Contract No:

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Defense Waste Processing Facility Canister Closure Weld Current Validation Testing

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Materials Science and Technology, Energy Materials

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1.0 APPROVALS/TASK TECHNICAL REQUEST IDENTIFICATION

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Task Technical Request Title: Support Testing/Evaluation of Canisters S04480 and S04500 for Low Weld Peak Current Values	**TTR Number:** **M-TTR-S-00041** **Revision: 0**	**TTR Date:** **10/11/2016**

LIST OF REVISIONS		
Revision Number	**Summary of Changes**	**Date**
0	Initial Issue	1/17/2018

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LIST OF ACRONYMS

Acronym	Definition
ARDP&MC	Analytical Research and Development Programs and Materials Characterization
ATM	Atmosphere
AWS	American Welding Society
cc	Cubic Centimeters
DAS	Data Acquisition System
DWPF	Defense Waste Processing Facility
D&S-FE	DWPF and Saltstone Facility Engineering
E	Energy
He	Helium
HPL	High Pressure Laboratory
I	Current
ICC	Inner Canister Closure
kA	Kilo-amperes
LWO	Liquid Waste Operations
M&TE	Measurement and Test Equipment
MS&T	Materials Science and Technology
NCW	Nonconforming Weld
QA	Quality Assurance
RDE	Research and Development Engineering
RFW	Resistance Forge Weld
RPD	Radiological Protection Department
sec	Seconds
SEM	Scanning Electron Microscope
SRNL	Savannah River National Laboratory
TNW	Test Nozzle Weld
TTQAP	Task Technical and Quality Assurance Plan
V	Voltage

2.0 INTRODUCTION

Two closure welds on filled Defense Waste Processing Facility (DWPF) canisters failed to be within the acceptance criteria in the DWPF operating procedure SW4-15.80-2.3 (1). In one case, the weld heat setting was inadvertently provided to the canister at the value used for test welds (i.e., 72%) and this oversight produced a weld at a current of nominally 210 kA compared to the operating procedure range (i.e., 82%) of 240 kA to 263 kA. The second weld appeared to experience an instrumentation and data acquisition upset. The current for this weld was reported as 191 kA. Review of the data from the Data Acquisition System (DAS) indicated that three of the four current legs were reading the expected values, approximately 62 kA each, and the fourth leg read zero current. Since there is no feasible way by further examination of the process data to ascertain if this weld was actually welded at either the target current or the lower current, a test plan was executed to provide assurance that these Nonconforming Welds (NCWs) meet the requirements for strength and leak tightness. Acceptance of the welds is based on evaluation of Test Nozzle Welds (TNW) made specifically for comparison. The TNW were nondestructively and destructively evaluated for plug height, heat tint, ultrasonic testing (UT) for bond length and ultrasonic volumetric examination for weld defects, burst pressure, fractography, and metallography. The testing was conducted in agreement with a Task Technical and Quality Assurance Plan (TTQAP) (2) and applicable procedures.

3.0 EXPERIMENTAL APPROACH

All testing was conducted in agreement with standard operating procedures (3 & 4) or task specific written instructions. The requirements and measurement techniques that were employed for this task were:

Criteria	**Limits**
Visual	Workmanship
Leak (5)	$\leq 1x10^{-4}$ atm-cc/sec He
Burst (5)	≥ 2600 psi
Bond Length (5)	≥ 0.335 inch
Plug Height	For information only
Heat tint coloration	For information only

Leak and burst data were directly measured from tests conducted using standard testing procedures (4). The bond length was inferred from ultrasonic examination of all six test welds. Weld ligament was measured based on the fracture surfaces of the burst test sample and measured on the metallographic sample and the process defined in Reference 3.

Table 1. Weld parameters used for production and proposed for test nozzle welds.

Canister Closure Weld Parameter Chart			
Type of Weld	**Ram Force (LBS.)**	**Welding Current (kA)[1]**	**Weld Duration (Sec.)[2]**
Production[3]	79,000 – 85,000	240 - 263	1.50 – 1.67
Test Nozzle	(same as above)	186 -196 (i.e., 191 ± 5)	(same as above)

NOTES:
1. Current is the only variable that is being intentionally changed from the production parameters.
2. Pulsed DC weld.
3. Allowable range is as specified in Manual SW4-15.80-Section 2.3, Welding a Canister – Automatic Mode (1).

Visual inspection was conducted under ambient light conditions for the TNW.

Leak testing was conducted using a commercial leak detector with a Level 3 certified technician in agreement with Reference 4.

Burst testing was conducted in the Savannah River National Laboratory (SRNL), RDE High Pressure Laboratory. The test nozzles were filled with water and pressurized with gas to failure, in agreement with Reference 3.

The bond length was measured using UT. Ultrasonic examinations were conducted from the outer cap using a Sigma SSFA4 4 MHz, .26” X .26”, 45 and a 60-degree shear wave transducer measuring the projected distance from the weld top and the weld bottom. The bond length was measured on each of the test nozzles in eight locations, i.e., at approximately 45° intervals.

The plug height was measured using a Measurement and Test Equipment (M&TE) calibrated dial indicator in agreement with Reference 3.

The heat tint width was measured during optical inspection. The transition from yellow to metallic gray was measured using a scale incremented at 32^{nds} of an inch and performed in accordance with a schematic as shown in Figure 1. The edge of the transition was determined having a single operator evaluate the TNW.

The TNWs with the lowest and highest burst pressures were selected for fractographic examination. The plugs were sectioned into pieces that could be easily fit into the Scanning Electron Microscope (SEM) in the 723-A Materials Laboratory. An accelerating voltage of 20 kV was used. The samples were examined from low to high magnifications. Low magnifications were used to correlate the measured bond lengths with ultrasonic data bond length measurements.

One test nozzle weld was selected for metallographic examination and fracture mode characterization. Six segments were removed from the TNW at nominally equal locations, approximately 60° apart. Four metallographic samples were mounted in epoxy and mechanically polished to 1 µm and then etched electrolytically with oxalic acid. The bond length was measured based on the shortest weld ligament (3). The remaining two samples were fractured through the weld by clamping in a vice and breaking the sample. These fracture surfaces were examined to determine the failure process (i.e., ductile or brittle).

4.0 RESULTS of ACTIVITIES (Reference Attachment 3)

Activity 1 (TTR Task #3c – Attachment 2) installed a voltage meter that can be used to calculate the weld heat. The previous acceptance of NCWs was accomplished without requiring extensive weld trials since the weld heat was readily calculated based on the measured current and voltage (6). Maintaining this data capture capability for use in the future may decrease or eliminate the need for additional testing in the event another NCW event occurs.

Activity 2 (TTR Task 2a, 2b, 2c, 2e, 3a, 3b, 3c) provided the primary data to ascertain the acceptability of the NCW canisters. The test nozzles were welded at currents of 191 $\pm$ 5 kA and were tested for comparison to the NCW S04480 and S04500; Table 1 lists the proposed weld parameters and Table 2 is comprised of the actual weld parameters. A total of six test welds were made in the target range of 191 $\pm$ 5 kA, five test welds were used for leak and burst testing (Activity 2) and one for metallographic analysis, Activity 3. The welds were:

- Visually examined for workmanship and heat tint with typical heat tint images from the test nozzles shown in Figure 1. The dimensions of the heat tint are indicated in Table 3 and the value of this measurement is seen in the comparison of the TNW made at the production parameters, which exhibits a slightly larger heat tint zone.
- Measured for plug height at approximately four locations around the weld/plug circumference using an M&TE calibrated dial indicator. Measurements are recorded in Table 4, these are all greater than the values reported in the parametric weld qualification report (7).
- Ultrasonically tested for bond length determination with results listed in Table 5. As noted the bond length compared favorably with that shown from the SEM fractography samples, Table 7.
- All the TNW were leak tested and five were burst tested with the results listed in Table 6, and exhibit an average burst pressure of 9026.6 psi with a standard deviation of 586.7 psi. A typical burst test pressurization-assembly is shown in Figure 2. The burst data were statistically analyzed and are reported in Reference 8. A typical nozzle and plug after testing are shown in Figure 3. Four of the samples failed by complete separation of the plug from the nozzle and one failed along approximately 98% of the circumference. As seen from the burst tested nozzle, the length of the weld ligament is apparent. Low magnification images from each segment are shown in Figures 4 and 6; the bond lengths estimated at each location are listed in Table 7. The fracture surfaces of two plugs were examined in the scanning electron microscope (SEM). Higher magnification images of the fracture surface, shown in Figure 8 indicate that the weld separated in a ductile fashion and exhibits the classic cup and cone fracture expected for Type 304 stainless steel.

