Nuclear and Emerging Technologies for Space, American Nuclear Society Topical Meeting
Richland, WA, February 25 – February 28, 2019, available online at http://anstd.ans.org/

Re-establishment of Light-Weight Radioisotope Heater Unit Platinum-30% Rhodium Alloy Components Production at Oak Ridge National Laboratory

Kenneth R. Veach, Jr.[1], Brian R. Friske[2], and Roger G. Miller[3]

[1]1 Bethel Valley Road, Oak Ridge, Tn, 37831, (865) 574-1692, veachkrjr@ornl.gov
[2]1 Bethel Valley Road, Oak Ridge, Tn, 37831, (865) 576-1417, friskeb@ornl.gov
[3]1 Bethel Valley Road, Oak Ridge, Tn, 37831, (865) 241-7338, millerrg@ornl.gov

During FY2018 the Oak Ridge National Laboratory (ORNL) Radioisotope Power Systems (RPS) Program completed re-establishment of capability to produce platinum-30% rhodium (Pt-30Rh) alloy components for the Light Weight Radioisotope Heater Unit (LWRHU) Program. These components were last produced at Mound Laboratory in the mid/late-1990s for the National Aeronautics and Space Administration (NASA) Cassini mission. The LWRHU Pt-30Rh Clad Body Subassembly and component fabrication operations are being performed in the iridium alloy Clad Vent Set (CVS) production area at ORNL. Existing equipment (furnaces, electron beam welders, presses, inspection, etc.) are being utilized along with new equipment (two lathes and laser marker) that were purchased for this work. ORNL purchased and qualified an initial quantity of starting materials (Pt powder, Pt-30Rh foil, sheet, and tubing). Equipment, tooling, and materials were procured/fabricated and qualified. Drawings and specifications were updated/modified/developed to the ORNL RPS Program format. Procedures were developed and qualified. All drawings, specifications, and procedures were reviewed/approved by the Idaho National Laboratory (INL) RPS Lead Lab Document Configuration Control Board (DCCB). The dimensional inspection operations and special processes (cleaning, heat treating, sintering, dye penetrant inspection, leak testing, and welding) were successfully qualified and documented. This paper will discuss the process of re-establishing LWRHU production at ORNL to provide for future NASA space exploration science mission needs[10].

I. INTRODUCTION

LWRHU are radioisotope fueled heat sources designed to help maintain desired temperatures in crucial locations throughout the spacecraft. These heater unit clads are fabricated from Pt-30Rh alloy sheet, foil, and seamless tubing. LWRHU clad subassemblies consist of five-piece parts (i.e. Shim, Vent Cap, Frit, Closure Cap, and Clad Body) that are manufactured using various metalworking processes and/or finish machining operations (see Figure 1).

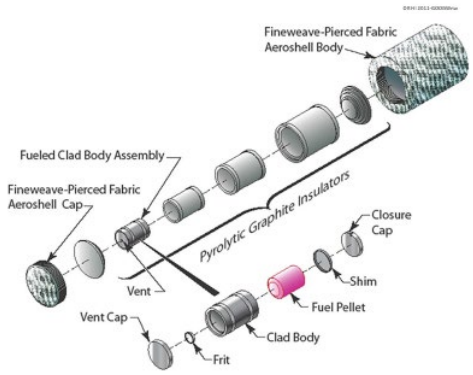

Fig. 1. LWRHU configuration

A Frit fabricated from platinum powder is electron beam welded to a Vent Cap to create a Vent Cap Assembly. A Vent Cap Assembly is electron beam welded to a Clad Body to create a Clad Body Subassembly. The Shim, Closure Cap, and Clad Body Subassembly will be shipped to Los Alamos National Laboratory for fueling[1].

II. LOGISTICS

As early as 2008, inquiries were made to ORNL about establishing the capability to produce LWRHU for future NASA missions. ORNL was asked to prepare a manufacturing capability plan based on previous production activities at Mound Laboratory.

After it was determined that ORNL would be the Laboratory to re-establish the capability for production of LWRHU Pt-30Rh components, it was necessary for the LWRHU Operations Team to decide on the best location for production. It was determined that the LWRHU clad component production would take place in the same area where the CVS are being manufactured and processed because of the similarity between the manufacturing equipment and processes.

