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## WELDING PLUTONIUM STORAGE CONTAINERS

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### ABSTRACT

The outer can welder (OCW) in the FB-Line Facility at the Savannah River Site (SRS) is a Gas Tungsten Arc Weld (GTAW) system used to create outer canisters compliant with the Department of Energy 3013 Standard, DOE-STD-3013-2000, Stabilization, Packaging, and Storage of Plutonium-Bearing Materials. The key welding parameters controlled and monitored on the outer can welder Data Acquisition System (DAS) are weld amperage, weld voltage, and weld rotational speed.

Inner 3013 canisters from the Bagless Transfer System that contain plutonium metal or plutonium oxide are placed inside an outer 3013 canister. The canister is back-filled with helium and welded using the outer can welder. The completed weld is screened to determine if it is satisfactory by reviewing the OCW DAS key welding parameters, performing a helium leak check, performing a visual examination by a qualified weld inspector, and performing digital radiography of the completed weld. Canisters with unsatisfactory welds are cut open and repackaged. Canisters with satisfactory welds are deemed compliant with the 3013 standard for long-term storage.

### I. INTRODUCTION

Plutonium metal and oxide have been stored at the Savannah River Site (SRS) for several years. In order to be compliant with the DOE 3013 standard, the FB-Line Facility at SRS is packaging plutonium metal and stabilized plutonium oxide into outer canisters using the OCW system.

Initial development and testing of the OCW system was performed by the Savannah River Technology Center (SRTC).

This testing included the welding of over 200 outer canisters to verify that the key weld parameters were adequate and would produce ASME acceptable outer 3013 canisters. The testing by SRTC led to the key welding parameters that are used as the first screening for acceptable welds.

#### Key Weld Parameters:

Weld Amperage	173-187 Amps
Weld Voltage	8.5-10.0 Volts
Weld Rotational Speed	
Phase I (First 135°)	0.50-0.56 RPM
Phase II (Second 242.5°)	0.57-0.63 RPM

### II. OUTER CANISTER SCREENINGS

The outer 3013 canisters undergo several screenings to verify successful weld completion. Four screenings are performed in the FB-Line facility and are performed on each production canister welded. The first screening is a review of the key weld parameters. The key weld parameters are recorded on the OCW DAS and summarized for operator review. The results of the weld amperage, weld voltage, and weld rotational speed must be within the limits as defined above.

Second, the outer canisters undergo a helium leak test. A helium leak detector analyzes the outer canister for helium leaks, and reports a helium leak rate to the operator. The helium leak rate must be less than  $2.0\text{E-}7$  std.  $\text{cm}^3$  helium/second for the outer canister to be satisfactory. The helium leak detector reports acceptability based on a maximum acceptable leak rate of  $1.8\text{E-}7$  std.  $\text{cm}^3$  helium/second.

Third, the outer canisters undergo a visual examination by an ASME qualified visual examiner. The visual examination

consists of an examination of the outer canister weld area. The weld area must be free from a rolled or consumed edge, free from lack of fusion, cracks, or pinholes, and the undercut must be less than 0.012 inches.

Fourth, the outer canisters undergo a screening by the digital radiography (DR) system for weld porosity. The DR system analyzes the weld area of the outer canister, and the DR operator is able to locate and size any relevant pores that are present in the weld by using the DR software. The DR criteria are based on ASME Section VIII, and they take into consideration the pore size measurement uncertainty associated with the DR system. The DR operator reviews the results of the screening and bases the acceptability of the outer canister on the following criteria listed below. The DR system acceptance was established by comparing DR system results against known ASME film radiography results.

Isolated Rounded Indications – must be less than 0.038 inches.

Random Rounded Indications – must be less than 0.028 inches.

In addition, the DR operator may determine that an outer canister is unacceptable based on other indications that cause the weld to be suspect. The DR system is operated by an ASME qualified inspector.

### III. WELD QUALIFICATION PLAN

A weld qualification plan was written to outline the activities and parameters required to meet the 3013 standard during creation of outer 3013 canisters. The quality of the outer 3013 canister closure weld depends upon compliance with these activities and parameters. During development testing of the system, the canisters underwent various non-destructive and destructive tests to confirm that satisfactory welds were being produced by the OCW at the key weld parameters. Additional testing was also required after installation of the OCW in the FB-Line facility. A welding procedure specification (WPS) as defined by ASME Section IX was established for the OCW. This was completed by welding an “ASME test lid” on an outer 3013 canister. These special lids underwent tensile and bend tests and weld metallography to determine weld penetration. Each operator qualified on the OCW system obtains a welding operators performance qualification record (WPQR). The WPQR is earned by welding an outer 3013 canister using the established procedure. These operator qualification canisters underwent screenings in FB-Line as well as film radiography.

### IV. INSTALLATION AND TESTING

The OCW system was installed in FB-Line in December 2002. The start-up testing consisted of a 25 canister run as required by the weld qualification plan in order to verify that the OCW produced compliant outer 3013 canisters. Surrogate inner canisters (weighted and welded) were placed inside of an outer 3013 canister and welded using the standard procedure. These canisters were subjected to the screenings in FB-Line, as well as film radiography and weld metallography. If the outer canisters did not pass one of the screenings, another can was substituted. This start-up testing validated the welding process and screening tools.