Activity 3 (TTR Task 2d) provided metallographic sample data to compare the weld throat measurements and fracture surface with that observed during the parametric study, as indicated in Table 8 and Figure 5. The typical weld microstructure is shown in Figure 9.

5.0 DISCUSSION

Test Weld Nozzles that were prepared at a current of 191 $\pm$ 5 kA were subjected to a series of evaluations to determine the suitability to retain vitrified nuclear waste. These evaluations are similar to those previously performed during the closure weld qualification efforts (9 & 10). The test welds were successfully leak and burst tested, and were fractographically and metallographically examined. The samples met all the technical requirements defined in the TTQAP (2), Waste Form Compliance Plan (WCP) (11), and Waste Acceptance Product Specifications (WAPS) (12). In addition, data generated for information purposes only provided useful reference data to infer weld heat, and weld integrity for the TNW. Additional data is required for these data to be deployed as a quality metric and for potential future use.

6.0 CONCLUSIONS

This report completed TTR tasks 2a – 2e and 3a – 3c for the test weld nozzles, Attachment 2. None of the work for the conforming welds was accomplished. The data for TTR Activity 1 was also developed based on the efforts reported herein. TTR task 1 was reported in Ref. 8.

The test welds prepared at currents that are approximately 50 kA lower than that allowed by the closure welding operating procedure (1) successfully passed the leak and burst (weld) strength requirements of the WCP and WAPS. Therefore, the NCWs performed on production canisters S04480 and S04500 are expected to meet the leak and burst strength requirements of the WCP and WAPS.

The welding range as specified in the operating procedure (1) should not be modified based on these results, despite the welds meeting the burst and leak requirements.

The weld force and time must remain consistent within the range specified in the operating procedures.

The microstructures were acceptable and consistent with the expected weld conditions.

Future closure welds performed outside of the weld parameters (1) specified in the operating procedures shall be evaluated.

7.0 REFERENCES

1. Manual SW4-15.80, Section 2.3, Rev. 43, Welding a Canister - Automatic Mode, Savannah River Site, Mar. 2017.

2. SRNL-RP-2016-00637, Rev. 3, Task Technical and Quality Assurance Plan (TTQAP) for the DWPF Weld Current Validation, P.S. Korinko, Jan. 2018.

3. L9.3, Procedure R-MST-5600, Rev. 0, Testing of DWPF Closure Welds, Savannah River National Laboratory, Jan. 2017.

4. Manual L9.4, Procedure 10100, Rev. 5, Pressure Test/Leak Test Procedure, Savannah River National Laboratory, June 2016.

5. WSRC-TR-94-00402, Rev. 1, Burst Test Qualification Analysis of DWPF Canister-Plug Weld (U), N.K. Gupta & C. Gong, Feb. 1995.

6. OPS-DTE-970056, Rev. 2, Canister S00424 Acceptance Justification (U), G.R. Cannell & R.B. Heise, Nov. 1997.

7. WSRC-TR-94-024, Rev. 1, DWPF Welder Parametric Study, M.J. Plodinec & J. Harbour, August 1995.

8. SRNL-TR-2017-00197, Rev.0, Statistical Analysis of Burst Pressure Data for DWPF Weld Current Validation, S.P. Harris, May 2017.

9. WSRC-TR-2001-00369, Rev. 0, Testing and Evaluation of Welded Mockup Test Nozzles Associated with the Closure Weld of Canister S01079 (U), W. L. Daughtery & D.N. Maxwell, Oct. 2001.

10. SRT-SCS-2001-00058, Rev. 0, Statistical Analysis of Burst Pressure Data for Disposition of DWPF Canister S01079 (U), S.P. Harris, Dec. 2001.

11. WSRC-IM-91-116-0, Rev. 11, DWPF Waste Form Compliance Plan (U), Savannah River Remediation LLC, July 2016.

12. DOE/EM-0093, EM-WAPS, Rev. 2, Waste Acceptance Product Specifications for Vitrified High-Level Waste Forms, Office of Environmental Management, Dec. 1996.

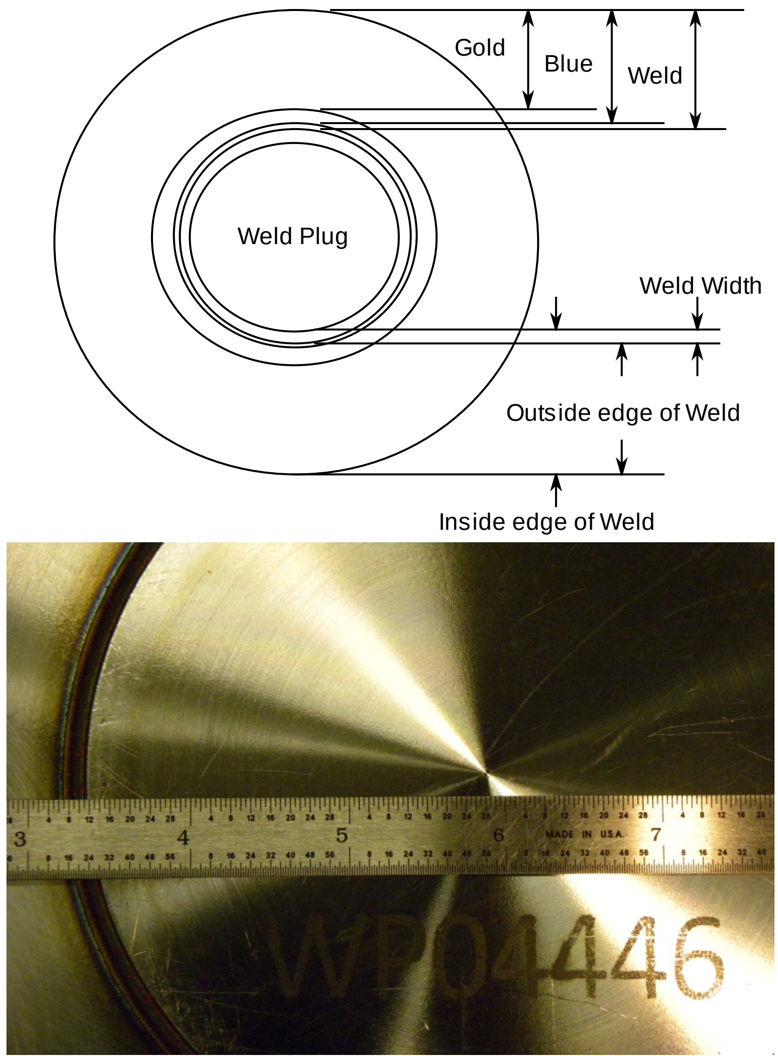


Figure 1. (a) Schematic of heat tint measurement approach and (b) a photo of test nozzle weld plug WP04446.