In late 2010, the ORNL RPS Program completed the necessary National Environmental Policy Act (NEPA) Action Review and Documentation Form that was screened for compliance of any potential adverse environmental concerns for the potential production area and the scope of activities that would take place in that area. The RPS Program was notified that the LWRHU component fabrication project scope was compliant with NEPA requirements.

III. CONFIGURATION MANAGEMENT

All Mound Laboratory tooling/clad component drawings, procedures, and specifications that were utilized during previous production of LWRHU were transferred to INL for storage after closure of the Mound Laboratory. INL transferred the documents to ORNL once it was determined that the ORNL RPS Program would be re-establishing production of LWRHU Pt-30Rh alloy components.

The Mound Laboratory tooling/piece part drawings were revised and/or modified, then converted to the ORNL format by the Non-Nuclear Facilities Division Engineering Design group. The specifications and procedures were updated/modified and converted to the ORNL RPS Program format by the ORNL RPS Program Task Managers.

The LWRHU documents were approved through the ORNL RPS Program Configuration Control Board, then they were sent to the Lead Laboratory DCCB and DOE-NE Office for final acceptance. All LWRHU controlled documents are stored electronically and protected from access by non-RPS Program approved personnel.

IV. PROCUREMENT

The LWRHU Operation Team evaluated the existing material, tooling, supporting documents that were transferred from INL, to better understand what procurements would be necessary to re-establish LWRHU clad component production capability.

In 2010, it was determined that it would be necessary to purchase two CNC lathes (see Figure 2) to perform fabrication operations on two of the clad components. The LWRHU Operation Team determined the necessary amount of raw/fabricated materials (i.e., platinum powder and Pt-30Rh sheet, foil, and seamless tubing) to be ordered to produce LWRHU clad components at a constant-rate.

Fig. 2. Haas SL-10 lathe used for all but two machining operations during LWRHU fabrication.

Drawing/blanking/pressing dies and other miscellaneous tooling had to be fabricated in accordance with detailed drawings to enable production. All raw/fabricated materials were purchased from evaluated suppliers based on the ORNL Supplier Evaluation Program as a part of the ORNL Quality Management System.

All LWRHU tooling and materials were procured to quality significant reviewed purchase orders in accordance with RPS Program controlled purchase specifications and/or detailed drawings. Receipt inspections by the cognizant RPS Program Task Managers and/or Quality Representative were performed to ensure that the materials met the established acceptance criteria (i.e., drawings and specifications). Final acceptances for qualification were based on tooling qualification studies, dimensional and visual inspection, non- and destructive examination, metallography, outside service provider chemical analysis testing (e.g., impurity and carbon and oxygen analyses), supplier

certifications and/or data, and tensile testing results in accordance with the purchase orders and LWRHU established acceptance criteria on the detailed drawings and/or specifications.

IV. QUALIFICATION

The initial step in qualifying the dimensional inspection processes for the LWRHU clad components was to determine the best measuring system (e.g., instrumentation, calibration standards, environmental influences, human operator limitations, and features of the parts being measured) to use for the features detailed in each part drawing. The appraisers had to be knowledgeable about what must be measured and the requirements that need to be met using the selected measuring instrument. It was vital to examine the different methods and characteristics when selecting the proper measuring equipment. A senior dimensional inspector evaluated and determined the best equipment to be used to measure the dimensions for all four LWRHU clad parts. The preferred method for determining the best measuring system for the LWRHU parts was to conduct Gage Repeatability and Reproducibility (GR&R) studies. GR&R studies can be a critical part of a successful process control system to help determine: 1) if measuring systems are acceptable for their intended use, 2) which part of a measuring system is contributing the most variation, and 3) if improvements to the measuring system are needed.

The ORNL-fabricated LWRHU parts that were measured for process capability are representative of pre-production parts made during the initial set-up of machining equipment. The fabricated clad components were all within specification limits. It has been established that some nominal values were not optimum for production and had to be targeted to the upper or lower side of the specification limits to improve manufacturing. With continued improvement of the measuring methods and process control, dimensional inspection personnel, environment, machines and equipment, and tooling the process variability will be reduced and targeting of specification limits will be more centered. The process capability study indicates that the dimensional inspection process is adequate for the measurement of Pt-30Rh alloy component parts.

