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

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As Managed By Advanced Technology International (ATI) dba SCRA Applied R & D

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TECHNICAL REPORT

INDEX FILE PAGE NN 198-12 (REV 11) REPORT NO. CHARGE NO. PROJECT NO 0000-5809-T-1 E.66-7 2012-57 AUTHOR DEPT. 037 Greg Pike TITLE Evaluation of the Tip Tig Welding System, a Semi-automatic Hot Wire GTAW Process, Compared to Manual GTAW SECURITY CLASSIFICATION NO. OF PAGES DATE 26 9/17/2013 Unclassified 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 but 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.



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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 $25^{\circ} \pm 10^{\circ}$, and the other half was welded with a drag angle of $25^{\circ} \pm 10^{\circ}$. 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

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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

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.

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Procedure Qualifica	rocedure Qualification Record											
PQR Number:		N/A	Qualificati	on Standard:	N/A	Fabrica	tion Document:	N/A				
Process SMAW X GTAW	GMA FCAV	W GMAW-P	SAW	X Manual Semiauto Mechanize	Auto	Position Vertical prog.	3G Up	Preheat (min/max) Interpass (min/max) Preheat Method	32°F/NC 32°F/NC Ambient			
Equipment Power S	Supply/Mo	del	Closed loop MILLER MAXSTAR 200 DX N/A	X Open loop	В	Closed loop Op	en loop	Measured by Max. interpass reached	Thermocouple d? Yes X No			
Torch/Gas Cu	p/Wire Fee Curi	der Weldcraft ent AC	HW24 5&6 DCEP	N/A X DCEN	AC	DCEP	DCEN	Tungsten Type Diameter	EWTh-2 3/32"			
Torch Angle	Work a	ngle	0° to 10°	Travel ang	le (+push/-drag)	0° - 10° push		Point prep/shape	Pointed			
Filler Material Size/Br PO	and/Type /Heat/Lot	A A#: A-2B 1/16" I 43	Form/shape: Bare Lincoln MIL- 200069593 / NA / 834B	e Wire 70S-3	B A#:	Form/shape:		3:1 Shielding Method	Taper			
Spe	cification	A <u>C#.</u> C 1	MiL-E-23765/1E	lata	B c# c	1 Formi Motalli	a Packing	Shielding gas type Flow rate (cfh)	100%Ar 25			
Base Material Pre-weld Interpass Type/Di PO, Spe	l cleaning s cleaning imensions /Heat/Lot ccification	A S#: S-1 Method Grind / Method HTS 450	Form: P1 Sanded Distance Grinding 1/2"(T) x + 0300893-68-9 / NA / NA MIL-S-22698	2" 9 1/2"x 18"	B S#: S Method Gri Method Carbon Steel	nd & Sanded Distance Grinding 2" x 22 Project Stock MIL-S-22698	2" 'x 3/8"(T)	Purge gas type Purge flow rate (cfh) Flux brand/Lot# Flux type Flux specification Flux size	N/A N/A N/A N/A N/A N/A			
Backside Prep/NDT As welde NNS F Proce Accep Initial	ed Procedure edure std. tanee std. and Date	Ground MT	Satisfactory Unsat	Final Visual Ir X As welded NNS Pr Proce Accepta Initial a	ance std. ance std. CGE	X Satisfactory Unsat Unsat QAI 612.1 / QAI 612.10 T9074-AS-GIB-010/271 MIL-STD-2035 Class 1 / / 03/ 11	Final	MT/PT X MT PT NNS Procedure Procedure std. T90 Acceptance std. MII Initial and Date CGE /	X Satisfactory Unsat SSP N-21/121 74-AS-GIB-010/271 -STD-2035 Class 1 03/ 13 /2013			
Final RT NNS Proced Procedure Acceptance Initial and I	X S dure std. std. Date	Satisfactory SSP N-4 T9074-AS-GI MIL-STD-20: MCT 03/	Unsat //141 3-010/271 55 Class 1 14 /2013	Final UT NNS Pr Proces Accepta Initial	Final UT Satisfactory Unsat Post Weld Heat Treatment NNS Procedure Temp. Range Procedure std. Holding Time Acceptance std. Heat rate Initial and Date Cooling rate							
$\begin{array}{c c c c c c c c c c c c c c c c c c c $												
Joint type: Root gap (in): Backgouge depth (in): Backgouge radius & be	evel angle:	B1V.5 3/8" Beve N/A	Land (in): el angle (included): 	0" 45° N/A	Cer Cer Pas	ramic backing manufacture ramic backing designation: ramic backing configuratio is size <1/2" thick?	er: n:	N/A N/A N/A X Yes	No			
Technician Name/Pe	ersonnel I	Number			Charge	በበ 5800 ፹ 1	Date(s) of V	Welding	1_2013			
Welding Engineer/S	ignature/	Date			00	00-3007-1-1	Joint Numb	2-21-2013 t0 3-1 per 2012 57 0	1-2013			
Greg Pike /								2012-57-0.	L			

W.E. Technical Report E.66-7 Figure 4 (continued)

Weldi	Welding Data - Manual, Semiauto, Mechanized, Automatic Welding													
Pass	Filler	Electrode	Gas Cup-	Wire Feed	Current	Voltage	Arc '	Time	Bead	Travel	Heat	Oscil	ation Paramet	ers
No	Mat'l.	Stickout	to-Work	Speed	(A)	(V)	Min.	Sec.	Length	Speed	Input	Amplitude	Frequency	Dwell
		Distance (in)	Distance (in)	(ipm)	()			~	(in)	(ipm)	(kJ/inch)	(in)	(cpm)	Time (s)
1	А	5/16	3/8	N/A	103	10.7	12	52	18.0	1.4	47.2	N/A	N/A	N/A
2	А	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	А	5/16	3/8	N/A	118	10.3	10	52	18.0	1.7	42.9	N/A	N/A	N/A
6	Α	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	Α	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
Charli	e Estes	/ 13717	number				Cha	rge 00	00-5809-Т	-1	Date(s) of	2-21-2013	to 3-11-2013	
weldi	ng Engi	neer/Signature/	Date			/					Joint Nun	iber	57.01	
Greg	Pike /				1							2012	-57-01	