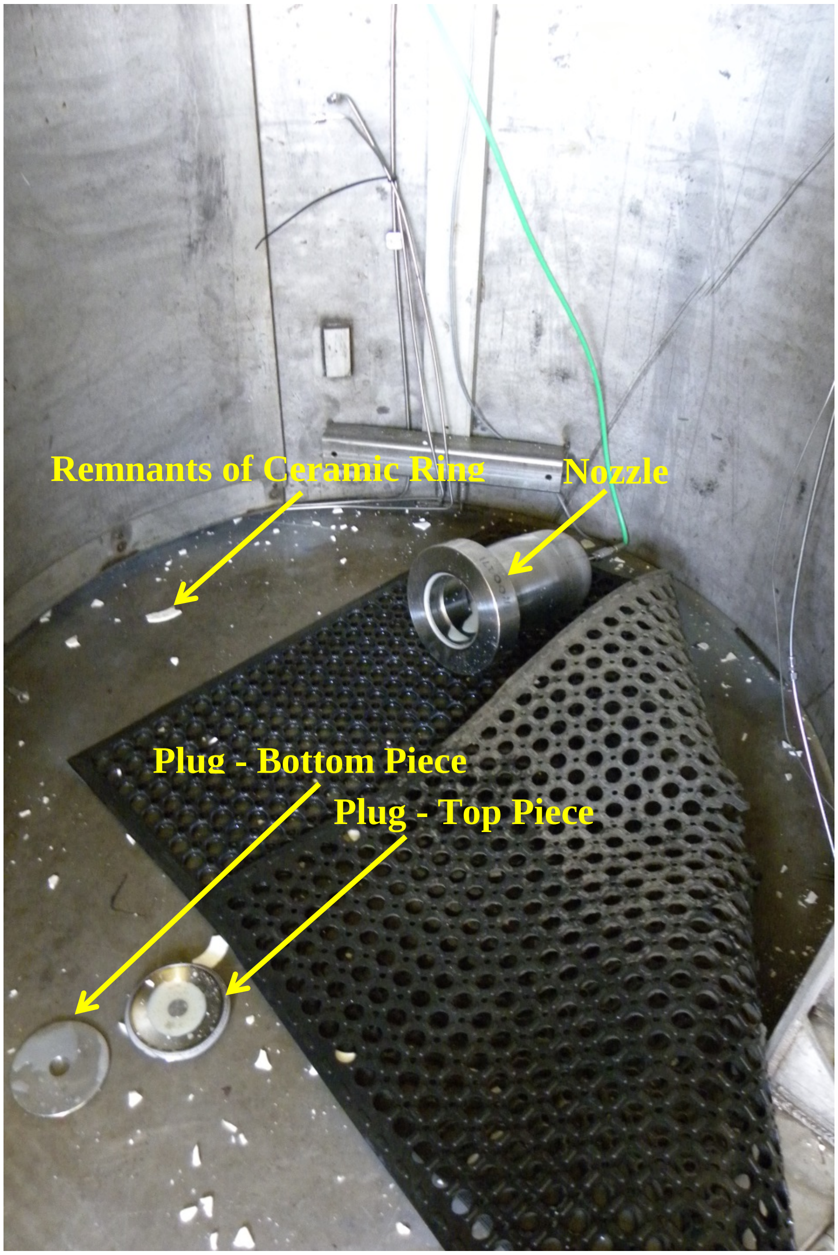
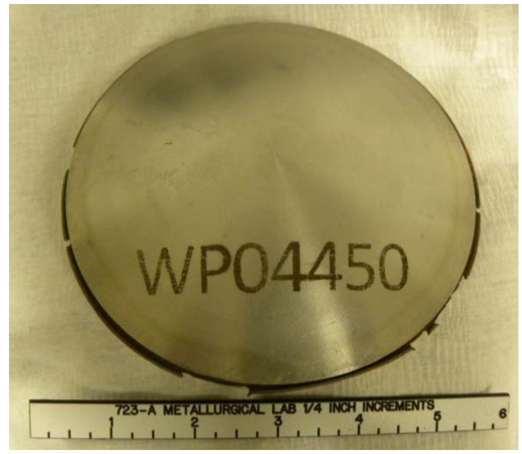


Figure 2. Burst tested nozzle in the gun barrel showing complete separation of the nozzle and plug.

a)



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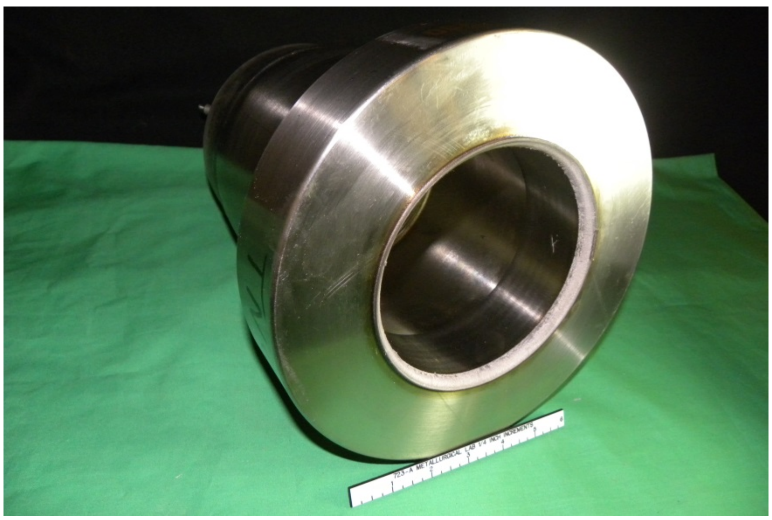

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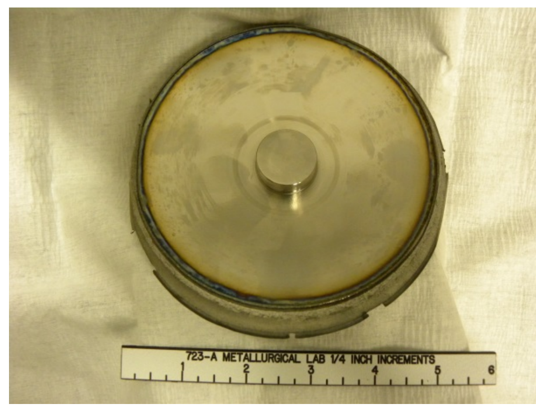

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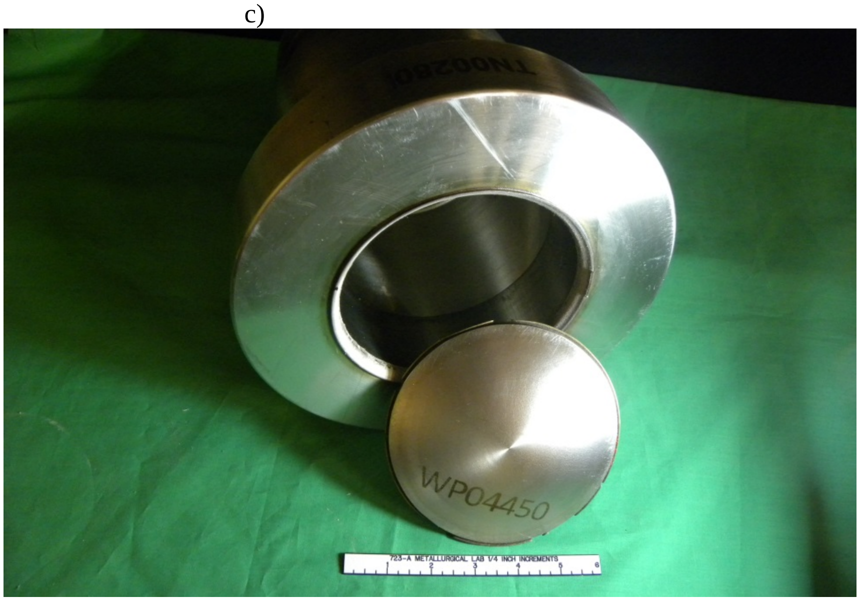
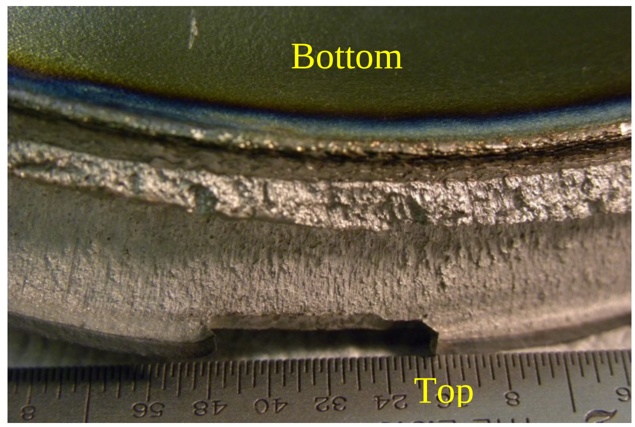


e)

