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REMOTE ENGINEERING PROGRESS REPORT
JANUARY THROUGH DECEMBER 1984

D. E. Phillips

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NORTH AMERICAN SPACE OPERATIONS
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This report discusses the development of a device to automate size-reduction operations on recycled plutonium parts. The experience gained from production use of a first generation machine has led to a second generation design. The first generation machine utilized a combination of crushing and shearing steps to size-reduce each part. The proposed second generation device consists of a three-axis press to compact the parts to the required size.

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The report discusses automating the molten-salt button-breakout operations in Building 776. Areas of automation include button breakout, salt crusher, button number marking, and button cleaning. The project is under development and is expected to enter production in November 1985.

PYROCHEMICAL PROCESS EQUIPMENT (BUILDING 371 PLUTONIUM RECOVERY MODIFICATION PROJECT) 6

Presently, pyrochemical processing of plutonium which includes electrorefining (ER), direct oxide reduction (DOR), and molten-salt extraction (MSE), is accomplished by utilizing the tilt-pour furnace systems. Production in these furnace systems has been unreliable. In late 1983, a pyrochemical task team was formed as part of the Building 371 Plutonium Recovery Modification Project (PRMP). The primary objective was to establish a remedial plan which offered positive resolution of current production deficiencies.

The task team studied several paths to resolve equipment problems, including the possibility of redesigning and improving the tilt-pour-type furnace. This study concluded that the best candidate for furnace replacement would be the stationary-type furnace system. The report discusses the engineering effort thus far completed, that which is currently progressing, and future tasks to be accomplished.

PLUTONIUM OXIDE/SKULL-BURN AND REBURN PROCESS 7

High radiation exposure and low production output have dictated a need for a new plutonium oxide/skull-burn facility. This report discusses the design of an induction-heated furnace system for evaporative removal of oil and carbon tetrachloride from plutonium sludge and a controlled oxidation of plutonium for reprocessing. Fabrication and noncontaminated testing have been completed and installation is underway.

Work on a plutonium chip degreasing process in Building 707, intended to improve material accountability, is discussed. Two conceptual designs for automating the process were generated: one which emulates the manual dipping process to clean the chips and one which utilizes a new spray cleaning process. The spray cleaning process was judged to be feasible, but the final analysis showed that the present manual process was the best choice. No final resolution as to whether the process will be automated has been made.

The Automated Part-Brushing System is being developed to automatically clean plutonium oxide from the surface of weapon components. An infinite number of brushing patterns can be developed to fit the requirements of the W87 or other future weapon designs. This will eliminate the present necessity of providing one brushing machine per weapon design requiring oxide removal. A five-axis cartesian robot and two indexing heads will be utilized. A dual-chambered glovebox will house the robot and brushing equipment. The production start date is scheduled for February 1986.

This report discusses the design of a hot-dip, zinc-galvanizing pot to be utilized in the development and demonstration of techniques for galvanizing special materials being produced in Building 883.

The design and status of an automated cutting system for plutonium analytical samples are presented. The system will remove the oxide, cut the required analytical aliquots, and record the mass of each aliquot and the remaining sample. A robot will transfer the sample between stations.

The design and status of an automated random-access storage and retrieval system are discussed. The automated system will replace the present manual storage of analytical samples within Building 559 by automatically storing and retrieving up to 3,072 samples of fissile material in one of two storage systems, each consisting of two carousels and one robot.

A pneumatic transfer system is being designed to transfer samples and aliquots to different analytical areas within Building 559. Currently, a lab model is being developed and tested in Building 439.

A chemical operations robotic system was purchased from Zymark, Incorporated, to automate the preparation of liquid samples for a new analytical instrument in Building 559. Process programming is currently under development in the laboratory in Building 439.

The laser part marking process is being developed to provide a fast, consistent, and legible part marking system for production parts manufactured at Rocky Flats. This process is being accomplished by installing computerized laser marking systems and various part positioning systems in Buildings 881, 460, 707, 991, and 444.

This report discusses the development of a system that completely radiographs, without operator intervention, two fixtures loaded with components. Remote Engineering is developing two separate systems for use in Buildings 991 and 460, where an increase in productivity per shift is required. The Building 460 system is complicated by the great variety of sizes and shapes of the components being X-rayed. The goal is to install both systems in Calendar Year 1985.

The status of the development of deburring methods for J-line parts is discussed. Four processes for deburring precision parts are being investigated: vibratory, abrasive blasting, thermal energy method, and modified Harperizing.

The status of an ingot-gripping device, which has been designed to reduce the hazards of loading and unloading the furnaces in the foundry of Building 444, is discussed. At the time of this writing, the gripper is undergoing testing in Building 444, with initial results being successful.

The design and development of a crucible-cleaning station for the Metallurgical Operations uranium foundry in Building 444 are discussed. The work is being performed to reduce radiation exposure by replacing a manual cleaning operation with an automated operation. A conceptual design utilizing an industrial robot was generated and accepted as the design choice. Design is anticipated to be completed during second quarter FY85.

LIST OF FIGURES

ABSTRACT

This report summarizes progress on work performed in the Remote Engineering group at Rocky Flats from January to December 1984. Remote Engineering's goals in all 1984 projects were to help increase production capacity, reduce radiation exposure, improve operation safety, improve product quality, or alleviate material-accounting errors. To convert manual operations to automated operations, Remote Engineering provided design, fabrication, and assembly of new equipment for varied plant operations.

Seventeen separate projects were handled by Remote Engineering in 1984. Four of the projects automate related operations in Building 559, the Chemical Analytical Laboratory. In Building 559, the following operations needed mechanizing: Sample Cutting, Storage and Retrieval, Pneumatic Transfer System, and Chemical Operations Robotic System.

Remote Engineering has completed the design of the hot-dip zinc-galvanizing furnace, and Maintenance will complete the assembly and installation. Three systems are in production use but are still undergoing development: the Unimate robot, the Laser Marker, and the Ingot Gripper. The Plutonium Oxide/Skull–Burn Furnace is awaiting installation. The other projects are at various states of design and development.

These reports reflect the status of the projects as they existed December 31, 1984, except the Future Work sections which were updated August 27, 1985.

REMOTE ENGINEERING PROGRESS REPORT
JANUARY THROUGH DECEMBER 1984

D. E. Phillips

SITE RETURN COMPACTOR FOR BUILDING 776 PYROCHEMICAL OPERATIONS

J. J. Lucerna, R. D. Leinwand, and P. L. Montano

OBJECTIVES

The objectives of this project are to reduce radiation exposure, to increase safety, and to increase productivity by providing a device to automatically reduce the size of site return parts.

PRIOR WORK

Preliminary design concepts for the first generation (Mod. I) machine were initiated in FY81. Mod. I equipment design and development were previously reported in RFP-3569, while testing and installation were described in RFP-3694.[1, 2]

ACHIEVEMENTS AND DISCUSSION

Nuclear weapons in storage have finite shelf lives; therefore, weapons components are regularly returned to Rocky Flats for reprocessing. These site return components are disassembled and the plutonium is processed for reuse. One of the first steps in refining the plutonium is reducing the plutonium shells to a size small enough to fit into the molten-salt crucibles. Presently, this operation is accomplished inside a glovebox by manually cutting or breaking the parts into pieces. The americium content of the unrefined plutonium shells results in high radiation exposure to the hands and forearms of the operators. The task is also time consuming and the hazard of cutting or puncturing a glove always exists.

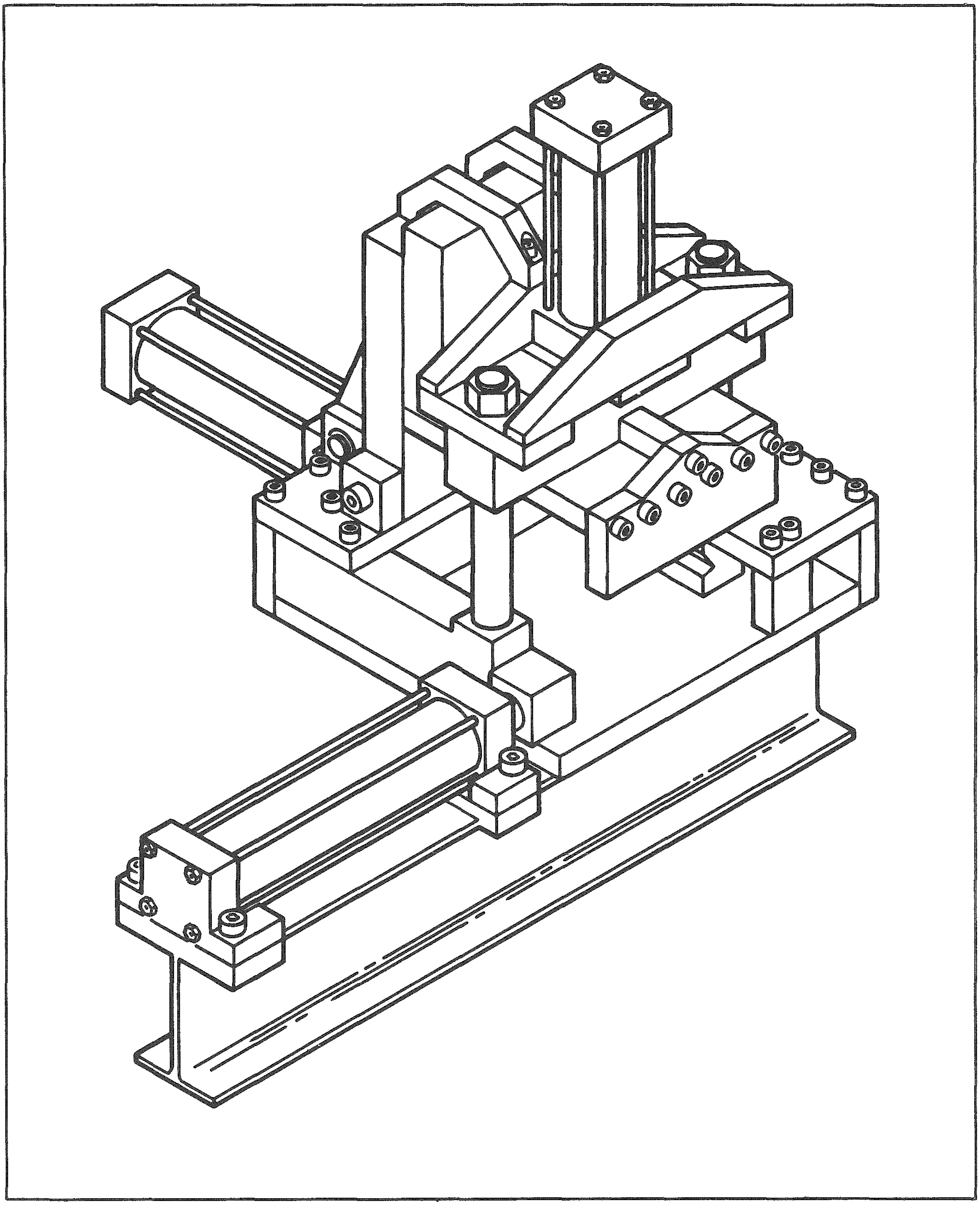
The Mod. I machine was designed to utilize both a pressing and a shearing action to size reduce the parts. However, the operators were damaging the machine by attempting to use the press to compact the parts in three axes. This problem existed even after the operators were trained repeatedly in the proper operation of the machine. After evaluating this situation and considering the high forces the machine is capable of producing, a decision was made that reliance on administrative controls was not adequate. Therefore, a new compactor design was initiated to improve the reliability of the compaction process.

The Mod. II machine is designed as a hydraulically powered three-axis press because the operators seem to favor this type of machine and it will be simpler to automate. The 2,000-psi hydraulic power supply and as many other components as possible from the existing Mod. I machine will be reused. Figure 1 shows a layout of the proposed machine. During operation, a site return part is manually placed into the pressing chamber. The sequence is started by actuating the first stage ram which descends to the level where the second stage is actuated automatically. This ram compacts the part to the point where the third stage is automatically activated. The third stage ram finally reduces the part to a cube which is then automatically ejected from the machine. The compacted part can then be manually weighed, sealed in a Vollrath can, and sent on for further processing.

Actual pressing forces were determined through testing with the Mod. I machine. All components have also been sized and analyzed for operating stresses. The proposed design has been tentatively approved by Nuclear & Facilities Safety, Industrial Safety, and the users.

The existing cutting box in Building 776 was modified for installation of the Mod. I machine. Installation requirements for the Mod. II compactor will be very similar, allowing the same

FIGURE 1. Site Return Compactor



glovebox to be reused. A two-handed control system will be located outside the glovebox for operator safety. The Mod. II control system will allow both automatic and semi-automatic operation.

FUTURE WORK

Detailed drafting of the Mod. II compactor is scheduled for completion by the end of February 1985. These drawings will then become part of a bid package for outside fabrication of the machine. A contractor should be picked by April 1985, and delivery of the compactor is scheduled for August 1985. The control system should be completed in-house by October 1985. Non-contaminated testing will continue through November 1985. A two-month installation period has been scheduled, so the compactor will be production-ready by the first of March 1986.

REFERENCES

1. C. M. Brown, *Remote Engineering Progress Report January Through December 1982,* RFP-3569, Rockwell International, Rocky Flats Plant, Golden, CO, February 27, 1984.

2. C. M. Brown, *Remote Engineering Progress Report January Through December 1983,* RFP-3694, Rockwell International, Rocky Flats Plant, Golden, CO, February 22, 1985.

AUTOMATION OF MOLTEN-SALT BUTTON-BREAKOUT OPERATIONS

R. M. Prudencio, J. D. Bert, A. Schaffer,
D. Y. Martinez, and T. A. Jackson

OBJECTIVES

The objectives of this project are to improve productivity, improve the accountability of the recovered americium salts from the plutonium button, and reduce radiation exposure to personnel during the molten-salt button-breakout operations in Building 776.

PRIOR WORK

Previous work on the project was reported in RFP-3175, RFP-3311, RFP-3569, and RFP-3694.[1-4]

ACHIEVEMENTS AND DISCUSSION

Site-return plutonium is purified by molten-salt extraction of americium which results in a plutonium button with an americium salt crust. The button-breakout operation consists of four operations on the button: removal from the crucible, cleaning, serial number marking, and sealing the button in a can prior to bagout. Currently, removal of the button from the crucible is accomplished by manually striking the crucible on the glovebox floor until the button is dislodged and can be removed. Next, the button is held in a gloved hand and any remaining salt crust is manually removed with a chip hammer. Any salt residue remaining after chipping is removed with a motorized wire brush. All salt removed from the button must be collected from the glovebox floor. A six-digit serial number is impressed into the button by striking number stamps with a hammer. Finally, the buttons are sealed in a steel can with hand-cranked can sealer and carried back into the line for temporary storage prior to bagout. This present operation is labor-intensive and results in relatively high radiation exposure to personnel. Collection and accountability of the americium salts removed from the button are difficult. This project was initiated to develop equipment to automate the button-breakout and cleaning operations.

