

# **Single Pass Pipe Socket Welds Final Report**

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Category B

**NSRP SP-7 Welding Panel Project**  
**Single Pass Pipe Socket Welds Using the Semi-Automatic GMAW-Pulsed Arc Process**  
**NSRP Contract Number: 2005-339 (Task #8, Mod #01)**

**Technical Point of Contact**

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**Abstract**

Military specification NAVSEA S9074-AH-GIB-010/278 requires two weld layers on pressure boundaries of pipe socket joints and in the Navy shipbuilding industry this welding is typically done with the high quality but relatively slow manual GTAW process. In an effort to reduce costs of fabricating ship's piping systems, new welding equipment technology has been used to develop semi-automatic GMAW-Pulsed Arc parameters that achieve full socket weld size in one layer (pass) while maintaining acceptable weld quality. Weld procedure qualification testing was approved to the requirements of NAVSEA S9074-AQ-GIB-010/248 and a welder training package was developed to allow consistent implementation within the Navy shipbuilding industry. Forty-two production socket joints were Shop welded with one layer using the semi-automatic GMAW-Pulsed Arc process and were considered acceptable based on visual inspection (VT) and hydrostatic pressure testing. During this project it became evident that welder training and skill was critical to successful production implementation.

**1.0 Introduction**

Attempts had been made in the past to reduce pipe socket fabrication costs by making use of the GMAW-Pulsed Arc process. Semi-automatic GMAW-P is an inherently faster method of depositing weld metal than the traditional manual GTAW process and because of lower heat input seemed like a favorable method of welding thin wall pipe socket joints (Schedule 10 and Class 200.) However, the older GMAW-P welding power supply technology produced spatter which required removal by grinding/sanding and the need to deposit two weld layers on pipe pressure boundaries, per Navy specs, created substantially oversized fillet welds.

Recent advances in welding equipment's electronic technology allows for development of GMAW-P weld parameters with substantially reduced spatter. Additionally, weld parameter programs can be transferred to similar Pipe Shop power supplies for consistent production implementation.

The next item addressed was the Navy's two weld layer requirement. Research into the commercial pipe fabrication standard ASME B31.1 indicated there was no parallel requirement for two weld layers on a pressure boundary. NAVSEA S9074-AR-GIB-010/278 paragraph 6.2.6 also provided an option, with Navy approval, for use of less than two weld layers on pipe pressure boundaries. The shipbuilder would have the responsibility to demonstrate to the Navy that one weld layer could be done while maintaining high weld quality.

Welder training on use of the new equipment and the associated special welding techniques would be important to successful implementation.

**2.0 Goals / Objectives**

The goal of this project was to demonstrate the feasibility of implementing single pass (one layer)

socket welding on thin wall pipe for Navy ships using the GMAW-P process and acquire specific approval as allowed by NAVSEA S9074-AR-GIB-010/278. To this end, project objectives were established as follows:

- Develop weld parameters and techniques in the 2F pipe position that achieve required fillet weld size & quality in a single pass using the semi-automatic GMAW-Pulsed Arc process.
  - The targeted pipe materials were Schedule 10 300 Series Stainless Steel and Class 200 CuNi (90/10) in diameters ranging from 3" nps to 10" nps.
- Perform weld procedure qualification testing and submit PQR data for Navy approval.
- Identify specific welder training techniques to support consistent implementation within the Navy shipbuilding industry.
- Confirm feasibility of production application by pressure testing approximately fifty Shop welded pipe joints.
- Estimate production cost savings to support Navy approval of production implementation and to offset shipbuilder efforts.
- Issue a report detailing the results of this project.

**3.0 Approach**

A Fronius Transpulse Synergic 3200 power supply and Feeder would be used to develop specific weld parameters and techniques for each tested pipe material and diameter. The Fronius power supply offers the advantage of recording a weld program in the power supply, downloading to a notebook PC, and then uploading to other Fronius power supplies. This maintains consistent parameter settings for each welder. Weld programs would be developed to cover a range of each pipe material, diameter and wall thickness.



Fronius Transpulse Synergic 3200 power supply and Feeder

### 3.1 Procedure Qualification Record (PQR)

A matrix of pipe material, diameters, and wall thickness tested during procedure qualification (PQR) is found in TABLE 1. The PQR effort developed parameters and performed NDT / mechanical testing on the smallest and a larger diameter pipe that would be production welded with the GMAW-P process. The smallest diameter was limited by the thinnest pipe wall that could be welded without getting melt-through.

TABLE 1, PQR Test Material

Pipe/Sleeve Material	Pipe Diameter	Pipe Schedule	Pipe Thickness
CRES (304)	3" nps	Schedule 10	0.120"
CRES (304)	8" nps	Schedule 10	0.148"
CuNi (90/10)	4" nps	Class 200	0.109"
CuNi (90/10)	8" nps	Class 200	0.151"

PQR welding was done with the pipe oriented horizontally (2F position) using a mechanized positioner to rotate the pipe. Joint design was in accordance with NAVSEA S9074-AH-GIB-010/22, Joint P-13 (see FIG. 1.)

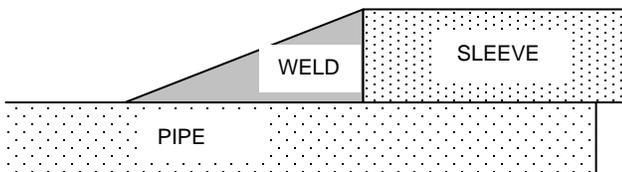


FIG. 1, PQR JOINT, P-13

Specific welder techniques were recorded for inclusion in a welder training manual. NDT test included Visual Inspection (VT) and Penetrant Testing (PT) of the exterior weld surface and Visual Inspection (VT) of the interior pipe surface in way of the socket weld for

unacceptable melt-through conditions. Destructive testing required Macro-Etch samples from each 90 degree position on the test pipe. (See FIG. 2 & 3)

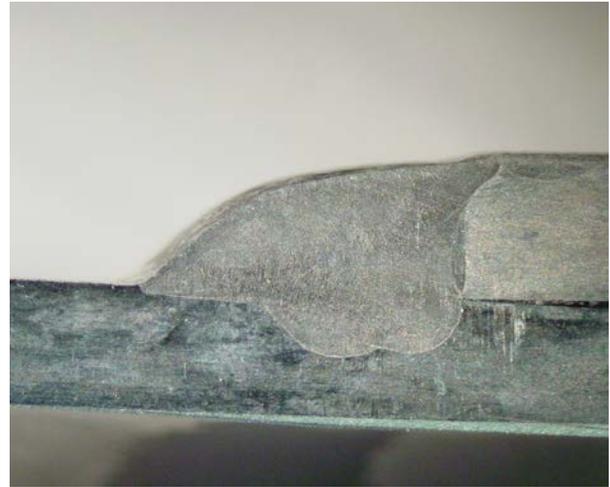


FIG. 2, PQR Macro-Etch Sample (CRES)



FIG. 3, PQR Macro-Etch Sample (CuNi)

Additionally, hydrostatic pressure testing was performed for 10 minutes at the highest pressure required for completed shipboard piping systems for each material, diameter, and wall thickness as recorded in TABLE 2. The PQR and associated Weld Procedure Specification (WPS) were submitted to the local Navy SUPSHIP and approved to NAVSEA S9074-AQ-GIB-010/248. (See Enclosure 1 PQR.)