Figure 3 - Typical post burst test photos of welded test nozzles and plugs a) a fully separated plug b) top of plug WP04450 c) test nozzle d) internal side of plug WP04450 e) Plug WP04450 and nozzle.

a)



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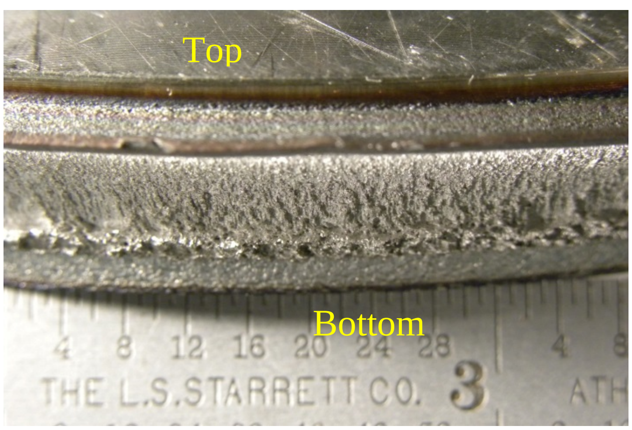

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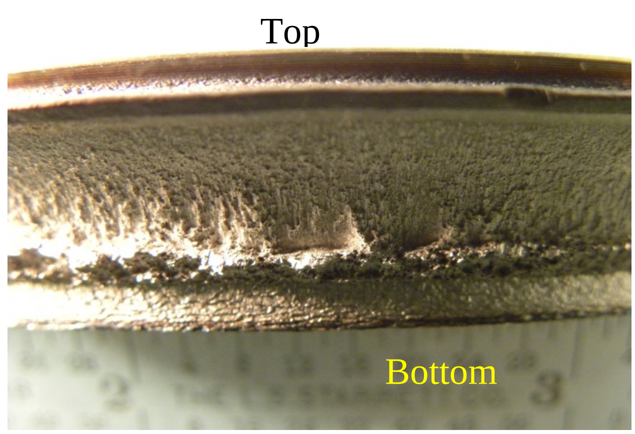


d)

Figure 4. Low magnification optical photographs from test nozzle WP04445 Plug a) overview b) area with a large piece missing c) a typical area d) a second typical area, all of the close-up images indicate ductile fracture.

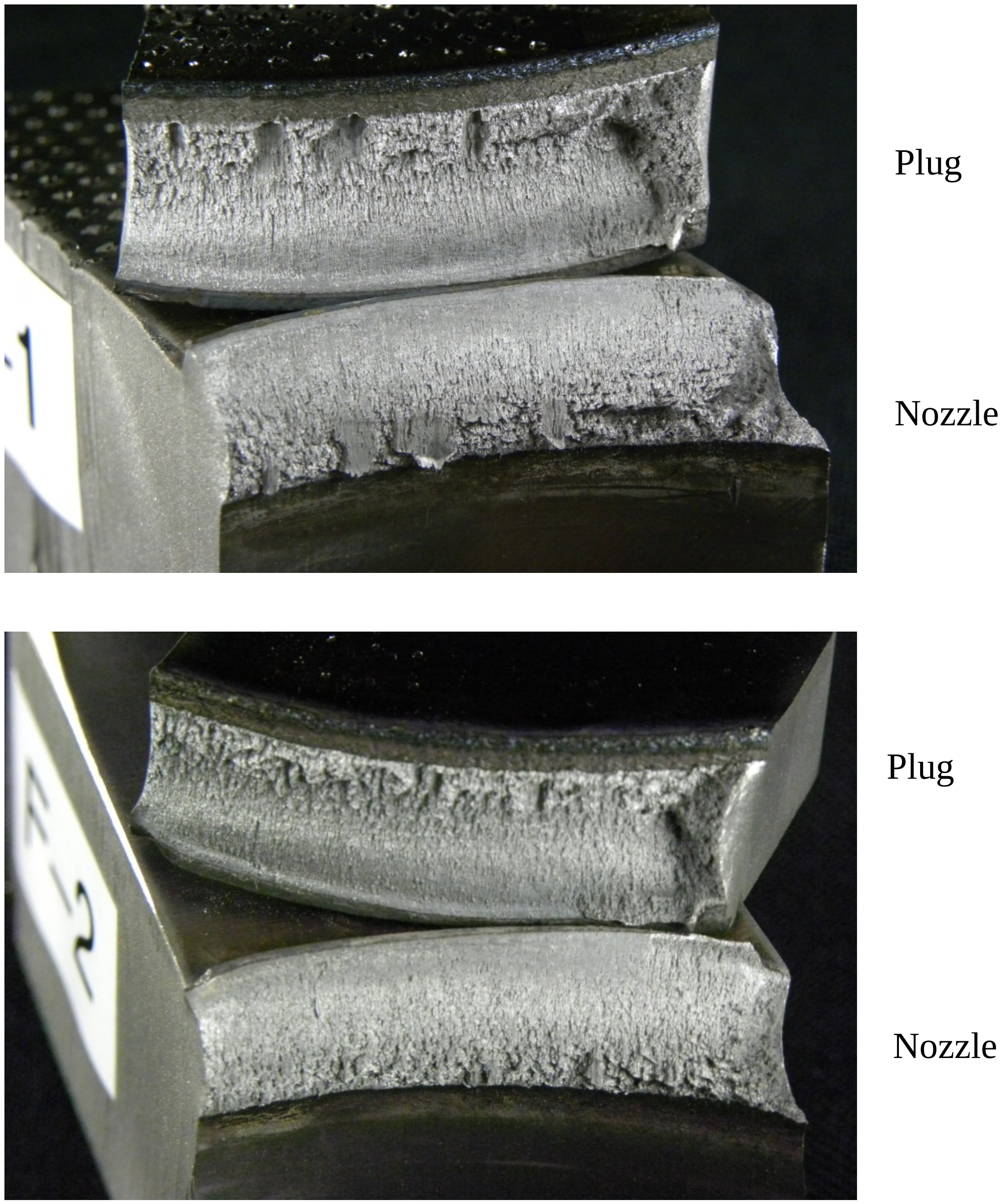


Figure 5. Macrophotographs of bending fracture test samples removed from nozzle/plug ID No. TN00275/WP04448, a) sample F-1; b) sample F-2 both test samples exhibit ductile fracture.

