: 0° to 10° | Travel angle (+push/-drag): 10° to 20° Drag

Filler Material

	A	B
A#:	A-43B	
Form/shape:	Spooled	
Size/Brand/Type	.045" Arcos MIL-EN625	
PO/Heat/Lot	4500286454 / QH553 / YM8938	
Specification	MiL-E-21562 E	

Shielding Method: Shielding gas type: 100%Ar | Flow rate (cfh): 35 | Purge gas type: N/A | Purge flow rate (cfh): N/A | Flux brand/Lot#: N/A | Flux type: N/A | Flux specification: N/A | Flux size: N/A

Base Material

	A	B
S#:	S-1	
Form:	Plate	
Pre-weld cleaning	Method: Grind Distance: > 3"	Method: Distance:
Interpass cleaning	Method: S/S Wirebrush	Method:
Type/Dimensions	Carbon Steel 21" x 5 1/2" x 0.375"	
PO/Heat/Lot	project stock	
Specification		

Backside Prep/NDT: MT | Satisfactory | As welded | Ground | PT | Unsat | NNS Procedure | Procedure std. | Acceptance std. | Initial and Date

Final Visual Inspection: X Satisfactory | X As welded | Ground | Unsat | NNS Procedure: QAI 612.1 / QAI 612.10 | Procedure std.: T9074-AS-GIB-010/271 | Acceptance std.: MIL-STD-2035 Class 1 | Initial and Date: CGE / 04/ 10 /2013

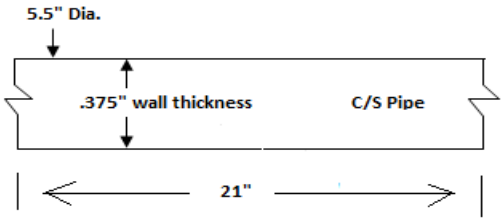
Final MT/PT: MT | Satisfactory | PT | Unsat | NNS Procedure | Procedure std. | Acceptance std. | Initial and Date

Final RT: Satisfactory | Unsat | NNS Procedure | Procedure std. | Acceptance std. | Initial and Date

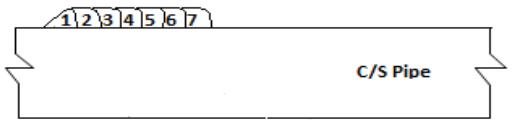
Final UT: Satisfactory | Unsat | NNS Procedure | Procedure std. | Acceptance std. | Initial and Date

Post Weld Heat Treatment: Temp. Range | Holding Time | Heat rate | Cooling rate

Joint Sketch



Bead Placement



Joint type: Cladding | Land (in): N/A
Root gap (in): N/A | Bevel angle (included): N/A
Backgouge depth (in): N/A
Backgouge radius & bevel angle: N/A N/A

Ceramic backing manufacturer: N/A
Ceramic backing designation: N/A
Ceramic backing configuration: N/A
Pass size <1/2" thick? X Yes No

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	4/10/2013

Welding Engineer/Signature/Date	Joint Number
Greg Pike /	2012-57-05

Welding Data - Manual, Semiauto, Mechanized, Automatic Welding

Pass No	Filler Mat'l.	Electrode Stickout Distance (in)	Gas Cup-to-Work Distance (in)	Wire Feed Speed (ipm)	Current (A)	Voltage (V)	Arc Time		Bead Length (in)	Travel Speed (ipm)	Heat Input (kJ/inch)	Oscilation Parameters		
							Min.	Sec.				Amplitude (in)	Frequency (cpm)	Dwell Time (s)
1	A	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
2	A	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
3	A	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
4	A	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
5	A	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
6	A	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
7	A	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A

Notes:

To eliminate crater cracks the "final slope" on the power supply was adjusted to 4.0.
The welding was relatively continuous as the pipe rotated under the torch and it was noticed that the torch was getting very hot.
At completion of welding different locations on the torch handle were measured with a contact pyrometer and the peak was about 150F.
The old shipyard chiller was circulating coolant but it was apparently not sufficient.

* Parameter not considered essential for evaluation and was not captured.

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	4/10/2013
Welding Engineer/Signature/Date		Joint Number
Greg Pike / /		2012-57-05

W.E. Technical Report
E.66-7
Figure 9

Form # O37-17A, Rev. 6

Procedure Qualification Record

PQR Number: N/A | Qualification Standard: N/A | Fabrication Document: N/A

Process
SMAW | GMAW | GMAW-P | SAW
X GTAW | FCAW | X OTHER hot wire (Tip Tig)

Manual | Auto
X Semiauto
Mechanized

Position 2G
Vertical prog. N/A

Preheat (min/max) NC/350°F
Interpass (min/max) NC/350°F
Preheat Method Ambient

Equipment

	A	B
	Closed loop / X Open loop	Closed loop / Open loop
Power Supply/Model	Miller Maxstar 350	
Carriage Type (if required)	N/A	
Torch/Gas Cup/Wire Feeder	Tip Tig Torch 18 SC 6 & # A-4600	
Current	AC / DCEP / X DCEN	AC / DCEP / DCEN