V. SPECIAL PROCESSES

The LWRHU clad component re-establishment effort had some individual processes whose results could not be completely verified by measurements or an objective check, and that possible discrepancies could have affected the performance of the clad components. These special processes (i.e., acid cleaning[7], leak testing[6], welding[9], heat treatment[4], frit fabrication[5], and dimensional inspection[8]) required assigned personnel that were specifically trained and qualified. The tools/equipment utilized during the special processes were validated to ensure that the planned results were achieved.

VI. TRAINING

It is the responsibility of the LWRHU Task Manager to assure that all personnel are trained/qualified to perform their assigned work, to provide training to maintain job proficiency, and to maintain personnel training/qualification records. The LWRHU Task Manager is responsible for assuring that all personnel performing production activities for his/her task are sufficiently trained/qualified. The extent of training is commensurate with the scope, complexity, and nature of the activity, and the education, experience, and proficiency of the person. The LWRHU Task Manager maintains a list of all trained/qualified personnel performing production work.

VII. READINESS ASSESSMENT

A readiness assessment plan was generated to evaluate the processes established for LWRHU production start-up and verify compliance to RPS Program requirements. The plan described the responsibilities, requirements, and actions required for a readiness assessment of the LWRHU Task. It was intended to confirm programmatic "state of readiness" for startup of LWRHU production activities[2].

The readiness assessment process provided a graded approach through independent verification of readiness for startup production activities. It was not intended to be a management tool to achieve readiness. Rather, the readiness assessment confirms readiness to start operations. The methodology employed for this readiness assessment included the following elements:

- Lines of Inquiry – Evaluation of LWRHU production start-up activities against criteria contained in the general lines of inquiry.
- Document reviews – Applicable requirements and supporting operating procedures and protocols.

In conclusion, the development and implementation of the LWRHU quality assurance infrastructure met the applicable requirements

conveyed through DOE-mandated requirements to support production start-up[3].

ACKNOWLEDGMENTS

This work was sponsored by the United States Department of Energy Office of Nuclear Facilities Management (NE-31). Primary funding was provided by the NASA Science Mission Directorate. The authors gratefully acknowledge the support and guidance of George B. Ulrich, RPS Program Manager at ORNL.

REFERENCES

1. B. R. FRISKE and K. R. VEACH, JR, Characterization of Platinum Powder for Light Weight Radioactive Heater Unit Frit Production, NETS (2018).
2. K. R. VEACH, JR., Oak Ridge National Laboratory Readiness Assessment Plan for Start-up of Light Weight Radioisotope Heater Unit Component Production (2018).
3. M. C. VANCE, Readiness Assessment for Start-up of Light Weight Radioisotope Heater Unit Component Production at the Oak Ridge National Laboratory (2018).
4. R. G. MILLER, Qualification of LWRHU Foil Heat Treatment Procedure LWRHU-MPJ-018, Route Card A, Recrystalization of Platinum 30% Rhodium Alloy Foil (2018).
5. B. R. FRISKE, Qualification of LWRHU Frit Fabrication at ORNL (2018).
6. B. R. FRISKE and J. M. PRYOR, Qualification of Clad Body Subassembly Leak Testing Operation in Procedure LWRHU-K-023 (2015).
7. B. R. FRISKE, Qualification of LWRHU Acid Cleaning Procedure LWRHU-Y-006 (2015).
8. K. R. VEACH, JR., Qualification of LWRHU Dimensional Inspection (2018).
9. R. G. MILLER, Qualification of Welding Procedures and Welding Operators for LWRHU-K-22, Vent Cup Assembly Welding and Inspection Procedure and LWRHU-K-023, Clad Body Subassembly Welding and Inspection Procedure (2018).
10. S. G. JOHNSON, J. LOPEZ-BARLOW and G. B. ULRICH, Light Weight Radioisotope Heater Units (LWRHU) Path Forward (2018).