



National Aeronautics and
Space Administration
John C. Stennis Space Center
Stennis Space Center, MS 39529-6000

SSTD-8070-0125-WELD
Rev. C
MARCH 2020

John C. Stennis Space Center Standard PROCEDURE FOR WELDING COPPER TUBE

Approved in DDMS by:

<u>C. Brennan Sanders</u> NASA SSC Center Operations Facilities Engineering Test Complex Support	<u>3-17-2020</u> Date
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<u>Todd Mannion</u> NASA SSC Center Operations Directorate Facilities Services	<u>3-13-2020</u> Date
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<u>Bartt J. Hebert</u> NASA SSC Engineering & Test Directorate	<u>3-12-2020</u> Date
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<u>Son Le</u> NASA SSC Safety & Mission Assurance	<u>3-19-2020</u> Date
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Issued by

<u>ISSUED CEF</u> Central Engineering Files	<u>3-19-2020</u> Date
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	Review Date: March 9, 2025	
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Responsible Office: NASA SSC Center Operations Facilities Engineering Test Complex Support		
SUBJECT: Procedure for Welding Copper Tube		

Document History Log

Revision	Date	Originator / Phone	Description
Basic	2/25/05	Doug Dike 8-2803	Initial Release.
A	2/09/10	Doug Dike 8-2803	Updated references. Corrected typographical and grammatical errors. Administrative changes only, no changes to technical meaning or content.
B	2/12/15	Doug Dike 8-2803	Five-year review. Updated references and acronyms. Administrative changes required. NASA SSC Project Management Division and Safety and Mission Assurance added as Concurrence Organizations. In 1.0 Purpose and 2.0 Applicability, replaced “seamless copper tube P No. 31” with “P No. 31 copper tube, pipe, fittings, plate, bar, rod, shapes, and forgings (UNS Numbers C10200, C10400, C10500, C10700, C11000, C12000, C12200, C14200, and C19200)”. Redefined 5.2 Base Material to indicate, “The base material shall be copper tube, pipe, fittings, plate, bar, rod, shapes, or forgings with UNS Numbers C10200, C10400, C10500, C10700, C11000, C12000, C12200, C14200, or C19200 (designated as a P No. 31 material in ASME Boiler and Pressure Vessel Code, Section IX) conforming to any of the applicable material specifications in Section 3.0.” Updated 5.5 Position to note, “This procedure allows for welding in any position provided that each individual welder is qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, for the weld position he or she is using to produce welds under this procedure.”
C	3/9/2020	Doug Dike 8-2803	Five-year revision. Updated directorate titles on cover sheet as necessary. Updated references and acronyms. Minor administrative changes. 5.1-b: Revised to specify WPS alternate approval requirements. 5.4: Added “≥” to 99.9% argon shielding gas. 5.8: Specified joint design as indicated. 5.13: Deleted. Updated WPS to SSC-937.

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1.0 PURPOSE

This John C. Stennis Space Center (SSC) standard (SSTD) specifies the procedure for Gas Tungsten Arc Welding (GTAW) of ASME P-No. 31 copper tube, pipe, fittings, plate, bar, rod, shapes, and forgings (UNS Numbers C10200, C10400, C10500, C10700, C11000, C12000, C12200, C14200, and C19200) at SSC.

2.0 APPLICABILITY

This SSTD applies to contractor and subcontractor personnel involved in the GTAW welding of ASME P-No. 31 copper tube, pipe, fittings, plate, bar, rod, shapes, and forgings (UNS Numbers C10200, C10400, C10500, C10700, C11000, C12000, C12200, C14200, and C19200).

3.0 REFERENCED DOCUMENTS

Referenced documents shall be the latest edition unless otherwise specified.