W.E. Technical Report E.66-7 Figure 4 (continued)

Weldi	Velding Data - Manual, Semiauto, Mechanized, Automatic Welding													
Pass	Filler	Electrode	Gas Cup-	Wire Feed	Current	Voltage	Arc	Time	Bead	Travel	Heat	Oscil	lation Parame	ters
No	Mat'l.	Stickout Distance (in)	to-Work Distance (in)	Speed (ipm)	(A)	(V)	Min.	Sec.	Length (in)	Speed (ipm)	Input (kJ/inch)	Amplitude (in)	Frequency (cpm)	Dwell Time (s)
21	А	5/16	3/8	N/A	135	10.9	8	28	18.0	2.1	42.0	N/A	N/A	N/A
22	Α	5/16	3/8	N/A	135	11.1	9	45	18.0	1.8	50.0	N/A	N/A	N/A
23	А	5/16	3/8	N/A	135	10.9	10	36	18.0	1.7	51.9	N/A	N/A	N/A
24	Α	5/16	3/8	N/A	135	11.4	10	4	18.0	1.8	51.3	N/A	N/A	N/A
25	А	5/16	3/8	N/A	135	11.5	7	42	18.0	2.3	40.5	N/A	N/A	N/A
26	А	5/16	3/8	N/A	135	11.2	10	26	18.0	1.7	53.4	N/A	N/A	N/A
27	А	5/16	3/8	N/A	135	11.1	10	52	18.0	1.7	52.9	N/A	N/A	N/A
28	Α	5/16	3/8	N/A	135	11.7	8	19	18.0	2.2	43.1	N/A	N/A	N/A
29	А	5/16	3/8	N/A	135	11.7	9	11	18.0	2.0	47.4	N/A	N/A	N/A
	Notes:												1	
То	tal arc o	on welding tim	ne of 4 hrs. 53	min. and 10	sec.									
Techn	ician Ne	me/Personnel	Number				Cha	roe			Date(s) of	Welding		
Charli	e Estes	/ 13717						00	00-5809-Т	-1		2-21-2013	to 3-11-2013	
Weldi	ng Engi	neer/Signature	/Date			,					Joint Nun	nber	57 01	
Greg	Pike /					/						2012	-57-01	

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

Procedure Qualific:	rocedure Qualification Record												
PQR Number:		N/A	Qualification	n Standard:	N/A	Fabr	ication Document:	: N/A					
Process SMAW X GTAW	GMAW FCAW	GMAW-P X OTHER hot wire	SAW Tip Tig)	Manual X Semiauto Mechanize	Auto	Position Vertical prog.	3G Up	Preheat (min/max) Interpass (min/max) Preheat Method	32°F/NC 32°F/NC Ambient				
Equipment Power :	Supply/Mode	A Closed loop 1 Miller	X Maxstar 350	Open loop	В	Closed loop	Open loop	Measured by Max. interpass reached	Thermocouple d? Yes X No				
Torch/Gas Cu	pe (if required p/Wire Feede Curren	r Tip Tig Torch 18 SC tAC	N/A #6 A- DCEP X	4600 C DCEN	AC	DCEP	DCEN	Tungsten Type Diameter	EWTh-2 1/8"				
Torch Angle	Work ang	le0° to 10°		Travel ang	le (+push/-drag)	± 20° push		Point prep/shape	Blunt				
Filler Material Size/Br PO Spe	Arand/Type /Heat/Lot ecification	A#: A-2B Form/s .035" Lincoln NA / NA MiL-E-23	hape: Spoo MIL-7 / 360E 765/1E	oled /0S-3	B A#:	Form/shape:		3:1 Taper Shielding Method Shielding gas type 100%Ar Elow rate (cfb) 35					
Base Material Pre-weld Interpass Type/Di PO Spe	A d cleaning s cleaning imensions /Heat/Lot ecification	S#: S-1 Method Grind / Sanded Method Grind / Sanded HTS 4500300893-68 MIL-S-2 MIL-S-2	Form: Pla Distance Grinding 1/2"(T) x 9 -9 / NA / NA 2698	te 2" 1/2"x 18"	B S#: S Method Gri Method Carbon Steel	-1 Form: Meta nd & Sanded Distance Grinding 2" x 2 Project Stock MIL-S-22698	2" 22" x 3/8"(T)	Flow rate (cm) Purge gas type Purge flow rate (cfh) Flux brand/Lot# Flux type Flux specification Flux size	35 N/A N/A N/A N/A N/A N/A				
Backside Prep/NDT As welde NNS F Proce Accep Initial	ed Gro Procedure edure std. tanee std. and Date	Dund PT	Satisfactory Unsat	Final Visual Ir X_As welded NNS Pr Procee Accepta Initial a	Final Visual Inspection X Satisfactory Final MT/PT X MT X As welded Ground Unsat PT PT PT NNS Procedure QAI 612.1 / QAI 612.10 NNS Procedure PT PT PT Procedure std. T9074-AS-GIB-010/271 Procedure std. T907 Acceptance std. MIL Initial and Date CGE / 03/ 12 /2013 Initial and Date CGE /								
Final RT NNS Proced Procedure Acceptance Initial and I	X Sat dure std. std. Date MC	isfactory Unsat SSP N-41/141 T9074-AS-GIB-010/271 MIL-STD-2035 Class 1 T 03/ 14	/2013	Final UT NNS Pr Proceed Accepta Initial	Satisfac rocedure dure std. ance std. md Date	tory Uns	at Post	Weld Heat Treatment Temp. Range Holding Time Heat rate Cooling rate					
$\begin{array}{c c c c c c c c c c c c c c c c c c c $													
Joint type: Root gap (in): Backgouge depth (in): Backgouge radius & be	evel angle:	B1V.5 8/8" Bevel angle (inc N/A	Land (in): luded): N/A	0" 45° N/A	Cei Cei Cei Pas	ramic backing manufactu ramic backing designatio ramic backing configuration ss size <1/2" thick?	urer: on: tion:	N/A N/A N/A X Yes	No				
Technician Name/Pe Charlie Estes /	ersonnel Nu 13717	mber			Charge 00	00-5809-T-1	Date(s) of	Welding 3/12/2013					
Welding Engineer/S	ignature/Da	nte					Joint Numl	ber					
Greg Pike /								2012-57-02	2				