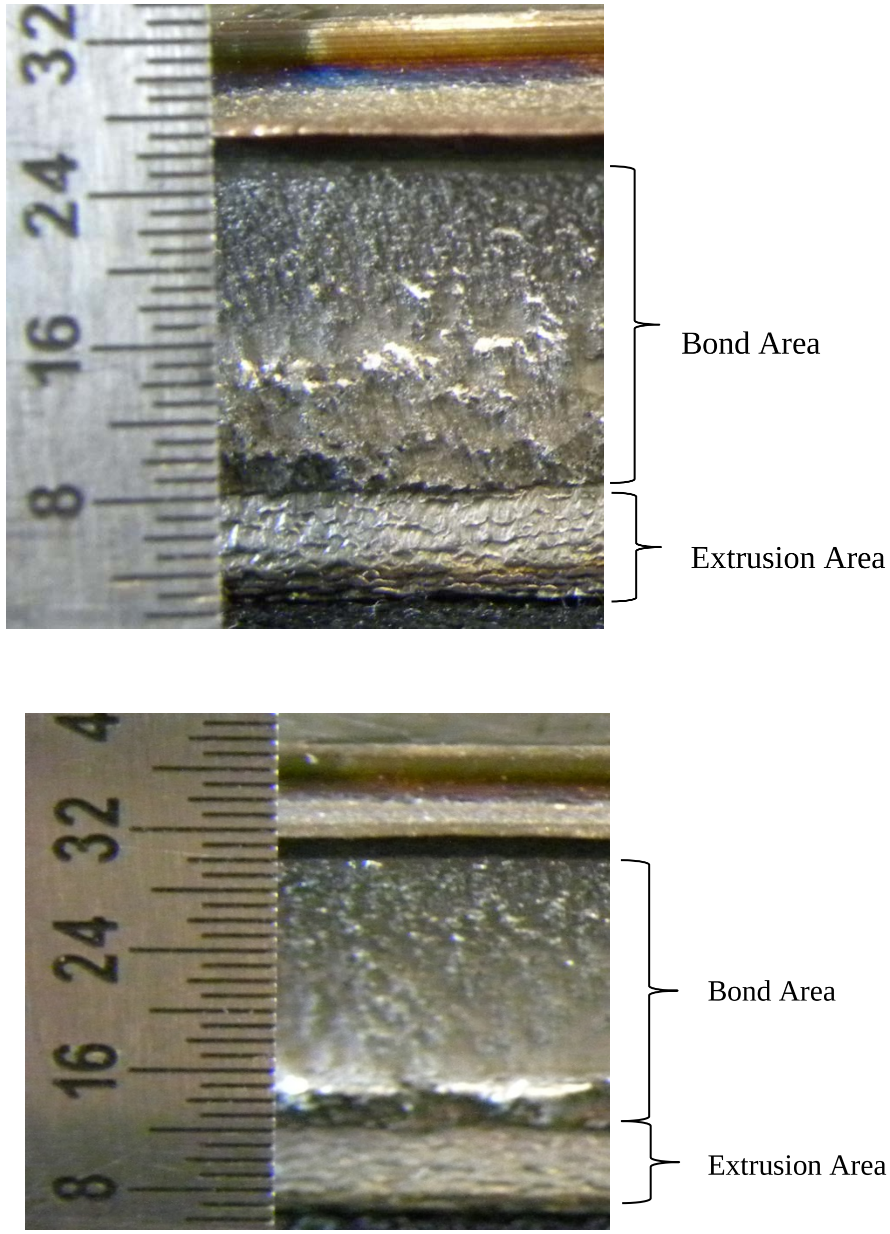
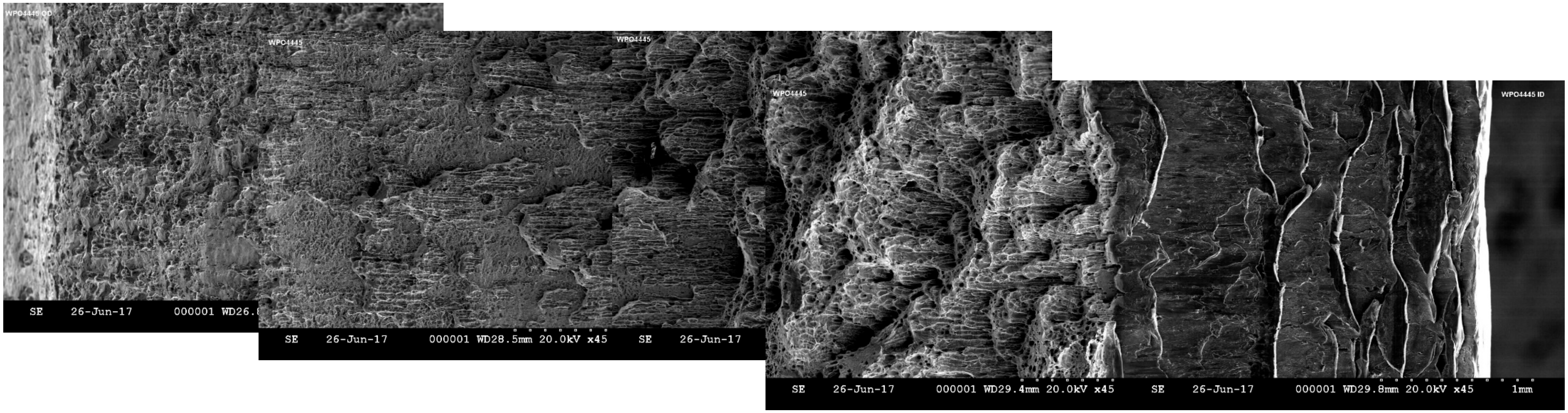
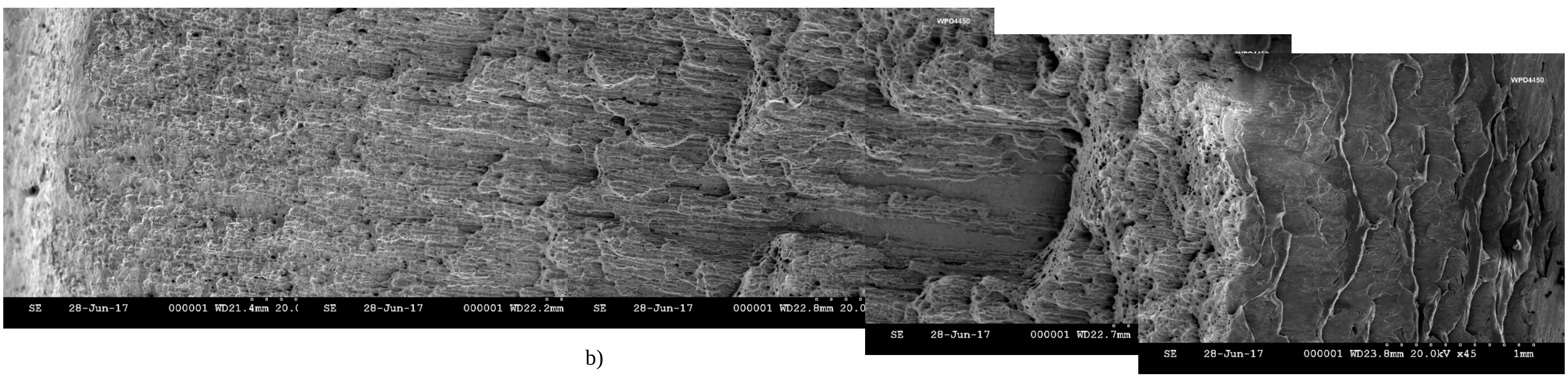


Figure 6. Showing fracture surface and method to determine the bond length for a burst tested sample.

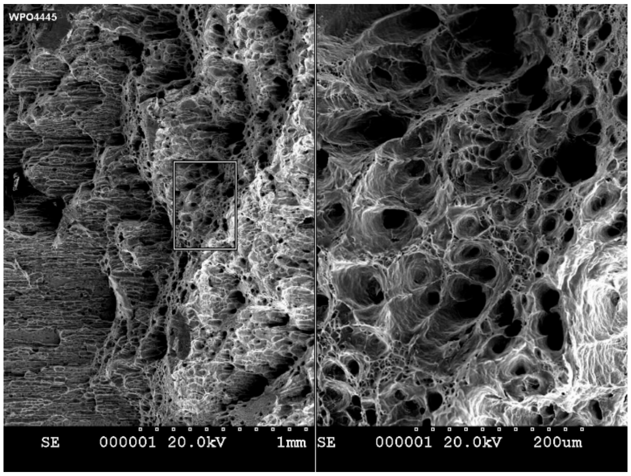


a)



b)

Figure 7. SEM fractographs from two areas of the TNW showing the top of the plug on the left and bottom on the right that exhibit ductile fracture. a) Plug WP04445 and b) WP04450.