ASME Boiler and Pressure Vessel Code, Section II, Materials, Part B, *Nonferrous Material Specifications*

ASME Boiler and Pressure Vessel Code: Section IX, *Welding, Brazing and Fusing Qualifications*

ANSI/AWS A5.7M, *Specification for Copper and Copper-Alloy Bare Welding Rods and Electrodes*

ASTM B5, *Standard Specification for High Conductivity Tough-Pitch Copper Refinery Shapes*

ASTM B42, *Standard Specification for Seamless Copper Pipe, Standard Sizes*

ASTM B68, *Standard Specification for Seamless Copper Tube, Bright Annealed*

ASTM B75, *Standard Specification for Seamless Copper Tube*

ASTM B88, *Standard Specification for Seamless Copper Water Tube*

ASTM B111, *Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock*

ASTM B124, *Standard Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes*

ASTM B187, *Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes*

ASTM B188, *Standard Specification for Seamless Copper Bus Pipe and Tube*

ASTM B280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*

ASTM B283, *Standard Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed)*

ASTM B302, *Standard Specification for Threadless Copper Pipe, Standard Sizes*

ASTM B306, *Standard Specification for Copper Drainage Tube (DWV)*

ASTM B359, *Standard Specification for Copper and Copper-Alloy Seamless Condenser and Heat Exchanger Tubes With Integral Fins*

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ASTM B372, *Standard Specification for Seamless Copper and Copper-Alloy Rectangular Waveguide Tube*

ASTM B395, *Standard Specification for U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes*

ASTM B447, *Standard Specification for Welded Copper Tube*

ASTM B465, *Standard Specification for Copper-Iron Alloy Plate, Sheet, Strip, and Rolled Bar*

ASTM B543, *Standard Specification for Welded Copper and Copper-Alloy Heat Exchanger Tube*

ASTM B640, *Standard Specification for Welded Copper Tube for Air Conditioning and Refrigeration Service*

ASTM B698, *Standard Classification for Seamless Copper and Copper Alloy Plumbing Pipe and Tube*

ASTM B743, *Standard Specification for Seamless Copper Tube in Coils*

ASTM B819, *Standard Specification for Seamless Copper Tube for Medical Gas Systems*

ASTM B837, *Standard Specification for Seamless Copper Tube for Natural Gas and Liquefied Petroleum (LP) Gas Fuel Distribution Systems*

ASTM B903, *Standard Specification for Seamless Copper Heat Exchanger Tubes With Internal Enhancement*

ASTM B919, *Standard Specification for Welded Copper Heat Exchanger Tubes With Internal Enhancement*

ASTM B956, *Standard Specification for Welded Copper and Copper-Alloy Condenser and Heat Exchanger Tubes with Integral Fins*

ANSI/AWS A5.12, *Specification for Tungsten and Oxide Dispersed Tungsten Electrodes for Arc Welding and Cutting*

MIL-T-24107, *Tube, Copper (Seamless) (Copper Alloy Numbers C10100, C10200, C10300, C10800, C12000, C12200, and C14200)*

SAE AMS 4500, *Copper, Sheet, Strip, and Plate Soft Annealed - UNS C11000*

SAE AMS 4501, *Copper Sheet, Strip, and Plate Oxygen-Free, Light Cold Rolled – UNS 10200*

SAE AMS 4602, *Copper Bars, Rods, and Shapes Oxygen-Free, Hard Temper (HO4) - UNS C10200*

SCWI-8715-0002, *John C. Stennis Space Center Personal Protective Equipment*

SPR 8715.1, *John C. Stennis Space Center Safety and Health Program Requirements*

SPR 1440.1, *John C. Stennis Space Center Records Management Program Requirements*

SSTD-8070-0013-WELD, *Classes of Welding Inspection*

SSTD-8070-0014-WELD, *Qualifying Welders and Welding Procedures*

4.0 RESPONSIBILITIES

- a. It is the responsibility of SSC personnel performing the procedure specified herein to follow the requirements set by this SSTD.
- b. Responsibilities for the qualification of the welder and the performance of the welding procedure are defined in Section 5.0.