TABLE 2, PQR Pressure Test Data

Pipe/Sleeve Material	Pipe Diameter	Pipe Thickness	Test Pressure
CRES (304L)	3" nps	0.120"	745 psi
CRES (304L)	8" nps	0.148"	425 psi
CuNi (90/10)	4" nps	0.109"	350 psi
CuNi (90/10)	8" nps	0.151"	262 psi

### 3.2 Welder Training/Testing

Welder training and performance qualification testing to NAVSEA S9074-AQ-GIB-010/248 was done using weld parameters and techniques developed during PQR testing. Welder training and testing took 3-5 days depending on previous experience with the Fronius equipment and the usual variability of acquiring a new skill or extending previous skills to a new application. Two welders were tested and successfully passed their pipe qualification on CRES and CuNi materials. (See Enclosure 2.)

### 3.3 Production Implementation

Production implementation of the GMAW-P process was accomplished on approximately forty socket joints. Visual Inspection (VT) and pipe system hydrostatic pressure testing was performed to demonstrate the quality of typical production welds. It was very evident that good quality welds were more easily achieved on CRES pipe materials than on CuNi materials. Occasional grinding of start/stop areas was necessary to pass VT inspection. Production implementation is illustrated in FIG. 4 & 5.



FIG. 4, Production Implementation on CRES Pipe



FIG. 5, Completed Production Weld on CRES Pipe

### 3.4 Cost Savings

Cost savings were investigated to provide cost justification for a shipbuilder to pursue use of the GMAW-P process in their pipe fabrication facility. Data was generated by comparing the cost estimates for applying two weld layers with manual GTAW vice one weld layer with semi-automatic GMAW-P. Three areas of savings identified were "arc-time" (one pass with GMAW-P verse 2-3 passes with GTAW), the elimination of interpass cool-down time normally required for multipass welds, and the higher deposition rate of GMAW-P. Average decrease in weld time was 86.9%. Time to set-up and take-down a pipe assembly in the positioner for welding and other miscellaneous welder activities was considered equal for both weld processes.

### 4.0 Results

Using 300 Series Stainless Steel (CRES) and CuNi (90/10) pipe material as defined in TABLE 1, weld parameters and techniques were developed to support successful procedure qualification testing, welder training / testing, and production implementation using a Fronius Transpulse Synergic 3200 programmable power supply and feeder.

Procedure Qualification Record data (PQR) was approved by the local SUPSHIP authority and two welders successfully completed training and performance qualification testing.

Production hydrostatic pressure testing results are documented in Enclosure 3. All joints that passed VT inspection were subjected to pressure testing. (Note: The first two CuNi joints had unacceptable rollover on pipe side of weld, were deleted from the test, and rewelded w/GTAW.) It was recognized that welder training and oversight is critical to successful implementation.

Analysis of cost savings indicated that a typical single pass socket pipe joint, in the 3" nps to 10" nps range, would show an average 86.9% decrease in weld time compared to two layer manual GTAW (i.e., time from start of arcing to finished weld.).

### 5.0 Conclusion

The following conclusions are made from the results of this project:

- a. GMAW-P pipe socket weld parameters for welding Schedule 10 CRES and Class 200 CuNi (90/10) pipe socket joints can be successfully developed to support weld procedure qualification testing per NAVSEA S9074-AQ-GIB-010/248.
- b. Using the latest welding power supply electronic technology, weld parameter programs can be recorded and uploaded to production equipment

to ensure consistent and reproducible weld settings.

- c. Based on successful welder training and testing, production socket joints can be consistently single pass Shop welded in the 2F position with the GMAW-P process and still meet the quality standard required by NAVSEA S9074-AR-GIB-010/278. Because of the nature of the materials and process, welder training and technique oversight is critical to success.
- d. There can be reasonable cost savings resulting from an 86.9% decrease in welding time when using single pass semi-automatic GMAW-Pulsed Arc process in lieu of the conventional two layer manual GTAW process.

## **6.0 Acknowledgements**

Bath Iron Works Corporation, a subsidiary of General Dynamics, conducted this research project under the National Shipbuilding Research Program (NSRP) Subcontract Agreement Number 2005-339. Advice and guidance was provided by Northrop Grumman Ship Systems (NGSS) Lee Kvidahl and Northrop Grumman Newport News Shipbuilding (NGNNS) Paul A. Hebert.

## **7.0 References**

- NAVAL SEA SYSTEMS COMMAND (NAVSEA) SHIP SYSTEMS, Technical Manual S9074-AR-GIB-010/278, Requirements for Fabrication, Welding, and Inspection for Machinery, Piping, and Pressure Vessels.
- NAVAL SEA SYSTEMS COMMAND (NAVSEA) SHIP SYSTEMS, Technical Manual S9074-AQ-GIB-010/248, Requirements for Welding and Brazing Procedure and Performance Qualification.
- NAVAL SEA SYSTEMS COMMAND (NAVSEA) SHIP SYSTEMS, Technical Manual S9074-AH-GIB-010/22, Welded Joint Design.
- ASME CODE for PRESSURE PIPING B31.1

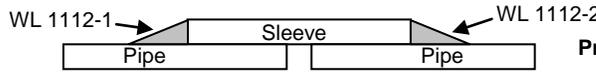
WELD PROCEDURE QUALIFICATION RECORD

**PQR#** S8.6-4      **W.L. #** 1112      **STANDARD:** S9074-AQ-GIB-010/248

**PROCESS:** GMAW-Pulsed Arc      **TYPE:** Semi-Automatic

<b>MATERIALS:</b>	<b>BASE 1</b>	<b>FILLER</b>
<b>Specification:</b>	ASTM A240	AWS A5.9
<b>Type/Class:</b>	Type 304 Pipe & Sleeve	E-308L
<b>Heat/Lot:</b>	na	na
<b>Thick/Dia:</b>	3" Sch 10, 0.120" wall	0.045" dia
<b>S.P.A.F.#:</b>	S-8	A-8B

**WELD JOINT:** **POSITION:** 2F, Horizontal Fillet  
**Joint Design:** Per S9074-AH-GIB-010/22, P-13      **WL#** 1112-1  
 Single Pass      1112-2



**Progression:** na

**Fillet Size:** T x 1-3/4T (1/8" x 7/32")

**WELD PROCEDURE**

<b>Equipment:</b>	Fronius Transpulse Synergic 3200, Program 11	<b>Power Supply:</b>	CV-Pulsed Arc
<b>Voltage:</b>	Arc Length Setting: -9; Inductance: -2	<b>Polarity:</b>	DCEP
<b>Travel Speed:</b>	6.5 ipm	<b>Heat Input:</b>	na
<b>Wire Speed:</b>	100 ipm	<b>Machine Type:</b>	Rectifier
<b># Weld Layers:</b>	1	<b>Root Travel Angle:</b>	10°-15° Push
<b>Electrode Type:</b>	E-308L <b>Diameter:</b> 0.045"	<b>Fill Travel Angle:</b>	na
<b>Tip to Work:</b>	1/2" <b>Torch Type:</b> Gas Cooled	<b>Work Angle:</b>	Approx. 45°
<b>Tip to Cup:</b>	Flush <b>Gas Cup Size:</b> #12	<b>Torch Location:</b>	15° before TDC

Note: Torch: Fronius AL Jobmaster  
 Note 2: Kept the arc moving to prevent melt-through.

