

HNF-29195-FP
Revision 0

Closure Welding Radioactive Materials Containers at the Department of Energy (DOE) Hanford Site

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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P.O. Box 1000
Richland, Washington

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Date Published
August 2006

To Be Presented at
FABTECH International & AWS Welding Show

AWS, FMA, SME
Atlanta, Georgia

October 30 through November 2, 2006


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Closure Welding Radioactive Materials Containers at the Department of Energy (DOE) Hanford Site

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INTRODUCTION

The Department of Energy's (DOE) responsibility for the disposition of radioactive materials has given rise to several unique welding applications. Many of these materials require packaging into containers for either interim or long-term storage. It is not uncommon that final container fabrication, i.e., closure welding, is performed with these materials already placed into the container. Closure welding is typically performed remote to the container, and routine post-weld testing and nondestructive examination (NDE) are often times not feasible.

Fluor Hanford has packaged many such materials in recent years as part of the Site's cleanup mission. In lieu of post-weld testing and NDE, the Fluor-Hanford approach has been to establish weld quality through "upfront" development and qualification of welding parameters, and then ensure parameter compliance during welding. This approach requires a rigor not usually afforded to typical welding development activities, and may involve statistical analysis and extensive testing, including burst, drop, sensitive leak testing, etc.

This paper provides an instructive review of the development and qualification activities associated with the closure of radioactive materials containers, including a brief report on activities for closure welding research reactor, spent nuclear fuel (SNF) overpacks at the Hanford Site.

TECHNICAL APPROACH

Welding development and qualification activities associated with the closure of radioactive materials containers typically require a greater level of effort than for most welding applications. As noted above, this is primarily due to the critical nature of the materials being packaged and the difficulty in performing routine post-weld testing and NDE. In addition, this work is performed in a highly regulated environment that is subject to significant review and analysis. The technical basis for development and qualification activities must ensure that requirements are met and that container performance will meet the design service.

The following activities should be considered for welding development and qualification for the closure of radioactive materials containers:

- Clearly identify and understand weld requirements and criteria, including container service – performance and regulatory.
- Based on weld requirements and criteria, select the best-suited welding process. Selection process may include performing a "down-select" or alternative selection review.
- Prepare a written development/qualification plan to include:
 - Welding trials (including mockup assemblies) to establish suitable parameters. Parameter development should target values that produce desired (optimum) weld characteristics, such as bead penetration, bead shape, deposition rate, etc.

- Qualification testing to include that specified by the applicable Code(s) and or Regulatory Body(s) and any additional testing necessary to establish required confidence in the process and parameters. Test and examination may include non-destructive examination (NDE), mechanical testing (burst, drop, tensile, bend), metallography, etc.
- Demonstration or validation testing.
- Procure or design a suitable data acquisition system (DAS) to be used to capture production weld data for weld parameter compliance verification.

RESULTS/DISCUSSION

Fluor Hanford has successfully completed several radioactive materials packaging campaigns, including those for plutonium-bearing Special Nuclear Materials (SNM) [Ref 1] and spent nuclear fuels (SNF) [Ref 2]. The following provides a brief review of the activities for the development and qualification of a Gas Tungsten Arc Welding (GTAW) process for closure of overpacks containing TRIGA®¹ research reactor SNF.

Requirements and Criteria

The overpack is designed to provide confinement of the packaged materials against release to the environment during interim storage over a 40-year design life. The materials of construction, heads, shell and miscellaneous pieces, are Type 304L. Qualification of the welding process, procedure and Welding Operators must meet the requirements of ASME Section IX. In addition, storage facility criteria require the welded overpack to be leaktight per ANSI N14.5 ($\leq 1 \times 10^{-7}$ atm cc/sec air).

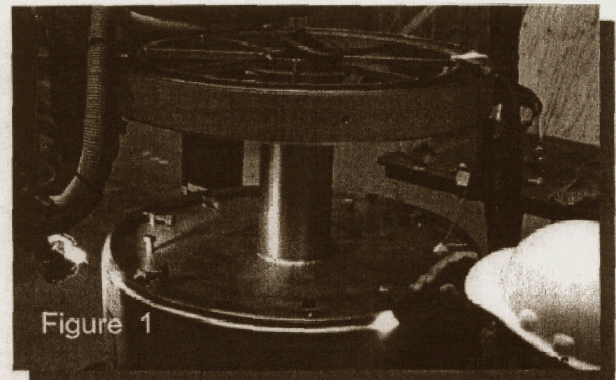
Welding Process Selection and Description of Equipment

The Gas Tungsten Arc Welding (GTAW) process, machine-welding mode, was selected for this process. Equipment includes a full-function, microprocessor controlled system (Gold Track V) manufactured by Liburdi Dimetrics®². Welding is performed remote to the overpack with the aid of a video console and cameras at the weld head. A fixture to support and align the weld head, with respect to the overpack closure, during welding was designed and fabricated – See Figure 1.

Welding Trials

Initial welding trials were made on flat plate test coupons, representative of the overpack weld joint with regard to material type, thickness, weld joint design and welding position. These were followed by trials on round sections, simulating the actual overpack.

One of the constraints considered during parameter development was weld joint fitup, i.e.,



¹ TRIGA (Training, Research, Isotopes, General Atomics) is registered trademark of General Atomics

² Liburdi Dimetrics is a registered trademark of Liburdi Dimetrics Corporation


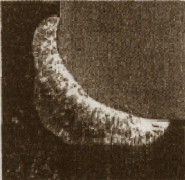

the potential for a gap at the shell/head interface. Per the design drawing, the gap could range from 0 to 3/32-inch. To ensure the welding parameters/process would accommodate fitup within this range, several test coupons were welded in which gaps varied from 0 to 5/32-inch. It was determined that a 3/32-inch gap could be successfully welded (bridged).