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5.0 PROCEDURES

5.1 GENERAL

- a. All procedures shall be performed in compliance with applicable requirements in SPR 8715.1 and SCWI-8715-0002. If ever there is a conflict between this standard and the Stennis Procedural Requirements (SPR), the SPR shall take precedence.
- b. Items denoted as essential variables in the attached weld procedure specifications (WPS) shall not be altered when using the WPS. An alternate WPS may be used only if approved prior to use by the NASA SSC Center Operations Directorate Project Management Division (PMD), the NASA SSC Engineering and Test Directorate (E&TD), the NASA SSC Safety and Mission Assurance (S&MA) Office, and in accordance with ASME Boiler and Pressure Vessel Codes, Section IX, requirements.
- c. Welders shall be qualified in accordance with SSTD-8070-0014-WELD and ASME Section IX.
- d. Inspection methods for the welds shall be in accordance with SSTD-8070-0013-WELD.

5.2 BASE MATERIAL

The base material shall be copper tube, pipe, fittings, plate, bar, rod, shapes, or forgings with UNS Numbers C10200, C10400, C10500, C10700, C11000, C12000, C12200, C14200, or C19200 (designated as a P No. 31 material in ASME Boiler and Pressure Vessel Code, Section IX) conforming to any of the applicable material specifications in Section 3.0.

5.3 FILLER MATERIAL

The filler metal shall conform to ANSI/AWS A5.7M-2007.

5.4 SHIELDING GAS

The shielding gas shall be $\geq 99.9\%$ argon gas (welding).

5.5 POSITION

This procedure allows for welding in any position provided that each individual welder is qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, for the weld position he or she is using to produce welds under this procedure.

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5.6 ELECTRODE

The electrode shall be 2% thoriated tungsten as per ANSI/AWS A5.12.

5.7 PREPARATION OF BASE MATERIAL

- a. The area of the base metal to be welded shall be cleaned of any grease and dirt using a detergent.
- b. Rinse off the detergent with water.
- c. Remove oxides by either pickling the areas to be welded using an acid solution or abrasion clean with Scotch Brite pads or equivalent until a bright metal surface is obtained.
- d. If acid is used, do a final rinse with water and dry.
- e. Prior to welding, the surface area is to have a final cleaning with an emery cloth.

5.8 JOINT DESIGN

Joint design shall be as specified within the attached Welding Procedure Specification, Page 3 of 3.

5.9 HEAT TREATMENT

No heat treatment is required.

5.10 PREHEAT

- a. Preheat shall be 350° F minimum.
- b. Interpass shall be 550° F maximum.

5.11 FINAL WELD TREATMENT

The complete area shall be smooth and free from undercutting in excess of 1/32" (inch), provided the minimum wall thickness is maintained.

5.12 INSPECTION

Dye-penetrant inspect final layers of all welds in accordance with approved procedures.

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5.13 POST HEAT

No post heat is required.

6.0 RECORDS AND FORMS

- a. Records required by the procedures of this SSTD shall be maintained in accordance with SPR 1440.1 and as specified in this SSTD.
- b. All records and forms are the latest version unless otherwise indicated.
- c. Forms may be obtained from the SSC Electronic Forms repository or from the NASA SSC Forms Management Officer. Quality Records are identified in the SSC Master Records Index.
- d. The original, signed WPS and PQR (copies of which are provided in the attachments of this SSTD) and the accompanying Certificate(s) of Analysis validation test documents shall be maintained in Central Engineering Files (CEF).

