



Fermi National Accelerator Laboratory

P.O. Box 500 - Batavia, Illinois - 60510

Fermilab Engineering Specification  
**MUON CAMPUS M4/M5 & MC-1 LOW CONDUCTIVITY WATER PIPING  
INSTALLATION SPECIFICATION**  
ED0004436, Rev.- A

Rev.	Date	Description	Originated By	Checked By	Approved By
-	Jan 2016	Initial Release	Joseph Hurd	Electronic signature on Teamcenter file	Electronic signature on Teamcenter file
A	March 2016	Specification is to acknowledge going from Fixed Price to T&M subcontracting work	Joseph Hurd	Electronic signature on Teamcenter file	Electronic signature on Teamcenter file

and associated costs for orbital welding equipment and accessories should be included in the bid but remain the burden of the SUBCONTRACTOR.

- 9.1.3 Steel filler metal alloy between 304/304L pipe to 304/304L pipe and 304/304L pipe to 316 or CF8M fitting are found below.

Connection 1	Connection 2	Filler
304/304L	304/304L	308/308L rod
304/304L	316/CF8M	316 rod

- 9.1.4 All weld joint preparation and welding techniques shall be done in accordance with Chapter V of the ASME Process Piping B31.3, and AWS B2.1-8-212:2001 (R2 12) Gas Tungsten Arc Welding of Austenitic Stainless Steel.
- 9.1.5 All welds shall be internally purged with weld grade Argon gas where Oxygen levels shall be less than 1% as read by a TOPAC oxygen monitor, which will be provided by Fermilab for SUBCONTRACTOR use.
- 9.1.6 The use of purge dams is advisable. However permanent or dissolvable dams are not to be used.
- 9.1.7 Welds that show evidence of lack of Argon purge will be deemed unacceptable.
- 9.1.8 Full penetration weld is required for all butt welds and socket welds.
- 9.1.9 All welding shall be done in such a manner that the weld surface is smooth and free of irregularities. No visible metal chips or foreign material may be detectable inside the piping system. All external surfaces in the weld area shall be cleaned of heat tint, slag, and other deposits. No mechanical process shall be used to achieve the smooth appearance.
- 9.1.10 The SUBCONTRACTOR shall provide a WPS appropriate for the work specified. Fermilab can provide a WPS for SUBCONTRACTOR use. If the SUBCONTRACTOR chooses to use a Fermilab supplied WPS, each welder shall be qualified for the specific WPS prior to onset of fabrication.
- 9.1.11 The SUBCONTRACTOR shall furnish copies of the WPQR for each welder in the operations stated in this specification. The documents shall be given to Fermilab prior to commencing work.
- 9.1.12 No production work shall be done until both the WPS and welders or welding operators have been qualified in accordance with Chapter V of the ASME/ANSI B31.3 code.

