

# FESHM 5031.1 PIPING ENGINEERING NOTE

## g-2 Transfer Line

### 1. GENERAL

#### 1.1 PIPING SYSTEM DESCRIPTION

Fermilab will be operating the Muon Campus cryogenic system to support the g-2 experiment. Two refrigerators are available for this experiment. The transfer line consists of three circuits: 1 phase He, 2 phase He, and LN2. The helium circuits will be rated for 65 psig, the outlet pressure of the wet engines. The nitrogen circuit will be rated for 150 psig, the MAWP of the system supply dewar. Initial cryogenic operation will be conducted with a Test Box at the end of the Transfer Line. In the future, the Test Box will be removed and the Transfer Line connected to the experimental hall cryogenic system.

This document addresses FESHM 5031.1 requirements for design, fabrication, and installation of the g-2 experiment Transfer Line.

**TABLE 1:** Summary of Components in the g-2 Transfer Line System

COMPONENT	ASSY DWG NUMBER(S)
Refrigerator transfer line, g-2	3973.710-ME-494107
coaxial anchor assembly, g-2	3973.710-ME-494101
Transfer line to g-2 hall, coaxial	3973.710-ME-494185
End Interface box	3973.710-ME-494250
g-2 Test Box (for commissioning only)	3973.710-ME-494417
Valve Box	1650-ME-258100
N2 jumper u-tube	F10017636

#### 1.2 REQUIREMENTS

Apply ASME B31.3 Piping Code. The LHe piping has a design pressure rating of 65 psig within full vacuum. The LN2 piping has a design pressure rating of 150 psig. Per Piping Code, this is Normal Fluid Service since operating at cryogenic temperatures.

#### 1.3 PHYSICAL LAYOUT AND FLOW SCHEMATIC

The Transfer Line schematic, a portion of the overall system schematics 3973.720-ME-484924 for g-2, is shown below in FIGURE 1. Transfer Line images from the 3D model are shown in FIGURES 2 & 3. The experimental hall Interface Box is shown in FIGURE 4. The Test Box, a temporary component to be used only during initial cryogenic system commissioning, is shown in FIGURE 5. For final connection to the g-2 experiment cryogenic system, this Piping Note will be amended to reflect this removal. The LN2 connection u-tube, a new component to complete the two valve box connections for nitrogen transfer line flow and relieving, is shown in FIGURE 6.

- Socket welds were done per B31.3 para. 328.5.2
- The welding process is performed as per Fermilab qualified WPS, for which PQR exists. WPS-9-002 was used for butt welding. It is included as APPENDIX E.
- The welder has current WPQRs for the listed WPS which are available upon request and their copies will be located in APPENDIX E

## 6. INSPECTION, EXAMINATION AND TESTING

### 6.1 INSPECTION

AD/Cryo shop supervisor, Greg Johnson (Fermi ID 0533N), served as Owner's Inspector for the fabrication process and delegated AD/Cryo Bill Hughes (Fermi ID 05049N) to perform Examination.

### 6.2 EXAMINATION

The Normal Service pressure boundary welds are butt welds and sockets welds. The number of butt welds in the full piping system and the inspection count is shown in TABLE 3. The inspected welds used visual in-process examination as per B31.3. para. 341.4.1(b)(1) and para.344.7. See APPENDIX F for in-process examinations records, which include weld maps and weld mapping lists.