W.E. Technical Report E.66-7 Figure 5 (continued)

Weldi	Velding Data - Manual, Semiauto, Mechanized, Automatic Welding													
Pass	Filler	Electrode	Gas Cup-	Wire Feed	Current	Voltage	Arc	Time	Bead	Travel	Heat	Osci	lation Parameters	
No	Mat'l.	Stickout	to-Work	Speed	(A)	(V)	Min.	Sec.	Length	Speed	Input	Amplitude	Frequency	Dwell
		Distance (in)	Distance (in)	(ipm)	()			~	(in)	(ipm)	(kJ/inch)	(in)	(cpm)	Time (s)
1	Α	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	Α	3/8	1/2	105	220	12.1	3	57	18.0	4.6	34.7	N/A	N/A	N/A
8	Α	3/8	1/2	105	215	12.7	3	58	18.0	4.5	36.4	N/A	N/A	N/A
9	Α	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
То	Notes:	on welding tim	ne of 53 min. a	nd 19 sec.										
Techr	ician Na	ame/Personnel	Number				Cha	rge	00 <u>-5800</u> T	<u>-1</u>	Date(s) of	f Welding	/2013	
Weldi	ing Engi	neer/Signature	/Date				<u> </u>	UL	00-2809-1	-1	Joint Nun	nber	42013	
Greg	Velding Engineer/Signature/Date Joint Number													

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

Procedure Qualification	ocedure Qualification Record												
PQR Number:		N/A		Qualificati	ion Standard:	N/.	ł	Fabrication Do	cument:		N/A		
Process					Manual	Auto	Positio	n 1G		Preheat (1	min/max)	60°F/350°F	
SMAW	GMAV	GMAW-F		SAW	X Semiauto	1	Vertical prog	g. <u>N/A</u>		Interpass (1	min/max)	60°F/350°F	
A GIAW	FCAW	X OTHER	not wire ((1p 11g)	Mechaniz	ed D			_	Preneat	t Method	Ambient	
Equipment Power	Supply/Mod	del	Closed loop Miller	Maxstar 350	X Open loop	в	Closed loop	Open loop		Mea Max. interp	asured by bass reached?	X Yes No	
Carriage Ty	pe (if requir	ed)		N/A			/				-		
Torch/Gas Cu	p/Wire Feed	ter Tip Ti	g Torch 18 SC	#6 A	A-4600		DCEI		J	Tungsten	Type	Lanthanated	
T. 1 A 1	Cuire W 1		08 - 108	JCEF	T				•		1	1/8	
Torch Angle	work an	igie	0° to 10°		I ravei an	gie (+pusn/-ara	g) 10° to 2	0° Drag		Point prep/s	snape	Blunt	
Filler Material	and/Type	A A#: A-43B	Form/sh	ape: Spo	poled	B A#:	Form/shap	e:			3:1 T	aper	
PO	/Heat/Lot	.045	4500286454 / QH5	53 / YM8938	EIN023					Shielding Metho	d		
Spe	ecification		MiL-E-21	562 E						Shielding	g gas type	100%Ar	
Base Material A S#: S-1 Form: Plate B S#: Form: Purse sas type												35 N/A	
Pre-weld	1 cleaning	Method C	rind / Sanded	Distance	ALL	Method	Dis	tance		Purge flow	rate (cfh)	N/A	
Interpass	s cleaning	Method	S/S V	Virebrush	10" 26"	Method				Flux bra	and/Lot#	N/A	
PO/	/Heat/Lot	4	500312900-1-4 / 8	42J31610 / NA	10 x 30					Flux spec	cification	N/A N/A	
Spe	ecification		MIL-S-22	698							Flux size	N/A	
Backside Prep/NDT			MT	Satisfactory	Final Visual	Inspection	X Satisf	actory	Final	MT/PT	MT	X Satisfactory	
As welde	edC	Ground	PT	Unsat	X As welde	dGro	und Unsat				X PT	Unsat	
NNS F Proce	Procedure edure std.		-		NNS I Proce	Procedure edure std.	QAI 612.1 / QAI 6 T9074-AS-GIB-01	0/271		NNS Procedure Procedure sto	re SS d. T9074-	SP N-21/121 -AS-GIB-010/271	
Accep	tanee std.				Accep	tance std.	MIL-STD-2035 C	lass 1		Acceptance std. MIL-STD-2035 Class 1			
Initial	and Date				Initial	and Date C	GE / 04/ 02	Initial and Dat	te CGE / 0	04/ 02 /2013			
Final RT	S	atisfactory	Unsat		Final UT	Sati	factory	Unsat	Post V	Weld Heat Treatm	nent		
NNS Procedure	std				NNS I Proce	Procedure				Temp. Rang Holding Tim	ge ne		
Acceptance	std.				Accep	tance std.				Heat ra	te		
Initial and I	Date				Initial	and Date				Cooling rat	te		
Joint Sketch						Bea	Placement						
		26"		< I									
		50											
			< <u> </u>	>	$\overline{\wedge}$								
1" Thic	ck (OSS)												
		_	[10"					10		and Lauran	
					\downarrow					20 weld pass	ies 1	lst Layer	
					<u> </u>		Oss base ma	aterial				1	
Ioint type:		Cladding	1	and (in).	N/A		Peramic backing ma	nufacturer:			N/A		
Root gap (in):		N/A	Bevel angle (incl	uded):	N/A		Ceramic backing des	ignation:			N/A		
Backgouge depth (in):		N/#	4				Ceramic backing con	figuration:			N/A		
Backgouge radius & be	evel angle:			N/A	N/A		Pass size <1/2" thick	?		Y	'es	No	
Technician Name/Pe	ersonnel N	lumber				Charge		Date	e(s) of V	Welding			
Charlie Estes /	13717	N -4-					0000-5809-T-1		· N7 ·	4-01-201	3 to 4-02-2	2013	
welding Engineer/S	ignature/L	Jate						Join	t Numb	er			
Greg Pike /										201	12-57-03		