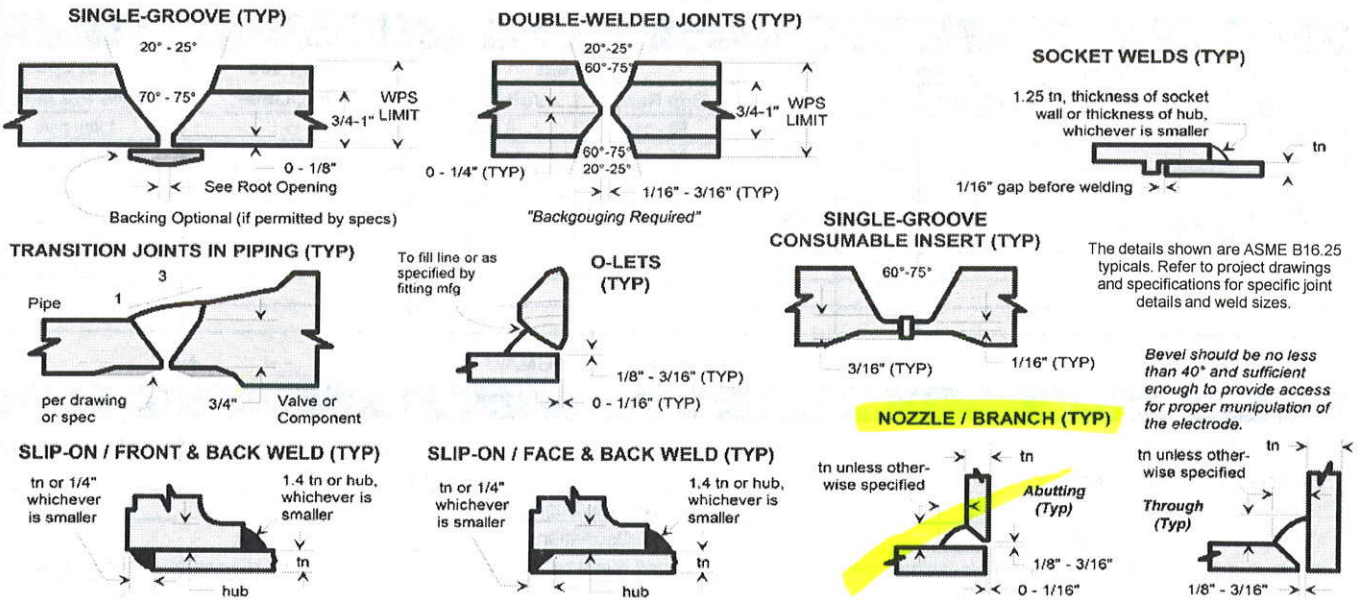
WPS No. <b>8.8-GT-SM</b>	Rev. 5	Date: 12/29/2015	Page: 1 of 2
Supporting PQR No: GT-SM-P8-0.218-AW; GT-SM-P8-0.75; GT-GM-P8-0.5; SM-FC-P8-1.5		Approved: <i>[Signature]</i> Digitally signed by Scot T. Forbes Date: 2015.12.29 12:55:59 -0600	
Project or Application: General Distribution			

Welding Procedure Specification (ASME Section IX)

**SCOPE (ASME B31.1, B31.3, B31.9, SECTION I & VIII - DIV. 1, API-620 & API-650)**

**Manual GTAW and SMAW .... P8 (Austenitic Stainless) Steels 1/16 to 8 In. Thick  
 .... Open Butt, Metal Backing or Consumable Inserts**

**JOINT (QW-402) REFER TO PRODUCTION DRAWING FOR WELD SIZE AND SPECIFIC JOINT DETAILS**



Joint Design: J, U & V single or double-welded groove, fillet, socket & seal welds  
 Metal Backing: Optional (type to match base), Note 1 Nonmetallic / Nonfusing Backing or Retainers: Not permitted  
 Alignment: As shown or per project drawings & specs Root Opening: 0 to 5/32 in. (1/8 to 1/4 in. with Metal Backing)

**BASE METALS (QW-403)**

P/S-No: 8 to P/S-No: 8  
 Group: Group 1 & 2 Group: Group 1 & 2  
 Base Metal Thickness Range: 1/16 to 8 in.  
 Base Metal Thickness Range for Fillets: Not Limited  
 Deposited Weld Metal, Groove: GTAW: 3/4 inch  
SMAW: 8 Inch  
 Deposited Weld Metal, Fillets: Not Limited  
 Pipe Diameter Range, Groove: Not Limited  
 Pipe Diameter Range, Fillet: Not Limited  
 Maximum Single Pass Thickness Limit: 1/4 in.

**FILLER METALS (QW-404)**

AWS Class: GTAW: ERXXX (see table on reverse side)  
SMAW: EXXX (see table on reverse side)  
 Product Form: GTAW: Solid Rods / SMAW: N/A  
 Supplemental Filler / Alloying: Not permitted  
 SFA Specification: GTAW: SFA-5.9  
SMAW: SFA-5.4  
 F-No. GTAW: F-No. 6 / SMAW: F-No. 5  
 Analysis: A-No. 8  
 Consumable Insert: Optional (SFA-5.30, Group C, Class INXXX)  
 Other: \_\_\_\_\_

**POSITIONS (QW-405)**

Groove: All Positions Fillet: All Positions Vertical Progression: Vertical Uphill

**PREHEAT & POSTWELD HEAT TREATMENT (QW-406 & QW-407)**

Thickness	Min Preheat Temp.		Max. Interpass Temp.	PWHT Temp.		Max Heat & Cool Rate		Min Time @ PWHT Temp.	
	Pipe/Tube	Vessels		Pipe/Tube	Vessels	Pipe/Tube	Vessels	Pipe/Tube	Vessels
All	50° F	50° F	350° F	Not Req'd	Not Req'd	N/A	N/A	N/A	N/A

Preheat is neither required or advisable when welding austenitic stainless steels as it promotes chromium carbide precipitation during welding. If preheat is necessary to remove dew, condensation or moisture from the surface of the material prior to welding, use only enough for that purpose. Infrared and hot air methods are preferred. However, if flame methods must be employed, use a neutral flame and do not allow the flame to contact the surface of the material as the resulting surface carburization will be harmful to the corrosion resistant properties of the final weld.