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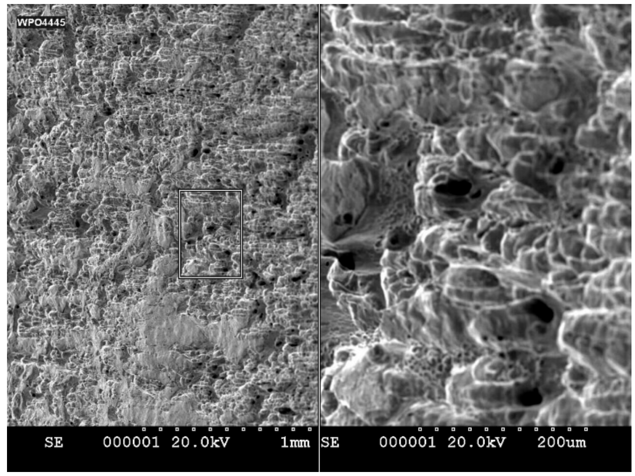

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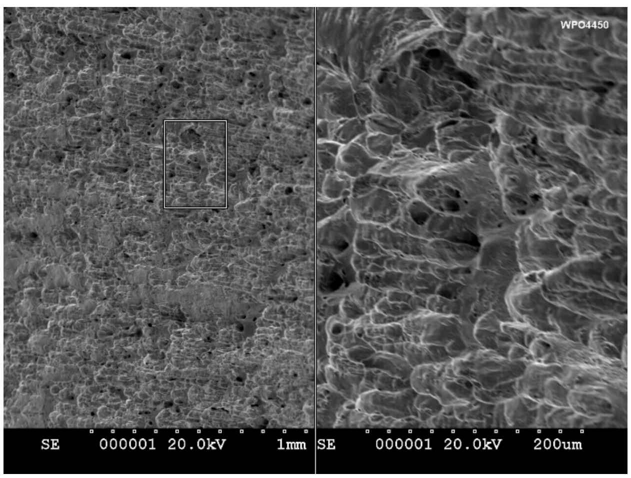

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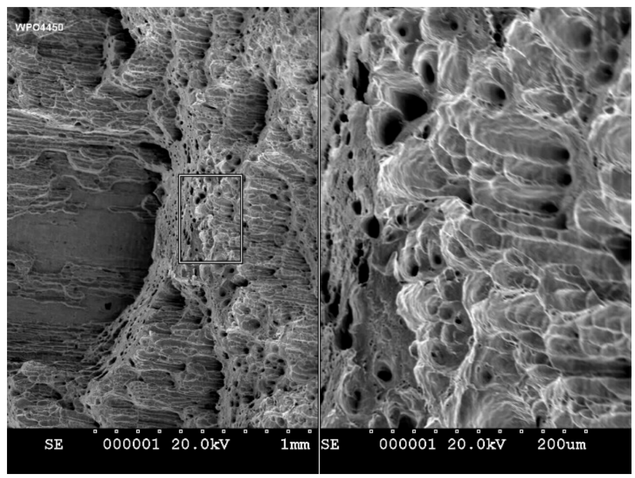

d)

Figure 8. Higher magnification fractographic images of TNW plug a) WP04445 area 1, b) WP04445 area 2, c) WP04450 area 1, and d) WP04450 area 2 all of the images exhibit ductile fracture.

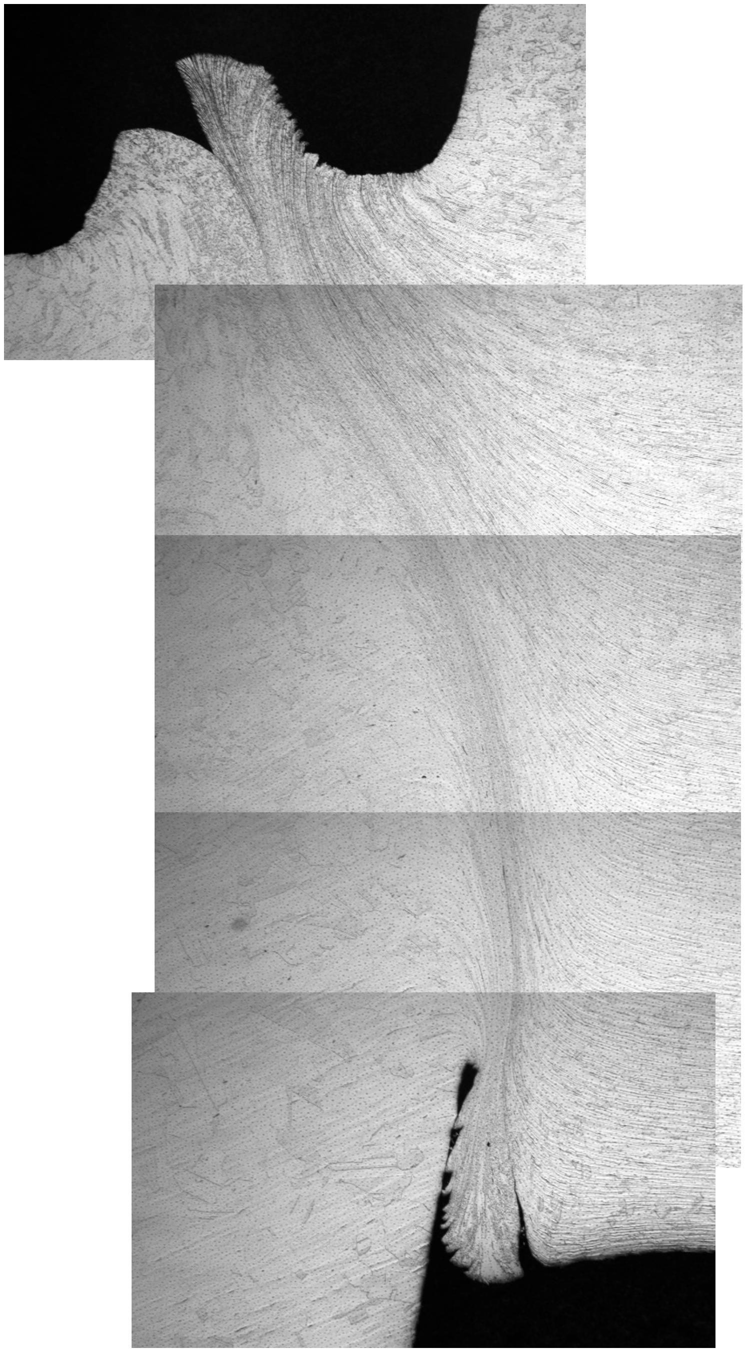

Figure 9. Typical weld microstructures showing the plug to nozzle resistance closure weld extending from the bottom of the plug to the top of the plug of Test Nozzle Weld No. TN00275/WP04448.

Table 2. Actual Conditions used for Production and Test Nozzle Welds

Test Weld No	Nozzle No.	Plug No	Current (kA)	Voltage (VDC)	Force (lbs.)	Weld Duration (sec)
0*	TN000279	WP04444	185.7	2.5875	80,250	1.563
1	TN00271	WP04445	189.7	2.3995	80,031	1.567
2	TN00268	WP04446	191.1	2.9458	80,607	1.567
3	TN00280	WP04447	190.7	2.3289	80,802	1.567
4	TN00275	WP04448	188.5	2.3790	80,096	1.567
5	TN00272	WP04449	190.0	2.2964	80,023	1.567
6	TN00267	WP04450	188.7	2.4655	80,007	1.567
7*	TN00278	WP04451	247.6	2.2794	80,023	1.587
Nonconforming Welds						
1	S04480	WP04325	210.2	NA	84,274	1.577
2	S04500	WP04335	191.6	NA	81,621	1.587

*Test nozzle welds were tested and examined for information only; weld parameters outside scope of TTQAP.