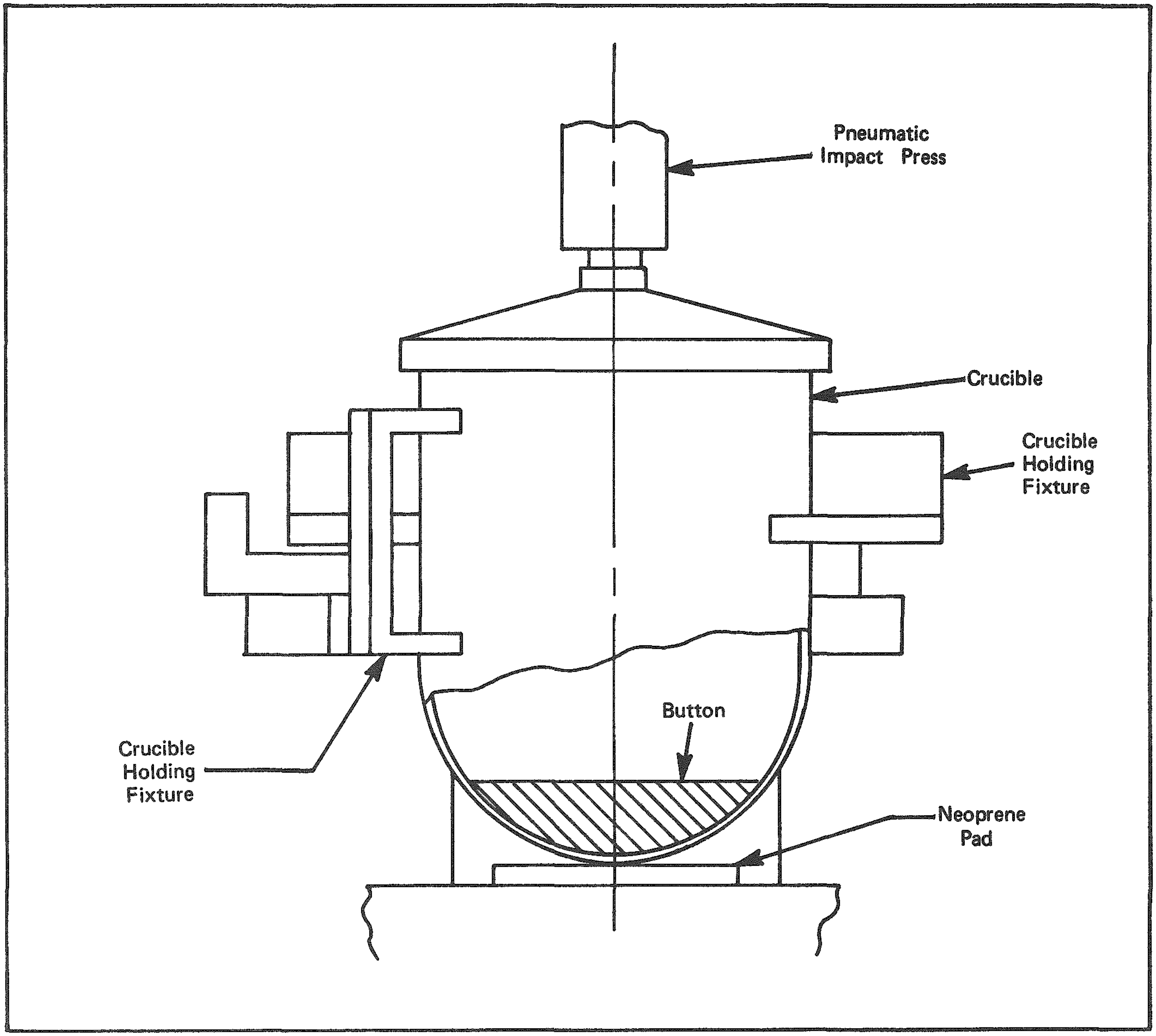
Button-Breakout Station

The original concept incorporated both the salt-crushing and the button-dislodging processes into the same device. The device would first crush the salt crust covering the top of the button and then dislodge the button from the crucible. Initial testing of the device using a surrogate button of copper/magnesium with a salt crust covering revealed design problems with the salt-crusher station and the button dislodger. The button-dislodge station was tested using an epoxy to bond the button to the crucible. The button dislodger, utilizing an eccentric force applied to the top of the button, was unable to free the button from the crucible. Due to the problems encountered during the testing, the two processes have been separated and will be accomplished as individual processes. Failure of the button dislodger to consistently dislodge buttons led to the testing of a commercial pneumatic impact press. When the press was used in conjunction with prototype crucible fixturing, the button was successfully dislodged from the crucible. Fixturing to replace the prototype setup has been successfully tested. The button-breakout station is complete and ready for final evaluation and user acceptance. See Figure 2.

Salt-Crusher Station

A salt-crusher station for crushing and dislodging the americium salt crust that covers the plutonium

FIGURE 2. Molten-Salt Button-Breakout Station



button has been designed and fabricated. Initial testing of the device, using a surrogate metal button of copper/magnesium with a salt-crust covering, has revealed the need for design modifications. These modifications have been incorporated into the device, and it is ready for further evaluation. Test crucibles have been requested, and further evaluation of the salt crusher will resume upon receipt of the crucibles.

Button Number-Marking Station

A commercial pneumatic impact press with a six-digit, automatic advance marking head has been purchased and will be used with a holding fixture to apply the button serial number. The button holding fixture has been designed, fabricated, and assembled. The button serial number-marking station is complete and ready for final evaluation/user acceptance.

Button-Cleaning Station

An automated button-cleaning process has been designed and built by Remote Engineering. This automated cleaning process basically consists of a steel shot blast gun, button holding/rotating mechanism, electromagnetic coils, shot diffuser, and a removable salt-collection tray. Several tests have been performed with this apparatus using different diffuser baffle configurations. The tests have yielded unacceptable results. Almost one-third of the steel shot bridges the gap between the electromagnet inner wall and the diffuser baffle outer diameters thereby forming an obstruction and a possible collecting area for the salt chips. The magnets were designed to catch all of the steel shot but approximately 3 mℓ is passing through with the salt. Further testing of the apparatus, with the shot diffuser baffles removed, produced three distinct "belts" of steel shot buildup on the inner wall of the electromagnet. Each belt of steel shot was separated by a belt without steel shot collected on it. An even distribution of steel shot on the inner wall of the electromagnet is a major requirement for the successful operation of this apparatus. This cleaning station is not suitable for its intended use in its present configuration. The electromagnet will be redesigned to evenly distribute the steel shot along its inner wall. Testing will resume to determine process feasibility.

Button-Breakout Glovebox

The new equipment developed for the button-breakout process requires a new L-shaped glovebox. This glovebox will replace the existing button-breakout glovebox in Building 776. The glovebox has been designed and fabricated and is awaiting installation. The glovebox segment housing the salt-crushing, button-breakout, and button-cleaning stations will be water shielded to reduce neutron exposure while the other segment containing the serializing and canning stations will only require lead shielding.

FUTURE WORK

Future work on this project will consist of (1) evaluation of the salt crusher station, (2) design of an alternate method of button cleaning or a redesign of the existing process, and (3) installation of the entire system in Building 776.

REFERENCES

1. R. J. Erfurdt, *Chemical Systems Engineering Progress Report January Through December 1980,* RFP-3175, Rockwell International, Rocky Flats Plant, Golden, CO, December 3, 1981.

2. R. J. Erfurdt, *Chemical Systems Engineering Progress Report January Through December 1981,* RFP-3311, Rockwell International, Rocky Flats Plant, Golden, CO, February 5, 1983.

3. C. M. Brown, *Remote Engineering Progress Report January Through December 1982,* RFP-3569, Rockwell International, Rocky Flats Plant, Golden, CO, February 27, 1984.

4. C. M. Brown, *Remote Engineering Progress Report January Through December 1983,*

RFP-3694, Rockwell International, Rocky Flats Plant, Golden, CO, February 22, 1985.

PYROCHEMICAL PROCESS EQUIPMENT (BUILDING 371 PLUTONIUM RECOVERY MODIFICATION PROJECT)

E. Ignelzi

OBJECTIVE

The objective of this project is to implement highly reliable electrorefining (ER), direct oxide reduction (DOR), molten-salt extraction (MSE), and other pyrochemical equipment to markedly increase plutonium processing capacity. The ultimate objective is to modernize the processing facility to reliably satisfy quantitative production requirements.

PRIOR WORK

No prior work has been reported.

ACHIEVEMENTS AND DISCUSSION

The tilt-pour furnace system was developed to perform three pyrochemical processes required to produce weapons-grade plutonium: ER, DOR, and MSE. Production processing in this furnace system has been unreliable, owing to the many operational problems inherent in its basic design, and to date continues to plague production output.

A pyrochemical task team was formed in late 1983 as part of the Building 371 Plutonium Recovery Modification Project (PRMP). The team's primary objective, as administratively directed to the task team, was to study the production equipment problems in-depth and, upon completion, establish a remedial plan based upon utilization of proven equipment and technologies which would positively resolve plutonium production deficiencies.

The task team performed an in-depth investigation and analysis of equipment problems. The investigation also included the possibility of redesigning, improving, and implementing new tilt-pour furnace systems. After evaluation of this idea, the team members agreed that the magnitude of this task would likely result in an extensive developmental project, which would violate the basic rule of the utilization of proven equipment and technologies.

The equipment investigation also concluded that the stationary-type furnace system would be the best candidate for replacement of the tilt-pour furnace. This conclusion was based upon the many years of experience in utilizing this equipment at the Rocky Flats Plant and also at Los Alamos, where the stationary furnace has been utilized for approximately 15 years.

Selection of the stationary-type furnace system will, as a consequence, require the implementation of many more furnaces to satisfy quantitative production requirements; i.e., the stationary furnace system requires approximately 40 hours to electrorefine a unit of plutonium as compared to only 16 hours for the tilt-pour furnace system. However, these furnaces have experienced many serious operational problems resulting in unacceptable maintenance, downtime, and loss of production. Based upon the processing times of 40 hours for the stationary and 16 hours for the tilt-pour, 2.5 stationary furnaces are required to replace each tilt-pour furnace system. Approximately the same proportions are true for DOR and MSE processes. Ultimately, it would be necessary to add additional floor space to implement a sufficient quantity of stationary furnace systems. However, most members of the task team agree that obtaining high equipment reliability was a justifiable tradeoff for the additional floor space required.

In addition to having a member on the task team, Remote Engineering was asked to prepare conceptual design layouts depicting all pyrochemical and other supportive equipment. In the first round of equipment layouts, only one room, Room 3206 of Building 371, was allocated for utilization. After reviewing all the equipment layouts, the task team agreed that utilization of only one room was grossly inadequate to accommodate the amount of equipment involved. A search for an additional room was conducted which succeeded in allocating and acquiring Room 3412. Several more equipment layouts were prepared utilizing both rooms and depicting all the pyrochemical and supportive equipment involved, which unquestionably provided a significant improvement to accomplish base-line design selection.

The final base-line conceptual design, depicting all equipment and utilizing both rooms, was formally reviewed and selected by the task team for inclusion in a Conceptual Design Report (CDR).

A preliminary estimate of all process equipment including quantities, power requirements, cooling requirements, gas utilities, equipment-installation hours, installation materials and costs, and purchased-equipment costs was prepared along with several process instrumentation drawings. All documents were released to Rockwell-Canoga Park, who is responsible for final preparation of the CDR. The CDR at this time is approximately 80% complete and scheduled to be submitted to the Department of Energy (DOE) in March 1985 for FY87 line-item funding.

Remote Engineering is currently involved with the engineering required to further improve the state-of-the-art of ER, DOR, and MSE processing equipment for stationary furnaces. To date, several conceptual designs of a production-prototype ER cell have been generated. The task team committee worked very closely with Remote Engineering in this endeavor and recently selected the base-line design to be definitively engineered, fabricated, and tested. The basic intent of building a production-prototype ER cell is to determine, via qualified testing, the extent to which this process may be improved. Design criteria adopted for guiding the design of this apparatus are quite in line with the basic rule of "utilizing proven equipment and technologies."

FUTURE WORK

Definitive engineering design and detail drafting of the production-prototype ER cell should commence in mid-January 1985. Fabrication is expected to be completed and received, ready for installation by September 15, 1985. Equipment testing and evaluation are scheduled to be completed by late FY86.

Future Remote Engineering responsibilities for this program are: engineering input for the final design criteria, which includes conceptual and definitive design and performance specifications of several other furnace systems, controlled-atmosphere enclosure system, gloveboxes, and conveyor design parameters.

PLUTONIUM OXIDE/SKULL-BURN AND REBURN PROCESS

C. D. Adams

OBJECTIVE

The objective of this project is to design a new furnace system to oxidize the plutonium skull generated by the foundry. The design will reduce radiation exposure, facilitate handling of the skull, and increase material output.

PRIOR WORK

Previous efforts in this program have been reported in RFP-3311, RFP-3569, and RFP-3694.[1-3]

ACHIEVEMENTS AND DISCUSSION

This project was initiated to examine methods of reducing the time to oxidize the skull and thereby increase material output. Skull, a plutonium metal/oxide mixture, is generated from the casting operations in the Building 707 tilt-pour furnaces. Currently, the skull is oxidized in two separate furnaces as outlined in RFP-3311.[1] The new oxidation process is discussed in RFP-3694, along with a description of the new facility.[3] See Figure 3.