**WELD BEAD:**

**Initial/Interpass Cleaning:** Initial: Sand to bright metal.

<b>Stringer:</b> yes	<b>Single pass:</b> yes	<b>Multipass:</b> na
<b>Weave:</b> yes	<b>Width:</b> 5/32	<b>Freq:</b> manual
<b>Backside Treatment:</b> na		<b>Dwell:</b> manual

A

**SHIELDING GAS:**

	<b>Gas</b>	<b>Mix</b>	<b>Flow Rate</b>
<b>Primary/Torch:</b>	ArCO2	95/5%	35 cfh
<b>Secondary/Trail:</b>			
<b>Backing/Purge:</b>			

**PREHEAT TEMP MIN.°F:** ambient      **INTERPASS TEMP MAX.° F:** na

**POSTWELD HEAT TREATMENT:** NONE

**WELDER/OPERATOR:**      **Name:** Dean Brown      **Badge:** 02007

We certify that the statements made in this record are correct and the welds were prepared, welded, and tested in accordance with the requirements of the above listed standard/specification, except as modified within this PQR.

*R.A. Marco*

**SIGNED** R. A. Marco, Welding Engineering      **DATE** 04-02-07

**WELD PROCEDURE QUALIFICATION RECORD**

<b>PQR#</b>	S8.6-4	<b>W.L. #</b>	1112	<b>STANDARD:</b>	S9074-AQ-GIB-010/248
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<b>PROCESS:</b>	GMAW-Pulsed Arc	<b>TYPE:</b>	Semi-Automatic
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**CHEMICAL ANALYSIS %:                      NONDESTRUCTIVE TESTING:**

<b>C</b>		<b>V.T.</b>	Satisfactory per MIL-STD-2035A
<b>Mn</b>			
<b>P</b>		<b>M.T.</b>	
<b>S</b>			
<b>Si</b>		<b>P.T.</b>	Satisfactory per MIL-STD-2035A
<b>Ni</b>			
<b>Cr</b>		<b>R.T.</b>	
<b>Mo</b>			
<b>Cb</b>		<b>U.T.</b>	
<b>Cu</b>			
<b>Fe</b>			
<b>Other</b>			

Note 1: Ground 1/8" long PT indication in start/stop area on WL 1112-1. Re-PT satisfactory.

**BEND TEST:**

	na	<b>Pin Dia:</b>	
<b>Type</b>	<b>Qty.</b>	<b>Result</b>	
<b>Face:</b>			
<b>Root:</b>			
<b>Side:</b>			

**TENSILE TEST:** na

WL #	Type	Ult. Ten. (psi)	Yield	% Elong (2")	R.A. %	Fracture Location

**CHARPY V-NOTCH:** na

No.	Temp°F	Ft Lbs	Lat Exp	% Shear
na				

No.	Temp°F	Ft Lbs	Lat Exp	% Shear

**OTHER:**

1. Macro-Etch specimens (4 each, 90° apart) are satisfactory per S9074-AQ-GIB-010/248, Para 4.5.2.6(b). No indications were found using 5X inspection. (Macro-Etch specimens removed from pipe test assembly per S9074-AQ-GIB-010/248, FIG. 3.)
2. Inside surface of pipe in way of socket weld was satisfactory per MIL-STD-2035A for melt-through, burn-through, and oxidation.
3. Hydrostatic pressure testing was done on pipe assembly at 745 psi for 10 minutes with no leaks. (The hydro test represents the maximum test pressure found on pipe systems for that size and material pipe, and meets or exceeds "design" pressures.)

WELD PROCEDURE QUALIFICATION RECORD

PQR# S8.6-4 W.L. # 1113 STANDARD: S9074-AQ-GIB-010/248

PROCESS: GMAW-Pulsed Arc TYPE: Semi-Automatic

<b>MATERIALS:</b>	<b>BASE 1</b>	<b>FILLER</b>
Specification:	ASTM A240	AWS A5.9
Type/Class:	Type 304 Pipe & Sleeve	E-308L
Heat/Lot:	na	na
Thick/Dia:	8" dia, Sch 10, 0.148" wall	0.045" dia
S.P.A.F.#:	S-8	A-8B

WELD JOINT: POSITION: 2F, Horizontal Fillet  
 Joint Design: Per S9074-AH-GIB-010/22, P-13 WL# 1113-1  
 Single Pass 1113-2



Progression: na

Fillet Size: T x 1-3/4T (5/32" x 9/32")

WELD PROCEDURE

Equipment:	Fronius Transpulse Synergic 3200, Program #10	Power Supply:	CV-Pulsed Arc
Voltage:	Arc Length Setting: -8; Inductance: -2	Polarity:	DCEP
Travel Speed:	7 ipm	Heat Input:	na
Wire Speed:	160 ipm	Machine Type:	Rectifier
# Weld Layers:	1	Root Travel Angle:	10°-15° Push
Electrode Type:	E-308L	Diameter:	0.045"
Tip to Work:	1/2"	Torch Type:	Gas Cooled
Tip to Cup:	Flush	Gas Cup Size:	#12
		Fill Travel Angle:	na
		Work Angle:	Approx. 45°
		Torch Location:	15° before TDC

Note: Torch: Fronius AL Jobmaster

Note 2: Kept the arc moving to prevent melt-through.

WELD BEAD:

Initial/Interpass Cleaning: Initial: Sand to bright metal.

Stringer:	na	Single pass:	yes	Multipass:	na
Weave:	yes	Width:	3/16"	Freq:	manual
Backside Treatment:	na	Dwell:	manual		

SHIELDING GAS:

	<b>Gas</b>	<b>Mix</b>	<b>Flow Rate</b>
Primary/Torch:	ArCO2	95/5%	35 cfh
Secondary/Trail:			
Backing/Purge:			

PREHEAT TEMP MIN.°F: ambient INTERPASS TEMP MAX.° F: na

POSTWELD HEAT TREATMENT: NONE

WELDER/OPERATOR: Name: Dean Brown Badge: 02007

We certify that the statements made in this record are correct and the welds were prepared, welded, and tested in accordance with the requirements of the above listed standard/specification, except as modified within this PQR.

SIGNED R. A. Marco, Welding Engineering

DATE 04-02-07

WELD PROCEDURE QUALIFICATION RECORD

<b>PQR#</b>	S8.6-4	<b>W.L. #</b>	1113	<b>STANDARD:</b>	S9074-AQ-GIB-010/248
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<b>PROCESS:</b>	GMAW-Pulsed Arc	<b>TYPE:</b>	Semi-Automatic
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CHEMICAL ANALYSIS %:                      NONDESTRUCTIVE TESTING:

<b>C</b>		<b>V.T.</b>	Satisfactory per MIL-STD-2035A
<b>Mn</b>			
<b>P</b>		<b>M.T.</b>	
<b>S</b>			
<b>Si</b>		<b>P.T.</b>	Satisfactory per MIL-STD-2035A
<b>Ni</b>			
<b>Cr</b>		<b>R.T.</b>	
<b>Mo</b>			
<b>Cb</b>		<b>U.T.</b>	
<b>Cu</b>			
<b>Fe</b>			
<b>Other</b>			

BEND TEST:

	na	<b>Pin Dia:</b>	
<b>Type</b>	<b>Qty.</b>	<b>Result</b>	
<b>Face:</b>			
<b>Root:</b>			
<b>Side:</b>			

TENSILE TEST: na

WL #	Type	Ult. Ten. (psi)	Yield	% Elong (2")	R.A. %	Fracture Location

CHARPY V-NOTCH: na

No.	Temp°F	Ft Lbs	Lat Exp	% Shear
na				

No.	Temp°F	Ft Lbs	Lat Exp	% Shear

OTHER:

1. Macro-Etch specimens (4 each, 90° apart) are satisfactory per S9074-AQ-GIB-010/248, Para 4.5.2.6(b). No indications were found using 5X inspection. (Macro-Etch specimens removed from pipe test assembly per S9074-AQ-GIB-010/248, FIG. 3.)
2. Inside surface of pipe in way of socket weld was satisfactory per MIL-STD-2035A for melt-through, burn-through, and oxidation.
3. Hydrostatic pressure testing was done on pipe assembly at 425 psi for 10 minutes with no leaks. (The hydro test represents the maximum test pressure found on pipe systems for that size and material pipe, and meets or exceeds "design" pressures.)