Table 3. Heat Tint Width Measurements from the Test Nozzle Welds

Test No.	Nozzle ID/Plug No	Gold Tint (in) (G)	Blue Tint (in) (B)	Outside Edge of Weld (in.) (O_e)	Inside Edge of Weld (in.) (I_e)	Weld Width (in.) (I_e-O_e)	Heat Tint Width (in) (O_e-G)
0*	TN00279/WP04444	1.67969	1.85938	1.90625	2.02734	0.12109	0.22656
1	TN00271/WP04445	1.67188	1.84375	1.89063	2.02734	0.13672	0.21875
2	TN00268/WP04446	1.6875	1.83984	1.88672	2.03125	0.14408	0.19922
3	TN00280/WP04447	1.67969	1.84375	1.89063	2.03125	0.14063	0.21094
4	TN00275/WP04448	1.67969	1.84766	1.88281	2.02344	0.14063	0.20312
5	TN00272/WP04449	1.67188	1.84375	1.88672	2.03906	0.15234	0.21484
6	TN00267/WP04450	1.67188	1.80859	1.88281	2.02734	0.14453	0.21093
7*	TN00278/WP04451	1.58203	1.75000	1.82422	2.03125	0.20703	0.24219

*Test nozzle welds were tested and examined for information only; weld parameters outside scope of TTQAP.

Table 4. Plug Height Measurements for the Test Nozzle Welds

Test Weld No.	Nozzle No.	Plug No	0°	90°	180°	270°	Plug Height Avg. (in)
0*	TN00279	WP04444	.164	.162	.161	.172	0.1623
1	TN00271	WP04445	.136	.135	.134	.134	0.1348
2	TN00268	WP04446	.129	.130	.128	.128	0.1288
3	TN00280	WP04447	.125	.124	.126	.125	0.1250
4	TN00275	WP04448	.138	.139	.139	.139	0.1388
5	TN00272	WP04449	.125	.124	.125	.125	0.1248
6	TN00267	WP04450	.141	.142	.140	.142	0.1413
7*	TN00278	WP04451	.075	.076	.076	.075	0.0760

*Test nozzle welds were tested and examined for information only; weld parameters outside scope of TTQAP.

Table 5. Ultrasonic Test Results of Test Nozzle Welds

Test No	Nozzle	Plug	Bond Length (in)
0*	TN00279	WP04444	0.26275
1	TN00271	WP04445	0.29025
2	TN00268	WP04446	0.29625
3	TN00280	WP04447	0.30000
4	TN00275	WP04448	0.28625
5	TN00272	WP04449	0.30025
6	TN00267	WP04450	0.28375
7*	TN00278	WP04451	0.34900

*Test nozzle welds were tested and examined for information only; weld parameters outside scope of TTQAP.

Table 6. Leak and Burst Test Results for The Test Nozzle Welds

Test No	Nozzle	Plug	Leak (std cc he/sec)	Burst (psig)
0*	TN00279	WP04444	< 9.6E-10	6,187
1	TN00271	WP04445	< 9.6E-10	8,195
2	TN00268	WP04446	< 9.4E-10	9,351
3	TN00280	WP04447	< 8.9E-10	8,661
4	TN00275	WP04448	< 9.5E-10	NA
5	TN00272	WP04449	< 8.9E-10	9,282
6	TN00267	WP04450	< 9.6E-10	9,644
7*	TN00278	WP04451	NA	NA

*Test nozzle welds were tested and examined for information only; weld parameters outside scope of TTQAP.

Table 7. Bond Lengths Estimated from the SEM Fractography

Nozzle	Plug	Bond Length (in)	Fracture Process
TN00271	WP04445	.2960	Ductile
TN00267	WP04450	.2810	Ductile

Table 8. Weld Throat Measurements Based on Metallographic Sample Examination of Nozzle/Plug TN00275/WP04448

Section No	Measurement 1 (in)	Measurement 2 (in)	Weld Throat (in)
C-1	0.3729	0.3559	0.3559
C-2	0.3572	0.3014	0.3014
D-1	0.3708	0.3509	0.3509
D-2	0.3709	0.3588	0.3588

Attachment 2. Liquid Waste (LW) Task Technical Request, M-TTR-S-00041

OSR 46-529
Rev. 3
02/25/2014

LW FORM

LIQUID WASTE (LW) TECHNICAL TASK REQUEST

Savannah River Site (SRS)

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Reference E7 2.02A, LW Baseline Technical Task Requests

TTR Title

Support Testing/Evaluation of Canisters S04480 and S04500 for Low Weld Peak Current Values

Funding Source	Modification Traveler No.	Technical Task Request No.	Revision
SLA-SRNL-00052, Line Item #1	N/A	M-TTR-S-00041	0

Design Authority Engineer		Date
Cleo Raiford		8-17-2016
Performing Organization: Savannah River National Laboratory (SRNL)	Design Authority Manager* (Signature): [redacted] [redacted]	Date: 10-10-16

Task and Scope Description — Due Date: TBD when Funding Authorized

Funding not currently authorized. Task work to begin upon receiving written Defense Waste Processing Facility (DWPF) and Saltstone Facility Engineering (D&S-FE) approval.

BACKGROUND:
DWPF uses an upset resistance welding process for final closure of radioactive glass filled canisters. The final canister weld is required to be leak tight to water (less than or equal to $1x10^{-4}$ atm cc/sec helium) and meet acceptable weld qualities. The DWPF Parametric Study (i.e., WSRC-TR-94-024) established ranges for welder operating parameters which determined acceptable welds.

Acceptable welds defined by this study require a peak weld current of 248,000 Amps (± 22,000) for a duration of 1.58 seconds (± 0.25) with an applied RAM force of 80,000 lbs (+25,000/-5,000). Welding within this "parametric window" ensures that the resulting weld will meet the waste acceptance requirements for leak tightness and meet weld strength requirements.

(Background, Task and Scope Description continue on Page 3 of 3)

Functional Classification

- ☐ Safety Class
- ☐ Safety Significant
- ☒ Production Support
- ☐ General Service

Functional Requirements

N/A

Quality Requirements

- ☒ All activities are to be performed and documented with Manual E7 and Manual 1Q.
- ☒ Task specific QA plan to be developed as an output of this TTR
- ☒ Other RW-0333P applies

* Design Authority Manager's signature required if request is not associated with an MT.

Continued on next page….

Attachment 2. Liquid Waste (LW) Task Technical Request, M-TTR-S-00041

OSR 45-529
Rev. 3
02/25/2014

LW FORM

Savannah River Site (SRS)

LIQUID WASTE (LW) TECHNICAL TASK REQUEST

Page 2 of 3

Design and Analysis / Technical Documents to be Developed

☐ Not applicable to this request

☐ Calculations	☒ Technical Report	☐ Technical Requirements and Criteria
☐ Drawings	☐ Temp Mod Change Notice	☐ SOW
☐ Specifications	☐ CHA	☐ Alternative Studies
☐ DSA	☐ Quality Inspection Plans	☐ Other, Specify ________

Other Reviews / Reports Required?

☒ No ☐ Yes, Specify ________

Define Review Process for TTR Output Documents

Report to be reviewed per Manual E7, Procedure 2.60.

Technical Agency Acceptance

Technical Agency	Name (print)
SRNL	R.L. Bickford

Acceptance of Task (Signature of Technical Agency Manager)	Date
[redacted]	10/11/2016

Closure

Closure / Deliverables Provided

Design Authority Engineer	**Date**
Design Authority Manager*	**Date**

* Design Authority Manager's signature required if request is not associated with an MT.