On January 11, 1984, the Title II meeting was held to discuss the new skull-burn facility. No major problems existed and the package was released for fabrication. High Vacuum Equipment Co. received the order to manufacture the vacuum chamber. All other equipment, including gloveboxes, were fabricated at Rocky Flats. Problems occurred with

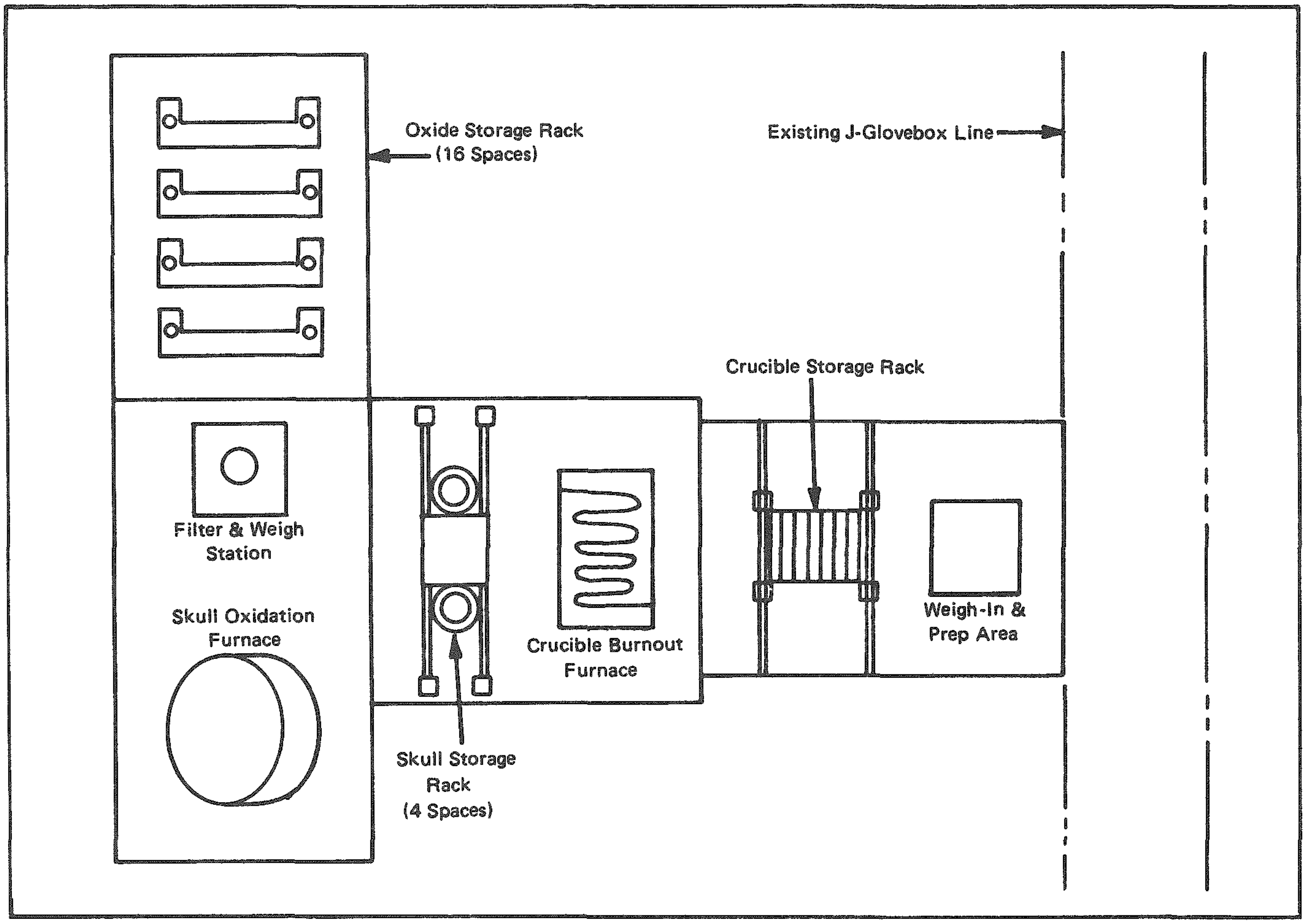


FIGURE 3. New Skull and Crucible Burn Facility

Maintenance lacked the experience to do vacuum welding. This resulted in a 5-week delay because Maintenance had to reweld the filters.

Currently, all equipment has been fabricated and tested. Gloveboxes have been installed. Initial cold testing has been completed and all internal glovebox equipment has been sent to Building 707 for installation. Equipment installation is approximately 30% complete.

To maintain the integrity of the vacuum chamber during an over-heat condition, it was necessary to fully anneal and stress-relieve the total chamber at 1093 °C. This requirement brought about the need to weld the cooling coils to the chamber wall instead of silver soldering. Nuclear Safety felt this violated the double-membrane rule. They were also concerned about the possibility of melting through the chamber wall during welding, thereby causing a leakpath, but the chance of melting the chamber wall before penetrating the tubing during welding is very slim. In addition, silver-adding contaminants are introduced that could corrode the chamber wall and tubing. Nuclear Safety required that the skull-oxidation furnace limited-volume cooling system be restricted to 24 liters.

Preliminary cold testing of the skull-oxidation furnace was done in Building 439. The vacuum chamber and condensing filters were set up to check the oil-vaporization and skull-oxidation cycles that the furnace is to perform. A charge of alumina oxide mixed with graphite was chosen to be used to test the skull-oxidation cycle of the furnace.

Final testing using plutonium oxide will be performed after installation.

Several runs were made to monitor the chamber-wall temperature, viewport window temperature, charge temperature, and susceptor temperature. Figure 4 shows the temperature relationship between the furnace charge and an inconel susceptor with an air purge. The graphite susceptor was removed during this test to protect it from oxidizing at the high temperatures. Results of a similar test run in a vacuum atmosphere are shown in Figure 5. To simulate the energy generated by the plutonium oxide, it was necessary to run at higher temperatures than will be seen in normal production. This showed a need for a Zircar plate that was installed to shield the chamber top to keep the chamber wall below 51.7 °C.

Experiments were also completed to test the oil-vaporization cycle of the skull-oxidation furnace. The furnace was designed to handle 45.4 grams (g) of oil per run. During testing, the crucible was loaded with 45 g of 643 oil. A temperature was maintained at 500 °C and the chamber was evacuated to 100 microns (μ). When the chamber was brought back to atmospheric pressure and the lid raised, examination revealed that all the oil had vaporized out of the crucible, condensed on the chamber wall, and drained down on the chamber floor. A funnel was built to collect the oil vapor and direct it into the exhaust port of the vacuum chamber. After a few modifications, the funnel was able to direct a large percentage of the oil vapor back into the exhaust. Results are shown in Figure 6. A third test run was made using a sealed crucible and a nitrogen purge of 1 cubic foot per minute (cfm). Nitrogen was chosen because it was inert and readily available in the building. The final result was oil condensing on the chamber lid directly above the exhaust port.

Health, Safety & Environment (HS&E) required that the new skull-oxidation furnace be an open system. In other words, the crucible could not be a closed container piped directly back to house exhaust. They were concerned about a missile effect that would be created if an explosion occurred. Experiments were performed with a funnel that allowed a 1/32-in. gap between the funnel and the crucible. Results are shown in Figure 7. This test was successful. The oil vapor was directed out of the chamber with no condensation on the chamber wall.

Several things were learned during the oil-vaporization testing. First, when the oil is in a vacuum and the temperature of the susceptor reaches 168 °C, the oil starts to vaporize causing a rise in pressure of nearly 300 μ. Second, a gas purge is required to evacuate the chamber of the oil vapors. This provides a travel medium for the oil molecules to escape from the chamber. Third, condensing of the oil vapors starts within 2 in. of the induction coils; therefore, piping from the funnel must be sloped to allow draining of the oil out of the chamber into the oil catch.

After successfully completing the oil-vaporization tests, a mixture of 30% oil and 70% carbon tetrachloride (CCl_4) simulating the sludge from the machines in Building 707 was tested. During this process, CCl_4 required vaporization at a low temperature. Following vaporization of the CCl_4, the oil must be vaporized at a temperature below 300 °C to prevent cracking of the oil. Data generated from the first CCl_4 and oil mixture are shown in Figure 8. A sudden rise in pressure that was expected due to the vaporization of the CCl_4 was not observed. In previous tests a distinctive pressure rise was observed as the oil began to evaporate (see Figure 7) and a gradual decrease in pressure corresponded to the removal of the oil from the system. A second CCl_4 and oil mixture was prepared and another run was made. The temperature was raised to 125 °C with vacuum pressure maintained at 3600 μ. Once 125 °C was reached, the motor generator set was turned off and the chamber was opened to atmosphere. A sample was taken of the mixture and analyzed for CCl_4. No trace of CCl_4 was found in the oil. From the previous findings, a process for vaporization of the oil was developed. The process is controlled by an Allen-Bradley PLC 2/15. The operator must select which cycle is to be used--either vaporization or oxidation.

FUTURE WORK

The installation of the new skull-burn facility is scheduled to be completed by September 30, 1985.

FIGURE 4. Skull Oxidation Furnace Charge and Susceptor Temperature Comparison (Performed With Air Purge)

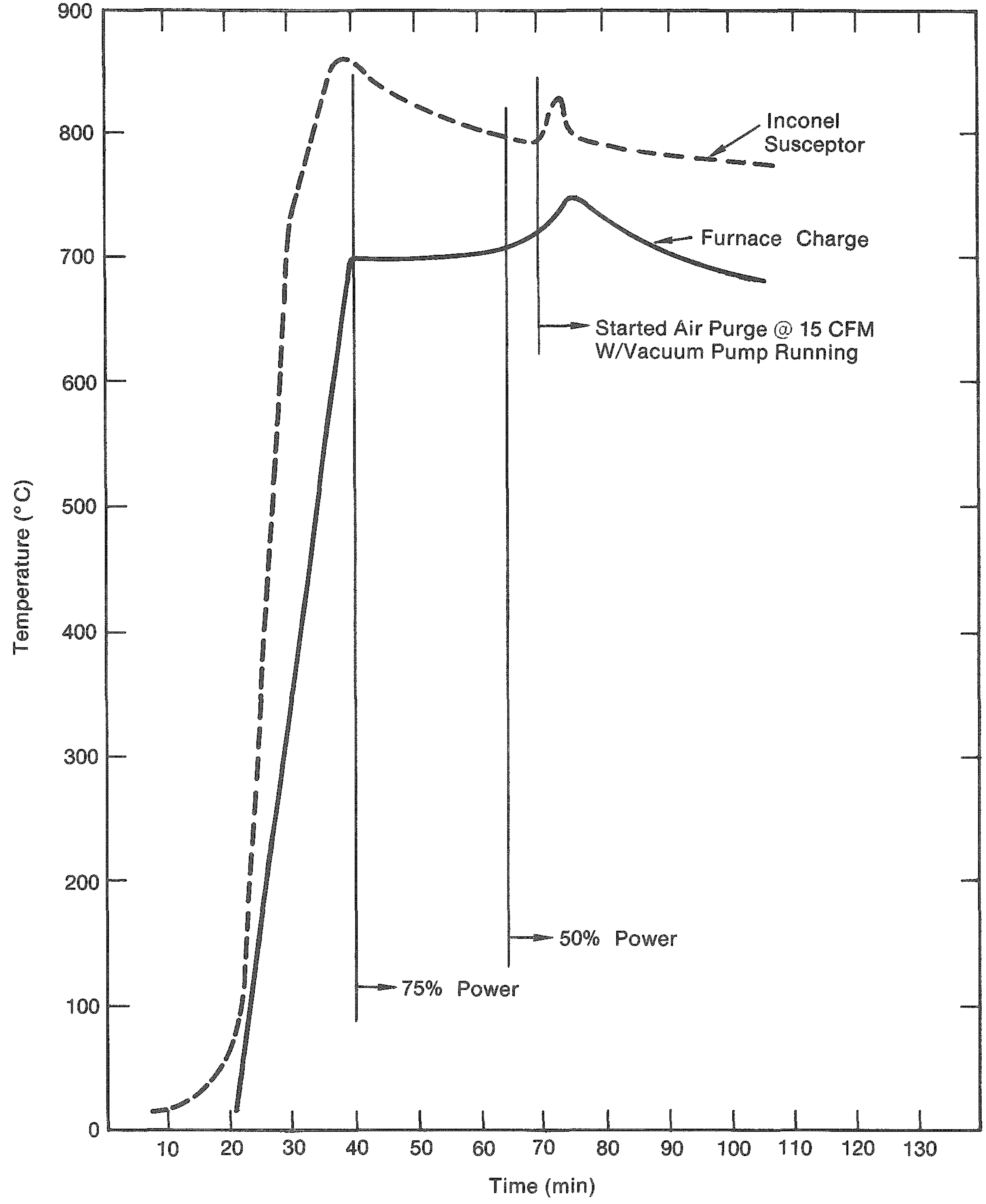


FIGURE 5. Skull Oxidation Furnace Charge and Susceptor Temperature Comparison (Performed in Vacuum)

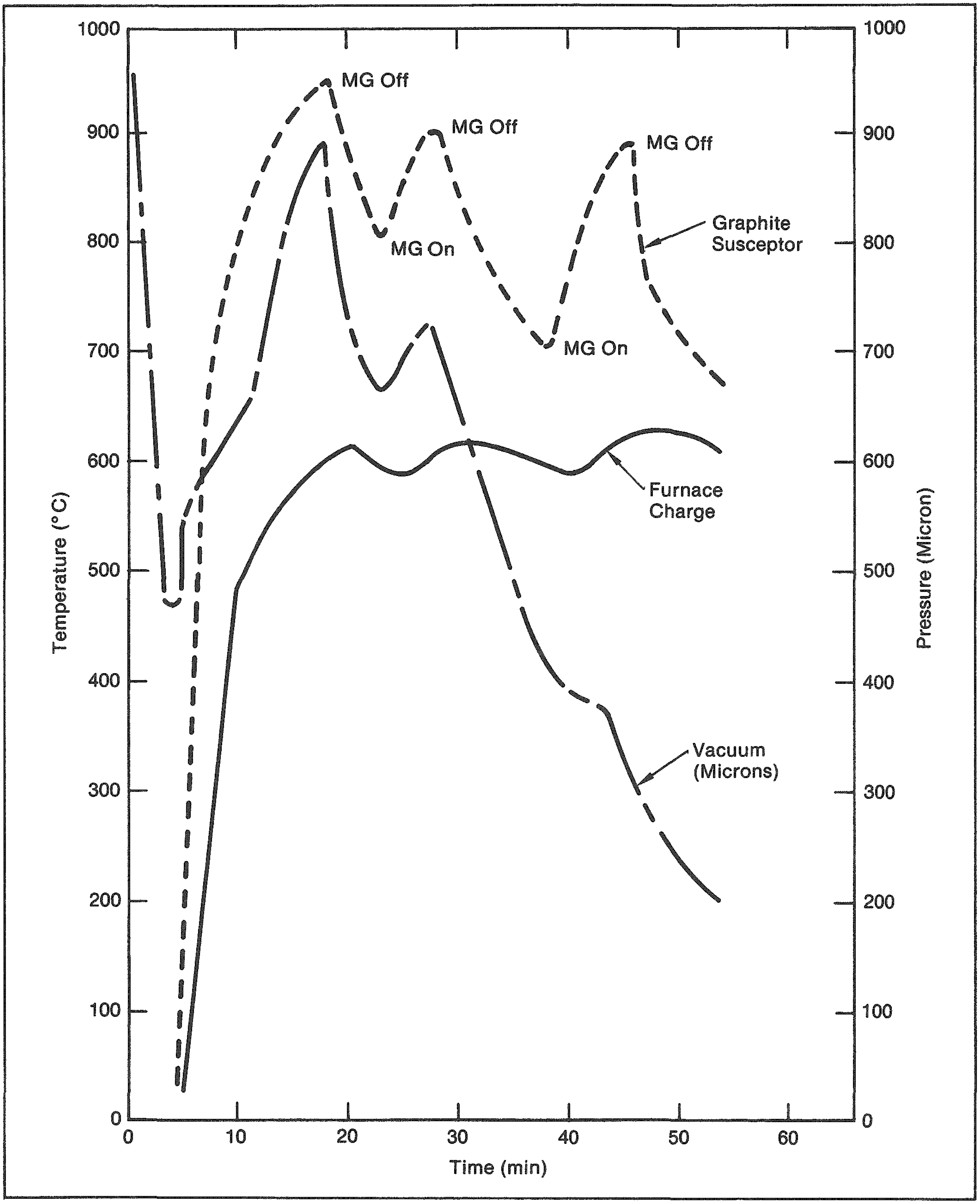


FIGURE 6. Skull Oxidation Furnace Oil-Vaporization Test
(No Gas Purge)

