WSRC-RP--90-271

DE91 005113

WESTINGHOUSE SAVANNAH RIVER CO.
SAVANNAH RIVER LABORATORY

Keywords: Plutonium-238, PEF

Retain 10 Years

CC: C.R. Goetzman, 221-H
D.S. Duarte, 703-F
P.E. Dillon, 235-F
R.E. Meadors, 703-F
A.P. Gouge, 221-H
M.J. Nagy, 235-F
D.P. Key, 235-F
H.D. Harmon, SRL, 773-A
E.W. Holtzscheiter, 773-A
G.T. Chandler, 773-41A
J.C. George, 235-F
W.D. Stephens, 235-11F
SRL Records (4)

March 5, 1990

TO: J.E. Black, 773-A

FROM: J.W. Congdon, 235-11F
G.H. Nelson, 235-11F

RENOVATION OF THE HOT PRESS IN THE PLUTONIUM EXPERIMENTAL FACILITY (U)

INTRODUCTION:

The Plutonium Experimental Facility (PEF) will be used to develop a new fuel pellet fabrication process[1,2] and to evaluate equipment upgrades[3]. The facility was used from 1978 until 1982 to optimize the parameters for fuel pellet production using a process which was developed at Los Alamos National Laboratory. The PEF was shutdown and essentially abandoned until mid-1987 when the facility renovations were initiated by the Actinide Technology Section (ATS) of SRL. A major portion of the renovation work was related to the restart of the hot press system.

This report describes the renovations and modifications which were required to restart the PEF hot press. The primary purpose of documenting this work is to help provide a basis for Separations to

Derivative Classifier

MASTER

determine the best method of renovating the hot press in the Plutonium Fuel Fabrication (PuFF) facility. This report also includes several SRL recommendations concerning the renovation and modification of the PuFF hot press.

SUMMARY:

The PEF hot press has been restored after extensive renovations. It was necessary to replace the bottom ram, nearly all of the vacuum system and vacuum seals, and many of the controls. Repairs and modifications were also required to the cooling system, hydraulic system, and the induction heating system.

BACKGROUND:

The PEF hot press is capable of fabricating full-scale Pu-238 fuel pellets. The press is designed for bidirectional powder compaction in a graphite die assembly which is inductively heated in vacuum. As illustrated by the PEF schematic (Figure 1), the hot press is located in the Maintenance Area and the control system is located in the Operating Area. The vacuum system is located in glovebox #13 which is also located in the Maintenance Area. The hydraulic pump and induction power supply are located in the PEF motor control room on the second level. A 40-ton water chiller is located outside the building.

The PEF hot press is very similar to the PuFF hot press. Both units were manufactured by Centorr and utilize MTS controls. The hydraulic systems and induction heating systems are nearly identical. The design capacity of the PuFF vacuum system is slightly greater than the PEF system, however, the difference in the performance of the systems was negligible.

The history of the the PEF and PuFF Facilities is also very similar. After the facilities completed their objectives for the Pu-238 program they were essentially abandoned. Due to staffing limitations, the facilities were inspected but only essential repairs were performed. In most cases, defective support systems were shutdown rather than repaired. The inert gas systems were shutdown soon after the missions for the facilities were completed. This resulted in severe corrosion problems when moisture from the incoming air condensed in the boxes. Corrosion problems were compounded by the residual Pu-238 contamination in the cells. The alpha radiation sputters the protective layers on most metals. Although stainless steel corrosion was not a problem, other normally corrosion resistant materials such as aluminum, galvanized steel, copper and brass corroded.

The useful life of organic materials is a continual problem in Pu-238 facilities. After approximately five years of exposure to residual Pu-238, <u>all</u> of the organic seals in the PEF had become brittle. This resulted in numerous vacuum leaks in the hot press chamber. None of the valves in the facility sealed properly.

The cooling system for the hot press is a recirculating system which also cools the sintering furnace and storage wells. The recirculating system relied on an organic inhibitor for corrosion protection. This inhibitor had a lifetime of only six months and also required pH control to prevent precipitation. Since the cooling system was not maintained, corrosion and precipitation occurred.

