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Plutonium Pit Manufacturing Unit Process Separation Options for Rapid Reconstitution

A Joint Position Paper of Lawrence Livermore National Laboratory and Los Alamos National Laboratory

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Plutonium Pit Manufacturing

Unit Process Separation Options for Rapid Reconstitution

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Scope

This document addresses technical issues regarding the manufacturing processes involved in making plutonium pits. It addresses acceptable approaches from a technical standpoint as to how the manufacturing processes can be separated and distributed among different manufacturing sites. Site selections, costs, and intra-site transfers are not addressed in this document.

Introduction

At the request of the Department of Energy Albuquerque Office, Lawrence Livermore National Laboratory and Los Alamos National Laboratory have analyzed the plutonium pit manufacturing process. The nuclear design labs (Labs) have determined logical break points in the manufacturing process where the sequence can be separated among sites without inherently jeopardizing product quality.

Production of pits can be broken up into two major component categories, non-nuclear and nuclear. At the completion of the manufacturing process, the components are integrated into a single unit. Non-nuclear components, either unclassified or classified, are relatively easy to handle, ship, and receive. They are relatively chemically inactive, in that they are unlikely to oxidize or undergo surface chemical reactions that would affect the quality or usefulness of the part. They are not radioactive, decreasing shipping requirements and making them relatively easy to inspect when received. Non-nuclear parts can be manufactured at existing DOE facilities or outside commercial facilities.

Nuclear components are by definition radioactive and typically exhibit chemically active surfaces, which can lead to surface corrosion and oxidation. Every step that potentially exposes nuclear materials to a non-inert environment can influence the quality and usefulness of the part in successive production steps.

The radioactivity and chemical reactivity of the product necessitates approved packing procedures, approved shipping containers, and special procedures when shipped, to facilitate any receiving inspection requirements. The following issues are common to each site engaged in process transfers:

- Transfers between manufacturing sites will require approved shipping containers for the items shipped.
- Transfers between manufacturing sites will require approved packing, unpacking, and inspection procedures.
- Transfer activities will affect worker ALARA radiation dose.
- Transfers will require nondestructive analysis, plutonium measurements on the shipping and receiving ends.

Discussion

The main pit manufacturing operations (excluding non-nuclear operations) are shown in Figure 1. These are:

- Disassembly - the dismantling of a plutonium pit assembly
- Metal Preparation - removal of the americium and purification of the plutonium metal
- Foundry Operations - melting, casting, and heat treating plutonium metal parts to be machined
- Machining - removing extra metal from the cast part to the final dimension
- Assembly - joining all parts to make a complete pit
- Post Assembly - final treatment and closure of the pit

The pit manufacturing process steps listed have been evaluated in terms of whether it is technically possible to **complete a given step** at one site and transfer it to the next process step at another site. Table 1 shows the pit manufacturing process steps that were considered for partitioning between manufacturing sites. The table shows:

(1) the unit operations,
(2) if splitting the manufacturing process after the completion of a listed unit operation is technically possible,
(3) support operations which are necessary at the site carrying out a given unit operation, and
(4) the Labs' recommendation on whether splitting the process at the completion of the step is acceptable.

The Labs' recommendations are based on the pros and cons associated with separating the sequence of unit operations. These pros and cons are listed in Appendix A.

It can be seen that it is technically possible to break the pit manufacturing process into a number of transfers among sites. However, history has shown that transfer after certain process steps may not be technically reasonable, feasible, or acceptable to both nuclear design laboratories.