Preheat Maintenance (Upon completing weld & prior to PWHT): None Other: \_\_\_\_\_

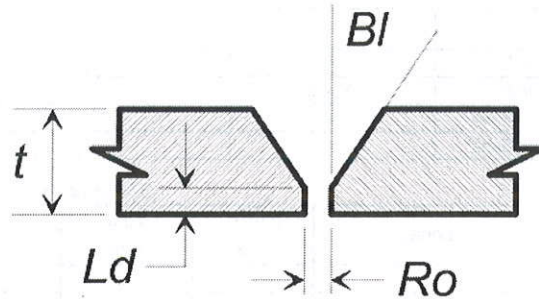
**GENERAL**

PQR Date: 9/17/2012 Welding Process(es): Gas Tungsten-Arc (GTAW) & Shielded Metal-Arc (SMAW)  
 Type (Manual, Automatic, Semiauto): Manual  
 Welding Procedure Specification Used: 8.8-GT-SM

**JOINT DESIGN (QW-402)**

Groove Design of Test Coupon

Coupon Thickness (t, in.): 0.75  
 Backing Type & Material: None  
 Land (Ld, in.): 0.0625  
 Bevel Angles (BI, Degrees): 35  
 Root Opening, (Ro, in.): 0.125



Actual deposit thickness of each process or filler metal used, in.	
GTAW	0.375
SMAW	0.375

**BASE METALS (QW-403)**

Base Metal Specification: ASME SA-240  
 Type or Grade: Type 304 to Type 304  
 P-No. P-8, Group 1 to P-No. P-8, Group 1  
 Thickness of Test Coupon: 0.75 in.  
 Maximum Pass Thickness: SMAW: Less than 1/2 in.  
 Other: \_\_\_\_\_

**GAS (QW-407)**

Gas / Gas Mixture GTAW: AWS Class SG-A (Argon) Flow Rate 20 CFH  
 Shielding: \_\_\_\_\_  
 Trailing: None N/A  
 Backing: None N/A  
 Nozzle Diam: GTAW Cup: Not Recorded  
 Contact Tube to Work Distance: N/A  
 Other: \_\_\_\_\_

**FILLER METALS (QW-404)**

SFA Specification: GTAW: SFA-5.9 / SMAW: SFA-5.4  
 AWS Classification: GTAW: ER308L / SMAW: E308L  
 Filler Metal F-No. GTAW: F-6 / SMAW: F-5  
 Weld Metal Analysis: A-No. 8  
 Size of Filler Metal: GTAW: 3/32 in. / SMAW: 1/8 in.  
 GMAW / GTAW Product Form: GTAW: Solid Rod  
 Supplemental Filler / Alloying: None  
 Other: \_\_\_\_\_

**TECHNIQUE (QW-410)**

Travel Speed: GTAW: 1.1 -3 ipm / SMAW: 3 - 4 ipm  
 String or Weave Bead: Both Oscillation: N/A  
 GMAW / FCAW Transfer Mode: N/A  
 Multi or Single Pass: Multiple Single / Multi Electrode: Single  
 GMAW, FCAW, SAW Wire Feed Rate: N/A  
 Heat Input Rate: Not Recorded  
 Method of Cleaning: Grind & Degrease  
 Method of Backgouge: N/A - Single Welded  
 Other: \_\_\_\_\_

**POSITION (QW-405)**

Position of Groove: 1G  
 Vertical Welding Progression N/A  
 Other: \_\_\_\_\_

**ELECTRICAL CHARACTERISTICS (QW-409)**

Current & Polarity: GTAW: Straight (DCEN) / SMAW: Reverse (DCEP)  
 Amps: GTAW: 90 - 95 / SMAW: 110  
 Volts: GTAW: 9 - 10 / SMAW: 11  
 Tungsten Electrode Type & Size: 1/8 in. EWTh-2 (2% Thoriated)