7.0 ACRONYMS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CEF	Central Engineering Files
°	Degrees
F	Fahrenheit
GTAW	Gas Tungsten Arc Welding
NASA	National Aeronautics and Space Administration
PQR	Procedure Qualification Record
SCWI	John C. Stennis Space Center Work Instruction
SPR	Stennis Procedural Requirements
SSC	John C. Stennis Space Center
SSTD	John C. Stennis Space Center Technical Standard
WPS	Welding Procedure Specification

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QW-482 WELDING PROCEDURE SPECIFICATION (WPS)

 National Aeronautics and Space Administration John C. Stennis Space Center Stennis Space Center, MS 39529-6000		ASME - WELDING PROCEDURE SPECIFICATIONS (WPS)																																					
Welding Procedure Specification Record Number SSTD-8070-0125-WELD		Date 01/30/2020	Revision Number A																																				
Qualified To ASME Boiler and Pressure Vessel Code		Company Name Syncom Space Services																																					
Supporting PQR(s) SSTD-8070-0125-WELD-BASIC		Reference Docs. SSTD-8070-0125-WELD																																					
Scope GTAW P-31 Alloy to P-31 Alloy		Joint See Weld Joint Design Sheet, attached, Page 3 of 3.																																					
BASE METALS		THICKNESS RANGE QUALIFIED																																					
Type	ASTM B-88	P-no.	31	Grp-no.																																			
Welded To	ASTM B-88	P-no.	31	Grp-no.																																			
Backing	Not Permitted	P-no.		Grp-no.																																			
Retainers	N/A																																						
Notes																																							
		<table border="1"> <thead> <tr> <th rowspan="2"></th> <th colspan="2">As-welded</th> <th colspan="2">With PWHT</th> </tr> <tr> <th>Min.</th> <th>Max.</th> <th>Min.</th> <th>Max.</th> </tr> </thead> <tbody> <tr> <td>Complete Pen.</td> <td>0.062</td> <td>0.268</td> <td>N/A</td> <td>N/A</td> </tr> <tr> <td>Complete Pen.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Impact Tested</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Impact Tested</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Fillet Welds</td> <td>All</td> <td>All</td> <td></td> <td>N/A</td> </tr> </tbody> </table>					As-welded		With PWHT		Min.	Max.	Min.	Max.	Complete Pen.	0.062	0.268	N/A	N/A	Complete Pen.					Impact Tested					Impact Tested					Fillet Welds	All	All		N/A
	As-welded		With PWHT																																				
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Fillet Welds	All	All		N/A																																			
		DIAMETER RANGE QUALIFIED																																					
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	Min.	Max.	Min.	Max.																																			
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FILLER METALS		THICKNESS RANGE QUALIFIED																																					
Process	SFA	Classification	F-no.	A-no.	Chemical Analysis or Trade Name																																		
GTAW	5.7	ERCu	31																																				
Cons. Insert		N/A																																					
Flux		N/A																																					
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	As-welded		With PWHT																																				
	Min.	Max.	Min.	Max.																																			
	0.062"	0.268"	N/A	N/A																																			
WELDING PROCEDURE																																							
Welding Process		GTAW																																					
Type		Manual																																					
Minimum preheat/interpass temperature (°F)		350°F (See Note A.)																																					
Maximum interpass temperature (°F)		550°F																																					
Tungsten Size		3/32" or 1/8"																																					
Tungsten Type		2% thoriated																																					
Filler Metal Size (in.)		3/32" or 1/8"																																					
Layer Number		All																																					
Position of Groove		All																																					
Weld Progression		Uphill																																					
Current/Polarity		DC/Straight																																					
Amperes		80 - 250																																					
Volts		18 - 30																																					
Travel Speed (in./min)		2 - 8 IPM																																					
Maximum Heat Input (kJ/in)		N/A																																					
DC Pulsing Current		N/A																																					
Shielding: Gas Type		Argon ≥99.9%																																					
Flow Rate (cfh)		Up to 30 CFH																																					
Trailing: Gas Type		Not Required																																					
Flow Rate (cfh)		N/A																																					
Backing: Gas Type		Argon ≥99.9% (See Note B.)																																					
Flow Rate (cfh)		up to 30 CFH																																					
String or Weave		Stringer or Weave (See Note C.)																																					
Orifice/Gas Cup Size		4-10																																					
Multi/Single Pass per Side		Multiple																																					
Weld Deposit Chemistry		Not Recorded																																					
Notes																																							
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Continued on next page.