Operating procedures were developed for the OCW system. These procedures underwent extensive review and validation to ensure that all parameters could be met satisfactorily and safely. The operators were ASME trained and qualified to operate the OCW.



Outer Can Welder Installed in FB-Line  
Figure 1

### V. OPERATION

The FB-Line outer can welder welded the first production outer canister on April 1, 2003. The operation of the outer can welder begins with selection of the inner canisters to be placed in an outer canister. The selected inner canisters are retrieved from the storage location and cleaned as necessary. The outer canister is placed in the outer can welder. The inner canisters are then placed inside of the outer canister. The outer canister lid is placed in a bell jar hood, which is then placed over the outer canister. The outer canister is back-filled with helium, and the outer canister lid is pressed onto the outer canister. The bell jar hood is removed, and the weld head is placed in position over the outer canister. The welder is started, and the programmed sequence completes the weld. During the welding, the DAS records the key weld parameters. The operator is able to watch and monitor the weld progress on the DAS screen. After completion of the weld, the outer canister is removed from the outer can welder and is allowed to cool.

If the review of the key weld parameters is satisfactory, the outer canister is helium leak checked using a leak detector. A bell jar is placed over the outer canister, and the leak detector pulls a vacuum on the outer canister. A mass spectrometer then analyzes for helium, and the leak detector determines a helium leak rate. The leak detector DAS compares the leak rate to the allowed limit, and provides the results to the operator.

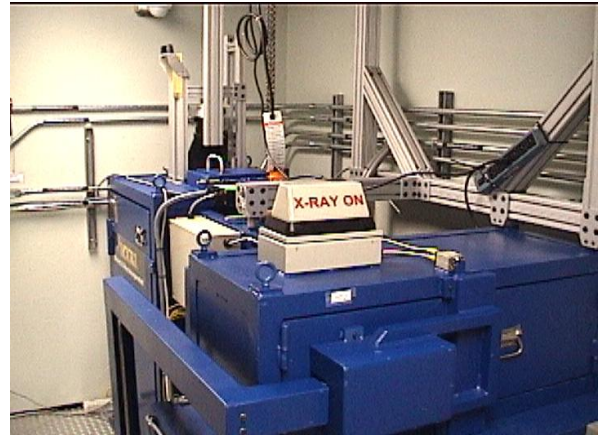


Leak Detector Installed in FB-Line  
Figure 2

A qualified weld inspector then performs a visual inspection using the criteria described in Section II. Upon satisfactory completion of the key weld parameter screening, helium leak test, and visual examination, the outer canister is transferred to the digital radiography system for the weld porosity screening.

## VI. DIGITAL RADIOGRAPHY

The digital radiography system analyzes the outer canister weld for porosity. The outer canister is placed inside of the digital radiography system, and a qualified digital radiography operator operates the digital radiography computer to perform the weld porosity screening. The digital radiography system rotates the outer canister in segments. The qualified operator reviews the digital image on the computer for evidence of pores in the weld area. If a pore is found, the operator is then prompted to properly size the pore using the computer. The pore location and size is recorded, and this process is repeated through each of the segments. If any pores are found that exceed the criteria described in Section II, the outer canister is rejected.



Digital Radiography System Installed in FB-Line  
Figure 3

## VII. PERFORMANCE REVIEW

After the completion of no greater than the 24<sup>th</sup> satisfactory production outer canister, a process parameter verification (PPV) outer canister weld must be completed. The PPV outer canister is used to qualify the lot of outer canisters consisting of up to 24 satisfactory production outer canisters welded since the completion of the previous PPV canister. The PPV weld consists of placing a surrogate inner canister inside of an outer canister and welding the outer 3013 canister following the production canister welding process. A surrogate inner canister is placed inside the outer canister so that the PPV canister weld accurately simulates a typical production weld. This PPV outer canister is welded and undergoes the four FB-Line screenings: key weld parameter review, helium leak test, visual inspection, and digital radiography porosity screening. In addition, the PPV outer canister undergoes film radiography and must pass Section VIII film radiography criteria. The PPV outer canister also undergoes metallography and must pass ASME Section VIII requirements for weld penetration, lack of fusion, cracks, and undercut. If the PPV outer canisters do not pass the screenings performed in FB-Line, another PPV canister may be substituted. If the PPV outer canister does not pass the film radiography or metallography tests, the entire lot of up to 24 canisters must be dispositioned.

The outer can welder currently has a failure rate of approximately 10 percent. These failures of the weld primarily come from unsatisfactory results from the visual inspections of the outer canister weld and from unsatisfactory results from the digital radiography porosity screenings of the outer canister weld. A review of each of the unsatisfactory outer canisters revealed that there is no apparent link between any of the weld parameters and unsatisfactory screenings.