Measured by Thermocouple
Max. interpass reached? X Yes No

Tungsten
Type Lanthanated
Diameter 1/8"
Point prep/shape Blunt
3:1 Taper

Torch Angle
Work angle 0° to 10°
Travel angle (+push/-drag) 25° ± 10° Push & Drag (see notes)

Filler Material

	A	B
A#:	A-34B	
Form/shape:	Spooled	
Size/Brand/Type	.035" Special Metals MIL-EN67	
PO/Heat/Lot	4500238659 / CN80A0HR / NA	
Specification	Mil-E-21562E (SH)	

Shielding Method
Shielding gas type 100%Ar
Flow rate (cfh) 35
Purge gas type N/A
Purge flow rate (cfh) N/A
Flux brand/Lot# N/A
Flux type N/A
Flux specification N/A
Flux size N/A

Base Material

	A	B
S#:	S-34	
Form:	Pipe	
Pre-weld cleaning Method	Sanded & Acetone Distance 2"	
Interpass cleaning Method	S/S Wirebrush	
Type/Dimensions	CUNI 70/30 4" x 3 1/8" x 0.375 (T)	
PO/Heat/Lot	1000192860 / 35901 / NA	
Specification		

Backside Prep/NDT
MT Satisfactory
As welded Ground PT Unsat
NNS Procedure
Procedure std.
Acceptance std.
Initial and Date

Final Visual Inspection
X Satisfactory
X As welded Ground Unsat
NNS Procedure QAI 612.1 / QAI 612.10
Procedure std. T9074-AS-GIB-010/271
Acceptance std. MIL-STD-2035 Class 1
Initial and Date CGE / 04/ 15 /2013

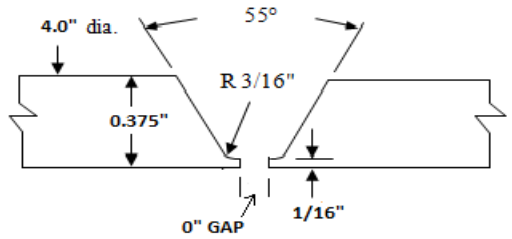
Final MT/PT
MT X Satisfactory
X PT Unsat
NNS Procedure SSP N-21/121
Procedure std. T9074-AS-GIB-010/271
Acceptance std. MIL-STD-2035 Class 1
Initial and Date CGE / 04/ 15 /2013

Final RT
Satisfactory Unsat
NNS Procedure
Procedure std.
Acceptance std.
Initial and Date

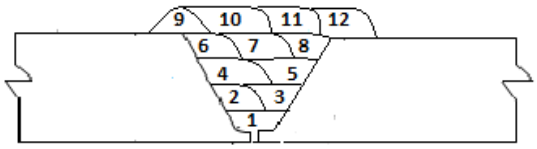
Final UT
Satisfactory Unsat
NNS Procedure
Procedure std.
Acceptance std.
Initial and Date

Post Weld Heat Treatment
Temp. Range
Holding Time
Heat rate
Cooling rate

Joint Sketch



Bead Placement



Joint type: PN-2 (modified) Land (in): 1/16"
Root gap (in): N/A Bevel angle (included): 55°
Backgouge depth (in): N/A
Backgouge radius & bevel angle: N/A N/A

Ceramic backing manufacturer: N/A
Ceramic backing designation: N/A
Ceramic backing configuration: N/A
Pass size <1/2" thick? X Yes No

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	4-11-2013 to 4-15-2013

Welding Engineer/Signature/Date	Joint Number
Greg Pike /	2012-57-06

Welding Data - Manual, Semiauto, Mechanized, Automatic Welding

Pass No	Filler Mat'l.	Electrode Stickout Distance (in)	Gas Cup-to-Work Distance (in)	Wire Feed Speed (ipm)	Current (A)	Voltage (V)	Arc Time		Bead Length (in)	Travel Speed (ipm)	Heat Input (kJ/inch)	Oscilation Parameters		
							Min.	Sec.				Amplitude (in)	Frequency (cpm)	Dwell Time (s)
1	A	3/8	1/2	60	125	*	*	*	12.8	*	*	N/A	N/A	N/A
2	A	3/8	1/2	60	125	*	*	*	12.8	*	*	N/A	N/A	N/A
3	A	3/8	1/2	60	125/135	*	*	*	12.8	*	*	N/A	N/A	N/A
4	A	3/8	1/2	60	135	*	*	*	12.8	*	*	N/A	N/A	N/A
5	A	3/8	1/2	75	165	*	*	*	12.8	*	*	N/A	N/A	N/A
6	A	3/8	1/2	75	165	*	*	*	12.8	*	*	N/A	N/A	N/A
7	A	3/8	1/2	75	165	*	*	*	12.8	*	*	N/A	N/A	N/A
8	A	3/8	1/2	75	165/175	*	*	*	12.8	*	*	N/A	N/A	N/A
9	A	3/8	1/2	75	160	*	*	*	12.8	*	*	N/A	N/A	N/A
10	A	3/8	1/2	75	160	*	*	*	12.8	*	*	N/A	N/A	N/A
11	A	3/8	1/2	75	160	*	*	*	12.8	*	*	N/A	N/A	N/A
12	A	3/8	1/2	75	160	*	*	*	12.8	*	*	N/A	N/A	N/A

Notes:

This was an infomal PT (inspector not currently qualified).