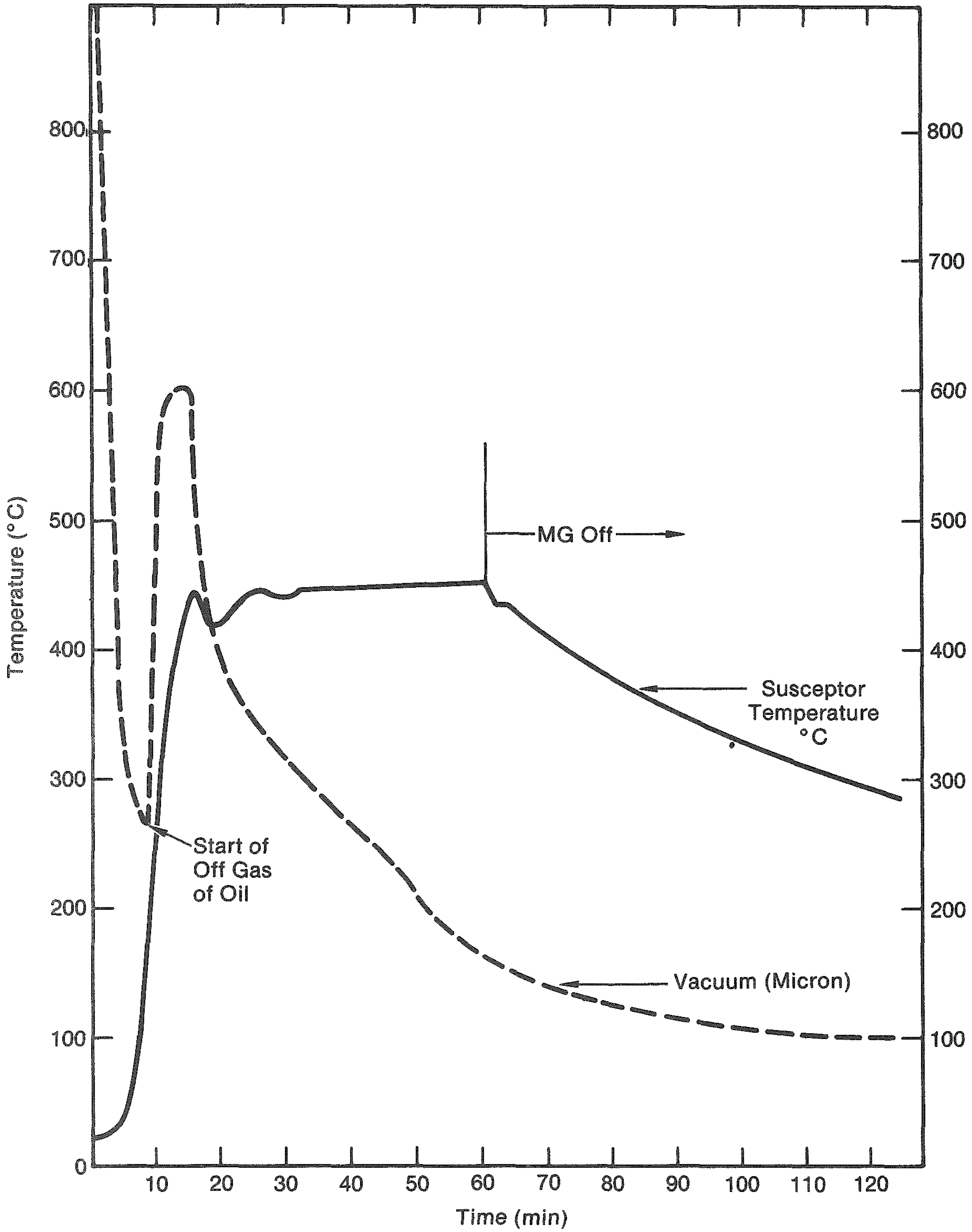


FIGURE 7. Skull Oxidation Furnace Oil-Vaporization Test (Nitrogen Purge)

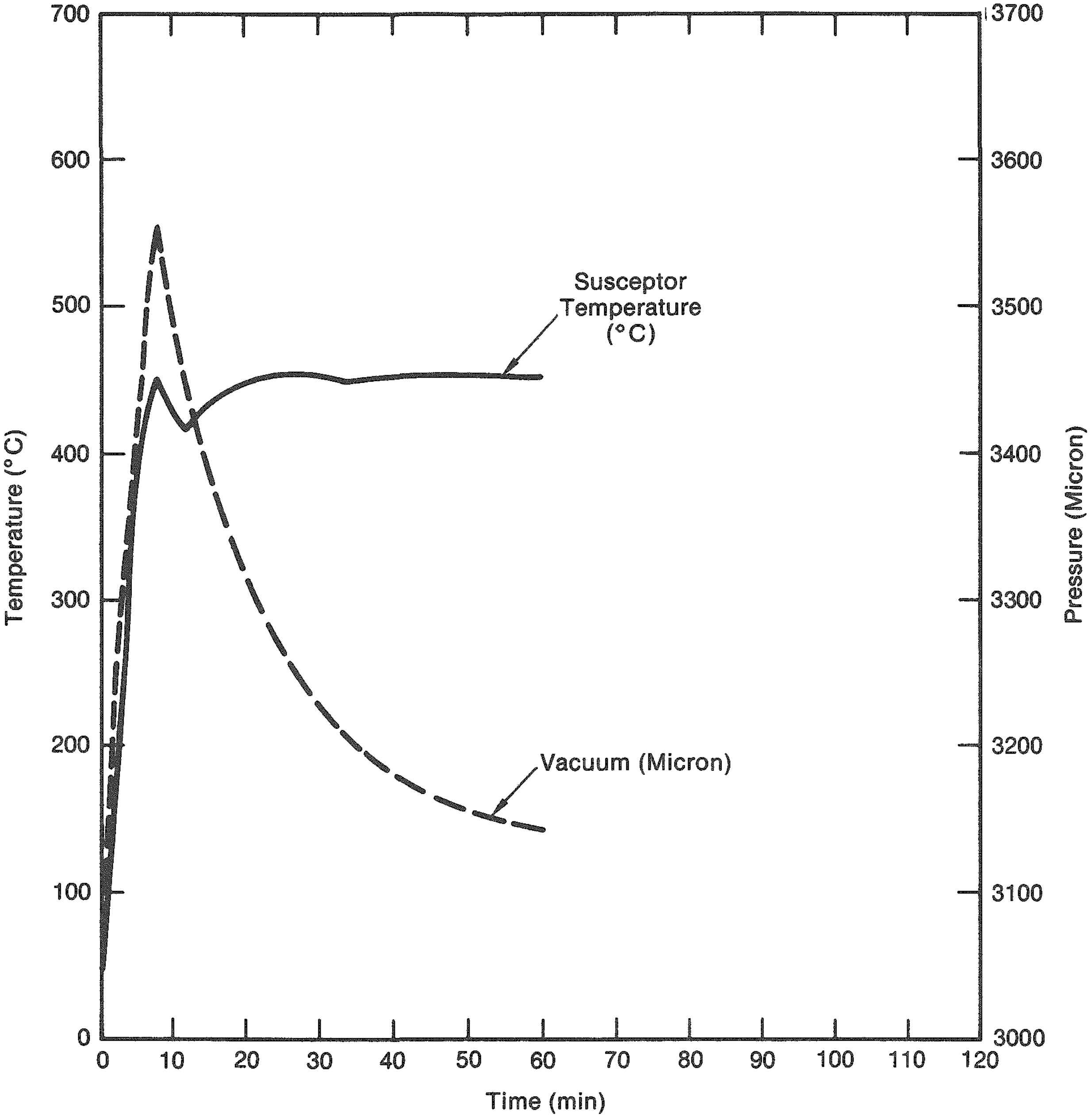
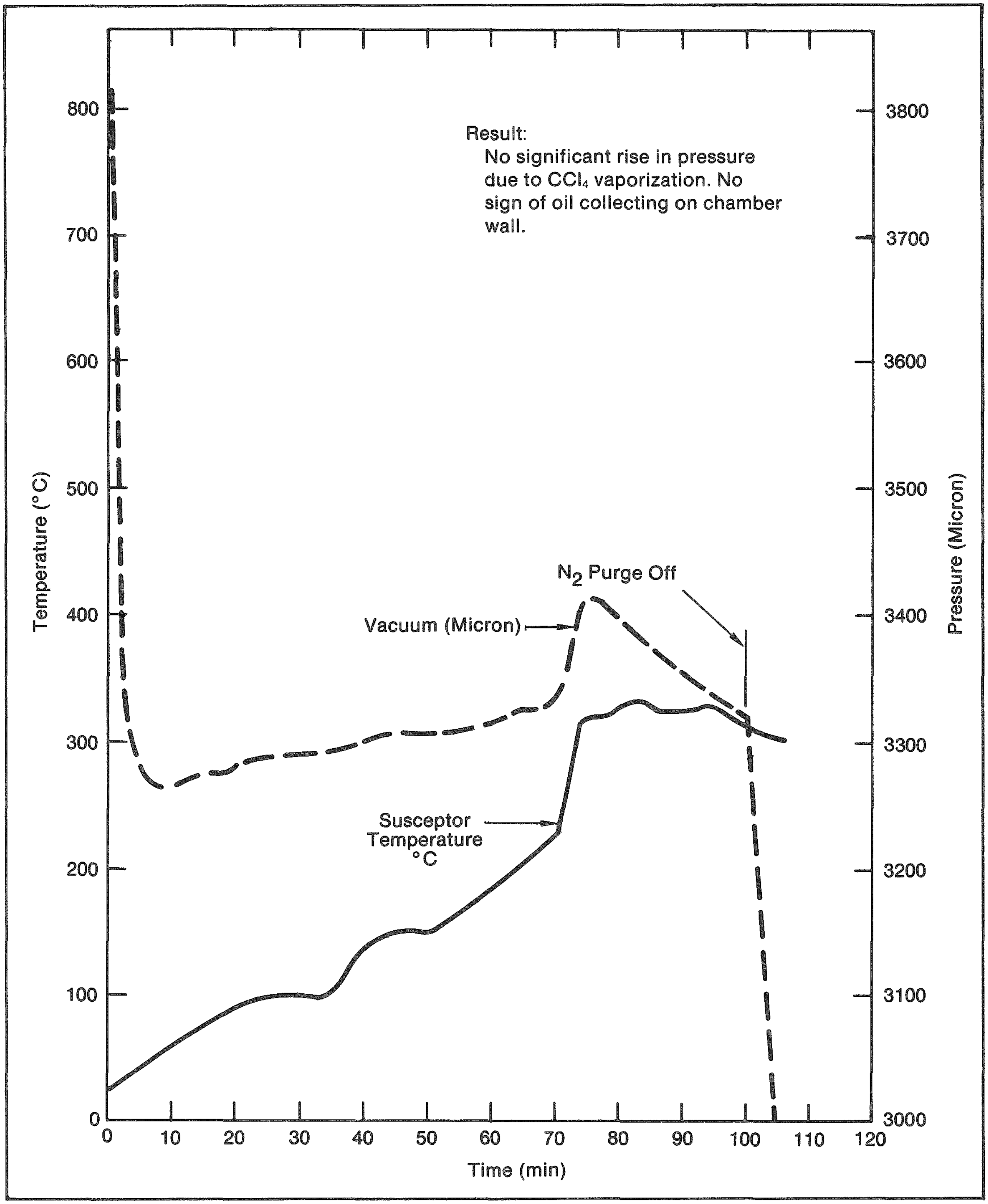


FIGURE 8. Skull Oxidation Furnace Oil and Carbon Tetrachloride Vaporization



One month of testing is planned before implementation into production.

REFERENCES

1. R. J. Erfurdt, *Chemical Systems Engineering Progress Report January Through December 1981,* RFP-3311, Rockwell International, Rocky Flats Plant, Golden, CO, February 5, 1983.
2. C. M. Brown, *Remote Engineering Progress Report January Through December 1982,* RFP-3569, Rockwell International, Rocky Flats Plant, Golden, CO, February 27, 1984.
3. C. M. Brown, *Remote Engineering Progress Report January Through December 1983,* RFP-3694, Rockwell International, Rocky Flats Plant, Golden, CO, February 22, 1985.

PLUTONIUM CHIP DEGREASING AUTOMATION

P. W. Herrmann, R. M. Prudencio,
and A. Schaffer

OBJECTIVE

The objective of this endeavor was to study the plutonium chip degreasing process to determine the best method to alleviate the plutonium accounting errors which resulted from lubricant residues remaining in the chips after degreasing. Product Integrity and Surveillance had primary responsibility to prepare the final recommendations. Remote Engineering was requested to participate on a consultant basis to provide recommendations for automating the degreasing process.

PRIOR WORK

No prior work has been reported.

ACHIEVEMENTS AND DISCUSSION

In 1983, a need was recognized for resolving the accounting discrepancy problems. The degreasing process consisted of dipping vented cans of chips into baths of carbon tetrachloride. The bath scheme consisted of five wash vats containing successively cleaner solvent. After the dip-cleaning, the can contents were blow-dried then compressed into briquettes. All of the operations were either manual or manually assisted.

Early in Calendar Year 1984, design of the off-loading/blow-dry station was completed by Remote Engineering and the design and the design concepts for the dipping station, developed by Physical Metallurgy, were reviewed by Criticality Engineering. Several safety concerns were noted and a decision was made to have a second review after redesign. Remote Engineering was called upon to assist with the dipping station design. The secondary examination of the dipping station revealed that the automation of the manual degreasing process by adding a chip-can transfer mechanism to the existing glovebox and solvent vats was not practically feasible. The dipping process of lowering irregular chip cans into the small baths is a simple manual process but did not translate into a simple automated process especially with the throughput requirements set by the end user and the safety requirements set by Criticality Engineering.

The design review led to a conceptual design with much simpler automated equipment requirements. A pallet or shuttle with wells to hold the chip cans would be manually loaded with the cans. Upon starting the cycle, the cans would be transported to a spray wash station where the solvent would be sprayed down into the cans. After spraying, the shuttle would move to a blow-dry station where the chips would be dried. The final station would be an off-loading station where the operator would remove the cans from the shuttle and press the clean chips into briquettes. Two methods of transport patterns were discussed: one with the shuttle moving linearly and the other with the shuttle moving circularly.

The design concept was reviewed by Criticality Engineering and found to be acceptable in principle. However, there was one question as to the efficacy of the spray process itself. Product Integrity and

Surveillance performed testing of the spray process using several different spray nozzles and solvent-flow rates until a nozzle/flow combination was found which cleaned the chips to specification.