WELD PROCEDURE QUALIFICATION RECORD

**PQR#** S34.6-3      **W.L. #** 1114      **STANDARD:** S9074-AQ-GIB-010/248

**PROCESS:** GMAW-Pulsed Arc      **TYPE:** Semi-Automatic

<b>MATERIALS:</b>	<b>BASE 1</b>	<b>FILLER</b>
<b>Specification:</b>	MIL-T-16420	MIL-E-21562E
<b>Type/Class:</b>	CuNi 90/10 Pipe w/CuNi 70/30 Sleeve	MIL-EN67
<b>Heat/Lot:</b>	na	na
<b>Thick/Dia:</b>	4" nps, Class 200, 0.109" wall	0.045"
<b>S.P.A.F.#:</b>	S-34	A-34B

**WELD JOINT:** **POSITION:** 2F, Horizontal Fillet  
**Joint Design:** Per S9074-AH-GIB-010/22, P-13      **WL#** 1114-1  
 Single Pass      1114-2



**Progression:** na

**Fillet Size:** T x 1-3/4T (1/8" x 3/16")

**WELD PROCEDURE**

<b>Equipment:</b>	Fronius Transpulse Synergic 3200, Program #8	<b>Power Supply:</b>	CV-Pulsed Arc
<b>Voltage:</b>	Arc Length Setting: 0; Inductance: -4	<b>Polarity:</b>	DCEP
<b>Travel Speed:</b>	7.3 ipm	<b>Heat Input:</b>	na
<b>Wire Speed:</b>	120 ipm	<b>Machine Type:</b>	Rectifier
<b># Weld Layers:</b>	1	<b>Root Travel Angle:</b>	10°-15° Push
<b>Electrode Type:</b>	EN67	<b>Diameter:</b>	0.045"
<b>Tip to Work:</b>	1/2"	<b>Torch Type:</b>	Gas Cooled
<b>Tip to Cup:</b>	Flush	<b>Gas Cup Size:</b>	#12
		<b>Fill Travel Angle:</b>	na
		<b>Work Angle:</b>	Approx. 45°
		<b>Torch Location:</b>	15° before TDC

Note: Torch: Fronius AL Jobmaster

**WELD BEAD:**

**Initial/Interpass Cleaning:** Initial: Sand to bright metal.

<b>Stringer:</b> na	<b>Single pass:</b> yes	<b>Multipass:</b> na
<b>Weave:</b> yes	<b>Width:</b> 1/8"	<b>Freq:</b> manual
<b>Backside Treatment:</b> na		<b>Dwell:</b> manual

Note: Weave back and forth only. Do not go back into puddle.

**SHIELDING GAS:**

	<b>Gas</b>	<b>% Mix</b>	<b>Flow Rate</b>
<b>Primary/Torch:</b>	HeAr	75/25	35 cfh
<b>Secondary/Trail:</b>			
<b>Backing/Purge:</b>			

**PREHEAT TEMP MIN.°F:** 60F      **INTERPASS TEMP MAX.° F:** na

**POSTWELD HEAT TREATMENT:** NONE

**WELDER/OPERATOR:** **Name:** Dean Brown      **Badge:** 02007

We certify that the statements made in this record are correct and the welds were prepared, welded, and tested in accordance with the requirements of the above listed standard/specification, except as modified within this PQR.

*R.A. Marco*

**SIGNED** R. A. Marco, Welding Engineering      **DATE** 04-02-07

**WELD PROCEDURE QUALIFICATION RECORD**

<b>PQR#</b>	S34.6-3	<b>W.L. #</b>	1114	<b>STANDARD:</b>	S9074-AQ-GIB-010/248
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<b>PROCESS:</b>	GMAW-Pulsed Arc	<b>TYPE:</b>	Semi-Automatic
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**CHEMICAL ANALYSIS %:**                      **NONDESTRUCTIVE TESTING:**

<b>C</b>		<b>V.T.</b>	Satisfactory per MIL-STD-2035A
<b>Mn</b>			
<b>P</b>		<b>M.T.</b>	
<b>S</b>			
<b>Si</b>		<b>P.T.</b>	Satisfactory per MIL-STD-2035A
<b>Ni</b>			
<b>Cr</b>		<b>R.T.</b>	
<b>Mo</b>			
<b>Cb</b>		<b>U.T.</b>	
<b>Cu</b>			
<b>Fe</b>			
<b>Other</b>			

**BEND TEST:**

	na	<b>Pin Dia:</b>	
<b>Type</b>	<b>Qty.</b>	<b>Result</b>	
<b>Face:</b>			
<b>Root:</b>			
<b>Side:</b>			

**TENSILE TEST:** na

WL #	Type	Ult. Ten. (psi)	Yield	% Elong (2")	R.A. %	Fracture Location

**CHARPY V-NOTCH:** na

No.	Temp°F	Ft Lbs	Lat Exp	% Shear

No.	Temp°F	Ft Lbs	Lat Exp	% Shear

- OTHER:**
1. Macro-Etch specimens (4 each, 90° apart) are satisfactory per S9074-AQ-GIB-010/248, Para 4.5.2.6(b). No indications were found using 5X inspection. (Macro-Etch specimens removed from pipe test assembly per S9074-AQ-GIB-010/248, FIG. 3.)
  2. Inside surface of pipe in way of socket weld was satisfactory per MIL-STD-2035A for melt-through, burn-through, and oxidation.
  3. Hydrostatic pressure testing was done on pipe assembly at 350 psi for 10 minutes with no leaks. (The hydro test represents the maximum test pressure found on pipe systems for that size and material pipe, and meets or exceeds "design" pressures.)

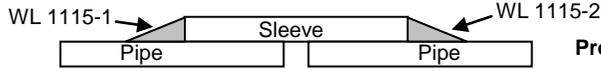
WELD PROCEDURE QUALIFICATION RECORD

**PQR#** S34.6-3      **W.L. #** 1115      **STANDARD:** S9074-AQ-GIB-010/248

**PROCESS:** GMAW-Pulsed Arc      **TYPE:** Semi-Automatic

<b>MATERIALS:</b>	<b>BASE 1</b>	<b>FILLER</b>
<b>Specification:</b>	MIL-T-16420	MIL-E-21562E
<b>Type/Class:</b>	CuNi 90/10 Pipe w/CuNi 70/30 Sleeve	MIL-EN67
<b>Heat/Lot:</b>	na	na
<b>Thick/Dia:</b>	8" nps, Class 200, 0.151" wall	0.045"
<b>S.P.A.F.#:</b>	S-34	A-34B

**WELD JOINT:** **POSITION:** 2F, Horizontal Fillet  
**Joint Design:** Per S9074-AH-GIB-010/22, P-13      **WL#** 1115-1  
 Single Pass      1115-2