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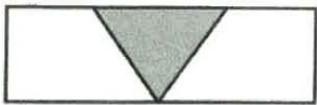
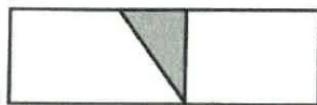
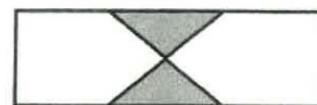
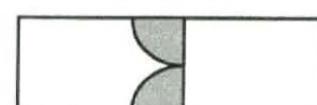
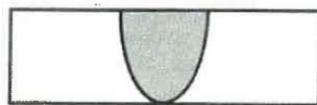
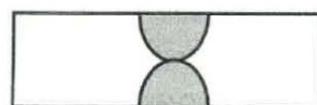
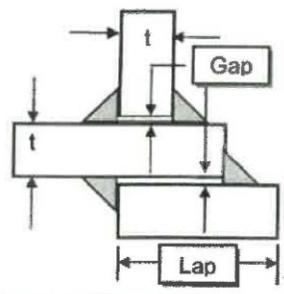
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Stennis Space Center, MS 39529-6000

ASME - WELDING PROCEDURE SPECIFICATIONS (WPS)

Welding Procedure Specification Record Number SSTD-8070-0125-WELD	Date 01/30/2020	Revision Number A
Qualified To ASME Boiler and Pressure Vessel Code	Company Name Syncom Space Services	

Weld Joint Designs

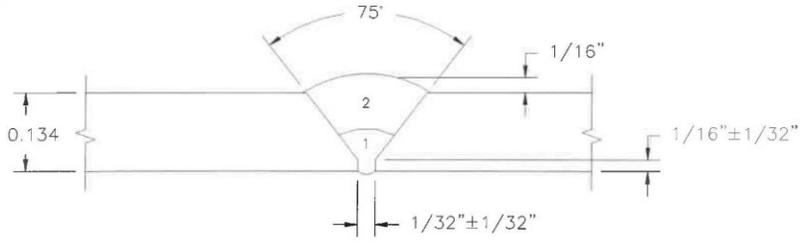
Attachment #1

Single-V Groove	Single-Bevel Groove	Double-V Groove
		
Groove Angle: 50 to 75 deg Root Opening: 1/16 to 3/16 in. Root Face: 0 to 1/16 in. Misalignment: 1/16-in. max.	Groove Angle: 37.5 to 45 deg Root Opening: 1/16 to 3/16 in. Root Face: 0 to 1/16 in. Misalignment: 1/16-in. max.	Groove Angle: 50 to 75 deg Root Opening: 1/16 to 3/16 in. Root Face: 0 to 1/16 in. Misalignment: 1/16-in. max.
Double-Bevel Groove	Single-J Groove	Double-J Groove
		
Groove Angle: 37.5 to 45 deg Root Opening: 1/16 to 3/16 in. Root Face: 0 to 1/16 in. Misalignment: 1/16-in. max.	Groove Angle: 37.5 to 45 deg Groove Radius: 3/8 in. Root Opening: 1/16 to 3/16 in. Root Face: 0 to 1/16 in. Misalignment: 1/16-in. max.	Groove Angle: 37.5 to 45 deg Groove Radius: 3/8 in. Root Opening: 1/16 to 3/16 in. Root Face: 0 to 1/16 in. Misalignment: 1/16-in. max.
Single-U Groove	Double-U Groove	Fillet Weld T or Lap
		
Groove Angle: 50 to 75 deg Groove Radius: 3/8 in. Root Opening: 1/16 to 3/16 in. Root Face: 0 to 1/16 in. Misalignment: 1/16-in. max.	Groove Angle: 50 to 75 deg Groove Radius: 3/8 in. Root Opening: 1/16 to 3/16 in. Root Face: 0 to 1/16 in. Misalignment: 1/16-in. max.	