No further action was taken after completion of the spray testing. A report from Product Integrity and Surveillance is pending with summaries of the various automation concepts and a recommendation for future courses of action. Given that the manual process is simple and meets the production requirements, the probable outcome will be a recommendation that the manual operation be maintained, perhaps with some operator training or supervision to eliminate the varying results due to different operator techniques.

A portion of the design of the off-load/blow-dry station has been incorporated into the present manual process. The dryer motor housings formerly were sealed units requiring total replacement when the blower motors burned out. The improved design allows replacement of the burned out motors so that the housing may be reused. Three of the improved design housings are presently being fabricated.

FUTURE WORK

No future work is planned pending the outcome of the final recommendation report.

AUTOMATED PART-BRUSHING SYSTEM

P. M. Williams and J. A. Smith

OBJECTIVE

The objective of this project is to provide a flexible cleaning system to remove plutonium oxide from plutonium weapon components. This system will have the capability of simple reprogramming when a new weapon design requires a new cleaning procedure.

PRIOR WORK

Previous work on this project was reported in RFP-3694.[1]

ACHIEVEMENTS AND DISCUSSION

The Automated Part-Brushing System (APBS) program has been in progress since its conception in October 1983. Reduction in allocated manpower has extended the APBS one year beyond the original completion date. At this time the basic concept and process description described in RFP-3694 have remained intact with few exceptions.

The new APBS will provide maximum brushing flexibility. An infinite number of brushing patterns can be developed to fit the requirements of the W87 or other future weapon designs. The new automated brushing system as shown in Figure 9 will have a five-axis cartesian robot. Two indexing tables will be used to hold the part. One indexer will have 90° vertical to horizontal movement. The second indexer will traverse on a slideway. A catch tray mounted on the slideway will be positioned under the part at all times to catch the plutonium oxide during brushing. A tool changing fixture will be attached to the brush motor, permitting automatic tool change by the robot.

The complete system will be located inside a glovebox designed specifically for the APBS.

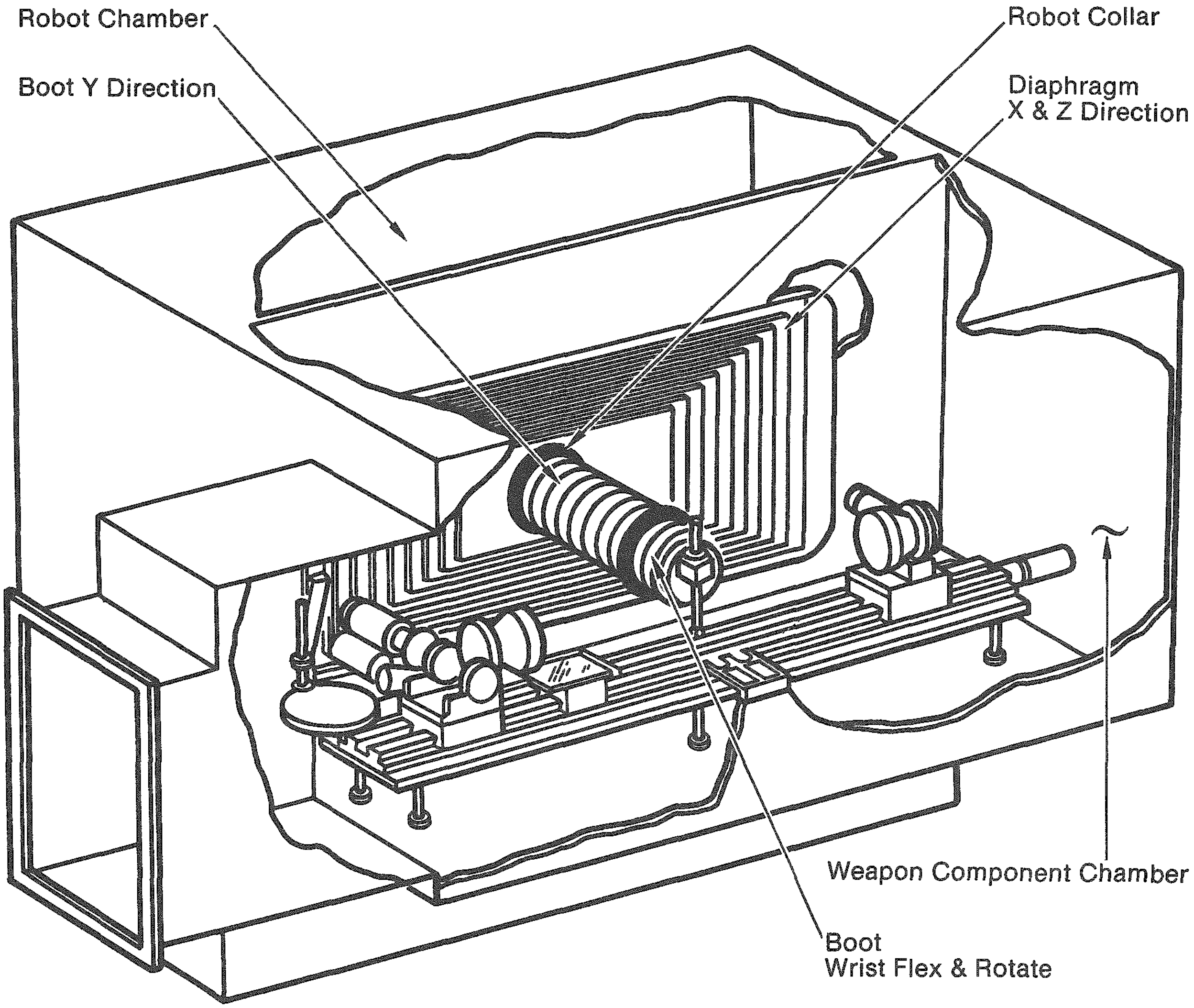
Force Sensor Change

The six-axis force sensor originally intended to provide feedback to the robot for closed-loop operation will be used for data collection on brushing pressures only. This change was necessary due to the excessive amount of memory required by the robot to process the signals generated by the force sensor. The data obtained from this sensor will still be used to determine the best brushing method for removing plutonium oxide. A spring-loaded brush will provide a constant brush pressure during the process.

Diaphragm/Boot Design

The diaphragm/boot assembly is designed to provide an environmental barrier between the robot components with lubricants and the weapon component, giving protection against contamination of the

FIGURE 9. Automated Part-Brushing System



plutonium part. A secondary benefit with this diaphragm/boot may be the delayed contamination of the robot. While the robot is uncontaminated, maintenance of the robot should be less restrictive. The spread and degree of contamination will be monitored. However, the robot eventually is expected to become radioactively contaminated.

The diaphragm/boot dividing the two chambers of the glovebox will consist of three separate parts. See Figure 9. The first part will be a rectangular diaphragm connected to the glovebox at the outer perimeter and attached to a special collar located at the origin of the robot arm. This diaphragm will be designed to flex 52 in. in the horizontal (X) direction and 16 in. in the vertical (Z) direction. A boot will be connected to the special collar and extend out to the wrist plate of the robot. A second boot will be attached to the wrist plate and extend out to the tool interface of the robot at the wrist rotate. This boot will be designed to flex 108° with the wrist and 360° with the wrist rotate. All the flexible components will be made of natural rubber.

The diaphragm/boot design is in the conceptual design stage. Further refinement is expected prior to final implementation.

Motor Reliability Concerns

The glovebox will have a depleted oxygen atmosphere. The robot motors are DC servos with special low oxygen environment brushes. If excessive motor brush wear is experienced after experimental operations, an air-feed system will be provided to introduce air into the motor brush areas. The higher oxygen atmosphere will be in the robot chamber of the glovebox and exit through an exhaust separate from the chamber containing the weapon component.

The chamber housing the weapon component and carriage assembly will contain five brushless stepping motors. They will operate the brush, index slide, two revolving indexers, and a 90° indexer.

Brush Design

The first brushing system design was duplicated from the present production part-brushing machine. After testing, this design was found to be inadequate and a second design made specifically for the APBS was developed. This brushing system has 60% the mass of the original, providing less stress on the robot wrist. Also, the stepping motor driving the brush can be set to a more precise rotation, ensuring constant brushing velocity.

Robot

The APBS requires two identical robots. The first one (Robot A) will be used as an offline/cold area development programming system. The second robot (Robot B) will be located in the contaminated containment of the glovebox and will be used exclusively for production. Upon completion of development, the tooling and software generated from Robot A will be transferred to Robot B.

The robot presently being used for experimentation is an Automatix AID 600. This robot will be replaced by an updated AID 600. The new robot will have the same design dimensions and cartesian-coordinate system as the present robot. In addition, it will have a faster, master printed circuit board, microdisk storage system instead of tape cassettes, three more RS232 communications interfaces, tachometer-controlled wrist motion, two cable links from the controller to the robot instead of the present five and advanced software compatible with the new master board.

This change was precipitated by a major manufacturing upgrade of the robot model presently being used on the APBS. A request was made to Automatix for an assessment of upgrading the present robot or trading for a new robot. After investigation, Automatix concluded that a modification of the existing robot to an upgraded status would be impossible. Automatix agreed to furnish a new robot and controller in exchange for the existing robot and controller and the value difference in money.

Present Status

The APBS is in the mock-up fabrication and assembly stage. All major components have been procured for the mock-up and preliminary testing is underway. Preliminary programming of the robot and stepper-motor controller has been completed. This program provides for open-loop operation only. Future closed-loop programming will take place when the stepper-motor optical encoders, nuclear safety system, and operation-safety system have been installed.

The replacement robot (Robot A) and production robot (Robot B) have been approved for purchase and the solicitation has been sent to Automatix. Both robots will be purchased together to ensure duplication.

FUTURE WORK

Completion of the APBS mock-up testing is scheduled for February 1986. A procurement package will be developed by Remote Engineering for bidding by robotic systems companies. This package will have enough information for the successful bidder to build the duplicate production APBS. The production robot will be Government-furnished equipment (GFE). FE&C will design and procure the glovebox for the APBS. Installation, R&D testing, and engineering evaluation are scheduled for completion prior to the July 1987 production startup date.

REFERENCE

1. C. M. Brown, *Remote Engineering Progress Report January Through December 1983,* RFP-3694, Rockwell International, Rocky Flats Plant, Golden, CO, February 22, 1985.

HOT-DIP ZINC-GALVANIZING FURNACE

G. F. Hackman, C. H. Jacobson,
and D. B. Burry

OBJECTIVE

The purpose of this project is to design the equipment needed to develop and demonstrate galvanizing techniques for special materials being produced in Building 883.

PRIOR WORK

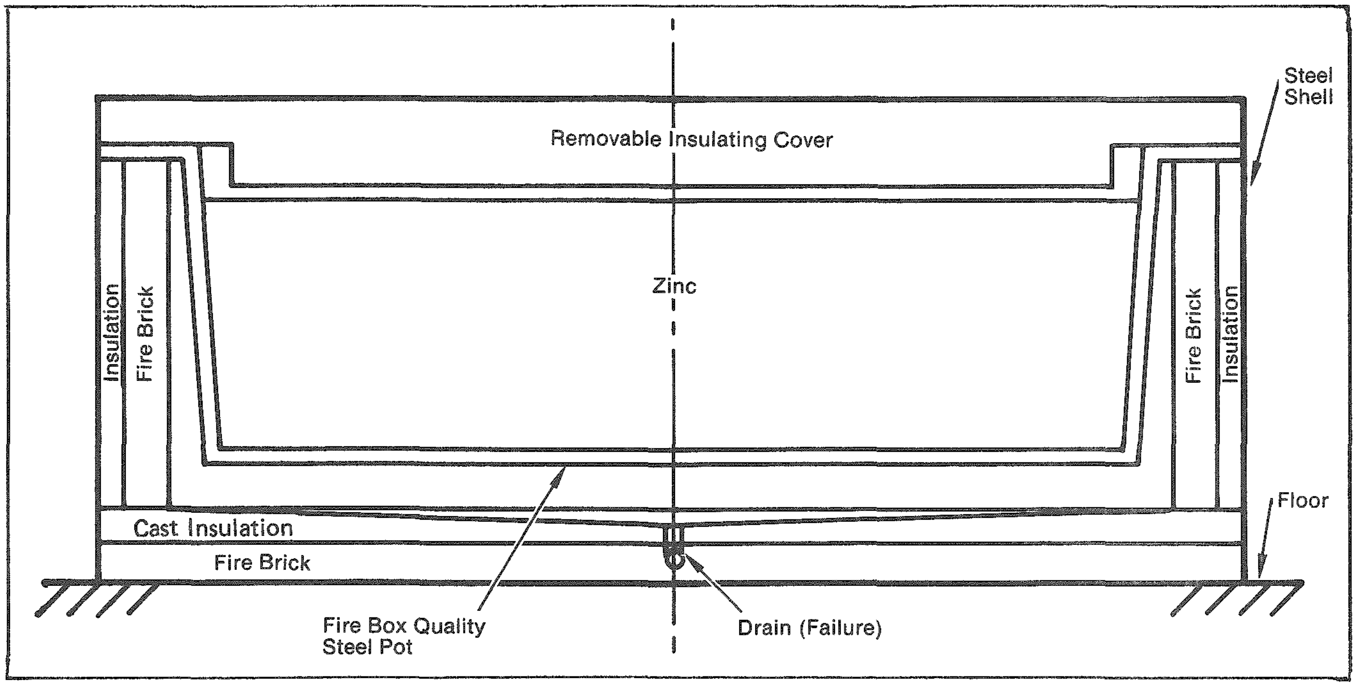
This is a new project.

ACHIEVEMENTS AND DISCUSSION

Remote Engineering designed a hot-dip galvanized pot to accommodate an 80-in. X 24-in. X 0.125-in.-thick, 160-lb metal sheet using an attached jib crane to dip the sheets into the pot. The entire assembly, including the pot, jib crane, and all the electrical controls will be skid-mounted for transportability.

The design shown in Figure 10 consists of an electrically-heated, heavy-walled, fire-box quality

FIGURE 10. Hot-Dip Zinc-Galvanizing Furnace



metal pot supported and enclosed in a fire brick base. The pot has a removable insulating cover to reduce heat losses during the heat-up and stand-by operations. The jib crane is swivel-mounted and has a variable speed electric motor drive to allow development of the proper insertion and extraction speeds.

Remote Engineering delivered complete fabrication and installation drawings to the General Metallurgy group, Building 865, who then initiated all necessary work and purchase orders. The fabrication of all metal parts will be handled by the Building 334 Sheet Metal Shop, and Area 800 Maintenance personnel will complete the assembly and installation.

FUTURE WORK

There is no future work scheduled for Remote Engineering.

AUTOMATED SAMPLE CUTTING LINE

L. M. Hess-Frey and J. J. Lucerna

OBJECTIVES

The objectives of this project are to reduce radiation exposure to personnel and increase laboratory capacity and productivity. The automated sample cutting line will clean and cut laboratory samples.