**Progression:** na

**Fillet Size:** T x 1-3/4T (5/32" x 9/32")

**WELD PROCEDURE**

<b>Equipment:</b>	Fronius Transpulse Synergic 3200, Program #9	<b>Power Supply:</b>	CV-Pulsed Arc
<b>Voltage:</b>	Arc Length Setting: -3; Inductance: -4	<b>Polarity:</b>	DCEP
<b>Travel Speed:</b>	10.5 ipm	<b>Heat Input:</b>	na
<b>Wire Speed:</b>	180 ipm	<b>Machine Type:</b>	Rectifier
<b># Weld Layers:</b>	1	<b>Root Travel Angle:</b>	10°-15° Push
<b>Electrode Type:</b>	EN67	<b>Diameter:</b>	0.045"
<b>Tip to Work:</b>	1/2"	<b>Torch Type:</b>	Gas Cooled
<b>Tip to Cup:</b>	Flush	<b>Gas Cup Size:</b>	#12
		<b>Fill Travel Angle:</b>	na
		<b>Work Angle:</b>	Approx. 45°
		<b>Torch Location:</b>	15° before TDC

Note: Torch: Fronius AL Jobmaster

**WELD BEAD:**

**Initial/Interpass Cleaning:** Initial: Sand to bright metal.

<b>Stringer:</b> na	<b>Single pass:</b> yes	<b>Multipass:</b> na
<b>Weave:</b> yes	<b>Width:</b> 3/16"	<b>Freq:</b> manual
<b>Backside Treatment:</b> na		<b>Dwell:</b> manual

Note: Weave back and forth only. Do not go back into puddle.

**SHIELDING GAS:**

	<b>Gas</b>	<b>% Mix</b>	<b>Flow Rate</b>
<b>Primary/Torch:</b>	HeAr	75/25	35 cfh
<b>Secondary/Trail:</b>			
<b>Backing/Purge:</b>			

**PREHEAT TEMP MIN.°F:** 60F      **INTERPASS TEMP MAX.° F:** na

**POSTWELD HEAT TREATMENT:** NONE

**WELDER/OPERATOR:** **Name:** Dean Brown      **Badge:** 02007

We certify that the statements made in this record are correct and the welds were prepared, welded, and tested in accordance with the requirements of the above listed standard/specification, except as modified within this PQR.

*R.A. Marco*

**SIGNED** R. A. Marco, Welding Engineering      **DATE** 04-02-07

**WELD PROCEDURE QUALIFICATION RECORD**

<b>PQR#</b>	S34.6-3	<b>W.L. #</b>	1115	<b>STANDARD:</b>	S9074-AQ-GIB-010/248
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<b>PROCESS:</b>	GMAW-Pulsed Arc	<b>TYPE:</b>	Semi-Automatic
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**CHEMICAL ANALYSIS %:**                      **NONDESTRUCTIVE TESTING:**

<b>C</b>		<b>V.T.</b>	Satisfactory per MIL-STD-2035A
<b>Mn</b>			
<b>P</b>		<b>M.T.</b>	
<b>S</b>			
<b>Si</b>		<b>P.T.</b>	Satisfactory per MIL-STD-2035A
<b>Ni</b>			
<b>Cr</b>		<b>R.T.</b>	
<b>Mo</b>			
<b>Cb</b>		<b>U.T.</b>	
<b>Cu</b>			
<b>Fe</b>			
<b>Other</b>			

Note 1: Ground 1/8" diameter indication at start/stop location on joints 1115-1 and 1115-2.  
Re-PT satisfactory.

**BEND TEST: na**

	na	<b>Pin Dia:</b>	
<b>Type</b>	<b>Qty.</b>	<b>Result</b>	
<b>Face:</b>			
<b>Root:</b>			
<b>Side:</b>			

**TENSILE TEST: na**

WL #	Type	Ult. Ten. (psi)	Yield	% Elong (2")	R.A. %	Fracture Location

**CHARPY V-NOTCH: na**

No.	Temp°F	Ft Lbs	Lat Exp	% Shear
na				

No.	Temp°F	Ft Lbs	Lat Exp	% Shear

**OTHER:**

1. Macro-Etch specimens (4 each, 90° apart) are satisfactory per S9074-AQ-GIB-010/248, Para 4.5.2.6(b). No indications were found using 5X inspection. (Macro-Etch specimens removed from pipe test assembly per S9074-AQ-GIB-010/248, FIG. 3.)
2. Inside surface of pipe in way of socket weld was satisfactory per MIL-STD-2035A for melt-through, burn-through, and oxidation.
3. Hydrostatic pressure testing was done on pipe assembly at 262 psi for 10 minutes with no leaks. (The hydro test represents the maximum test pressure found on pipe systems for that size and material pipe, and meets or exceeds "design" pressures.)

**Welder training information for production implementation of NSRP SP-7 project:  
Single Pass Pipe Socket Welds using the Semi-Automatic GMAW-Pulsed Arc  
Process.**

ATTACHMENTS: (1a) Welder Performance Qualification WPQ 34B.2-2F-P (Pipe)  
(1b) Welder Performance Qualification WPQ 8B.2-2F-P (Pipe)  
(1c) Variation in weld penetration pattern with 300 Series Austenitic Stainless Steels

SCOPE: The following information provides welder training guidelines for single pass welding of CRES and CuNi, thin walled pipe sockets, using the GMAW-Pulsed Arc process with rolled pipe in the horizontal fillet position.

Weld parameters, techniques, and training practices presented here are based on specific testing under an NSRP SP-7 project and are not intended to be all inclusive.

Implementation for Navy application is governed by ABS NVR 8-3-3 (modified NAVSEA S9074-AR-GIB-010/278) with welder performance qualification per ABS NVR 8-3-4 (modified NAVSEA S9074-AQ-GIB-010/248.)

Each manufacturer choosing to use this process may adjust the information presented herein to suit their individual needs within the limits of weld procedure qualification and the contractual fabrication document.

WELDER PREREQUISITE:

Welders should have a working knowledge of, and experience with, the semi-automatic GMAW-Pulsed Arc process on plate or pipe prior to training on single pass thin walled pipe socket applications.

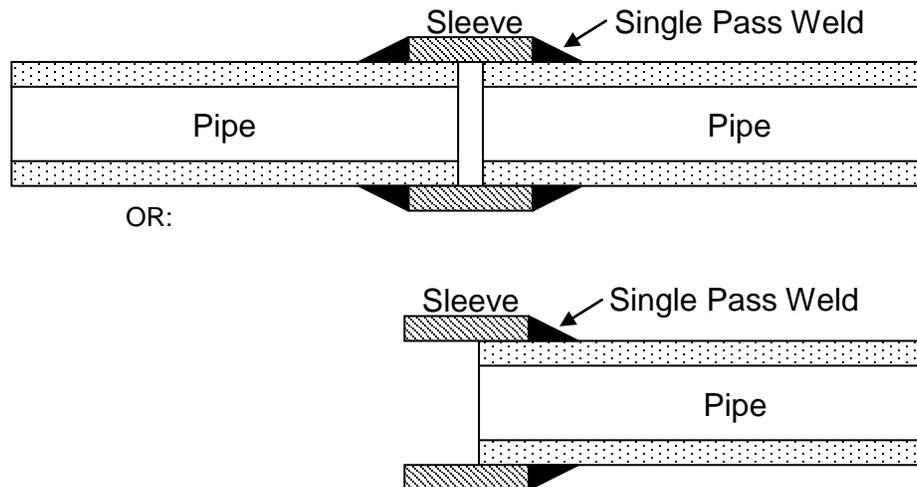
NAVY WELDER QUALIFICATION STANDARD:

NAVSEA S9074-AQ-GIB-010/248 directs pipe welder qualification requirements. The following referenced paragraphs are specific to this project only and are not intended to be all inclusive for general welder qualification.