The PN2 joint type normally requires a consumable insert ring but this joint was welded open root because a ring was not readily available.

Half of this joint was welded with a push technique and the other half was welded with a drag technique - both were satisfactory.

* Parameter not considered essential for evaluation and was not captured.

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	4/11/2013 to 04-15-2013
Welding Engineer/Signature/Date		**Joint Number**
Greg Pike / /		2012-57-06

Destructive Test Results

Transverse Tensiles

Test #	Specimen Dimensions (in)	(in)	(in^2)	Ultimate Load (lbs)	Tensile Strength (ksi)	Test Type 1/	Failure Location 2/
1	0.433	1.502	0.650	47,700	73,385	RST	Base
2	0.429	1.500	0.644	47,550	73,835	RST	Base

Note 1: RST (Reduced Section) or RND (Round)

Note 2: Weld, Base or F.L. (Fusion Line)

All Weld Metal Tensile Tests

Test #	Yield Strength (ksi)	Tensile Strength (ksi)	Elong. (%)	Red. in Area (%)	Specimen Dia. (in)

Guided Bend Tests

Test #	Results	Specimen Dimensions (in)		Bend Radius (in)	Test Type 3/
SB-1	Sat.	0.375	0.375	0.75	Side
SB-2	Sat.	0.375	0.375	0.75	Side
SB-3	Sat.	0.375	0.375	0.75	Side

Note 3: Side, Face, Root or Longitudinal

Charpy V-Notch Impact Tests

Test #	Test Loc.	Test Temp. (0^oF)	Impact Energy (ft-lbs)	Lateral Expansion (Mils)	Lateral Expansion (%)	Shear Per Test (%)	Shear Avg. (%)

Dynamic Tear Tests

Test #	Test Location	Test Temp. (^oF)	D.T. Energy (ft.-lbs)

Test #	Test Method 4/	Location of Impressions (BM, HAZ, FZ, etc)	Individual Hardness Values	Average Hardness

Note 4: B (Brinell), R (Rockwell A, B, or C), V (Vickers), MK (Microhardness Knoop), MV (Microhardness Vickers), PH (Portable Hardness)

Macro-Etch Specimens

Test #	Macro Type	Sat.	Unsat.

Dest. Testing Performed IAW:	AWS B4.0:2007
Laboratory Services Report No:	100108879

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	2-21-2013 to 3-11-2013
Welding Engineer/Signature/Date		**Joint Number**
Greg Pike /		2012-57-01

Destructive Test Results

Transverse Tensiles

Test #	Specimen Dimensions (in)	(in)	(in^2)	Ultimate Load (lbs)	Tensile Strength (ksi)	Test Type 1/	Failure Location 2/
1	0.443	1.503	0.661	49,050	74,206	RST	Base
2	0.436	1.499	0.654	48,900	74,771	RST	Base

Note 1: RST (Reduced Section) or RND (Round)

Note 2: Weld, Base or F.L. (Fusion Line)

All Weld Metal Tensile Tests

Test #	Yield Strength (ksi)	Tensile Strength (ksi)	Elong. (%)	Red. in Area (%)	Specimen Dia. (in)

Guided Bend Tests

Test #	Results	Specimen Dimensions (in)		Bend Radius (in)	Test Type 3/
SB-1	Sat.	0.375	0.375	0.75	Side
SB-2	Sat.	0.375	0.375	0.75	Side
SB-3	Sat.	0.375	0.375	0.75	Side

Note 3: Side, Face, Root or Longitudinal

Charpy V-Notch Impact Tests

Test #	Test Loc.	Test Temp. (0^oF)	Impact Energy (ft-lbs)	Lateral Expansion (Mils)	Lateral Expansion (%)	Shear Per Test (%)	Shear Avg. (%)

Dynamic Tear Tests

Test #	Test Location	Test Temp. (^oF)	D.T. Energy (ft.-lbs)

Test #	Test Method 4/	Location of Impressions (BM, HAZ, FZ, etc)	Individual Hardness Values	Average Hardness

Note 4: B (Brinell), R (Rockwell A, B, or C), V (Vickers), MK (Microhardness Knoop), MV (Microhardness Vickers), PH (Portable Hardness)

Macro-Etch Specimens

Test #	Macro Type	Sat.	Unsat.

Dest. Testing Performed IAW:	AWS B4.0:2007
Laboratory Services Report No:	100108879

Technician Name/Personnel Number	Charge	Date(s) of Welding
Charlie Estes / 13717	0000-5809-T-1	3/12/2013
Welding Engineer/Signature/Date		**Joint Number**
Greg Pike /		2012-57-02