HOT PRESS RENOVATIONS:

The extent of degradation of the hot press system was not immediately obvious. Therefore, the hot press and the support systems were systematically checked out and a large portion of the effort involved troubleshooting equipment. Many of the standard spare parts (o-rings and gages) were ordered as the renovations began. Some spare parts were available on-site, however, purchase orders had to be submitted for several other items and for service contracts with vendors. In many cases, despite efforts to expedite the orders, the renovations were often held up by the procurement system.

Job Plans were prepared and approved for the major and more hazardous repair procedures. Many of these procedures required the construction of plastic huts or other special precautions to prevent the spread of contamination.

The following sections provide detailed descriptions of the troubleshooting procedures and renovations which were performed to restore the PEF hot press.

Vacuum System: Troubleshooting of the vacuum system was performed by working from the mechanical pump to the chamber and isolating portions of the system. A new pump head was installed on the mechanical pump. The vacuum hoses and fittings were also replaced. It was later determined that a larger capacity mechanical pump was required and a larger pump with 30% more capacity was purchased and installed.

New thermocouple gages and a new ionization gage were installed and calibrated. Many of the leaks in the vacuum system and vacuum chamber were located with the aid of an in-line leak detector which was installed for the hot press renovation.

A vacuum leak was located in a T-joint in one of the copper vacuum lines. The leak was repaired by soldering the joint. Clean-out of the vacuum lines was accomplished by pumping on the lines with frequent oil changes in the pumps. Strip heaters were wrapped around the lines and used to accelerate the clean-up process.

It was necessary to replace or rebuild all of the vacuum valves in the system. The o-rings in some of these valves had to be replaced several times during the PEF renovations. The internal components of the 6" Hi-Vac valve were replaced. The new valve was equipped with position indicators which indicate whether the valve is opened or closed. An instrument air line that services the pump box was also leaking and had to be repaired. A new pressure relief device was installed to repair a vacuum leak. Instrumentation was installed on the hot press to detect low vacuum levels in the hot press chamber with indicators in the operating and maintenance areas.

Although the diffusion pump was operational, it was determined that the pump was not operating at full efficiency. At first this was attributed to problems associated with the cooling system, however, when these cooling problems were corrected the pump still did not operate at full efficiency. A new diffusion pump was installed when the larger capacity mechanical pump was installed. Three panels on the pump box had to be removed to install these pumps. One of the windows cracked when it was reinstalled. A new window panel was fabricated and installed.

Several vacuum problems were related to the system which evacuates the space between the gloves and the glove port covers. Leaks were found throughout the manifold. The entire manifold was replaced and leak checked. All of the valves in this system had to be replaced. A thermocouple gage was installed to measure the pressure between the glove port covers and the gloves. Pressure switches, which act as interlocks, were installed to prevent the roughing valve from opening until a slight vacuum (-0.5 psi) is established on the glove ports.

Vacuum Chamber: The interior of the vacuum chamber and its components were cleaned several times to remove the moisture which had condensed and the oil which had backstreamed from the mechanical pumps. Numerous vacuum leaks were detected in the vacuum system and vacuum chamber. Vacuum leaks were also located around the seals for the windows on the hot press chamber. In the original design, the windows protruded into the chamber and the vacuum decreased the effectiveness of the gasket seals. The design was modified to mount the windows on the outside of the chamber such that a vacuum pulled the windows tighter and improved the ability of the gaskets to form a seal. This new design also allowed the window assemblies to be installed without breaching containment. The old window assemblies were not removed until the new ones were installed.

Leaks were located in all of the heat shield shafts which penetrate the chamber. Several attempts were made at repairing these leaks by installing new o-rings of various sizes. New shafts and with mounting flanges were designed, fabricated, and installed. The leaks around all but one heat shield shaft were eventually sealed. This heat shield was no longer required since the window had been relocated further from the heat source. The shield and shaft were removed and the hole was plugged.

The quad seal on the the transfer door between the chamber and glove box #9 had to be replaced. It is often difficult to obtain an effective seal on this transfer door and it may be necessary to make some modifications.

Three rams penetrate the chamber from each end. Vacuum leaks were located in the bottom ram assembly. Several attempts were made to repair these leaks by installing new o-rings on the inner seals. A Teflon shim was also installed in an attempt to repair the seal around the ram.