W.E. Technical Report E.66-7 Figure 6 (continued)

Form	# O37-1	17-2A,	Rev.	2
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Weldi	Velding Data - Manual, Semiauto, Mechanized, Automatic Welding													
Pass	Filler	Electrode	Gas Cup-	Wire Feed	Current	Voltage	Arc '	Гime	Bead	Travel	Heat	Oscil	ation Paramet	ters
No	Mat'l.	Stickout	to-Work	Speed	(A)	(V)	Min.	Sec.	Length	Speed	Input	Amplitude	Frequency	Dwell
	,I	Distance (in)	Distance (in)	(ipm)	<u> </u>	Ļ	<u> </u>		(in)	(ipm)	(kJ/inch)	(in)	(cpm)	Time (s)
1	А	23/32	27/32	75	200	*	*	*	6.0	*	*	N/A	N/A	N/A
2	А	23/32	27/32	75	200	*	*	*	6.0	*	*	N/A	N/A	N/A
3	А	23/32	27/32	75	200	*	*	*	6.0	*	*	N/A	N/A	N/A
4	Α	23/32	27/32	75	200	*	*	*	6.0	*	*	N/A	N/A	N/A
5	А	23/32	27/32	75	200	11.7	*	*	6.0	*	*	N/A	N/A	N/A
6	А	23/32	27/32	75	200	11.6	0	49	6.0	7.3	19.1	N/A	N/A	N/A
7	Α	23/32	27/32	75	200	11.2	0	47	6.0	7.7	17.5	N/A	N/A	N/A
8	Α	23/32	27/32	75	200	11.3	0	46	6.0	7.8	17.4	N/A	N/A	N/A
9	А	23/32	27/32	75	200	11.0	0	46	6.0	7.8	16.9	N/A	N/A	N/A
10	А	23/32	27/32	75	200	11.1	0	55	6.0	6.5	20.5	N/A	N/A	N/A
11	Α	23/32	27/32	75	200	11.2	0	49	6.0	7.3	18.4	N/A	N/A	N/A
12	Α	23/32	27/32	75	200	11.4	0	47	6.0	7.7	17.8	N/A	N/A	N/A
13	А	23/32	27/32	75	200	11.3	0	51	6.0	7.1	19.1	N/A	N/A	N/A
14	Α	23/32	27/32	75	200	11.3	0	49	6.0	7.3	18.6	N/A	N/A	N/A
15	Α	23/32	27/32	75	200	11.3	0	50	6.0	7.2	18.8	N/A	N/A	N/A
16	Α	23/32	27/32	75	200	11.4	0	49	6.0	7.3	18.7	N/A	N/A	N/A
17	А	23/32	27/32	75	200	11.4	0	46	6.0	7.8	17.5	N/A	N/A	N/A
18	Α	23/32	27/32	75	200	11.4	0	50	6.0	7.2	19.0	N/A	N/A	N/A
19	А	23/32	27/32	75	200	11.3	0	47	6.0	7.7	17.6	N/A	N/A	N/A
20	А	23/32	27/32	75	200	11.5	0	51	6.0	7.1	19.4	N/A	N/A	N/A
	Notes:	· · · · · · · · · · · · · · · · · · ·	•		C 1	****					****	****		

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

W.E. Technical Report E.66-7 Figure 6 (continued)

Weldi	Welding Data - Manual, Semiauto, Mechanized, Automatic Welding													
Pass	Filler	Flectrode	Gas Cup-	Wire Feed	Current	Voltare	Arc.	Time	Read	Travel	Heat	Oscil	ation Paramet	ors
I ass No	Mat'l	Stickout	to-Work	Speed		(V)	Min	Sec	Length	Speed	Input	Amplitude	Frequency	Dwell
140	Wiat I.	Distance (in)	Distance (in)	(ipm)	(A)	(•)	IVIIII.	Sec.	(in)	(inm)	(kI/inch)	(in)	(cpm)	Time (s)
				(1911)					(111)	(ipiii)		(111)	(epiii)	
21	А	23/32	27/32	75	200	12.3	0	26	3.0	6.9	21.4	N/A	N/A	N/A
22	А	23/32	27/32	75	200	11.9	0	25	3.0	7.2	19.8	N/A	N/A	N/A
23	А	23/32	27/32	75	200	11.4	0	26	3.0	6.9	19.8	N/A	N/A	N/A
24	А	23/32	27/32	75	200	11.0	0	28	3.0	6.4	20.6	N/A	N/A	N/A
25	А	23/32	27/32	75	200	11.2	0	28	3.0	6.4	21.0	N/A	N/A	N/A
26	А	23/32	27/32	75	200	10.9	0	30	3.0	6.0	21.8	N/A	N/A	N/A
27	А	23/32	27/32	75	200	11.0	0	32	3.0	5.6	23.6	N/A	N/A	N/A
28	А	23/32	27/32	75	200	10.9	0	31	3.0	5.8	22.6	N/A	N/A	N/A
29	А	23/32	27/32	75	200	10.9	0	30	3.0	6.0	21.8	N/A	N/A	N/A
30	А	23/32	27/32	75	200	10.9	0	28	3.0	6.4	20.4	N/A	N/A	N/A
31	А	23/32	27/32	75	200	10.8	0	29	3.0	6.2	20.9	N/A	N/A	N/A
32	Α	23/32	27/32	75	200	10.7	0	29	3.0	6.2	20.7	N/A	N/A	N/A
33	А	23/32	27/32	75	200	10.7	0	29	3.0	6.2	20.7	N/A	N/A	N/A
34	Α	23/32	27/32	75	200	10.9	0	30	3.0	6.0	21.8	N/A	N/A	N/A
35	Α	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	А	23/32	27/32	75	200	10.8	0	20	3.0	9.0	14.4	N/A	N/A	N/A
	Notes:													
* P	aramete	r not considere	ed essential for	evaluation an	d was not	captured.								
Techn	ician Na	me/Personnel	Number				Cha	rge			Date(s) of	Welding		
Charli	e Estes	/ 13717						00	00-5809-T	-1		4-01-2013	to 4-02-2013	
Weldi	ng Engi	neer/Signature	/Date								Joint Nun	nber		
Greg	Pike /				/	/						2012-	-57-03	