**PREHEAT (QW-406)**

Preheat Temp. 70° F Interpass Temp: 375° F  
 Preheat Maintenance: None  
 Other: \_\_\_\_\_

**POSTWELD HEAT TREATMENT (QW-407)**

PWHT: None - Tested in the as-welded condition  
 Temperature: N/A  
 Time: N/A  
 Heating & Cooling Rate: N/A  
 Other: N/A

Welder's Name Nichols, Brandon J. System Identification XXX-XX-5194 Welder's Symbol BN5194  
 Welding Process (type) GTAW (Manual) Base Metal(s) SA-106, Gr. B  
 Fill Process (type), if applicable SMAW (Manual) Thickness 0.6250  
 WPS No. 1.1-GT-SM & 8.8-GT-SM

Manual and Semiautomatic Variables (QW-350)		Actual Variables	Range Qualified
Backing (QW-402) .....	<u>GTAW</u>	<u>Open Butt</u>	<u>Optional (No consumable inserts)</u>
	<u>SMAW</u>	<u>Weld Metal</u>	<u>Backing Required</u>
Base Metal P-Numbers (QW-403, QW-423) ....		<u>P-No 1 to P-No 1</u>	<u>P1-15F, 34, 41-49 (Note 1)</u>
<input type="checkbox"/> PLATE <input checked="" type="checkbox"/> PIPE <input type="checkbox"/> TUBE Diameter, if applicable .....		<u>2.5 in. NPS</u>	<u>Groove - 1 in. O.D. &amp; Larger</u>
<i>Note 1: And unassigned metals of similar chemical composition to these metals.</i>			
Deposited Weld Metal Thickness .....	<u>GTAW</u>	<u>0.125 in.</u>	<u>Groove - 0.25 in. max. deposit</u>
	<u>SMAW</u>	<u>0.5 in. (3 or more layers)</u>	<u>Fillets - Unlimited Thickness</u>
Filler Metals (QW-404, QW-433)			<u>Groove - Unlimited Thickness</u>
<u>GTAW</u> SFA No. <u>5.18</u> AWS Class <u>ER70S-2</u> F-No. <u>6 (Solid)</u>			<u>Fillets - Unlimited Thickness</u>
<u>SMAW</u> SFA No. <u>5.4</u> AWS Class <u>E309</u> F-No. <u>5</u>			<u>F-No. 6 (Solid or Comp)</u>
Welding Position (QW405) .....		<u>6G</u>	<u>F-No. 5</u>
Progression - Vertical Welding (QW-405) ...	<u>GTAW</u>	<u>Uphill</u>	<u>Groove: All Positions</u>
	<u>SMAW</u>	<u>Uphill</u>	<u>Fillets: All Positions</u>
Gas Backing (QW-408) .....		<u>Without Gas Backing</u>	<u>Uphill</u>
GMAW Transfer Mode (QW-409) .....	<u>GTAW</u>	<u>N/A</u>	<u>Optional, Per WPS</u>
	<u>SMAW</u>	<u>N/A</u>	<u>N/A</u>
GTAW Current Type (QW-409) .....		<u>Straight Polarity</u>	<u>N/A</u>
			<u>Direct Current Only</u>
			<u>Straight Polarity Only</u>

Automatic and Machine Variables (QW-360)	Actual Variables	Range Qualified
Backing .....	<u>N/A</u>	<u>N/A</u>
Single / Multiple Pass Per Side .....	<u>N/A</u>	<u>N/A</u>
Direct / Remote Visual Control .....	<u>N/A</u>	<u>N/A</u>
Automatic Voltage Control (GTAW) .....	<u>N/A</u>	<u>N/A</u>
Automatic Joint Tracking .....	<u>N/A</u>	<u>N/A</u>
Position .....	<u>N/A</u>	<u>N/A</u>

**Mechanical Test Results**

Form: TAL-ASME-1, Rev. 2

Type	Figure No.	Results
Side Bend	QW-462.2	Acceptable
Side Bend	QW-462.2	Acceptable
Side Bend	QW-462.2	Acceptable
Side Bend	QW-462.2	Acceptable