- a. Paragraph 5.3.5.1: requires a mock-up assembly of a socket weld with nominal pipe wall less than 3/16"; testing per paragraph 4.4.7.  
- See paragraph 5.3.5.1(d) for pipe diameter
- b. Paragraph 4.4.7.5: requires VT, PT, and four (4) Macro-Etch specimens located 90° apart.
- c. Paragraphs 4.5.1 & 4.5.2: provide evaluation criteria for NDT and Macro-Etch specimens.
- d. Paragraph 4.5.2.6(b), last sentence: provides VT acceptance criteria for the pipe internal surface in way of the socket weld.
- e. Paragraphs 5.2.8 & 5.2.9: provide guidelines for repair of test assembly and retest, when necessary. (Note that "cracks" are a VT attribute.)
- f. Paragraph 5.5.1: provides direction for Welder qualification test records.

WELDER TEST MOCK-UP ASSEMBLY:

- a. Mock-up assembly should consist of one (1), or two (2), pipe piece(s), with pipe wall less than 3/16", socket welded to a pipe sleeve or coupling similar to sketch.

WELDER TEST MOCK-UP ASSEMBLY (cont.):

- b. Position: 2FR, horizontal fillet on rolled pipe
- c. Diameter: smallest diameter pipe for each material to be welded in production applications.
- See applicability of NAVSEA S9074-AQ-GIB-010/248 Paragraph 5.3.5.1(d) for pipe diameter
- d. Single pass weld size shall be sized at  $T \times 1-3/4T$ , where  $T$  = pipe wall thickness. (Reference NAVSEA S9074-AR-GIB-010/278)

WELDER PERFORMANCE QUALIFICATION (WPQ)  
WITH WELD PARAMETERS & TECHNIQUES:

- a. Weld equipment: FRONIUS Transpulse Synergic Model 3200 with a "semi-automatic" torch.
- b. Attachments (1a) & (1b), Welder Performance Qualification parameter sheets, contain applicable weld parameters and techniques associated with each test pipe material, diameter, and wall thickness used to qualify Welders for this SP-7 project. Application on heavier walled pipe requires parameter adjustments to suit.
- c. Visual Inspection (VT) of the internal pipe surface in way of the socket weld is specified in ABS NVR 8-3-3 (modified NAVSEA S9074-AR-GIB-010/278) as follows:
- *In Table IX, insert "19" in the "VT" column. Add a new note 19 to read as follows: "19 VT of the inside root surface of full penetration joint designs and socket type joints with wall thicknesses less than 3/16 inch shall be accomplished at the time of maximum accessibility (e.g. before subsequent welded sections render the surface inaccessible). This inspection is only required if location can permit inspection by the use of mirrors or other ready means. Use of borescopes is not required."*
  - VT inspection criteria of the internal surface for melt-through and oxidation are found in MIL-STD-2035A, Paragraphs 4.2.7 & 4.2.9.
  - See Attachment (1c) for a brief discussion and illustration of the variability of pipe wall melt-through associated with welding 300 Series Austenitic Stainless (CRES) materials.

# WELDER PERFORMANCE QUALIFICATION – WPQ Enclosure 2, Attachment (1a)

**PROCESS:** Gas Metal Arc Welding Semi-automatic  
(Pulsed Spray)

**WPQ #** 34B.02-2F-P (Pipe)  
**REV:** A **DATE:** 04-26-07  
**STANDARD:** S9074-AQ-GIB-010/248

**BASE MATERIAL:** (CuNi, 90/10 or 70/30)

**"S" #** 34 **to**  
**TYPE:** 90/10 **to**  
**THICK:** 0.109" **to**  
**THK QUAL:** 0.109" **to** unlimited  
**PIPE DIA:** 4" nps, Class 200

**JOINT DESIGN:** GROOVE FILLET yes  
Weld Size: T x 1-3/4T.

Pipe fitting may be any socket or sleeve of nominal thickness. (See illustration of mock-up assembly on Page 02.)

**FILLER MATERIAL:**

**A #:** 34B  
**SPEC:** MIL-E-21562E  
**TYPE:** MIL-EN67  
**SIZE:** 0.045" dia.  
**FLUX:** None  
**SUPPLEMENTAL FILLER:** None

**TYPE OF GROOVE:** SINGLE DOUBLE  
SQUARE BEVEL V U  
CONSUMABLE INSERT

**BACKING COMPOSITION:** na  
**METALLIC:** NONMETALLIC:  
**FUSING:** NONFUSING:

**SHIELDING GAS:**

**COMPOSITION:** He/Ar (75/25)  
**FLOW RATE:** 35-50 cfh  
**TORCH TYPE:** Gas Cooled  
**CUP SIZE:** 10 - 12  
**GAS LENS:** none **TRAIL:** none  
**PURGE:** none

**POSITION:** 2F (Rotated Pipe)  
**PROGRESSION:**  
**ACCESSIBILITY:** Un-Restricted

**TECHNIQUE:**  
(See Page 02)

**ELECTRICAL CHARACTERISTICS:**

**CURRENT:** DCEP / CV  
**HEAT INPUT:** (Note 1)  
**ARC MODE:** Pulsed Spray  
**VOLTAGE:** (See page 02)  
**AMPERAGE:** (See page 02)  
**POWER SUPPLY:** Fronius Transpulse Synergic  
Model 3200

**INITIAL & INTERPASS CLEANING:**  
Wire brush, alcohol wipe

**TESTING REQUIREMENTS:** (Note 2)  
VT (External and Internal surfaces)  
PT (External Surface only)  
Macro-Etch (4 each @ 90° apart)

**HEAT TREATMENT:**

**PREHEAT:** Ambient (60°F)  
**INTERPASS:** 350F  
**STRESS RELIEF:** None

**NDT ACCEPTANCE CRITERIA:**  
MIL-STD-2035A

**MACRO-ETCH ACCEPTANCE CRITERIA:**  
S9074-AQ-GIB-010/248, Para 4.5.2.6(b)  
at 5X magnification

**NOTES:**

1. Weld parameters & techniques shall ensure no pipe wall melt-through in way of fillet.
2. Internal pipe surface in way of fillet weld shall be VT inspected for oxidized melt-through ("sugar") which is considered a rejectable condition per MIL-STD-2035A, Paragraphs 4.2.7 & 4.2.9.

**CAUTION: THIS WPQ IS FOR WELDER PERFORMANCE QUALIFICATION ONLY AND IS NOT INTENDED FOR PRODUCTION WELDING**

# WELDER PERFORMANCE QUALIFICATION – WPQ Enclosure 2, Attachment (1a)

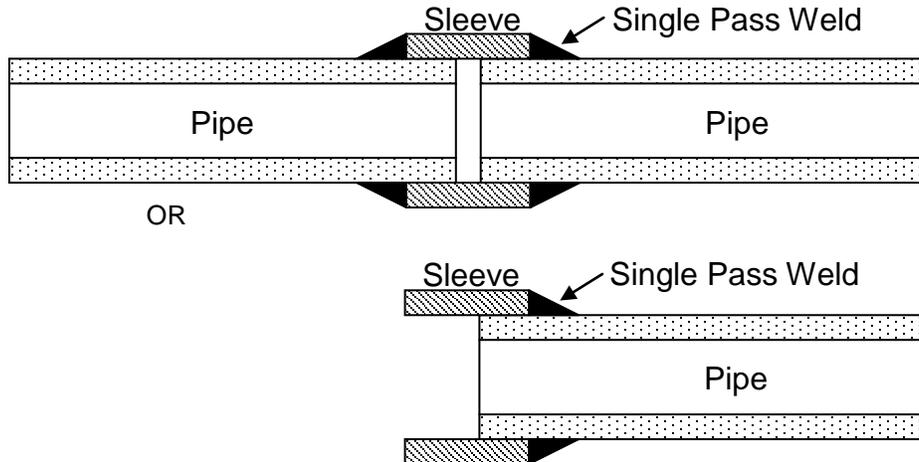
WPQ # 34B.02-2F-P (Pipe)

REV: A DATE: 04-26-07

STANDARD: S9074-AQ-GIB-010/248

## WELDER TEST MOCK-UP ASSEMBLY:

- a. Mock-up assembly shall consist of one (1), or two (2), pipe piece(s), with pipe wall less than 3/16", socket welded to a pipe sleeve or coupling similar to sketch.