A review of the key weld parameters as recorded by the DAS reveals that the averages of the weld amperage and weld

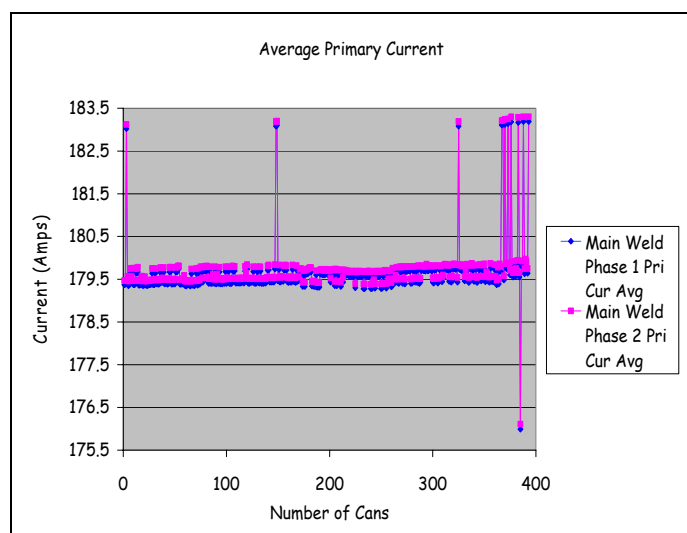
voltage have remained virtually constant. The weld rotational speed has remained constant for both phases.

The averages and standard deviations for the weld amperage, weld voltage, and weld rotational speed from approximately 400 outer canisters are shown in the table below.

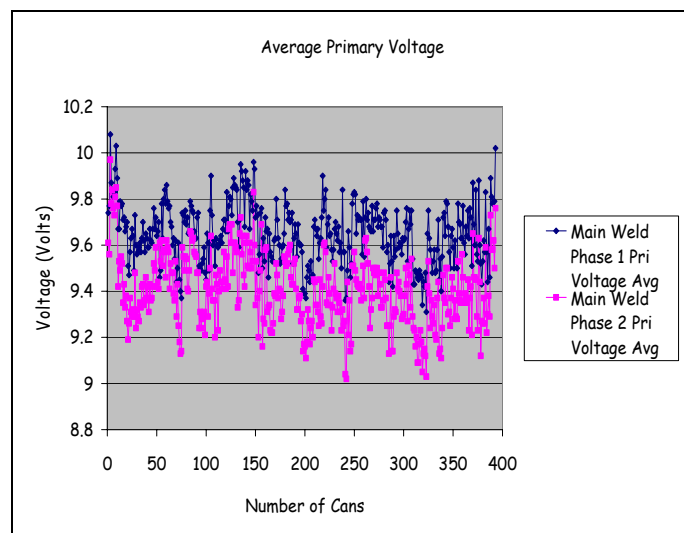
Parameter	Average	Standard Deviation
Main Weld Phase 1 Pri Cur Avg	179.6	0.66
Main Weld Phase 1 Pri Voltage Avg	9.7	0.13
Main Weld Phase 1 RPM Avg	0.54	0.01
Main Weld Phase 2 Pri Cur Avg	179.7	0.66
Main Weld Phase 2 Pri Voltage Avg	9.4	0.16
Main Weld Phase 2 RPM Avg	0.61	0.01

Weld Parameters Statistical Results  
Table 1

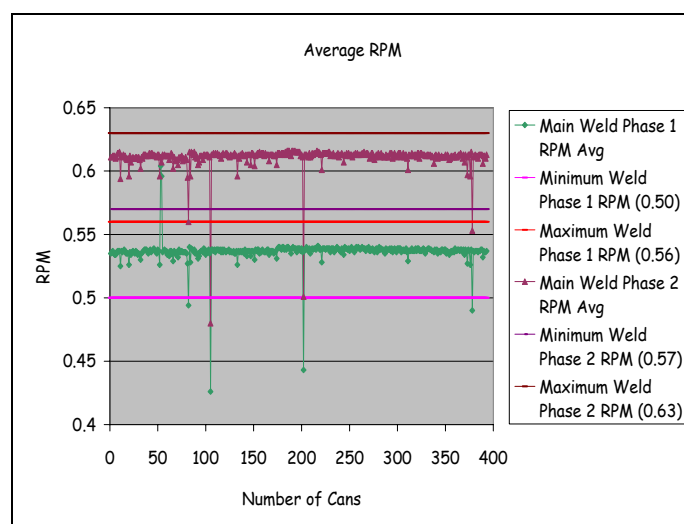
The results of the key weld parameters from approximately 400 outer canisters are shown on the figures below.



Weld Amperage  
Figure 4



Weld Voltage  
Figure 5



Weld Rotational Speed  
Figure 6

## VIII. CONCLUSIONS

The outer can welder provides a successful means for creating an adequate plutonium storage container. As of November 19, 2003, 331 satisfactory production outer canisters have been welded in the FB-Line facility. The four screenings discussed allow for assurance that these outer canisters meet all of the weld requirements. The satisfactory production outer 3013 canisters generated by the FB-Line outer can welder system are suitable for long term storage.

**IX. ACKNOWLEDGMENTS**

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**X. REFERENCES**

DOE STANDARD, Stabilization, Packaging, and Storage of Plutonium Bearing Materials, DOE-STD-3013-2000.