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

Procedure Qualification Record										
PQR Number:		N/A	Qualificatio	n Standard:	N/A	Fal	brication Documen	nt:	N/A	
Process SMAW X GTAW Equipment	GMAW FCAW	GMAW-P X OTHER hot w	SAW vire (Tip Tig)	Manual X Semiauto Mechanize C Open loop	Auto ed B	Position Vertical prog. Closed loop	5G Up Open loop	Preheat (min/maz Interpass (min/maz Preheat Metho Measured b	x) NC/350°F x) NC/350°F d Ambient y Thermocouple	
Power S Carriage Typ Torch/Gas Cu	Supply/Model pe (if required) p/Wire Feeder	M Tip Tig Torch 18 SC	iller Maxstar 350 N/A 6 & # A-	4600				Max. interpass read	Lanthanated	
Torch Angle	Work angle	0° to 10)°	Travel ang	le (+push/-drag)	25° ± 10° Pu	JCEN	Point prep/shape	Blunt	
Filler Material Size/Bra	and/Type	A#: A-8B Fo 5/32" Arcos	rm/shape: Insert (C MIL-3	Class 1) 608-L	B A#: A-8B .035"	Form/shape: Arcos	Spooled MIL-308-L		3:1 Taper	
PO/ Spe	'Heat/Lot cification	Q0 MII	600901 I-23413		4	500240398 / NA / XT86 MIL-E-19933 E		Shielding Method Shielding gas typ Flow rate (cfl	be <u>100%Ar</u> n) <u>35</u>	
Base Material Pre-weld Interpass Type/Di PO/ Spec	A cleaning s cleaning mensions /Heat/Lot cification	S#: S-8 Method Sanded & Acetor Method S/S 304L Proj	Form: Pip te Distance S/S Wirebrush 6" x 12" x ect Stock	ALL 0.718 (T)	B S#: Method Method	Form: Distance	2	Purge gas typ Purge flow rate (cfl Flux brand/Lot Flux typ Flux specificatio Flux siz	in 20 # N/A pe N/A n N/A ze N/A	
Backside Prep/NDT As welde NNS P Proce Accept Initial	d Grou Procedure edure std. tanee std. and Date	MT indPT	Satisfactory Unsat	Final Visual Ir As welded NNS Pr Procee Accepta Initial a	And Date CGE	Satisfactor X Unsat QAI 612.1 / QAI 612.1 T9074-AS-GIB-010/27 MIL-STD-2035 Class / 04/ 08 /20	y Fina 0 1 1 013	al MT/PT X P NNS Procedure Procedure std. 7 Acceptance std. 1 Initial and Date CGE	AT X Satisfactory T Unsat SSP N-21/121 '9074-AS-GIB-010/271 MIL-STD-2035 Class 1 i/ 04/ 09 /2013	
Final RT NNS Proced Procedure Acceptance Initial and I	Satis lure std. std. Date	sfactoryUnsat		Final UT NNS Pr Proces Accepta Initial	Satisfac rocedure dure std. ance std. md Date	tory Ur	Isat Post	t Weld Heat Treatment Temp. Range Holding Time Heat rate Cooling rate		
Joint Sketch	5" dia. ↑ 0.718 ↓ 5/32" insert -	55° R 3/16"			Bead P	lacement	$ \begin{array}{c} 3 & 14 \\ 12 \\ 9 & 10 \\ 7 \\ 5 \\ 3 \\ 2 \\ 11 \end{array} $	15 16 11 8 6 4		
Joint type: Root gap (in): Backgouge depth (in): Backgouge radius & be	N/	PN-2 /A Bevel angle N/A	Land (in): (included): 	<u>1/16"</u> 55° N/A	Ce Ce Pa:	ramic backing manufar ramic backing designat ramic backing configur as size <1/2" thick?	cturer: tion: ration:	N/A N/A N/A X Yes	No	
Charlie Estes /	13717	nder			Cnarge 00	00-5809-T-1	Date(s) of	4-03-2013 to 4	-05-2013	
Welding Engineer/Si Greg Pike /	ignature/Dat	e					Joint Num	nber 2012-57	-04	

W.E. Technical Report E.66-7 Figure 7 (continued)