PRIOR WORK

Previous work on this project was reported in RFP-3694.[1]

ACHIEVEMENTS AND DISCUSSION

The present manual sample cutting operation is time consuming and physically difficult. Plutonium sample ingots are received in Building 559 from R&D and the production foundry. After entry into the glovebox, the sample ingots are reduced in size with bolt cutters to allow storage in vials. The vials are then stored in metal "shoe boxes" until analytical aliquots are required. As aliquots are required for analysis, the vials are manually retrieved and the oxide is removed from the sample with a hand file. The aliquots are then cut from the sample with side cutters. Aliquots range in size from 50 to 1000 mg.

Several automated steps are necessary to perform the sample cutting operation (Figure 11). These steps are bar code label printing and application, temporary storage before and after cutting, bar code reading, vial uncapping, vial unloading, oxide removal, aliquot cutting and weighing, vial capping and weighing, and transfer between stations.

In February, the Automated Sample Cutting Line Title 1 package was reviewed and approved with only minor design changes required. As a result of Title 1, a vacuum cleaner system was added to the design of the oxide removal station to collect the oxide. Also, the D.C. gear motors were replaced with D.C. stepping motors to prevent the rapid wearing of the motor brushes, which occurs in a nitrogen environment. At the output storage carousel, an interlock was added to turn the system off when the carousels are full. The design of the capping station was modified so that the tightening torque can be controlled. The modifications include a gripper to hold the cap, and a power spring to control the torque.

A base for all the stations being served by the robot has been designed. This base features adjustment in the X, Y, and Z axes and minimizes alignment time. A similar base has been designed for the robot with the addition of a two-way rotary union for the nitrogen supply and exhaust.

Measurements of the cast plutonium samples were taken to determine the tolerances required on the sample unload station and the fixture holding the sample during cutting. Due to sprue and flashing left from the casting, the samples varied too widely in size for an automated operation. The foundry has started work on obtaining a more uniform sample.

Cutting tests were performed in Advanced Nuclear Projects using plutonium to determine depth of cut

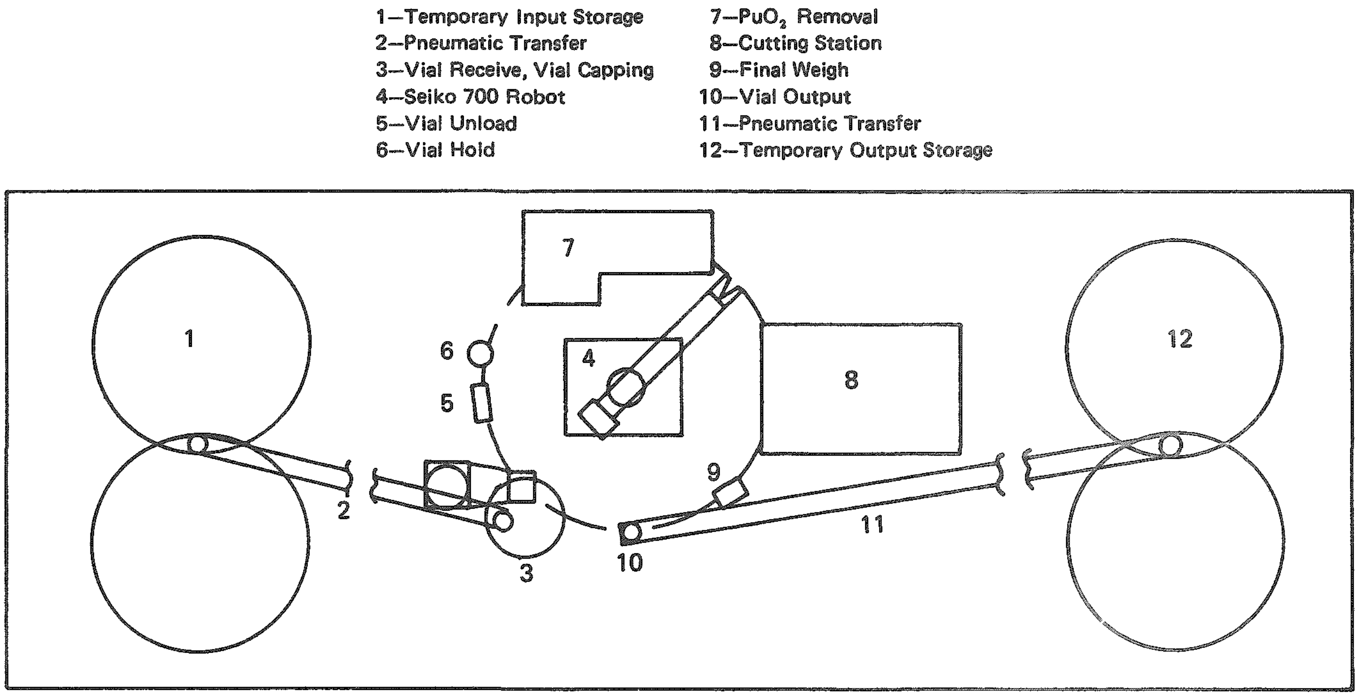


FIGURE 11. Automated Sample Cutting Line

and feed rate necessary to obtain a chip with a mass of 50 mg. The same tests were performed on a mini-CNC milling machine using meehanite and aluminum to simulate plutonium. After several tests, the mini-milling machine was found to not have the capability of obtaining a large enough chip for chemical analysis. Another problem with using a milling machine is the plutonium welding to the cutting tool due to the lack of lubricant. Lubricants are not allowed when cutting the samples because they will alter the chemical analysis. Research into another cutting method has been initiated.

Facilities Engineering has started design on the nitrogen recirculation system and the glovebox modifications needed to install the automated sample cutting system.

Approval was obtained to contract an offsite firm to do the detailed design and drafting for the cutting system.

FUTURE WORK

This project is inactive until priorities allow its completion.

REFERENCE

1. C. M. Brown, *Remote Engineering Progress Report January Through December 1983*, RFP-3694, Rockwell International, Rocky Flats Plant, Golden, CO, February 22, 1985.

AUTOMATED STORAGE AND RETRIEVAL SYSTEM

S. W. Cowles and S. G. Cox

OBJECTIVE

The purpose of this project is to automate the storage and retrieval of samples in the Building 559 Analytical Laboratory. The system will result in increased laboratory capacity, increased productivity, improved material accountability, reduced radiation exposure to personnel, and an automated inventory routine.

PRIOR WORK

Previous work on this project was reported in RFP-3694.[1]

ACHIEVEMENTS AND DISCUSSION

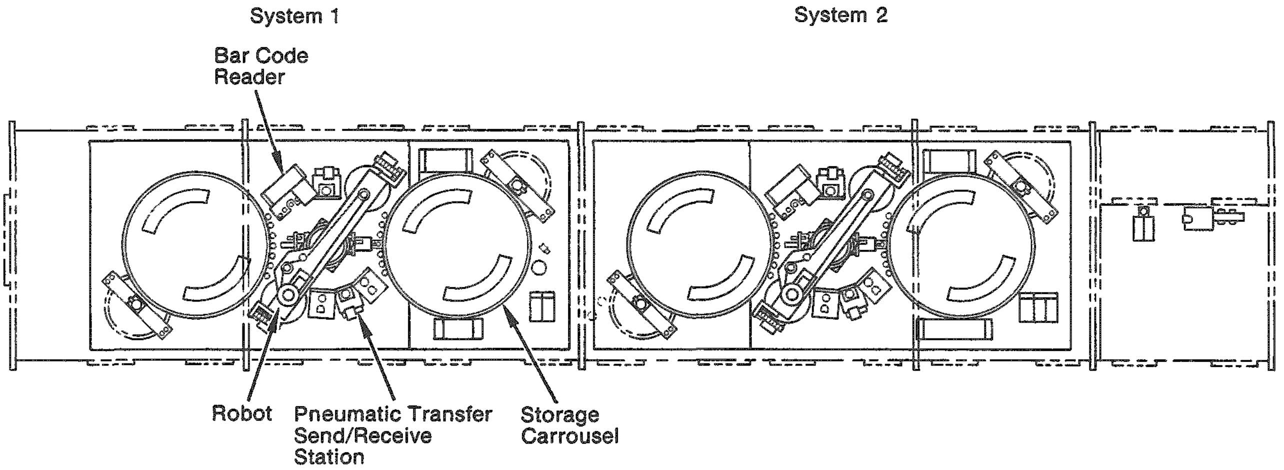
Presently, small aliquots for chemcial analysis are manually cut from samples of fissile material after the material comes into the analytical laboratory. The leftover samples are placed in vials, labeled with a grease pencil, and randomly placed in metal shoe boxes for storage.

If additional aliquots are required for further analysis, laboratory personnel manually sort through the shoe boxes until the desired samples are found. After the new aliquots are obtained, the leftover samples are again randomly stored. When no further aliquots are required, the samples are retrieved and purged from the laboratory. The storage period may last up to six weeks.

An automated storage and retrieval system to upgrade the existing manual process is currently under development. Two parallel projects are also underway. One will automatically cut the small aliquots from the samples, weigh the aliquots, label vials with the sample's requisition number in both bar code and alphanumeric characters, and place the samples and aliquots in the individually labeled vials. The second project is a pneumatic transfer system which will transfer the sample vials between the storage glovebox and the cutting gloveboxes and also transfer the aliquot vials throughout the analytical laboratory.

Upon receiving a sample vial from either the Automated Sample Cutting System or the manual sample cutting glovebox, the Automated Storage System will read the vial's bar code label and weigh the vial and enclosed sample. The weight is put in the computer's database for future weight verifications. Finally, the vial is stored on one of the storage carousels with a pick-and-place robot and its storage location stored in the database. See Figure 12. At any time a trained operator may request the system to perform one of four tasks: (1) retrieve a sample and send it back to either the manual or the automated sample cutting gloveboxes so additional specimens may be cut; (2) retrieve a sample so it may be purged from the laboratory; (3) perform an automated inventory

FIGURE 12. Automated Storage and Retrieval System



routine whereby sample vials are again individually weighed and the weight compared to the weight stored in the database; and (4) display the total weight of fissile material in the system. The storage carousels will have a freewheeling capability to allow the sample vials to easily be accessed should the system be down for repair.

All mechanical design of the storage system and most component assembly was complete by May 1984, when the user requested the storage capacity be increased from the originally requested 1536 vials. A conceptual review leads to doubling the weight of the carousels, thereby increasing storage capacity to 3072. System redesign was initiated after receiving verbal approval for the expansion from Health Physics, Nuclear Safety, and the Fire Department. Components needing redesign include the vertical actuator for the robot arm, the backup vial input/output device which will consist of a pressurized pneumatic transfer system within the glovebox, and the storage carousels consisting of a second level attached to the existing first level. A new glovebox will also be required to accommodate the taller carousels. The glovebox atmosphere must be inert to reduce the chance of fire. Also a 2-in.-thick, water-filled panel must be placed in front of each carousel to reduce radiation exposure to personnel. The panels will be hung from rollers engaged in an overhead track within the glovebox.

Redesign of most mechanical components for Phase 1 of the storage system is complete. Phase 1 consists of the storage carousels, pick-and-place robots, weighing stations, and the backup vial input/output device. Also, the Phase 1 scope was expanded to include a bar code reading station and a simple pneumatic transfer line between the existing manual sample cutting glovebox (north end of Room 102) and the storage system (south end of Room 102). Phase 2 consists of integrating the Phase 1 storage system with the Automated Sample Cutting System and expanding the Pneumatic Transfer System throughout the Analytical Laboratory.

A mockup of the new storage system is being constructed in Building 439 as the redesigned components are fabricated. The mockup will be used for system evaluation and operator training.

FUTURE WORK

Development work, fabrication, and assembly will continue on Phase 1 of the Automated Storage and Retrieval System. All of the computer software remains to be written and the entire system must be assembled, tested, and debugged. The completed system is scheduled for installation in Building 559 in April 1986. Design of Phase 2 of the system will begin during the second quarter of FY86 and is scheduled for installation in December 1986.

REFERENCE

1. C. M. Brown, *Remote Engineering Progress Report January Through December 1983*, RFP-3694, Rockwell International, Rocky Flats Plant, Golden, CO, February 22, 1985.

PNEUMATIC TRANSFER SYSTEM

O. B. Haugen

OBJECTIVE

The purpose of this project is to automate the transfer of plutonium samples and aliquots between the automated/manual sample cutting, automated sample storage, and analytical stations within Building 559. The Pneumatic Transfer System (PTS) will result in improved sample distribution accuracy, reduced sample-transfer time, and reduced radiation exposure to laboratory personnel.

PRIOR WORK

Previous work on this project was discussed in RFP-3569 and RFP-3694.[1,2]

ACHIEVEMENTS AND DISCUSSION

Currently, aliquots used for chemical analysis are cut from samples of plutonium which have been delivered to the analytical laboratories in Building 559. After being cut from the samples, the aliquots are manually transferred to their designated analytical stations. This transfer procedure is a bagout operation involving one Radiation Monitor and two Laboratory Technicians. The current procedure is tedious, time consuming, and it greatly increases the risk of airborne contamination. Aliquots may become lost during transfer. When this occurs, the sample from which the aliquot was cut must be retrieved, a new aliquot cut from the sample, and that single aliquot transferred to the proper analytical station.

Design and development of the PTS is currently in progress. Two parallel projects also in progress are the Automated Sample Storage and Retrieval System (ASSARS) and the Automated Sample Cutting System (ASCS). Previous annual reports included the PTS as part of the ASSARS. However, because of the expanded scope of the PTS, it has become a separate project.

The PTS will be installed in two phases because of the time frame difference in the two parallel projects. Phase 1 will consist of two PTS lines between an existing sample cutting glovebox at the north end of Room 102 and the ASSARS at the south end of Room 102. Currently, there are two gloveboxes in Room 102 used for manual sample cutting and storage. The ASSARS will be installed where the south cutting glovebox now exists and all of the sample cutting will be done in the north cutting glovebox. The transfer of aliquots to analytical stations will still be by bagout procedure, but the samples will be delivered to the ASSARS through the PTS. Phase 2 of the PTS will be an upscaled version of Phase 1. Design and development of Phase 2 includes aliquot transfer from the ASCS to 12 analytical stations, aliquot transfer from the manual cutting line to 12 analytical stations and sample transfer between the ASCS, the manual cutting line, and the ASSARS.

A basic laboratory model of the PTS has been constructed in Building 439 to help determine whether vacuum or pressure should be used for aliquot transfer, how much gas flow is required, and whether the gas flow will adversely affect the process exhaust system in Building 559. The present model is constructed of polyethylene tubing connected to a 10-cfm vacuum pump and plant air. This parallel hookup allows the use of vacuum and/or pressure in the laboratory tests. Present results indicate that both vacuum and pressure will work in this application.

The Part IV estimate for the PTS was submitted to cost engineering in October 1984, by FE&C and capital funding through the Reduced Radiation Exposure Program was obtained.

FUTURE WORK

The lab model in Building 439 will be expanded to include several receiving stations, an in-line diverter, photodetectors and controls. Physical layouts and detailed design will begin in February 1985. Phase 1 design will be completed by December 1985, and installation is scheduled for completion by July 1986. Phase 2 is scheduled for completion in July 1987.