**TABLE 3:** Welding examination

ASSY DWG #	QTY	DESCRIPTION	BUTT WELD #	INSPECTED #
494107	1	g-2 Transfer Line, Refrigerator Room	62	5
494101	1	coaxial anchor assembly, g-2	2	1
494185	1	Transfer line to g-2 hall, coaxial	8	0
494250	1	g-2 TL end Interface Box	28	3
494417	1	g-2 Test Box (for commissioning only)	34	3
		<b>TOTAL</b>	<b>134</b>	<b>12</b>

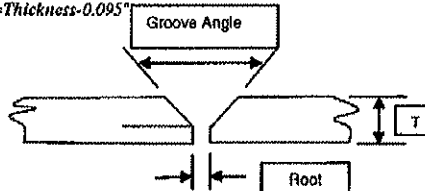
### 6.3 TESTING

The piping assembly will be pneumatically pressure tested as per para. 345.5 at 10% above the design pressure. The helium assembly test pressure will be 73 psig with full vacuum. The nitrogen assembly test pressure will be 167 psig with full vacuum. See APPENDIX G-1 for helium piping test record and APPENDIX G-2 for nitrogen piping test record

<b>Fermilab</b>		<b>Fermi National Accelerator Laboratory</b>	
<i>Technical Division-Machine Shop</i>			
<b>Welding Procedure Specification</b>		<b>No. Fermi WPS SS-9-002</b>	
Date: 6/07/2010		Date: 6/07/2010	
Revision: R1	Date: 6/04/2012	Remarks: Changed Pipe Diameter Range	Supporting PQR No.(s) Fermi PQR SS-9-001
Welding Processes	(1) GTAW	Type 1	(Manual, Auto, Semi) <b>Manual</b>
Welding Processes	(2)	Type 2	(Manual, Auto, Semi)

<b>Joints (QW-402)</b>			
Joint Design	V Groove-Open Root		
Backing Material (Type)	Argon Gas Only		
Retainer	None	Type	
Backing	Argon Gas		
Remainder	Deposited Metal		
Non-Metallic	Metallic(non-fusing)		

**Details:** Single-V Groove Weld    Open butt, no back weld  
 Root Opening: 0-1/8"    Root Face: 0-1/8"    Groove Angle: 60°-90°  
 T=Thickness=0.095"



SA213 Tube x 1/2"Ø

<b>Base Metals (QW -403)</b>			
P No. 8	Group No. 1	TO	P No. 8
Specification Type & Grade	SA 213-07a Type 304/304L	TO	Specification Type & Grade SA 213-07a Type 304/304L
or Chemical Analysis & Mechanical Properties		N/A	
to Chemical Analysis & Mechanical Properties		N/A	
<b>Thickness Range</b>		<b>Process</b>	
Base Metal	Groove: 0.0625"-0.190"	Fillet: Unlimited	
Deposited Weld Metal	Groove: 0.0625"-0.190	Fillet: Unlimited	
Pipe Diameter Range	Groove: <b>**Note**</b>	Fillet: Unlimited	
<b>Other: Approved for all diameters, all fillet sizes, all joint types (QW211 &amp; QW451.3)</b>			

<b>Filler Metals (QW-404)</b>	<b>Process 1</b>	<b>Process 2</b>
Specification No. (SFA)	5.9	N/A
AWS No. (Class)	308/308L	N/A
F-No.	6	N/A
A No.	8	N/A
Size of Filler Metals	.045, 1/16, 3/32	N/A
Deposited Weld Metal Thickness Range	0.0625 "-0.190"	N/A
Electrode-Flux (Class)		N/A
Flux Trade Name		N/A
Consumable Insert		N/A

Each Base Metal-Filler Metal combination should be recorded individually

Use of Fermilab Welding Procedures and Welder Qualifications for non-Fermilab work shall be at the sole risk and responsibility of the Subcontractor, and the Subcontractor shall indemnify and save Fermilab and the government harmless from any and all claims, demands, actions or causes of action, and for any expense or loss by reason of Subcontractor's and their employees possession and use of Fermilab procedures and qualifications.