Visual Examination Results (QW-302.4) Acceptable Radiographic Test Results (QW-304 QW-305) N/A  
 Weld test conducted / supervised by Chuck Rachke  
 Mechanical / RT tests by Chuck Rachke Laboratory Test No., if applicable N/A

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

Welder's Name Malloy, Craig System Identification XXX-XX-8973 Welder's Symbol CM8973  
 Welding Process (type) GTAW (Manual) Base Metal(s) SA-106, Gr. B  
 Fill Process (type), if applicable SMAW (Manual) Thickness 0.6250  
 WPS No. 1.1-GT-SM/8.8-GT-SM

Manual and Semiautomatic Variables (QW-350)	Actual Variables	Range Qualified
Backing (QW-402) .....	<u>GTAW</u> Open Butt <u>SMAW</u> Weld Metal	Optional (No consumable inserts) Backing Required
Base Metal P-Numbers (QW-403, QW-423) ....	<u>P-No 1 to P-No 1</u>	P1-15F, 34, 41-49 (Note 1)
<input type="checkbox"/> PLATE <input checked="" type="checkbox"/> PIPE <input type="checkbox"/> TUBE Diameter, if applicable .....	<u>2.5 in. NPS</u>	Groove - 1 in. O.D. & Larger Fillets - All Diameters
<i>Note 1: And unassigned metals of similar chemical composition to these metals.</i>		
Deposited Weld Metal Thickness .....	<u>GTAW</u> 0.125 In. <u>SMAW</u> 0.5 In. (3 or more layers)	Groove - 0.25 in. max. deposit Fillets - Unlimited Thickness Groove - Unlimited Thickness Fillets - Unlimited Thickness
Filler Metals (QW-404, QW-433)		F-No. 6 (Solid or Comp) F-No. 5
<u>GTAW</u> SFA No. <u>5.18</u> AWS Class <u>ER70S-2</u> F-No. <u>6 (Solid)</u>		
<u>SMAW</u> SFA No. <u>5.4</u> AWS Class <u>E309</u> F-No. <u>5</u>		
Welding Position (QW405) .....	<u>6G</u>	Groove: All Positions Fillets: All Positions
Progression - Vertical Welding (QW-405) ...	<u>GTAW</u> Uphill <u>SMAW</u> Uphill	Uphill Uphill
Gas Backing (QW-408) .....	<u>Without Gas Backing</u>	Optional, Per WPS
GMAW Transfer Mode (QW-409) .....	<u>GTAW</u> N/A <u>SMAW</u> N/A	N/A N/A
GTAW Current Type (QW-409) .....	<u>Straight Polarity</u>	Direct Current Only Straight Polarity Only

Automatic and Machine Variables (QW-360)	Actual Variables	Range Qualified
Backing .....	<u>N/A</u>	<u>N/A</u>
Single / Multiple Pass Per Side .....	<u>N/A</u>	<u>N/A</u>
Direct / Remote Visual Control .....	<u>N/A</u>	<u>N/A</u>
Automatic Voltage Control (GTAW) .....	<u>N/A</u>	<u>N/A</u>
Automatic Joint Tracking .....	<u>N/A</u>	<u>N/A</u>
Position .....	<u>N/A</u>	<u>N/A</u>

Form: TAL-ASME-1, Rev. 2

**Mechanical Test Results**

Type	Figure No.	Results

Visual Examination Results (QW-302.4) Acceptable Radiographic Test Results (QW-304 QW-305) Acceptable  
 Weld test conducted / supervised by Chuck Rachke  
 Mechanical / RT tests by Mistras Laboratory Test No., if applicable N/A