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Weldi	Velding Data - Manual, Semiauto, Mechanized, Automatic Welding													
Pass	Filler	Electrode	Gas Cup-	Wire Feed	Current	Voltage	Arc '	Time	Bead	Travel	Heat	Oscil	ation Paramet	ters
No	Mat'l.	Stickout	to-Work	Speed	(A)	(V)	Min.	Sec.	Length	Speed	Input	Amplitude	Frequency	Dwell
		Distance (in)	Distance (in)	(ipm)					(in)	(ipm)	(kJ/inch)	(in)	(cpm)	Time (s)
1	А	5/16	5/16	*	*	*	*	*	*	*	*	N/A	N/A	N/A
2	В	3/8	1/2	69	150	*	6	51	21.3	3.1	*	N/A	N/A	N/A
3	В	3/8	1/2	66	130	*	*	*	*	*	*	N/A	N/A	N/A
4	В	3/8	1/2	66	150	*	*	*	*	*	*	N/A	N/A	N/A
5	В	3/8	1/2	66	170	*	*	*	*	*	*	N/A	N/A	N/A
6	В	3/8	1/2	66	180	*	*	*	*	*	*	N/A	N/A	N/A
7	В	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
8	В	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
9	В	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
10	В	3/8	1/2	105	190	*	*	*	*	*	*	N/A	N/A	N/A
11	В	3/8	1/2	105	190	*	*	*	*	*	*	N/A	N/A	N/A
12	В	3/8	1/2	105	190	*	*	*	*	*	*	N/A	N/A	N/A
13	В	3/8	1/2	75	180	*	*	*	*	*	*	N/A	N/A	N/A
14	В	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
15	В	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
16	В	3/8	1/2	90	180	*	*	*	*	*	*	N/A	N/A	N/A
	Notes:						1			1000				
We	eld pass	# 1 is the 5/32"	insert.	*****	****					****	****			nenenenenenenen
Th	e tip gro	unded to the jo	int on the first	weld fill pass	s. Putting	fiber glass	tape of	on the	tip preven	ted this fro	om happeni	ng again.		
A ŧ	f 6 shiel	ding gas cup w	as used throug	h pass # 6 the	en a # 8 cup	o for the re	maino	ler of	weld passe	es.		0.0		
Th	e purge g	gas was turned	off after weld	pass # 6.										
Th	e VT wa	s "unsat" due t	o the ID pushin	ng in as the re	emainder o	f the joint	was c	omple	ted.					
We	eld cross	sections were	taken at the 12	:00, 6:00, 4:3	0 and 11:3	0 o'clock p	ositio	ns. N	o indicatio	ons noted.				
* F	aramete	r not considere	d essential for	evaluation ar	nd was not	captured.								
Techn	ician Ns	me/Personnel	Number				Cha	rge			Date(s) of	Welding		
Charli	ie Estes	/ 13717					Cina	-50	00-5809-Т	-1	240(3) 01	4-03-2013	to 4-05-2013	
Weldi	ng Engi	neer/Signature/	Date								Joint Nun	nber		
Greg	Pike /				,	/						2012	-57-04	

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

Procedure Qualific	rocedure Qualification Record										
PQR Number:		N/A	Qualificat	ion Standard:	N	/A	Fabricati	on Document:	1	λ/A	
Process SMAW X GTAW	GMAV FCAW	W GMAW-P 7 X OTHER hot	SAW wire (Tip Tig)	Manual X Semiauto Mechaniz	Au	to Po Vertica	osition 10 Il prog. N/	G A	Preheat (min/max Interpass (min/max Preheat Metho	60°F/350°F 60°F/350°F d Ambient	
Equipment Power Carriage Ty	Supply/Mo pe (if requi	A Closed del	l loop Miller Maxstar 350 N/A	X Open loop	В	Closed loop	Oper	n loop	Measured b Max. interpass reac	y Thermocouple hed? X Yes No	
Torch/Gas Cu	p/Wire Fee Curr	der Tip Tig Torch 18 S ent AC	SC #6 . DCEP	A-4600 X DCEN		AC	DCEP	DCEN	Tungsten Type Diameter	Lanthanated 1/8"	
Torch Angle	Work an	ngle 0° to	10°	Travel ang	gle (+push/-di	rag) 10	0° to 20° Drag		Point prep/shape	Blunt	
Filler Material Size/Br PO	and/Type /Heat/Lot	A A#: A-43B F .045" Arcos 4500286454	Form/shape: Sp MIL 4 / QH553 / YM8938	ooled -EN625	B A#:	Form	/shape:		Shielding Method	3:1 Taper	
Spe	ecification	Mil	L-E-21562 E						Shielding gas typ Flow rate (cfh	e 100%Ar) 35	
Base Material Pre-welc Interpas: Type/Di PO Spe	d cleaning s cleaning imensions /Heat/Lot ccification	A S#: S-1 Method Grind Method Carbon Steel	Form: F Distance S/S Wirebrush 21" x 5 1 roject stock	> 3" > 2" x 0.375"	B S#: Method Method		Form: Distance		Purge gas typ Purge flow rate (cfh Flux brand/Lot Flux typ Flux specificatio Flux siz	e <u>N/A</u>) <u>N/A</u> # <u>N/A</u> e <u>N/A</u> e <u>N/A</u>	
Backside Prep/NDT Backside Prep/NDT As welde NNS I Proc Accep Initial	edO Procedure edure std. tanee std. and Date	Ground PT	Satisfactory Unsat	Final Visual I X As welded NNS P Proce Accept Initial	nspection Grocedure dure std. ance std. and Date	X 5 QAI 612.1 / 0 T9074-AS-Gi MIL-STD-20 CGE / 04/	Satisfactory Unsat QAI 612.10 IB-010/271 035 Class 1 10 /2013	Final	MT/PT M P NNS Procedure Procedure std. Acceptance std. Initial and Date	IT Satisfactory T Unsat	
Final RT		atisfactoryUnsat		Final UT	Sat	isfactory	Unsat	Post V	Weld Heat Treatment		
NNS Proced Procedure Acceptance Initial and I	dure std. std. Date			NNS P Proce Accept Initial	rocedure dure std. ance std.				Temp. Range Holding Time Heat rate Cooling rate		
Joint Sketch					Bea	d Placement			-		
5.5"	Dia. .375" w ↓	vall thickness C/	'S Pipe			[]	<u></u>	<u>)5)6)7)</u>	C/S Pir	pe	
Joint type: Root gap (in): Backgouge depth (in): Backgouge radius & be	evel angle:	Cladding N/A Bevel angl N/A	Land (in): e (included): N/A	N/A N/A N/A		Ceramic backing Ceramic backing Ceramic backing Pass size <1/2"	g manufacturer g designation: g configuration thick?	:	N/A N/A N/A X Yes	No	
Technician Name/Pe	ersonnel N	Jumber			Charge	0000 5000 5	1	Date(s) of V	Welding	12	
Welding Engineer/S	ignature/I	Date			ļ	0000-5809-T-	-1	Joint Numb	4/10/20	15	
Greg Pike /									2012-57-	-05	