REFERENCES

1. C. M. Brown, *Remote Engineering Progress Report January Through December 1982*, RFP-3569, Rockwell International, Rocky Flats Plant, Golden, CO, February 27, 1984.
2. C. M. Brown, *Remote Engineering Progress Report January Through December 1983*, RFP-3694, Rockwell International, Rocky Flats Plant, Golden, CO, February 22, 1985.

CHEMICAL OPERATIONS ROBOTIC SYSTEM

O. B. Haugen

OBJECTIVE

The purpose of this project is to automate the sample preparation for the Inductively Coupled Plasma Emissions Spectrometer (ICPES), a new analytical instrument in Building 559. The benefits of the Chemcial Operations Robot are as follows:

1. Reduced radiation exposure to laboratory personnel
2. Improved sample quality
3. Reduced sample preparation time
4. Elimination of a tedious task

PRIOR WORK

No previous work has been done on this project.

ACHIEVEMENTS AND DISCUSSION

In the Building 559 Analytical Laboratories, there are many different tests performed on plutonium samples to determine their content and purity. Some of these tests are used in detecting the quantity of trace elements such as iron or nickel. Currently, trace element analysis is performed using different forms of Emissions Spectrometry (ES) such as Direct reading, Atomic Absorption and/or Optical. In the near future, the ICPES will be added to the list of trace element detectors within the labs. The samples used for any of these instruments are obtained through extraction, meaning that the plutonium is removed or nullified, leaving only the trace elements. These liquid or solid sample extractions are then used in one of the analytical instruments for trace element detection.

Because the new ICPES will increase the precision level of trace element detection, the precision of the extractions must be increased. The Chemical Operations Robot will increase the precision level of the extractions to that required by the ICPES. The Robot also addresses the additional objectives stated earlier.

A Zymate system has been purchased and delivered to our laboratory in Building 439. The system manufactured by Zymark, Incorporated, Hopkinton, Massachusetts, includes: a robot, automated peripherals such as dispensing, vortexing, weighing and power controlling stations; precision pipette tips and test tube racks; specialized robotic hands; and a CRT-equipped controller. System layout and process programming are currently in progress within Building 439.

FUTURE WORK

System layout and process programming will continue and any required special fixture design will be completed. An installation package will be developed and the system will be installed in Building 559. Expected completion of this project is February 1986.

LASER PART MARKING

A. A. Peterson

OBJECTIVES

The objectives of this work are to improve productivity and quality of product marking in all WR production areas. These objectives will be accomplished by installing computerized laser marking systems and various automated parts-handling systems in Buildings 881, 460, 707, 991, and 444.

PRIOR WORK

Prior work on this program was reported in RFP-3569 and RFP-3694.[1,2]

ACHIEVEMENTS AND DISCUSSION

This project was initiated to investigate methods of reducing the amount of time currently dedicated to marking War Reserve (WR) product, as well as improving legibility, quality, permanence, and traceability of the marks. The problems with the present method of marking can be categorized into several general areas: (1) chemicals used in etching can contaminate parts; (2) electrochemical etching is very time consuming; (3) many parts, because of physical limitations, cannot be marked with conventional methods; (4) many parts must be remarked, since cleaning operations often remove the electromark; and (5) no automatic data-management system exists, creating a chance for duplication of serial numbers with no automatic prevention.

These problems will be reduced or eliminated by installing laser marking systems with various part positioning and data acquisition systems. The present basic implementation plan is as follows: (1) startup of the Building 460 system without positioning system--9/85; (2) initialize support of 707 system--6/85; (3) initialize support of 991 and 444 systems--6/85; (4) complete development of part positioning system on the 881 system--12/85; and (5) mate part positioning system to 460 system--2/86.

The 881 laser marker was installed and became operational in June 1984, with the first efforts directed at supporting W87 and W79 J-line marking. This marking was without any part positioning system and required "hard" fixturing to locate parts in the laser workchamber. New design agency requirements stated that no electrochemical contaminants be present on several weapon components, the net result being that 11 components and their assemblies must now be marked with the laser. Marking parameters were developed, fixturing was ordered, M-procedures were written, operators were trained and all process paperwork modified in an effort to meet critical Preproduction Inspection (PPI) and Tool Made Sample (TMS) need dates. All required deadlines were successfully met, and the system is currently marking production parts. A time savings of about 10:1 is being realized, based upon actual comparison times of laser marking versus electromarking.

The systems being developed, which will be added to the laser markers in Buildings 460, 444, and 991, consist of the following major components:

1. Four-axis part positioner
2. Computer and electrical hardware
3. Support structure and workchamber
4. Software system

The operation sequence for the system will be as follows:

1. The operator scans a bar code label which is attached to the production process card.
2. The computer decodes the bar code information and retrieves from memory or storage the correct marking program for the particular part about to be marked.
3. The operator sets the fixturing on the four-axis positioner and inserts the part into the fixture.
4. The four-axis positioner moves the fixture with the part to the required position for marking while the computer loads all marking parameters into the laser marking system.
5. The mark is executed and a record is made on magnetic disc of the part's serial number.
6. The operator removes the completed part.

The mechanical portion of the four-axis positioner was designed and assembled, and awaits testing. The main support structure for the laser and workchamber, as well as the workchamber, have been designed. Control Systems Development (CSD) personnel designed and assembled the computer system, as well as the electronic components necessary to operate the four stepper motors on the positioner. The software development, also a CSD effort, was significantly delayed because of higher priority work within that organization.

FUTURE WORK

Major work in 1985 will consist of developing the software for the positioning and data management systems, adding laser-marking capability in Building 460 and designing the system for Building 707.

REFERENCES

1. C. M. Brown, *Remote Engineering Progess Report January Through December 1982*,

RFP-3569, Rockwell International, Rocky Flats Plant, Golden, CO, February 27, 1984.

2. C. M. Brown, *Remote Engineering Progress Report January Through December 1983*, RFP-3694, Rockwell International, Rocky Flats Plant, Golden, CO, February 22, 1985.

AUTOMATION OF RADIOGRAPHY

R. L. Barnett and R. D. Leinwand

OBJECTIVE

The primary objective of this project is to increase the throughput of components per shift in Nondestructive Testing (NDT) in Buildings 991 and 460. Additional benefits of this project include improved product quality as a result of more consistent exposures, automated exposure documentation, process simplification, decreased operator intervention, and operator safety.

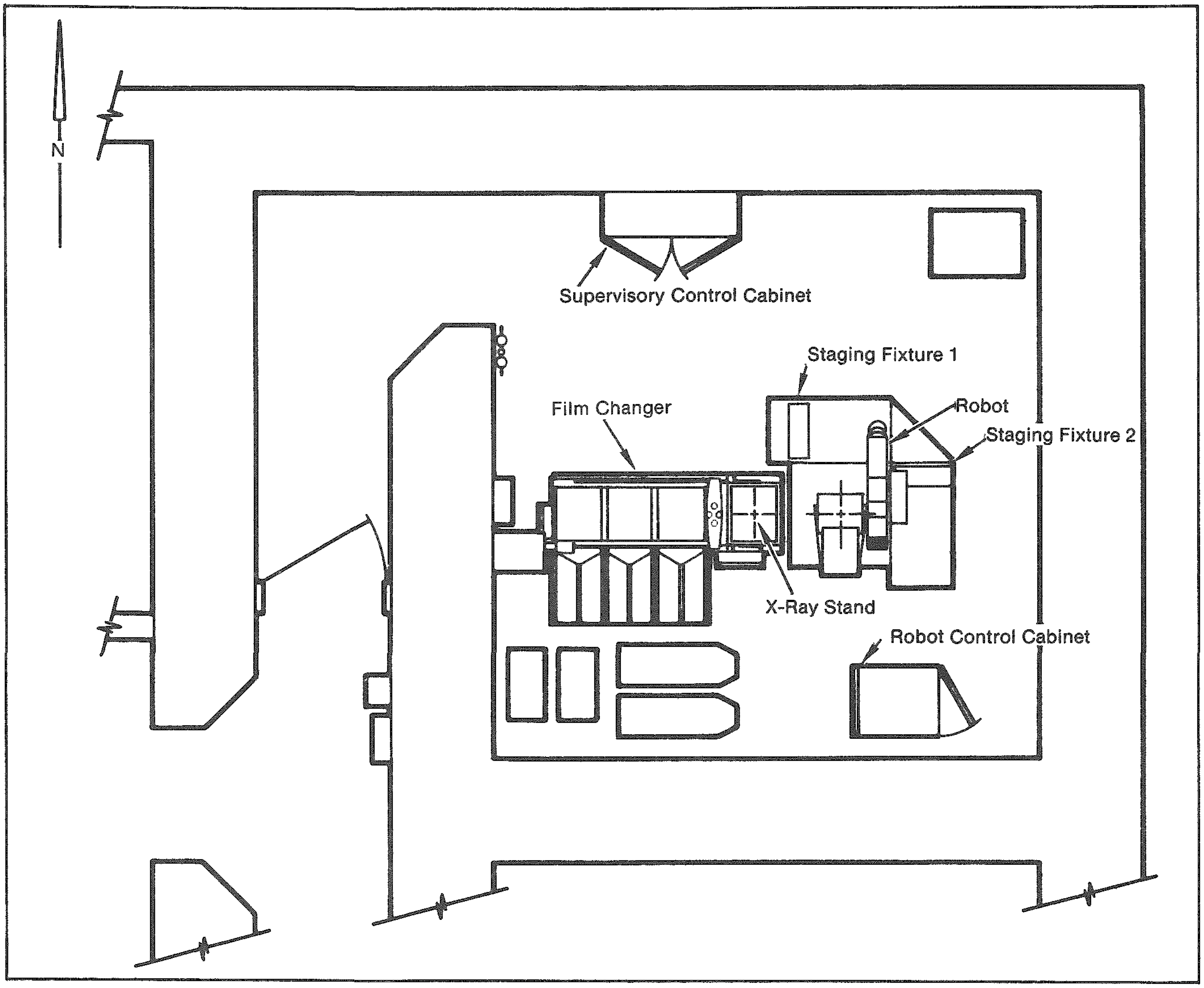
PRIOR WORK

RFP-3694 outlined the conceptual design of the automated system.[1]

ACHIEVEMENTS AND DISCUSSION

Currently, radiography is labor intensive and contains many operator-induced variables which may require a second X-ray to set a clear exposure of the components. The automated system under development will change film, rotate components, and set the X-ray unit's time of exposure and power for all views of two fixtures of components without operator intervention. See Figure 13.

FIGURE 13. Automation of Radiography Plan—Building 991



Operators can prepare the next two fixtures outside the X-ray vault without the interruption of rotating components every few minutes inside the vault. With the automated system a fixture may hold up to 25 components all of the same type.

A six-axis robot moves fixtures containing components from staging areas to the X-ray stand and back The X-ray stand holds the fixture at the proper position for exposure. The robot serves the additional purpose of rotating the components individually for subsequent exposures. American Robot Corp. was the successful bidder as the robot supplier and delivered two robots to the Rocky Flats Plant in July 1984.

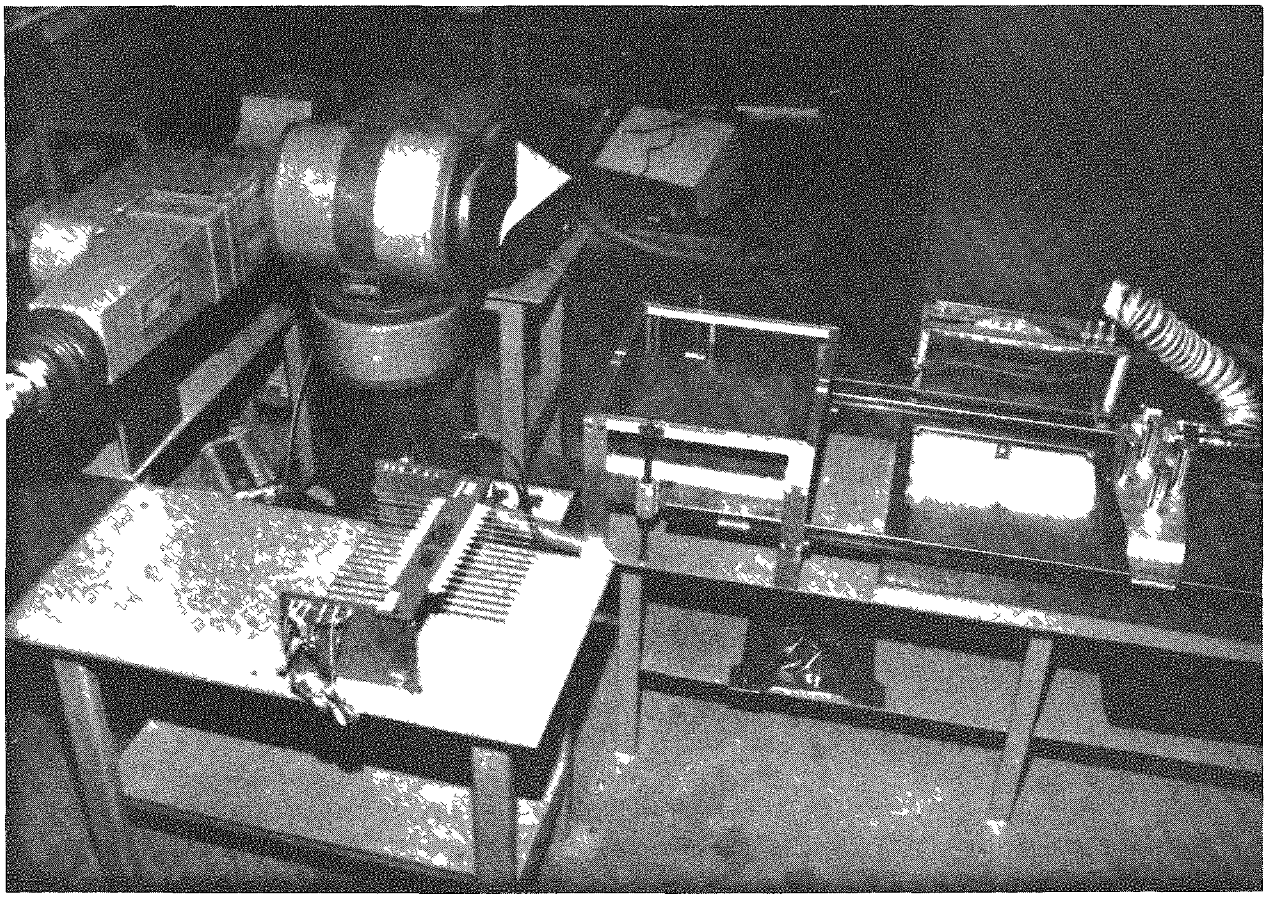
The film changer protects unexposed and exposed film, automatically positions film for exposure, and then stores the exposed film in a lead-shielded box. Fabrication, assembly, and testing have been accomplished for the 991 film changer. See Figure 14.