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

WELD EXAMINATION

DATE 4-2016

WELDER CLAY MALLORY

REQUESTER GRFG JOHNSON

COMPANY RPM

TEST TYPE 5-6 - GTAW

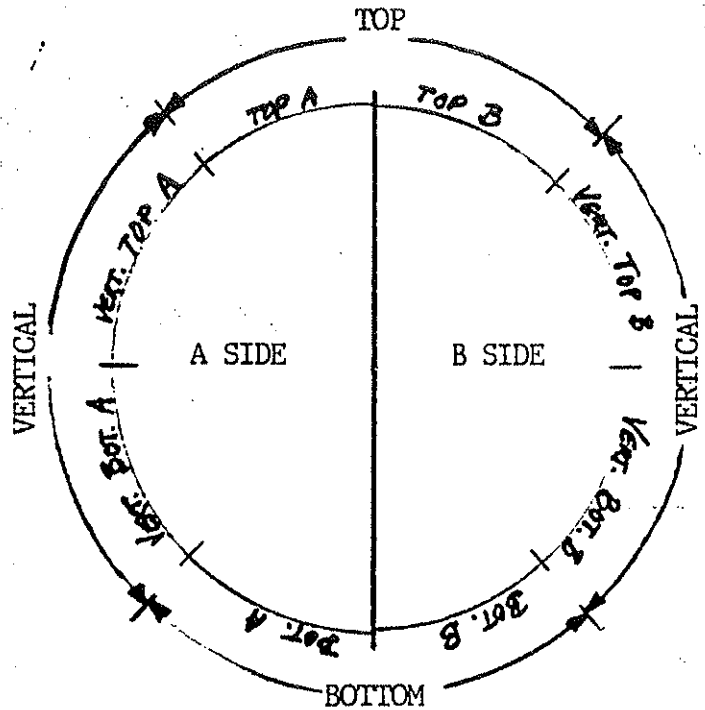
TEST LOCATION AP 30

TEST MATERIAL 304 S.S. / 2" SCH 10

TEST PROCEDURE: PIPE WELD USING INERT PURGE  
 FUSE WELD ROOT PASS  
 ADD FILLER ROD ON COVER PASS

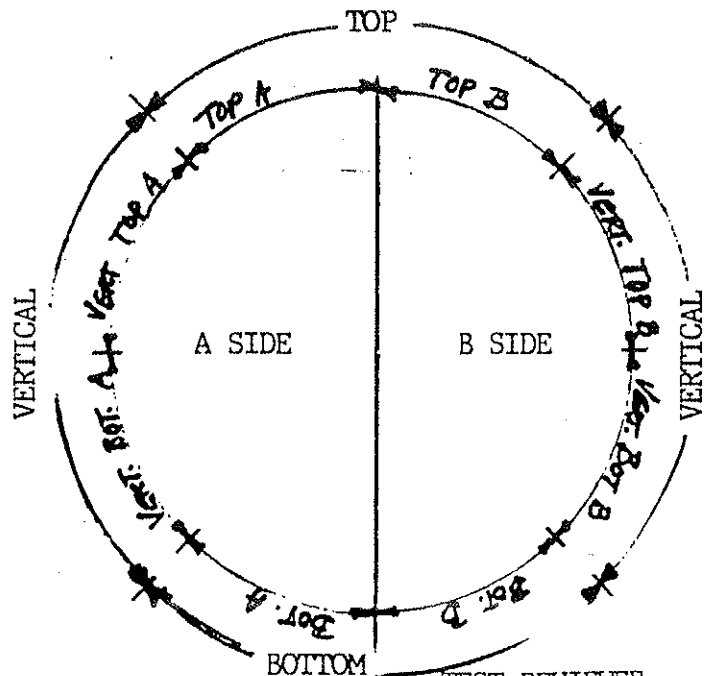
ROOT PASS

BOTTOM A	<u>PASS</u>	FAIL
BOTTOM B	<u>PASS</u>	FAIL
VERT. A BOT.	<u>PASS</u>	FAIL
VERT. A TOP	<u>PASS</u>	FAIL
VERT. B BOT.	<u>PASS</u>	FAIL
VERT. B TOP.	<u>PASS</u>	FAIL
TOP A	<u>PASS</u>	FAIL
TOP B	<u>PASS</u>	FAIL



COVER PASS

BOTTOM A	<u>PASS</u>	FAIL
BOTTOM B	<u>PASS</u>	FAIL
VERT. A BOT.	<u>PASS</u>	FAIL
VERT. A TOP	<u>PASS</u>	FAIL
VERT. B BOT.	<u>PASS</u>	FAIL
VERT. B TOP	<u>PASS</u>	FAIL
TOP A	<u>PASS</u>	FAIL
TOP B	<u>PASS</u>	FAIL