# Fermi National Accelerator Laboratory

Technical Division-Machine Shop

## Welder Performance Qualification Record

Welder's Name	Ryan Mahoney			FNAL #	15470N	ASME #	W-2
Welding Process:	1st	GTAW	Type	Manual	2nd	Type	
Performed in accordance with:	Fermi WPS-SS-9-002						

Joint:	Fillet		Production-Weld		Test Coupon		
Groove:	Double Welded:	Yes	No	Metal-Fused	Metal-Non-Fused	Non-Metal	Open Root
	Single Welded:	Adapted					
	With Solid Backing		Without Solid Backing				

Base Metal:	Specification:	SA 213, Type 304/304L	TO	SA 213, Type 304/304L	ASME P 08, Gr 1	°C	ASME P # 8, Gr 1
Plate	Pipe			Tube			
Actual Thickness:	Nominal Diameter:	Actual Diameter		Overall Diameter: 0.500"			
Qualified Range:	W/Schedule:	Qualified Thickness Range		Wall: 0.095"			
	Actual Thickness	Qualified Diameter Range		Qualified Thickness Range: 0.190" Maximum			
				Qualified Diameter Range: 0.500" Minimum			

Filler:	1 <sup>st</sup> Process		2 <sup>nd</sup> Process	
	Specification: 5.9	Class: 308/308L	Specification:	Class:
	Diameter(s): .045, 1/16, 3/32		Diameter(s):	
	F #: 6		F #:	
Deposit Thickness: 0.095	Range Qualification: 0.190" Maximum	Deposit Thickness:	Range Qualification:	

Welding Position:	6G	If Vertical:	Uphill	Down
Gas Type & Composition:	Shielding: Argon 99.9%		Root Side Backing: Argon 99.9%	
Electrical Characteristics	Type Current	AG	DCSP	DCEN
	Transfer-GMAW	Spray	Globular	Pulse
				Short-Circuit

Visual Inspection			
Appearance:	Satisfactory	Undercut:	None
		Piping Porosity:	None

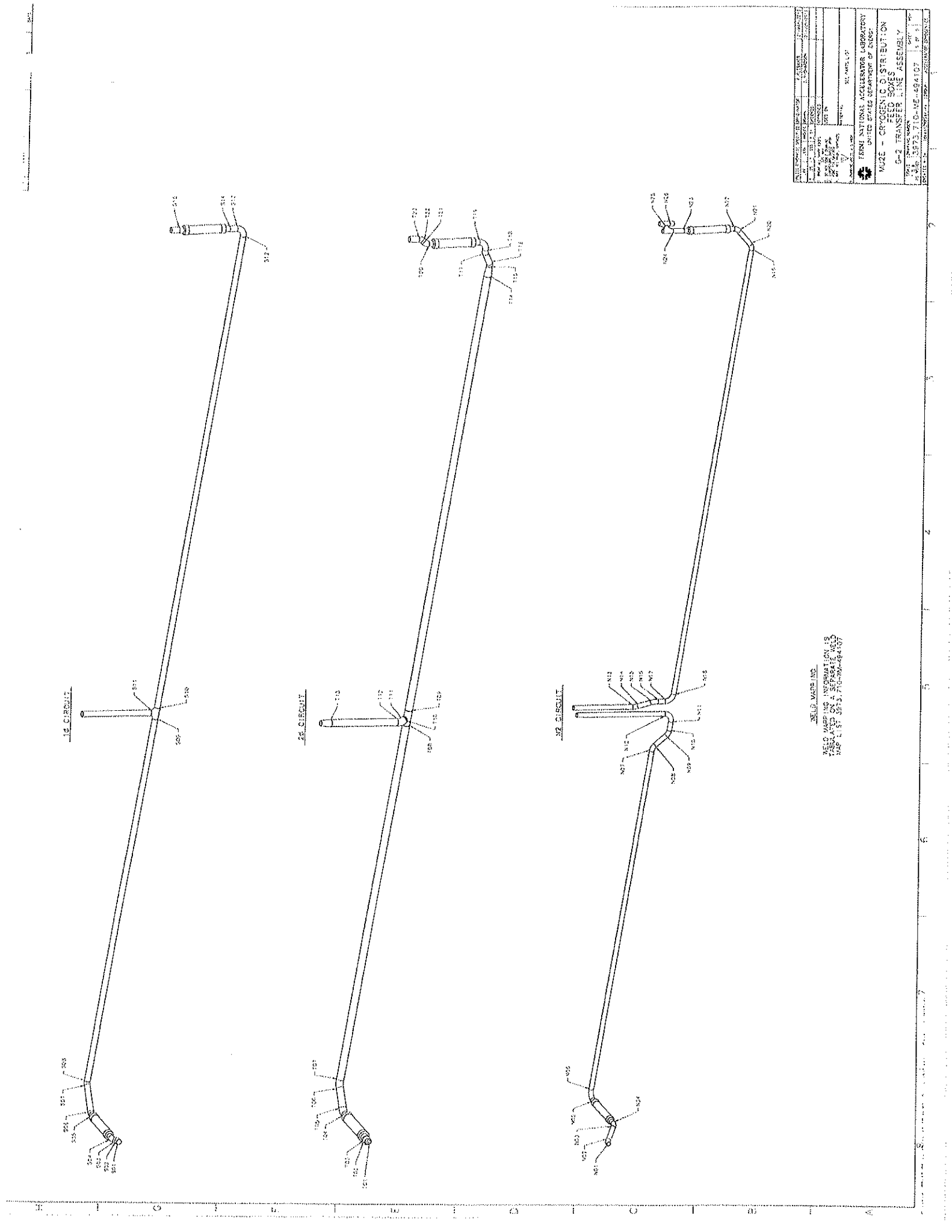
Guided Bend Test			
Type and Figure	Results	Type and Figure	Results
Test Conducted by:		Lab Test #:	Date:

Radiographic Test			
Results: Satisfactory	Per ASME IX-2007 and AWS D1.1-06		
Radiographer: Alloyweld Inspection Co., Inc.	Examiner: Jennifer Andya-Level II	Register # 5615	Date: 6/18/2010

Fillet Weld Test Results			
Fracture Test:	(Location, Nature, and size of Crack or Tear in Specimen)		
Length of Weld:	Length of Defect:	Percent of Defect	
Macro Test: Fusion			
Appearance: Fillet Size	inch X	inch	<input type="checkbox"/> Convex <input type="checkbox"/> Concave
Test Conducted by:	Lab Test #:		

Test Verified by: Roger Hiller 00362N	Verification Report #5272010-2	Signature
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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 ASME IX-2007 & AWS D1.1-06		Fermi National Accelerator Laboratory
By: Roger Hiller 00362N		Date: 6/18/2010
	Authorized Representative	



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# AD/CRYOGENICS WELD MAPPING LIST

WELD MAP LIST NUMBER

REV

Reference Dwg. 3973.710-ME-494107 SHT 5

3973.710-WM-494107

**TITLE: g-2 TRANSFER LINE ASSEMBLY**

RADIOGRAPHIC / IN-  
PROCESS INSPECTION

#	WELD #	DATE	WELDER ID	SIZE (in.)	TYPE	MATERIAL	RADIOGRAPHIC / IN- PROCESS INSPECTION
34	T19	1/10/14	DAN W.	3/4	Butt	304 SS	In-Process Inspected
35	T20	1/16/14	Ryan M	3/4	Butt	304 SS	
36	T21	1/16/14	Ryan M	3/4	Butt	304 SS	
37	T22	1/16/14	Ryan M.	3/4	Butt	304 SS	
38	T23	<del>1/16/14</del>	<del>Ryan M.</del>	<del>3/4</del>	<del>Butt</del>	<del>304 SS</del>	Deleted
39	N01	1/21/14	Ryan M	1/2	Butt	304 SS	
40	N02	1/10/14	DAN W.	1/2	Butt	304 SS	
41	N03	1/10/14	DAN W.	1/2	Butt	304 SS	
42	N04	1/17/14	RYAN M.	1/2	Butt	304 SS	
43	N05			1/2	Butt	304 SS	Field Weld
44	N06	1/21/14	Ryan M.	1/2	Butt	304 SS	
45	N07	1/2/14	Ryan M	1/2	Butt	304 SS	
46	N08	1/2/14		1/2	Butt	304 SS	
47	N09	1/2/14		1/2	Butt	304 SS	
48	N10	1/2/14		1/2	Butt	304 SS	
49	N11	1/2/14	Ryan M.	1/2	Butt	304 SS	
50	N12	12/30/13	Ryan M	1/2	Butt	304 SS	
51	N13	12/30/13	Ryan M.	1/2	Butt	304 SS	In-Process Inspected
52	N14	12/30/14	Ryan M.	1/2	Butt	304 SS	
53	N15	1/2/14	Ryan M.	1/2	Butt	304 SS	
54	N16	12/30/13	Ryan M	1/2	Butt	304 SS	
55	N17	12/30/13	Ryan M	1/2	Butt	304 SS	