The X-ray unit slated for Building 991 will not be available until the third quarter 1985, and Maintenance will install the automated system at that time. The automated system for Building 991 is mechanically complete, the robot programmed, and the control cabinet wired. The system program is under development and is scheduled for debugging in February 1985. Development is underway on the automated system for Building 460 and will closely resemble the 991 system.

FUTURE WORK

Completion and testing of the automated system for Building 991 are scheduled for the fourth quarter 1985, and it will be installed shortly thereafter. The

FIGURE 14. Automation of Radiography



system for Building 460 requires development of component fixtures, a gripper, and modified controls. Nondestructive Testing has asked that the Building 460 automated system not be installed until after October 1985 when their move to this new building will have been completed.

REFERENCE

1. C. M. Brown, *Remote Engineering Progress Report January Through December 1983*, RFP-3694, Rockwell International, Rocky Flats Plant, Golden, CO, February 22, 1985.

AUTOMATED DEBURRING SYSTEM FOR J-LINE COMPONENTS

L. M. Hess-Frey, Remote Engineering and
S. G. Fleming, Machining & Gaging R&D

OBJECTIVE

The objective of this project is to develop deburring methods for J-line parts that will improve quality and increase productivity.

PRIOR WORK

Several studies of the deburring problem and possible solutions have been completed, the most recent by Dr. Marvin Burnam in Machining and Gaging R&D on July 11, 1983.

ACHIEVEMENTS AND DISCUSSION

Presently, deburring of J-line parts is a labor-intensive, time-consuming process that can take up to two hours per part.

Several automated deburring processes are being investigated for use in the Building 460 Group Technology cell concept. The criteria used in this investigation include a machine requiring minimal fixturing, minimum floor space, and a proven record in finishing precision parts. Minimal fixturing is desired since fixturing would become a major cost with the large variety of parts that are made. Machines requiring minimum floor space are desired so that they can be used in all the cells in Building 460 that require a deburring process. This arrangement will reduce the transporting of parts to a central deburring area, for all but the final deburring process, when required. At present, four deburring processes are being investigated: vibratory, abrasive blasting, thermal energy method, and modified Harperizing. Included in the deburring process, tests are metallography and cleaning tests.

Vibratory deburring results from Bendix in Kansas City are not favorable. The method worked well on the exterior surfaces but did not affect the inside burrs. Manual methods were required to deburr the inside surfaces, first using a burr knife to take off the larger burrs, then completing the process using a Kratex abrasive bullet on an air motor.

Preliminary abrasive blasting results are very favorable. A micro-blaster has been purchased by Machining & Gaging to test deburring of several parts and various abrasives. Parts have been deburred using silicon carbide and aluminum oxide abrasives. The silicon carbide results in a poor quality weld if the part is later welded. The aluminum oxide has shown no compatibility problems with stainless steel, titanium, or vanadium. Abrasive blasting produced a matte finish, while the surface roughness improved from 49 microinches to 38 microinches.

Surf-Tran Company conducted the thermal energy deburring tests. The first parts sent were not cleaned before deburring resulting in machining oil burning onto the parts making cleaning tests inconclusive. The second batch of parts was cleaned before deburring. These deburred parts were cleaned in the regular cleaning process with no problems. Metallography tests to determine any surface or alloy change due to the thermal blast have not been completed.

Test parts are being fabricated with internal and external threads, intersecting holes and sharp edge breaks, which are difficult to deburr so that more tests on each deburring process can be completed.

The last process being investigated is a Harperizer that is modified by Surface Technology (a consulting group) to perform precision deburring. As soon as the test parts being fabricated are complete, some will be sent to Surface Technology for deburring.

FUTURE WORK

During the next year, the thermal energy, abrasive blast and modified Harperizing methods, and compatibility tests will be continued. Production parts will also be deburred and inspected to determine whether or not the parts remain in tolerance after each of the deburring methods.

Once the methods have been selected, the equipment will be purchased or leased. Development of deburring processes will then continue, as operators are being trained to run the equipment.

444 INGOT GRIPPER

A. A. Peterson

OBJECTIVE

The objective of this project is to provide for production personnel an effective and safe device which will grasp depleted uranium ingots (8-in. diameter by approximately 30-in. length, about 800 lb) for transfer to and from (at 800 °C) the annealing furnaces. Presently, the ingots are lassoed with a steel cable, a very dangerous operation, as the operators have to lean into the hot furnaces.

PRIOR WORK

This is a new endeavor.

ACHIEVEMENTS AND DISCUSSION

A conceptual design for the ingot stripper was completed at the request of Building 444 Foundry personnel. What was required was a device which could grasp depleted uranium ingots (8-in. diameter, 30-in. long, and about 700 lb) at room temperature, load them into the annealing furnaces, remove them at 800 °C, and lower them into water-filled quench tanks. An additional design requirement is that the gripper must not exceed 16 in. in diameter. The gripper uses the weight of the ingot to actuate the pawls which contact it; hence, the heavier the ingot the more the force which grips it. A prototype gripper was fabricated, and the basic concept was proved sound; however, the four pawls could operate independently, allowing the gripper to grasp the ingot offcenter. The offcenter condition is potentially unstable, so the gripper design was modified to correct the problem. The new design mechanically links together all four gripper pawls. The new design modifications were incorporated into the prototype gripper, and the device is undergoing testing in the foundry in Building 444. Other than small problems, the gripper is operating as designed and has been given a favorable response by production personnel.

FUTURE WORK

Possible work for 1985 will be to modify the design such that grippers can be fabricated to accommodate other diameters of ingots. Also, a second gripper for 8-in. ingots is being fabricated as a backup in the foundry.

URANIUM FOUNDRY CRUCIBLE CLEANING PROJECT

P. W. Herrman, R. D. Leinwand,
and D. Y. Martinez

OBJECTIVE

The objective for this project is to develop a crucible cleaning facility for the Metallurgical Operations' uranium foundry to reduce radiation exposure. Crucible cleaning is presently performed mannually, and the operation requires that workers wear full-face respirators and protective clothing when cleaning.

PRIOR WORK

No prior work has been reported.

ACHIEVEMENTS AND DISCUSSION

A number of conceptual designs to automate the crucible cleaning process were generated and studied until a final design was agreed upon by the user and the design groups. The agreed-upon design entails the construction of a highly ventilated enclosure in which the cleaning is to be performed. An overhead trolley hoist is provided in the enclosure for transporting the crucibles. A specially developed hoist gripper allows gripping and releasing of the crucibles to be controlled from outside the enclosure.

The graphite crucibles, ranging from approximately 14 to 35 in. in diameter, and weighing up to 350 lb, are removed from the induction furnaces after cooling down from a casting operation. Remaining in the used crucible is an atrium oxide mold wash, which is used to prevent carbon contamination and to simplify crucible cleaning, and reduce alloy metal residues known as skull, consisting primarily of depleted uranium. Up to 50 lb of skull can be found in the used crucibles. The used crucibles are transported to the cleaning enclosure on a cart, then moved into the enclosure using the trolley hoist.

The skull is a highly pyrophoric waste material which requires oxidation prior to disposal. After placing the crucible in the enclosure, the operator will ignite the skull and allow it to burn in the crucible. Space is allotted in the enclosure to allow three crucibles to burn out, then cool simultaneously. To reduce the time for periods of high production, a burn-out grate will be provided into which the operators can set the skull prior to igniting so the crucible does not have to heat up then cool down as required when burning the skull in the crucible.

After the skull has burned and the crucible has cooled, the operator will manipulate the crucibles, using the trolley hoist, and place the crucibles on a rotary table at the cleaning station. The cleaning station will consist of a six-axis articulated arm, electrically powered robot fitted with three cleaning tools; a scoop tool, a vacuuming tool, and a wire brushing tool. The robot will also have sensors for determining the crucible size and temperature. After the skull temperature drops below 110 °F, the robot will lower the scoop tool into the crucible. The rotary table will start to rotate the crucible and the scoop will fill with oxidized skull. The robot will then remove the scoop tool and dump its contents into a waste drum. This cycle will be repeated until most of the skull is removed. The robot will then take the vacuuming tool and trace the curvature of the inside of the crucible along a single plane while the crucible is being rotated. After vacuuming the inside of the crucible, the robot will use the wire brushing tool to abrasively clean the interior of the crucible. The final step of the automated cleaning process will be to repeat vacuuming the crucible and then signal the operator that the cleaning is done. The operator will use the trolley hoist to remove the crucible from the enclosure, then inspect and touch-up the crucible.

After acceptance of the conceptual design, detailed design work commenced on the project. Work was divided among three groups: Facilities Engineering & Construction preparing all of the demolition, enclosure, and utilities design; Equipment Design & Development preparing the vacuum cleaner specification and design of the trolley hoist gripper; and Remote Engineering preparing all of the equipment specification and design work related to the robot and the burn-out grate.

All of the Remote Engineering drawings for this project were drawn using Control Data's ICEM CAD system. This project constitutes a pilot or test run of CAD by Remote Engineering to evaluate the effectiveness of computerizing drafting for Remote Engineering. See Figure 15.

The major capital equipment on the project was identified as the robot, the rotary table, the screw conveyor, the burn-out grate, and the vacuum cleaning system. The purchasing/specifying process was completed on all of the above items except for the vacuum cleaning system and orders placed for the specified equipment. An order for the vacuum cleaner is pending. The robot selected for the cleaning station was a KUKA IR161/15 robot.

Design work was initiated on the individual components of the project. Title I approval was received on the FE&C portion of the project. The Title II review was held and included a Remote Engineering series of drawings on equipment installation. Design

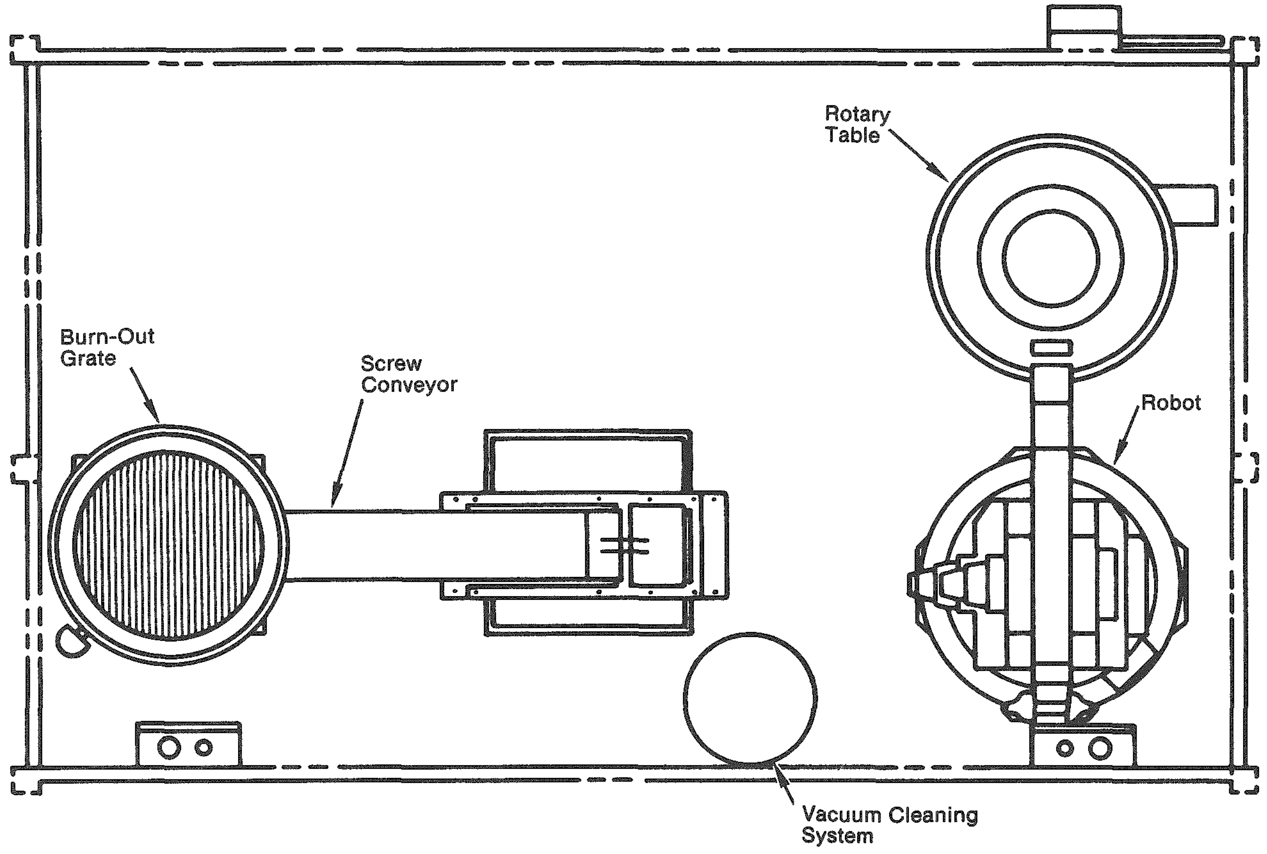


FIGURE 15. Burn-Out Equipment Installation

of the burn-out grate and the robot tooling were not included in the installation/construction packages.

Design of the burn-out grate was approximately three-quarters completed by the end of Calendar Year 1984. The burn-out grate will consist of a grate on which the skull will be set to burn. The reduced skull is a brittle, chunky material. At oxidation, the skull is converted into a fine powder with particle size ranging from 100 to 150 microns. After burning, the skull will fall through the grate into a hopper and fed into a screw conveyor. A vibrator will be provided to shake down the powder. The screw conveyor will be water-jacketed to cool the hot skull and will feed the material into a 30-gal waste drum. The waste drum will be situated on a scale for detection of the "drum-full" condition. Operation of the burn-out grate will be entirely automatic with backup controls for manual operation. Heat from the skull burning in the grate will be detected by bimetallic temperature switches and the signal will be relayed to a programmable-logic controller. Once burning skull is detected, a cycle will start with preprogrammed intervals of shaking down, conveying, and cooling. Temperature switches on the conveyor water jacket will provide cooling-water overheat signals so that measures may be taken to prevent the cooling water from reaching boiling temperature.

Design of the robot tooling is approximately half completed. The robot tooling will consist of five separate elements: a tool rack, a tool changer, and the three tools. The tool changer utilizes a novel design to allow changing tools solely utilizing the kinetic energy of the robot with no external air or power required to grip or release the tools. The changer utilizes a bayonet-type grip to hold the tools and has a lock mechanism mechanically released by contact with the tool changer. The tool changer also has feed-throughs to provide compressed air power to the tooling.

The scoop tool is the simplest of the tools, consisting essentially of a welded scoop. The vacuuming tool is based on a standard vacuuming brush nozzle. The brush itself is constructed from an industrial wire bristle, 2-in. arbor brush. The vacuum hose is festooned from a curved door track down to the tool and will travel along the track as the tool is moved from the tool rack to the crucible. The wire-brushing tool will be air-motor driven. The motor mount will be spring-loaded for axial compensation to allow for the large manufacturing tolerances of the graphite crucibles.

FUTURE WORK

Future work on this project calls for completing all design during the second quarter FY85.