FILLER TYPE 308L

PURGE GAS AR 60A

TEST REVIEWER

## AD/CRYOGENICS WELD MAPPING LIST

WELD MAP LIST NUMBER

REV

Reference Dwg. F10053893 (283)

TITLE: LCW PIPING M4/M5

RADIOGRAPHIC / IN-  
PROCESS INSPECTION

#	WELD #	DATE	WELDER ID	SIZE (in.)	TYPE	MATERIAL	RADIOGRAPHIC / IN- PROCESS INSPECTION
1		4-25-16	CM8973	olet	olet	304L	IN PROCESS
2		4-22-16	CM8973		olet	304L	IN PROCESS
3		4-26-16	CM8973	6"	Butt	304L	IN PROCESS
4		4-21-16	CM8973	6"	Butt	304	IN PROCESS
5		4-26-16	CM8973	6"	Butt	304L	IN PROCESS
6		4-21-16	CM8973	6"	Butt	304L	IN PROCESS
7		4-26-16	CM8973		olet	304L	
8		4-21-16	CM8973		olet	304L	IN PROCESS
9		4-26-16	CM8973	6"	Butt	304L	
10		4-22-16	CM8973	6"	Butt	304L	
11		4-22-16	CM8973	6"	Butt	304L	
12		4-20-16	CM8973	6"	Butt	304L	
13		4-25-16	CM8973	6"	Butt	304L	
14		4-20-16	CM8973		olet	304L	IN PROCESS
15		4-26-16	CM8973	6"	Butt	304L	
16		4-20-16	CM8973	6"	Butt	304L	
17		4-25-16	CM8973		olet	304L	
18		5-9-16	CM8973	6"	Butt	304L	IN PROCESS
19		4-25-16	CM8973	6"	Butt	304L	
20		5-6-16	CM8973	6"	Butt	304L	
21		5-6-16	CM8973	6"	Butt	304L	IN PROCESS
21 1/2		5-5-16	CM8973	6"	Butt	304L	
22		4-27-16	CM8973	6"	Butt	304L	Radiograph
23		5-3-16	CM8973	6"	Butt	304L	
24		4-27-16	CM8973	4"	Butt	304L	
25		4-28-16	CM8973	6"	Butt	304L	Radiograph
26		4-29-16	CM8973	6"	Butt	304L	Radiograph
27		4-29-16	CM8973	4"	Butt	304L	
28		5-10-16	CM8973	6"	Butt	304L	IN PROCESS
28 1/2		5-6-16	CM8973	6"	Butt	304L	IN PROCESS
29		4-28-16	CM8973	4"	Butt	304L	
29 1/2		5-12-16	CM8973	6"	Butt	304L	
30 1/2							



Rev: 0  
June 10, 2015

## Fermilab In-Process Weld Examination Form

Filled by engineer:		
Project: <u>M4/M5 LCW</u>	Weld Type: <u>Butt</u>	WPS #: <u>8.8-GT-SM</u>
Drawing #: <u>F10053893②</u>	Pipe #1 Size: <u>at least 4"</u>	Engineer: <u>J. Hurd</u>
Weld #: <u>63</u>	Pipe #2 Size: <u>4"</u>	Date: <u>5-3-16</u>

Filled by inspector:	
Welder: <u>BNS194</u>	Inspector: <u>Greg Johnson</u>
WPQ Qualified? YES <input checked="" type="checkbox"/> Other <input type="checkbox"/>	

Filled by examiner in field:	
Date: <u>5-4-16</u>	Examiner: <u>T-LYNN</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 ≥ 50° F [10° C]) ambient temp. _____ pre-heat temp. _____	N/A
c) AWS Filler Metal Specification <u>A5.9</u> Manufacturer <u>HARRIS</u> Filler rod: Class <u>308L</u> Diameter(s) <u>1/8"</u> Is filler certified? <input checked="" type="checkbox"/> Is a copy of CMTR or COA available <input checked="" type="checkbox"/> Heat #(s) <u>B3501697</u> Lot #(s) _____	✓
gap <u>1/8"</u> type of purge gas <u>ARGON</u> purge flow-rate & duration <u>20 SCFH</u> or O <sub>2</sub> reading <u>&lt; 1%</u>	✓ ✓
c)(1) for butt welds: confirm ID at end preparation is within ± 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) _____	✓ ✓ ✓