Continued on next page…

Attachment 2. Liquid Waste (LW) Task Technical Request, M-TTR-S-00041

Rev. 3
02/25/2014

LW FORM

LIQUID WASTE (LW) TECHNICAL TASK REQUEST

River Site (SRS)

Page 3 of 3

Continuation Page:

BACKGROUND continuation:
Non-conforming Canisters S04480 and S04500 weld peak current values were recorded outside of the operating procedure requirements (i.e., 240,000 – 263,000 Amps), as well as, outside of the Parametric Study requirements (i.e., 226,000 – 270,000 Amps). Weld data recorded and operational acceptance criteria for each canister are listed below:

Canister No.	Weld Peak Current (240 – 263) kAmps	Ram Force (79,000 – 85,000) LBS	Weld Duration (1.50 – 1.67) SEC	Welder MEDAR % Current (Heat)	Nonconformance Reports
S04480	210.2	84,274.0	1.577	72	2016-NCR-05-0038
S04500	191.6	81,621.2	1.587	81	2016-NCR-05-0057

TASK:
Provide required testing and evaluations of Canisters S04480 and S04500 for Low Weld Peak Currents to determine weld acceptability and durability. Provide justification which shows that the weld strength for both canisters is comparable to a canister having all weld specifications met. The evaluations should be based on statistical analysis and sound engineering practices. Activities should include the following:

1) Complete and approve a Statistical Report
2) Perform mechanical tests on DWPF test nozzle welds including:
   a. Ultrasonic Examination
   b. Helium Leak Tests
   c. Burst Tests
   d. Metallographic Examination
   e. Fractographic Examination
3) Perform evaluations on DWPF normal production canister welds, test nozzle welds and non-conforming canister welds with consideration of the following:
   a. Examination of the heat tint
   b. Measurement of the plug heights
   c. Weld parameters (i.e., voltage, current, pressure, force, and duration)

DELIVERABLES:
1. Updates to D&S-FE once work has begun.
2. TTQAP reviewed and approved by SRNL, SRNL Quality Assurance, and D&S-FE.
3. Technical reports for Task 1, 2, and 3 to be reviewed and approved by SRNL, SRNL Quality Assurance, and D&S-FE.

QUALITY ASSURANCE (QA)/RW-0333P:
The QA requirements of RW-0333P shall be applied to this wasteform affecting activity associated with verification of weld acceptability. The TTQAP shall identify the specific RW-0333P implementation procedures that will be used to control the task using a checklist of QA implementing procedures. As specified by QAP 2-3, Attachments 8.1 and 8.2, the Task Technical/QA Plan must identify any additional QA requirements. The Task activities shall be performed using approved E7, 1Q, and other applicable procedures. Personnel qualified to RW-0333P must perform and review this work. The following documents shall be treated by SRNL as lifetime records: Technical Report, Personnel Qualification Records, and any other pertinent documents that may be generated.

REFERENCES:
1. WSRC-TR-94-024, Rev. 1, "DWPF Welder Parametric Study"
2. SW4-15.80-2.3, Rev. 42, "Welding A Canister - Automatic Mode"
3. SW4-V5-CT-2.04, Rev. 5, "Technical Task Requests" [QA Requirements of DOE/RW-0333P]
4. WSRC Inter-Office Memorandum OPS-DTE-970056, R/2, dated 11/18/97 "Canister S00424 Acceptance Justification" (Ref: 96-NCR-05-0138, 2006-NCR-05-0074)
5. Y16.1-WPS-P8-RW(DWPF), Rev. 4, "Austenitic S/S Resistance Welding"
6. SRNL-RP-2016-00637, Rev. Draft October 2016, "Task Technical and Quality Assurance Plan (TTQAP) for the DWPF Weld Current Validation Task"

Attachment 3. Task Activity Matrix

Activity	**Tasks**
1 (TTR Task 3c)	**Capture Weld Voltage**
Responsible	DWPF Instrumentation Engineer
Prerequisites	Develop temporary facility modification documentation and approvals.
Deliverables	Validation that the instrument works during a "current test" and voltage, current, pressure, force data from the conforming welds performed to support this TTQAP.
2a	**Weld Current Test – Determine Heat Settings**
Responsible	DWPF Weld Operators
Prerequisites	Activity 1 and review of production weld data to draw a two-point calibration curve for nominal weld heat % and current from production weld and canister S04480.
Deliverables	% heat setting and measured current for current test to achieve a current of 191 ± 5 kA.
2b (TTR Task 2a, 2b, 2c, 2d, 2e, 3a, 3b, & 3c)	**Weld Six Test Welds at Nominally 191kA for Testing**
Responsible	DWPF Weld Operators,
Prerequisites	Temporary weld procedure & Activity 2a
Requirements	• Weld six test assemblies without ICC plugs at nominally 191 kA, 80,000 lbs force, for 1.50 – 1.67 seconds.
Deliverables	Six test weld nozzles for evaluation with weld data
2c (TTR Task 2a, 2b, 2c, 2d, 2e, 3a, 3b, & 3c)	**Clear Test Nozzle Welds for Release to SRNL**
Responsible	DWPF RPD Staff
Prerequisites	Activities 2a & 2b
Requirements	• Clear test welds from DWPF and transport to SRNL Building 723-A.
Deliverables	Eight cleared test weld nozzles

Continued next page

Attachment 3. Task Activity Matrix

2d (TTR Task 2a)	**Conduct UT Measurement**
Responsible	SRNL MS&T
Prerequisites	Activities 2a, 2b, & 2c
Requirements	• Conduct UT on the samples to determine the bond length and report the data from at least 4 locations including tabulating the minimum, maximum and average values.
Deliverables	UT Data Report
2e (TTR Task 2b)	**Prepare Test Nozzle Welds for Leak and Burst Testing**
Responsible	SRNL RDE
Prerequisites	Activities 2a, 2b, & 2c
Requirements	• Leak tight welded tubing compatible with high pressure testing
Deliverables	Five welded test nozzles with high pressure tubing attached
2f (TTR Task 2b)	**Conduct Leak Tests on all Six Test Nozzle Welds**
Responsible	SRNL RDE HPL
Prerequisites	Activities 2a, 2b, 2c, & 2e
Requirements	• Conduct leak tests on welded samples to verify they meet $1X10^{-4}$ atm-cc / sec He leak requirements.
Deliverables	Data reports
2g (TTR Task 3a & 3b)	**Perform Plug Height and Heat Tint Measurements**
Responsible	SRNL MS&T
Prerequisites	Activities 2a, 2b, & 2c
Requirements	• Measure and record the plug height at 4 locations around the weld, roughly 90° apart.
Deliverables	Completed data sheets

Continued next page

Attachment 3. Task Activity Matrix

2h (TTR Task 2c)	**Conduct Burst Tests on Five Test Nozzle Welds**
Responsible	SRNL RDE HPL
Prerequisites	Activities 2a, 2b, 2c, 2d, & 2e
Requirements	• Conduct Burst Testing of Five test welded articles and provide reports.
Deliverables	Data reports
2i (TTR Task 2e)	**Conduct SEM on at Least One Burst Tested Test Nozzle Weld Sample**
Responsible	SRNL MS&T
Prerequisites	Activities 2a, 2b, 2c, 2d, 2e, 2g, & 2h
Requirements	• Inspect the welded plug after burst testing to measure the bonded ligament.
Deliverables	SEM images

Continued next page

Attachment 3. Task Activity Matrix

3a (TTR Task 2d)	**Conduct Metallographic Examination of One Test Nozzle Weld at a Minimum of Locations where UT Indicates Minimum, Maximum and Two Nominal Weld Lengths**
Responsible	SRNL MS&T
Prerequisites	Activity 2a, 2b, & 2c
Requirements	• Section welded plug at areas that indicate shortest ligament length based on UT results, lowest weld heat based on heat tint, and at four representative areas. • Mount sections for metallographic preparation, polish, and etch electrolytically with 10% oxalic acid. • Measure bond length, take photographs showing overall weld length and at higher magnifications to show interfacial conditions.
Deliverables	Photomicrographs showing the overall bond lengths at the minimum, maximum, and nominal conditions. Dimensional data from same.
3b (TTR Task 2d)	**Conduct Bend Fracture of Weld, Characterize Fracture Surface and Determine Bond Length**
Responsible	SRNL MS&T
Prerequisites	Activity 2a, 2b, 2c, & 2f
Requirements	• Section welded plug to prepare a fracture sample. • Fracture weldment and examine the fracture surface for failure mode and correlation to UT bond length measurements.
Deliverables	Fractographs of the surfaces.

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