Qualification Testing

With the nominal set of welding parameters selected, a simple statistical experiment was designed to evaluate bounding limits for two of the welding parameters – primary welding current and primary travel speed. These parameters were judged to be of key importance in determining weld bead shape, puddle control and fusion at the root of the joint.

The purpose of the experiment was to identify a suitable/acceptable range for the critical parameters. Bounding values were set at the Welding Engineers discretion to bracket anticipated variability of the welding and measuring equipment and to accommodate potential upset conditions.

The experiment, a two-factor, two-level factorial with replication at high and low limit values, was performed on an actual production overpack. Welds were subjected to Visual Inspection (VT), Liquid Penetrant examination (PT), Helium Leak testing (LT) and metallographic evaluation. The following table provides test results and photomicrographs from three (of the eight) weld sections, representing the low, high and nominal heat-input settings.

Test ID	VT	PT	LT	Metallography		
SW-1-1	Accept No Indications	Accept No Indications	Accept Leak Rate: < 1×10^{-7} atm-cc/sec	Accept	Accept	Accept
SW-1-2				SW-1-1 (Low Heat)	SW-1-4 (High Heat)	SW-1-6 (Nom Heat)
SW-1-3				210 Amps / 4 ipm	270 Amps / 3.2 ipm	240 Amps / 3.6 ipm
SW-1-4						
SW-1-5						
SW-1-6						
SW-1-7						
SW-1-8						

One additional production overpack closure was completed, in which the entire weld was deposited using the nominal heat input parameters. Finally, ASME Section IX welding procedure testing was performed. All qualification testing requirements were met.

Additional Testing and Evaluation

Integrated Proof Testing

A production overpack in which both heads were fitted with lifting lugs (in production only the top head receives these lugs) was welded using the qualified process. This overpack was subjected to a pull test of 1.25 times the design lifting load – See Figure 2. The tested overpack was visually examined and liquid penetrant tested for damage and one of the head-to-shell welds was helium leak tested. All testing requirements were met.

Maximum Overpack Temperature

To understand the impact the heat of closure welding may have on the overpack contents, a temperature calculation, using the computer code FLUENT^{TM3}, was performed. The maximum overpack temperature, at approximately 3 inches from the weld (on the shell), was calculated to be 153^o C (307^o F). Testing to measure actual maximum temperatures, via thermocouples attached to the final qualification overpack weld, was performed. Temperature values were recorded using a vendor-calibrated data logger; thermocouple attachment locations and setup are shown in Figure 3. A comparison of the calculated value at 3 inches from the weld (on the shell) to the measured value at the same location, confirmed the conservative nature of the calculation. That is, 153^o C (307^o F) and 80^o C (176^o F) for the calculated vs. the measured values, respectively.

Discussion

In addition to the ASME Section IX certifications, the Welding Operators scheduled for production welding were those that performed the development work. This provided opportunity to become thoroughly familiar with the process and the specific technique developed. The "machine-welding" mode relies, to a degree, on the skill of the Welding Operator. The overall strategy for providing high confidence in the overpack closure welding includes both the development qualification activities and the skill of the qualified Welding Operators.

CONCLUSION

Fluor Hanford has successfully closure welded many radioactive materials packages. As nuclear site cleanup activities continue, there will be opportunity and need to develop and qualify additional closure-welding processes. The above outlined approach may be referenced when preparing/planning for these activities.

References

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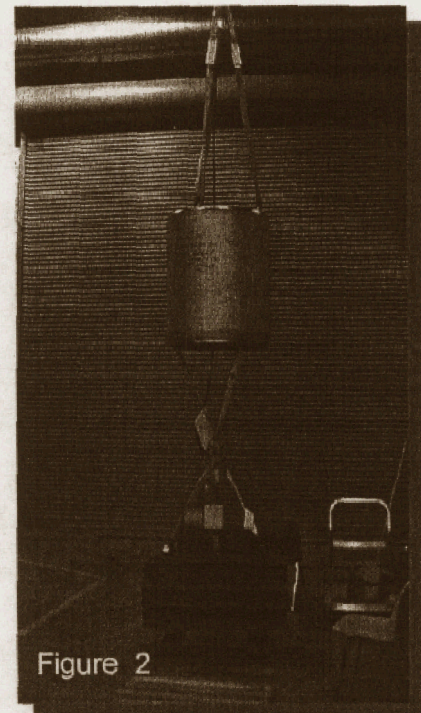


Figure 2

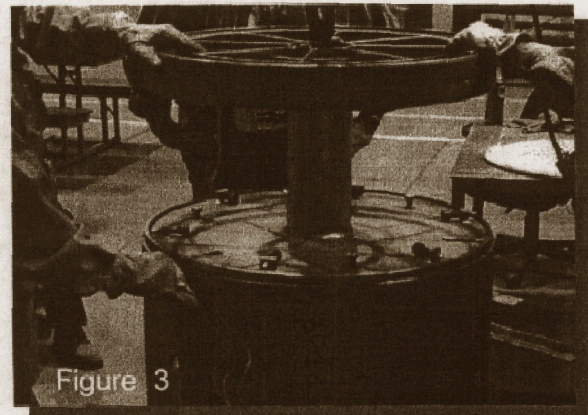


Figure 3

³ Fluent is a registered trademark of Fluent Incorporated