Complete removal of the bottom ram assembly would have been required to replace the outer o-ring seals. In an attempt to avoid this task, auxiliary mechanical pumps were installed to evacuate between the primary and secondary seals on the rams. Valves were also installed in the the lines from these pumps to the secondary seals so that the lines could be closed to prevent backstreaming at high vacuums. Although the auxiliary pumps improved the performance of the vacuum system, the performance still was not satisfactory.

The inability to obtain a good vacuum seal on the bottom ram assembly was attributed to scratches on the bottom ram and the rapid embrittlement of the inner o-ring seals. There is no mechanism in the hot press to prevent material from wedging between the rams and o-rings and scratching the o-rings and the rams. It was determined that the bottom ram must be replaced to ensure that an adequate vacuum seal could be maintained during hot pressing. It was necessary to remove both of the clamp rams and the induction coil prior to the removal of the bottom ram. A replacement ram for the PuFF hot press was obtained from spare parts, however the diameter of this ram was 0.020 inches greater than the PEF ram. The new ram was modified by the machine shop to the required specifications. The rams had to be exchanged from inside the chamber. All of the o-ring seals were also replaced at this time. After reassembly, leak checking indicated that the inner seals on the bottom rams did not seal tightly due to a slight deformation of the bottom flange. The design of the flange was modified to improve its strength. A new flange was fabricated and installed with back-up rings. Leak testing indicated that these modifications were successful in sealing all of the leaks in the bottom ram assembly.

Cooling System: The chilled water system for the PEF required several repairs and modifications. The controls for the 40-ton Carrier chiller unit were repaired by an off-site vendor. The Run/Start timers and two relays on the compressor were replaced. The coils were cleaned and the leaks in the coils were repaired. Arrangements are being made to replace the coils in this unit. The water lines were drained and flushed several times to remove rust and debris. Pressure gages were installed throughout the system. Water and antifreeze were added to the system.

The recirculating system in the PEF was also in need of repair. The lines in this system had to be drained and flushed several times to remove the corrosion products and the organic precipitate from the inhibitor. "Cuno" water filters were install in the return lines to remove debris from the lines. Several filter changes were required to clean up the cooling water. Some of the smaller diameter lines to the diffusion pump had to be replaced because the flow through these lines was severely restricted by corrosion products which were not removed flushing and filtering. Most of the flow switches in the cooling water manifold had to be replaced.

Water leaks in the heat exchanger were repaired. Flexible lines were added to the heat exchanger so that it could be relocated allowing better access to the pump box.

Hydraulics: Other than the need to replace the hydraulic controllers, the repairs to the hydraulic system were all minor. A few minor leaks were repaired and a pressure gage was replaced. The hydraulic oil was changed and the oil which had leaked from the unit was cleaned up.

The load cells were calibrated with a mini compression load cell. The output cable from the load cell was modified by extending its length and adding amphenol connectors for the glove box feedthrough. The mini load cell with the modified cable and the voltage output readouts were calibrated using an Instron Testing Machine which had a QA certified calibration. The mini load cell was placed in a graphite die body which had been modified for this procedure. This test confirmed that the load cells were producing accurate readouts.

Induction Heating: The induction coil is a water cooled, nickel plated, copper tube. Some minor corrosion was observed near the fittings. Prior to applying power to the coil, the coil was drained, purged, and leak tested by connecting the coil to a vacuum pump with an in-line thermocouple gage. The induction coil was removed to replace the bottom ram and had to be leak checked again. No leaks were detected in the coil during either test.

The accumulation of condensation on the power supply created a ground fault and the ground fault detector shutdown the unit. This problem was corrected by adding ventilation to the power supply.

Temperature Measurement: The optical pyrometer which was used to measure the temperature during hot pressing in the PEF during the previous development program was no longer available. It was necessary to site this pyrometer through the quarter inch square hole in the induction coil and into a one of a series of small black body in the die body. A laser pyrometer was selected for measuring the hot pressing temperature because it eliminated the need for a black body hole by continually measuring and correcting for changes in the emmisivity of the die body. Two laser pyrometers were purchased and calibrated. The pyrometer can be mounted on a tripod with an X-Y stage for alignment. A fixture, permanently mounted in the maintenance area of the PEF will be designed and fabricated to reduce the set-up time for the pyrometer. I/O cables were installed from the PEF Maintenance Area to the computer in the Operating Area to allow remote operation of the pyrometer.