W.E. Technical Report E.66-7 Figure 8 (continued) Page 22 of 26

Weldi	Velding Data - Manual, Semiauto, Mechanized, Automatic Welding													
Pass	Filler	Electrode	Gas Cup-	Wire Feed	Current	Voltage	Arc '	Time	Bead	Travel	Heat	Oscil	ation Parame	ters
No	Mat'l.	Stickout	to-Work	Speed	(A)	(V)	Min.	Sec.	Length	Speed	Input	Amplitude	Frequency	Dwell
		Distance (in)	Distance (in)	(ipm)					(in)	(ipm)	(kJ/inch)	(in)	(cpm)	Time (s)
1	А	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
2	А	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
3	Α	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
4	Α	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
5	А	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
6	А	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
7	Α	3/8	1/2	75	225	*	*	*	17.5	*	*	N/A	N/A	N/A
	I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I													
To The At The * P	Notes: elimina e weldin complet e old shi	te crater cracks og was relativel ion of welding pyard chiller w er not considere	the "final slop y continuous a different locat vas circulating d essential for	e" on the pow s the pipe rot: ons on the to coolant but it evaluation ar	ver supply ated under rch handle was appare ad was not	was adjus the torch a were mea ently not s captured.	ted to and it sured ufficie	4.0. was n with a ent.	oticed that a contact p	the torch v yrometer a	was getting nd the peak	very hot. was about 15	0F.	
Techn	ician Na	ame/Personnel	Number			•	Cha	rge			Date(s) of	Welding		
Charli	e Estes	/ 13/17/	/Data				1	00	00-5809-T	-1	Loint Nu-	4/10	/2013	
Creation	ng Engl	neer/signature/	Date			/					Joint Nuñ	1001	57.05	
Greg	гие /				1							2012	-37-03	

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

Procedure Qualific	rocedure Qualification Record										
PQR Number:		N/A	Qualification Stan	ıdard:	N/A	F	abrication Docum	ient:	N/A		
Process SMAW X GTAW	GMAW FCAW	GMAW-P SAV X OTHER hot wire (Tip 1	V X S Yig) N	Manual Semiauto Mechanized	Auto	Position Vertical prog.	2G N/A	Preheat (min Interpass (min Preheat M	n/max) NC/350°F n/max) NC/350°F Iethod Ambient		
Equipment Power Carriage Ty	Supply/Mode	A Closed loop Miller Max N/A	star 350	n loop	в	Closed loop	Open loop	Measu Max. interpas	red by Thermocoupl s reached? X Yes	le No	
Torch/Gas Cu	p/Wire Feede Curren	r Tip Tig Torch 18 SC 6 & t t AC DCE	A-4600 P X DCE	EN	AC	DCEP	DCEN	Tungsten Ty Diame	ter 1/8"		
Torch Angle	Work ang	e0° to 10°]	Travel angle	(+push/-drag)	25° ± 10° Push & Dr	ag (see notes)	Point prep/sha	pe Blunt		
Filler Material Size/Br PO	A and/Type /Heat/Lot	A#: A-34B Form/shape: .035" Special Metals 4500238659 / CN80A(Mil E 31567E (Spooled MIL-EN67 DHR / NA	B	A#:	Form/shape:		Shielding Method	3:1 Taper		
spe	cincation	Mil-E-21302E (SH)		\sim			Flow rat	e (cfh) 35		
Base Material Pre-welc Interpase Type/Di	A cleaning s cleaning imensions	S#: S-34 Form: Method Sanded & Acetone Method S/S Wire CUNI 70/30	Pipe Distance 2" brush 4" x 3 1/8" x 0.375	5 (T)	Method Method	Form: Distanc	ce	Purge ga Purge flow rat Flux brand Flu	Is type N/A e (cfh) N/A d/Lot# N/A x type N/A		
PO. Spe	/Heat/Lot cification	1000192860 / 3590	1 / NA		\angle			Flux specifi Flu	ication N/A 1x size N/A		
Backside Prep/NDT As welde NNS F Proce Accep Initial	ed Gro Procedure edure std. tanee std. and Date	MTSatis	factory Final t X A	l Visual Insp As welded NNS Proc Procedu Acceptand Initial and	Ground Ground cedure re std. ce std. d Date CGE	X Satisfacto Unsat QAI 612.1 / QAI 612. T9074-AS-GIB-010/2 MIL-STD-2035 Class / 04/ 15 /2	pry F 10 71 1 2013	inal MT/PT NNS Procedure Procedure std. Acceptance std. Initial and Date	MT X Satisfactory X PT Unsat SSP N-21/121 T9074-AS-GIB-010/2 MIL-STD-2035 Class CGE / 04/ 15 /20	y 271 5 1 13	
Final RT NNS Proced Procedure Acceptance	Sat dure std. std.	isfactory Unsat	Final	ll UT NNS Proc Procedu Acceptan	Satisfac cedure re std. ce std.	tory U	Insat P	ost Weld Heat Treatmen Temp. Range Holding Time Heat rate			
Initial and I	Date			Initial and	d Date			Cooling rate			
Joint Sketch	4.0" dia. ↓ ► 0.	55° R 3/16" 375" 0" GAP			Bead P	acement	9	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$			
Joint type: Root gap (in): Backgouge depth (in): Backgouge radius & be	P N evel angle:	N-2 (modified) Land J/A Bevel angle (included N/A N/A	l (in):	1/16" 55°	Cer Cer Cer Pas	amic backing manufa amic backing designa amic backing configu s size <1/2" thick?	acturer: ation: uration:	N N X Yes	I/A I/A I/A No		
Technician Name/Pe	ersonnel Nu	mber		(Charge	00 5900 7 1	Date(s)	of Welding	to 4 15 2012		
Welding Engineer/S	ignature/Da	te			00	00-3809-1-1	Joint Nu	4-11-2013 umber	w 4-13-2013		
Greg Pike /								2012	-57-06		

W.E. Technical Report E.66-7 Figure 9 (continued)