## Electrical Parameters: (Notes 1, 2)

Pipe Dia	Pipe Wall Class 200	Program #	Arc Length (setting)	Inductance (setting)	Wire Feed Speed (ipm)	Travel Speed (ipm)	Weave Width
4" nps	0.109"	8	0	-4	120	7.3	1/8"

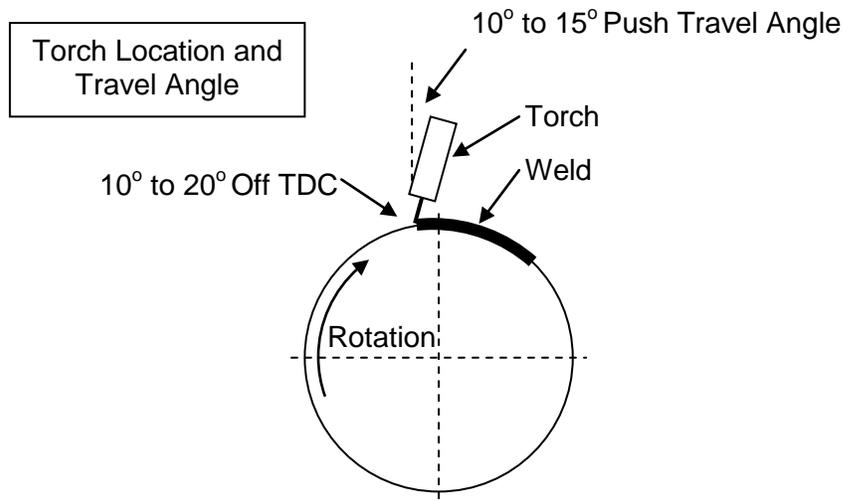
Note 1: Adjust Wire Feed Speed to suit varying wall thickness and to eliminate pipe wall melt-through.

Note 2: Keep the arc weaving (oscillating) to prevent melt-through of thin wall pipe. Dwell is allowed on fitting edge, but not on pipe surface. Weave shall be straight back and forth transverse to travel direction. Do not use circular weave that washes back onto the bead; this will cause rollover on the pipe side of weld bead.

Note 3: Contact Tip to Cup: Flush

## Technique

Travel Angle	Work Angle	Torch Location
10° to 15° Push	Approx. 45°	10° to 20° before TDC

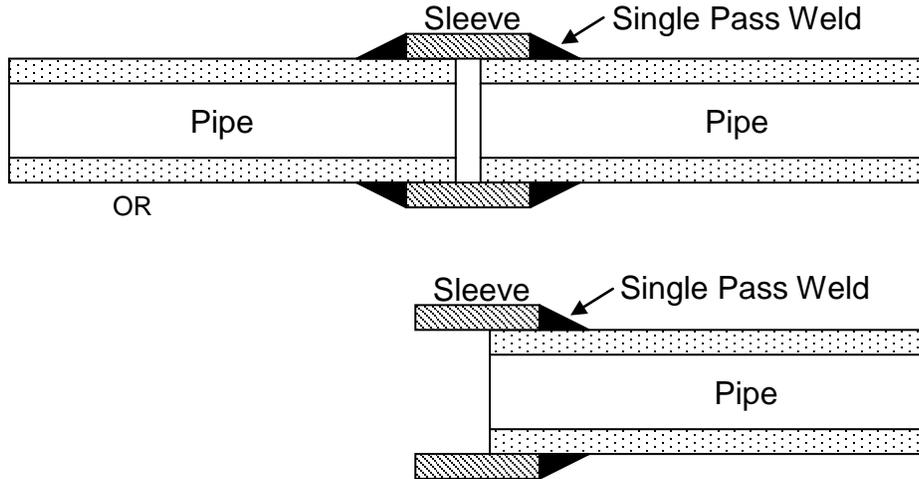




**WPQ #** 8B.02-2F-P (Pipe)  
**REV:** A **DATE:** 04-26-07  
**STANDARD:** S9074-AQ-GIB-010/248

**WELDER TEST MOCK-UP ASSEMBLY:**

- a. Mock-up assembly shall consist of one (1) pipe piece, with pipe wall less than 3/16", socket welded to a pipe sleeve or coupling similar to sketch.



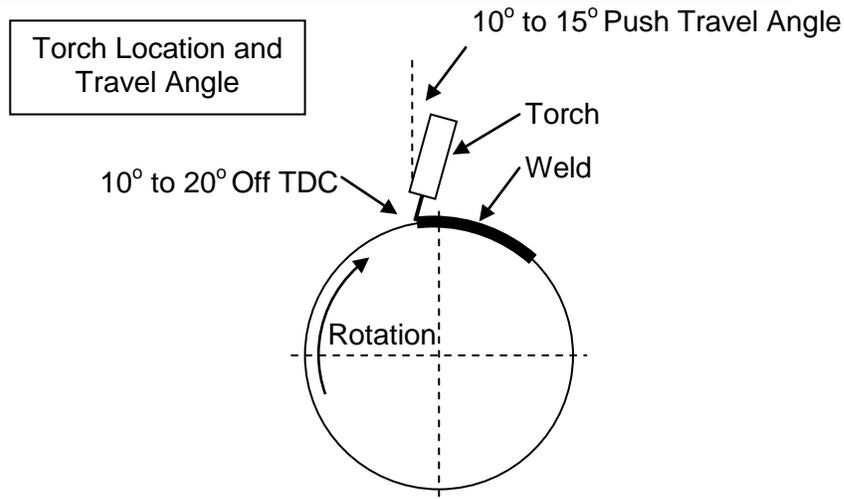
**Electrical Parameters:** (Notes 1, 2)

Pipe Dia	Pipe Wall Sch 10	Program #	Arc Length (setting)	Inductance (setting)	Wire Feed Speed (ipm)	Travel Speed (ipm)	Weave Width
3" nps	0.120"	11	-9	-2	100	6.5	None

- Note 1: Adjust Wire Feed Speed to suit varying wall thickness and to eliminate pipe wall melt-through. Austenitic Stainless Steel (CRES) is particularly variable regarding weld penetration pattern and may require weld parameter adjustment to suit.
- Note 2: Production implementation on larger diameter pipe will require a larger weld size. In those cases, keep the arc weaving (oscillating) to prevent melt-through of thin wall pipe. Dwell is allowed on fitting edge, but not on pipe surface. Weave shall be straight back and forth transverse to travel direction. Do not use circular weave that washes back onto the bead; this will cause rollover on the pipe side of weld bead.
- Note 3: Contact Tip to Cup: Flush

**Technique**

Travel Angle	Work Angle	Torch Location
10° to 15° Push	Approx. 45°	10° to 20° before TDC