Control Systems: A Centorr serviceman repaired the hydraulic controls for the hot press but recommended that new controls be purchased. Based on this recommendation and the age of the controls, new controls were purchased, installed, and calibrated. These controls are made by MTS and took several months to procure. The hydraulic controls were improperly adjusted by the manufacturer and required on-site adjustment by the Centorr serviceman. It was also necessary to replace two defective digital voltage displays on the hot press control panel. The vacuum controls were replaced with a more modern control panel. Several defective indicator lights were also replaced.

An IBM-PC/AT based data acquisition/process control system was installed as part of the upgrades to the PEF[4]. The control system uses Iconics GENESIS control software and Metrabyte I/O hardware.

Miscellaneous:

Attempts to repair the transfer trolley which was located in the tunnel connecting glovebox #9 to the chamber were unsuccessful. A new trolley is being designed as a replacement. The design of the trolley will be modified to accommodate the longer die which will be used for the direct fabrication process.

The moisture sensor in the pump box (g.b. #13) was defective and had to be replaced.

A glovebox window on the pumpbox, which was cracked during the previous development program, was replaced.

RECOMMENDATIONS FOR PuFF HOT PRESS RENOVATIONS:

The following recommendations are based on SRL's experience in renovating the PEF hot press. It was assumed that, based on the relative histories of the hot presses, that the degradation of the PuFF equipment will be even more severe than the PEF equipment.

- The entire vacuum system (pumps, valves, gages, and vacuum lines) should be replaced as a complete unit. This unit should be assembled and cold tested prior to installation. The number of repairs which are likely to be required do not justify the time to salvage or even to checkout the existing vacuum system.

- If the entire vacuum system is not replaced, it is recommended that that all of the pumps, gages, and valves be replaced prior to any efforts to checkout the system.

- The replacement of the entire vacuum chamber, induction coil, and hydraulic system may be justified. This decision will be dependent the time required to procure replacement systems and the difficulties associated with removing the existing contaminated equipment.

- If a new vacuum chamber is purchased, the design of the bottom ram assembly should be modified to prevent material from scratching the rams and o-rings.

- If the entire hot press system is not replaced, it is likely that it will be necessary to replace the bottom ram. It will also be necessary to change all of the seals on the windows and shafts.

- The design of the hot press windows should be modified such that the vacuum tightens the seal to the chamber.

- The design of the flange on the bottom ram assembly should be modified to increase its strength. Back-up rings should also be used to prevent the O-rings from shifting when the rams are moved.

- A complete spare parts inventory for the hot press should be reestablished.

- Arrange an extended service contract with Centorr to avoid delays which result from the procurement of contracts for each service call.

- A laser pyrometer should be purchased to perform temperature measurements during hot pressing.

- Add a new data acquisition/process control system to the hot press. If a system identical to the PEF system is purchased, it should be possible to transfer the software directly.

ACKNOWLEDGEMENTS:

Nearly all of hot press renovation work was performed by Technical Assistants in the Actinide Technology Section of SRL. This renovation would not have been a success without the dedicated efforts of Irene Reamer, Frank Corbett, Andy Cheek, Brian Antonicelli, Zane Nelson, Cathy Coffey, and Wanda Britt. Their perseverance under less than ideal working conditions is gratefully acknowledged.

REFERENCES:

1. DP-MS-89-75, J.W. Congdon and J.E. Marra, "Direct Fabrication of $^{238}PuO_2$ Fuel Pellets", Proceedings of the Seventh Symposium on Space Nuclear Power Systems, Albuquerque, NM, Jan. 7-10, 1990.

2. WSRC-RP-89-364, J.W. Congdon and J.E. Marra, "Direct Fabrication Development Program", June 1,1989.

3. WSRC-RP-90-233, J.W. Congdon, W.D.Stephens, J.E. Marra, and G.H. Nelson, "Equipment Upgrades for the Pu-238 Program", Feb. 14,1990.

4. DPST-88-448, J.E. Marra and J.W. Congdon, "Automated Hot-Press Control for the Plutonium Experimental Facility (PEF)", May 2,1988.

END

DATE FILMED

01 / 02 / 91