Gap: 1/16-in. max. / Lap: 5 x t or 1 in. min.

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QW-483 PROCEDURE QUALIFICATION RECORDS (PQR)

QW-483 SUGGESTED FORMAT FOR PROCEDURE QUALIFICATION RECORDS (PQR) (See QW-200.2, Section IX, ASME Boiler and Pressure Vessel Code) Record Actual Conditions used to Weld Test Coupon.																					
Company Name <u>Mississippi Space Services</u> Procedure Qualification Record No. <u>SSTD-8070-0125-WELD-BASIC</u> Date <u>2/23/05</u> WPS No. <u>SSTD-8070-0125-WELD</u> Welding Process(es) <u>GTAW</u> Types (Manual, Automatic, Semi-Auto) <u>Manual</u>																					
JOINTS (QW-402)  <p style="text-align: center;">Groove Design of Test Coupon (For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal or process used.)</p>																					
BASE METALS (QW-403) Material Spec. <u>ASTM B-88</u> Type or Grade _____ P-No. <u>31</u> to P-No. <u>31</u> Thickness of Test Coupon <u>0.134"</u> Diameter of Test Coupon <u>4" pipe</u> Other _____ _____ _____	POSTWELD HEAT TREATMENT (QW-407) Temperature <u>N/A</u> Time <u>N/A</u> Other _____ _____ _____																				
GAS (QW-408) <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2"></th> <th colspan="3">Percent Composition</th> </tr> <tr> <th>Gas(es)</th> <th>(Mixture)</th> <th>Flow Rate</th> </tr> </thead> <tbody> <tr> <td>Shielding</td> <td><u>Argon</u></td> <td><u>99.9%</u></td> <td><u>up to 30 CFH</u></td> </tr> <tr> <td>Trailing</td> <td><u>Not Required</u></td> <td></td> <td></td> </tr> <tr> <td>Backing</td> <td><u>Argon</u></td> <td><u>99.9%</u></td> <td><u>up to 30 CFH</u></td> </tr> </tbody> </table>				Percent Composition			Gas(es)	(Mixture)	Flow Rate	Shielding	<u>Argon</u>	<u>99.9%</u>	<u>up to 30 CFH</u>	Trailing	<u>Not Required</u>			Backing	<u>Argon</u>	<u>99.9%</u>	<u>up to 30 CFH</u>
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FILLER METALS (QW-404) SFA Specification <u>5.7</u> AWS Classification <u>5.7</u> Filler Metal F-No. <u>31</u> Weld Metal Analysis A-No. _____ Size of Filler Metal <u>3/32</u> Other _____ _____ Weld Metal Thickness <u>0.134"</u>	<u>ERCU</u> <u>ERCU</u> _____ _____ _____	ELECTRICAL CHARACTERISTICS (QW-409) Current <u>DC</u> Polarity <u>straight</u> Amps. _____ Volts _____ Tungsten Electrode Size <u>3/32" or 1/8"</u> Other _____ _____ _____																			
POSITION (QW-405) Position of Groove <u>5G</u> Weld Progression (Uphill, Downhill) <u>Uphill</u> Other _____ _____ _____	TECHNIQUE (QW-410) Travel Speed <u>2 to 8 IPM</u> String or Weave Bead <u>string & weave</u> Oscillation <u>N/A</u> Multipass or Single Pass (per side) <u>Multipass</u> Single or Multiple Electrodes <u>Single</u> Other _____ _____ _____																				
PREHEAT (QW-406) Preheat Temp. <u>350°F</u> Interpass Temp. <u>550°F</u> Other _____																					
This form (E00007) may be obtained from the Order Dept., ASME, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300																					

Continued on next page.