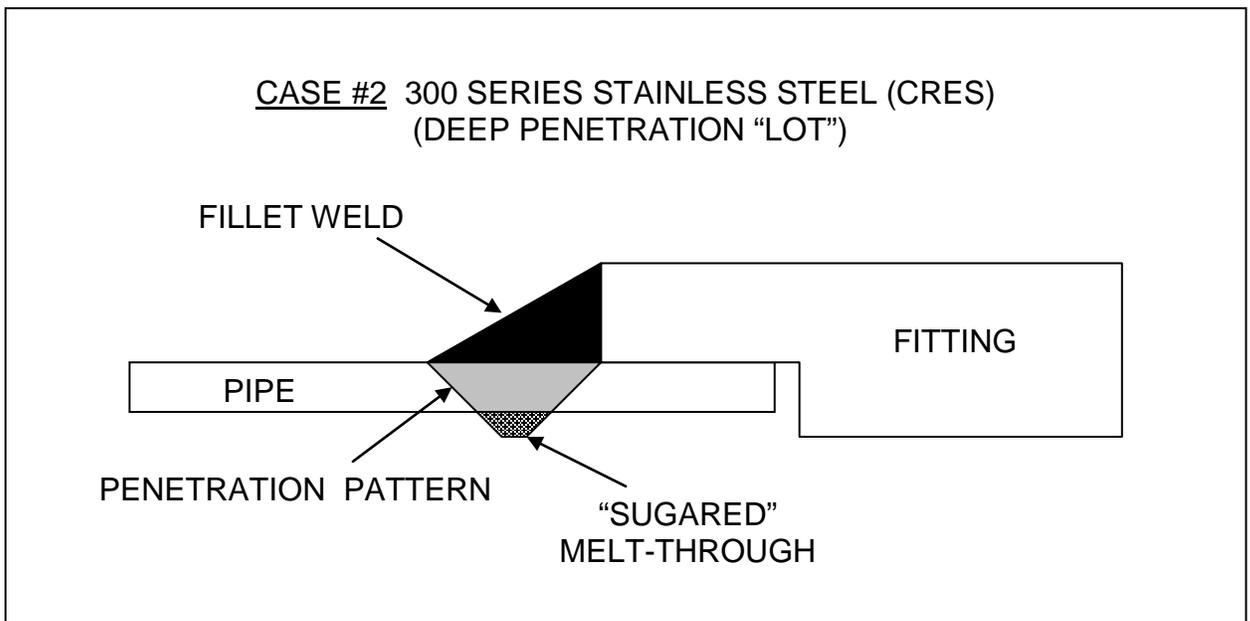
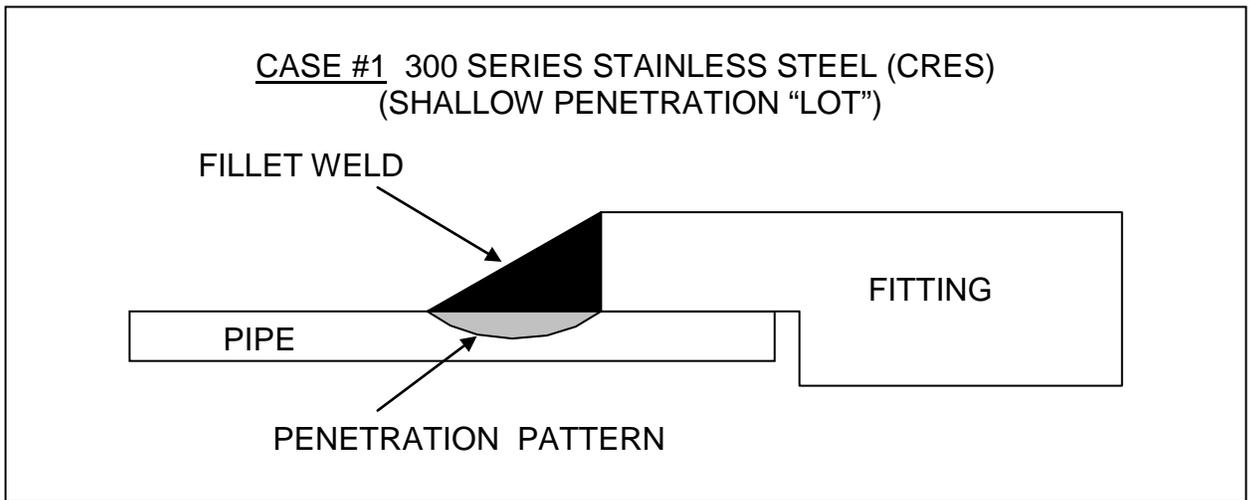


SUBJ: Variation in weld penetration pattern with 300 Series Austenitic Stainless Steels (CRES)

The following cases illustrate the difference in penetration pattern possible with small variations in trace elements ("Lot" specific) as allowed by material specs for 300 Series Austenitic Stainless Steels.

This variability is well recognized by the welding community and has been the subject of many technical papers. There is no way for the Welder to predict this variability and is a factor in melt-through of thin wall socket welded pipe joints.

Welder should inspect the pipe internal surface, if accessible, and adjust weld parameters as necessary for subsequent welds on that specific "Lot" of pipe, if "Lot" traceability is possible.



## Production Implementation Pressure Test Data:

Pipe Pc	# of Joints	Matl.	Pipe Dia.	Sch/ Class	Welder	System Test Pressure	Actual Test Pressure	Comments
CWA/04EC559A	2	CuNi 90/10	6"	200	A	202	202	SAT.
FDT/30EB516D	3	CRES 304L	6" 8"	10	P	270	270	Leak on 8" Flange to Pipe and 8" Reducer to Pipe. Weld repaired with GTAW; re-pressure tested SAT. 6" joint SAT.
LUD/04FB967D	2	CRES 304L	6"	10	P	162	30	SAT. Pipe pc ends would only accommodate low pressure plugs.
LUD/22FB940C	2	CRES 304L	4" 6"	10	P	162	162	SAT.
FMG/06DE48BK	3	CuNi 90/10	6"	200	A	245	30	SAT. Pipe pc ends would only accommodate low pressure plugs.
SWC/31GB259H	4	CuNi 70/30	5" 6"	200	P	88	40	SAT. Pipe pc ends would only accommodate low pressure plugs.
LUD/81HB624F	3	CRES 304L	6"	10	P	162	165	SAT.
FDT/31FB229C	1	CRES 304L	6"	10	P	270	30	SAT. Pipe pc ends would only accommodate low pressure plugs.
LUD/75FB950B	3	CRES 304L	6"	10	P	162	40	SAT. Pipe pc ends would only accommodate low pressure plugs.
LUD/81HB702G	1	CRES 304L	6"	10	P	162	30	SAT. Pipe pc ends would only accommodate low pressure plugs.
CWS/31GB257H	2	CuNi 70/30	5"	200	P	88	Static	SAT. Pipe pc ends would not accommodate any plugs.
FMD/27JD085B	1	CuNi 90/10	6"	200	A	243	30	SAT. Pipe pc ends would only accommodate low pressure plugs.
SWC/06EB484G	4	CuNi 70/30	4"	200	A	88	88	SAT.
FDT/23HB180G	6	CRES 304L	3"	10	A	75	65	SAT. Pipe pc ends would only accommodate low pressure plugs.
WDD/80LD397C	2	CuNi 90/10	4"	200	A	Static	Static	SAT.
WDD/80LD394A	2	CuNi 90/10	4"	200	A	Static	Static	SAT.
SWC/31GB263J	1	CuNi 70/30	8"	200	A	88	PT	SAT. PT was done in lieu of pressure test. Pipe pc ends would not accommodate plugs.