Weldi	ng Data	ı - Manual. Se	miauto. Mech	anized. Auto	omatic We	ding								
Pass	Filler	Electrode	Gas Cup-	Wire Feed	Current	Voltage	Arc	Time	Bead	Travel	Heat	Osci	lation Paramet	ters
No	Mat'l.	Stickout	to-Work	Speed	(A)	(V)	Min	. Sec.	Length	Speed	Input	Amplitude	Frequency	Dwell
		Distance (in)	Distance (in)	(ipm)					(in)	(ipm)	(kJ/inch)	(in)	(cpm)	Time (s)
1	A	3/8	1/2	60	125	*	*	*	12.8	*	*	N/A	N/A	N/A
2	Α	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	Α	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
								TRANSPORT						
	Notes			L										
Th	is was a	n infomal PT (inspector not ci	urrently qual	ified).									
Th	e PN2 jo	bint type norma	ally requires a c	consumable in	nsert ring b	ut this join	nt was	weld	ed open ro	ot because	a ring was	not readily av	ailable.	
Ha	lf of this	joint was wel	ded with a push	1 technique a	nd the othe	r half was	weld	ed wit	h a drag te	chnique - I	both were s	atisfactory.	****	
					*****		****	****				****	****	
* P	'aramete	r not considere	ed essential for	evaluation ar	nd was not	captured.								
Techn Charl	ician Na	ame/Personnel	Number				Cha	rge	00-5809-7	 Г_1	Date(s) of	f Welding 4/11/2013 t	0.04-15-2013	
Weldi	ing Engi	neer/Signature	/Date				<u> </u>		00-3007-1	1	Joint Nun		0 04-15-2015	
Greg	Pike /					/						2012	-57-06	

Bend

Radius

(in)

0.75

0.75

0.75

Test

Туре

3/

Side

Side

Side

Figure 11

			Transve	erse Tensile	s		
Test	Spe	cimen Dimen	sions	Ultimate	Tensile	Test	Failure
#				Load	Strength	Туре	Location
	(in)	(in)	(in ²)	(lbs)	(ksi)	1/	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

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

Guided Bend Tests

Specimen

Dimensions

0.375

0.375

0.375

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

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

Greg Pike /

								Test	Results	Speci	me
		Cha	arpy V-No	tch Impact	t Tests			#		Dimen	sio
Test	Test	Test	Impact	La	teral	S	Shear			(in)
#	Loc.	Temp.	Energy	Expa	ansion	Per Test	Avg.	SB-1	Sat.	0.375	
		(0°F)	(ft-lbs)	(Mils)	(%)	(%)	(%)	SB-2	Sat.	0.375	
								SB-3	Sat.	0.375	
								Note 3: S	ide, Face, Ro	ot or Longitudin	al
										Dynamic Te	ear
								Test	Test	Test T	em
								#	Location	(°F)
											-
				/							
				·							7
			-						/	1	
									/		
		/							/		
		/									
											_
]	Macro-Etch S	sp
	1							Test #		Macro Type	
/											-
											/
Test	Test						Average				
#	Method	Location of I	moressions	Individu	ual Hardness	Values	Hardness				
"	4/	(BM HAZ	FZ etc)	marvia		Vardes	Thardness				
	4/	(DM, HAZ	, FZ, etc)								
									/		
								-			
								D	est. Testing P	erformed IAW:	
	-							Lat	poratory Servi	ices Report No:	
Note 4: E	B (Brinell),	R (Rockwell A	, B, or C), V	(Vickers), M	IK (Microha	rdness					
	Knoop), N	IV (Microhard	ness Vickers)	, PH (Portab	le Hardness)						
											_
echnicia	an Name/	Personnel N	lumber				Charge		Date	e(s) of Weldin	ıg
		Charl	ie Estes / 1	3717			0000)-5809-T-1		2-21-	20
Velding	Engineer	/Signature/I	Date						Join	t Number	

	Ι	Dynamic Tear Tests	
Test	Test	Test Temp.	D.T. Energy
#	Location	(°F)	(ftlbs)
			/
		/	/
	/		
/			



> Joint Number 2012-57-01

2-21-2013 to 3-11-2013

100108879

Figure 12

Dago	26	of	26
Page	_20_	OI.	_20

			Transve	rse Tensile	S		
Test	Spe	ecimen Dimen	sions	Ultimate	Tensile	Test	Failure
#				Load	Strength	Туре	Location
	(in)	(in)	(in ²)	(lbs)	(ksi)	1/	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)

Destructive Test Results

		Ch	arpy V-No	tch Impac	t Tests			#		Dimen	sio
Test	Test	Test	Impact	La	teral	S	hear			(in)
#	Loc.	Temp.	Energy	Exp	ansion	Per Test	Avg.	SB-1	Sat.	0.375	
		(0°F)	(ft-lbs)	(Mils)	(%)	(%)	(%)	SB-2	Sat.	0.375	
								SB-3	Sat.	0.375	
								Note 3: S	ide, Face, Roo	t or Longitudin	al
					- /	1				Dvnamic Te	ear
								Test	Test	Test T	em
					/			#	Location	(°F)
				—							
				/						/	/
									/	/	
									/-		
	,										
									Ν	Aacro-Etch S	pe
-								Test #		Macro Type	
/											
Test	Test						A				\leq
#	Method	Location of 1	Impressions	Individ	ual Hardness	Values	Hardness				
	4/	(BM, HAZ	Z, FZ, etc)								
/								Lat	oratory Servic	ces Report No:	
Note 4: E	B (Brinell),	R (Rockwell A	, B, or C), V	(Vickers), N	IK (Microha	rdness					
	MIOOP), N	TV (IVIICIONALO	ness vickers)	, rn (Ponat	ne maruness)				-	/ \ A	
echnicia	an Name/	Personnel N Charl	Number ie Estes / 1	3717			Charge 0000)-5809-T-1	Date	(s) of Weldir	ıg 3
velding	Engineer	/Signature/	Date						Joint	Number	
eg Pike	e /										20

All Weld Metal Tensile Tests						
Test	Yield	Tensile		Red. in	Specimen	
#	Strength	Strength	Elong	Area	Dia.	
L	(ksi)	(ksi)	(%)	(%)	(in)	
1						
Guided Bend Tests						

Oulded Delid Tests						
Test	Results	Speci	men	Bend	Test	
#		Dimen	sions	Radius	Туре	
		(in	(in)	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	

Dynamic Tear Tests					
Test	Test	Test Temp.	D.T. Energy		
#	Location	(°F)	(frlbs)		



AWS B4.0:2007 100108879

3/12/2013

2012-57-02