56	N18	1/2/14	Ryan M	1/2	Butt	304 SS	
57	N19	1/22/14	Ryan M.	1/2	Butt	304 SS	
58	N20	1/3/14	Ryan M	1/2	Butt	304 SS	
59	N21	1/3/14		1/2	Butt	304 SS	
60	N22	1/3/14		1/2	Butt	304 SS	
61	N23	1/3/14	Ryan M	1/2	Butt	304 SS	
62	N24	1/21/14	Ryan M	1/2	Butt	304 SS	
63	N25	1/3/14	Ryan M	1/2	Butt	304 SS	
64	N26	1/3/14	Ryan M	1/2	Butt	304 SS	
65							
66							

Rev: 1  
February 7, 2013

### AD Cryogenics Department In-Process Weld Examination Form

Filled by engineer:		
Project: <u>MC-1 g-2 TL</u>	Weld Type: <u>Butt weld</u>	WPS #: <u>SS-9-002</u>
Drawing #: <u>3973.710-ME-494107</u>	Pipe #1 Size: <u>1 in.</u>	Engineer: <u>Alex Martinez</u>
Weld #: <u>T09</u>	Pipe #2 Size: <u>1 in.</u>	Date: <u>12/23/13</u>

Filled by inspector:	
Welder: <u>R. Mahoney</u>	Inspector: <u>G. Johnson</u>
WPQ Qualified? YES <input checked="" type="checkbox"/> Other <input type="checkbox"/>	

Filled by examiner in field:	
Date: <u>1/3/14</u>	Examiner: <u>W. Hughes</u>

**In-Process Visual Examination (see more info on the next page)**

*Check if OK*

a) joint preparation and cleanliness Joint surfaces are free of chips, particles, dust, rust, scale, oil, grease, etc.	✓
b) pre-heating: (N/A if ambient temperature $\geq 50^{\circ}$ F [ $10^{\circ}$ C]) ambient temp. _____ pre-heat temp. _____	N/A
c) variables specified by WPS (fill info below): filler rod material, class, diameter <u>308L, 1/16"</u>	✓
gap <u>-0-</u> type of purge gas <u>Argon</u>	✓
purge flow-rate & duration <u>10 SCFH / 10 min</u> or O <sub>2</sub> reading <u>2.01</u>	✓
c)(1) for butt welds: confirm ID at end preparation is within $\pm 1/32$ " and OD is aligned properly	
d) for brazing: position, flux, brazing temperature, wetting, and capillary action	N/A
e) for welding: condition of root pass (after cleaning) – external and/or internal	
e)(1) for SMAW (stick welding): slag removal and weld condition between passes	N/A
f) appearance of finished joint: No visible cracks, lack of fusion, porosity, obvious imperfections, incomplete penetration	✓
Filler material is fused to edges of parent material	✓
Depth of undercut ( $< 1/32$ ", N/A if non-existent) <u>N/A</u>	✓