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	Number _____ Rev. _____
	Effective Date: March 9, 2020
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Responsible Office: NASA SSC Center Operations Facilities Engineering Test Complex Support	
SUBJECT: Procedure for Welding Copper Tube	

QW-483 (Back)

PQR No. SSTD-8070-0125-WELD-BASIC

Tensile Test (QW-150)

Specimen No.	Width	Thickness	Area	Ultimate Total Load lb.	Ultimate Unit Stress psi	Type of Failure & Location
T-1	0.751	0.086	0.065	2,230	34,308	Base
T-2	0.758	0.106	0.080	2,580	32,250	weld

Guided-Bend Tests (QW-160)

Type and Figure No.	Result
Face Bend FB-1 QW 462.3(A)	180° satisfactory
Face Bend FB-2 QW 462.3(A)	180° satisfactory
Root Bend RB-1 QW 462.3(A)	180° satisfactory
Root Bend RB-2 QW 462.3(A)	180° satisfactory

Toughness Tests (QW-170)

Specimen No.	Notch Location	Specimen Size	Test Temp.	Impact Values			Drop Weight Break (Y/N)
				Ft. lbs.	% Shear	Mils	

Fillet-Weld Test (QW-180)

Result – Satisfactory: Yes _____ No _____ Penetration into Parent Metal: Yes _____ No _____

Macro – Results _____

Other Tests

Type of Test _____

Deposit Analysis _____

Other _____

Welder's Name Charles Hariel Clock No. _____ Stamp No. MSS-10

Tests conducted by: Tech Weld Laboratory Test No. 100-0205-2

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Manufacturer Mississippi Space Services

Date 2/24/05

By Richard J. King

(Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code.)

Stennis Standard	SSTD-8070-0125-WELD	C
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CERTIFICATE OF ANALYSIS



P.O. Box 1900 PASCAGOULA, MS 39568-1900
OFFICE: 228-762-2890 FAX: 228-769-5219

CERTIFICATE OF ANALYSIS

Report No. **100-5B**
Page **1 of 1**
Date **2/23/05**
Lab No. **100-0205-2**

Material	B543	Thickness	.120"	Dia.	4.5" O.D.	HI/ID No.	----
Material	B543	Thickness	.120"	Dia.	4.5" O.D.	HI/ID No.	----
Process	GTAW	Filler Metal	ERCu			Position	----
WPS	----			Welder	----	ID	----
From	Mississippi Space Services			PO	68422	Other	----
Test For	Guided Bend & Tension Test					Test Date	2/23/05
Machine Model & Serial No.	Tinus-Olsen Universal Tester #31193						
Calibration Certified By	Southern Calibration Service					Date	8/3/04
Specification Followed	ASTM E-74 and E-4						

THIS CERTIFICATE MAY NOT BE ALTERED, DELETED FROM, PUBLISHED AND/OR USED EXCEPT IN FULL

GUIDED BEND TEST

Type	Figure No.	Results
Face Bend FB-1	QW 462.3(a)	180° Satisfactory
Face Bend FB-2	QW 462.3(a)	180° Satisfactory
Root Bend RB-1	QW 462.3(a)	180° Satisfactory
Root Bend RB-2	QW 462.3(a)	180° Satisfactory

TENSION TEST

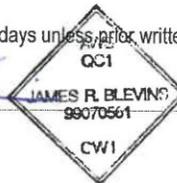
Spec. No.	Width (in.)	Thickness (in.)	Area (in ²)	Load at Fracture (lbs.)	Tensile Strength (psi)	Failure Location
T-1	0.751	0.086	0.065	2,230	34,308	Base
T-2	0.758	0.106	0.080	2,580	32,250	Weld

We certify that the statements in this record are correct and that the test samples were prepared and testing accordance with the requirements of Techweld PMT Procedure No. 1, ASTM E-8 and ASME Section IX 2001 Edition, 2003 Addenda.

Test materials will be discarded after thirty (30) days unless prior written notification is received.

Certified By

James R. Blevis
Techweld, Inc.



Date **2/23/05**