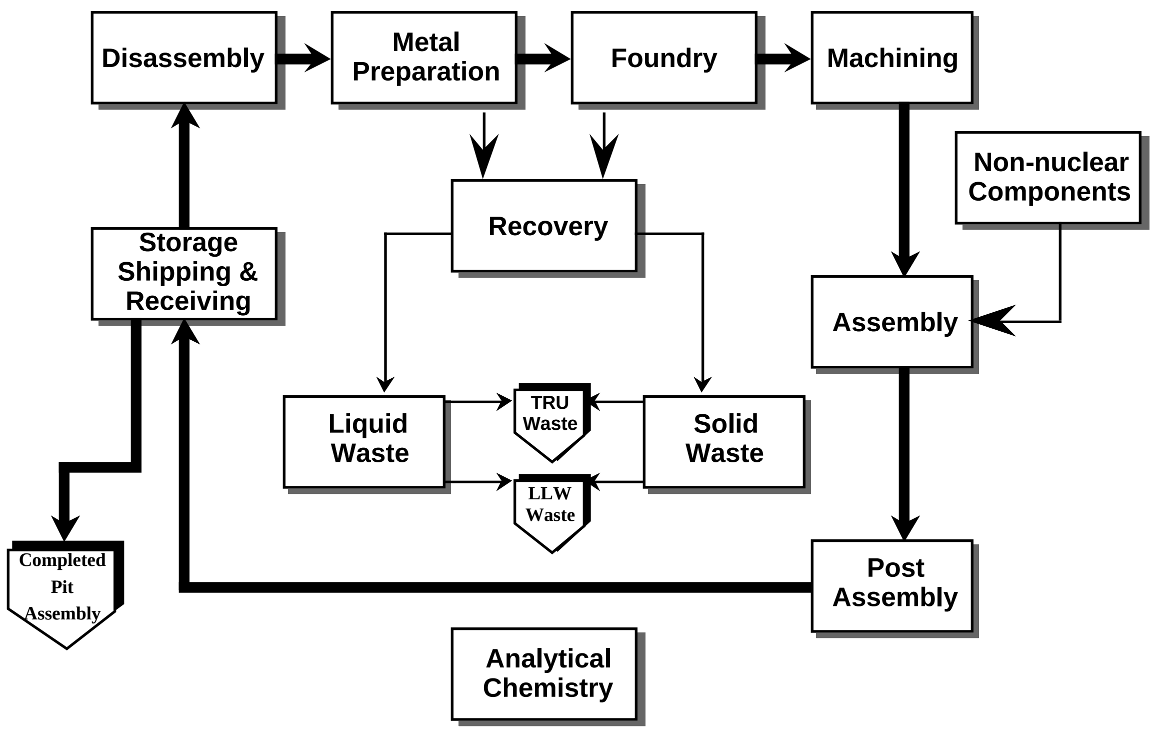

Figure 1

Pit Fabrication Flowsheet
(taken from LANL document: NMSM:96-097, July 26, 1996)

Table 1

Process Separation Under Rapid Reconstitution

(1) Completion of listed step and transfer to next process step:	(2) Technically Possible	(3) TRU support operations for process step †	(4) Acceptable to both nuclear design laboratories
Disassembly			
Pit dismantlement	yes	1, 2, 3, 4	yes
HYDOX - hydride and oxidize to plutonium oxide	yes	1, 2, 3, 4	yes
HYDEC - hydride and reduce to metallic plutonium	yes	1, 2, 3, 4	yes
Metal Preparation			
Reduction of plutonium oxide to plutonium metal	yes	1, 2, 3, 4	yes
Plutonium purification	yes	1, 2, 3, 4	yes
Americium extraction	yes	1, 2, 3, 4	yes
Foundry			
Foundry - cast plutonium feed ingots	yes	1, 2, 3, 4	yes
Foundry - cast plutonium components	yes	1, 3, 4, 5	yes
Machining plutonium components*	yes	3, 4, 6	no
Non-nuclear Components Coating	no	none	no
Assembly			
Assembly & Welding	yes	3, 4	no
Bonding	yes	3	no
Post Assembly	yes	3	yes

† 1) Plutonium analytical chemistry; 2) Plutonium recovery; 3) LLW handling; 4) TRU waste handling; 5) Plutonium metallography; 6) Radiography. Non-nuclear support requirements are not listed.

* Will require provisions for safely handling plutonium metal turnings by either (1) briquetting and melting into metal ingots or, (2) calcining into oxide powder.

Conclusion

The Labs agree that the ideal approach to pit manufacturing would have all manufacturing operations at one location. This would enable single-point responsibility and authority over all manufacturing operations, and would minimize duplicating support operations such as analytical chemistry, plutonium recovery, and waste handling. In the event that this ideal approach cannot be accommodated, it is technically possible to separate the manufacturing sequence between most unit operations with the exception of non-nuclear component coating, which must remain at the same site as assembly. However, from the standpoint of successfully accomplishing the pit production mission, the options are constrained.

Based on the analysis of the advantages and disadvantages associated with splitting the pit manufacturing processes between sites, the Labs make the following recommendations for feasible process separation, designated by broken lines in Figure 2.

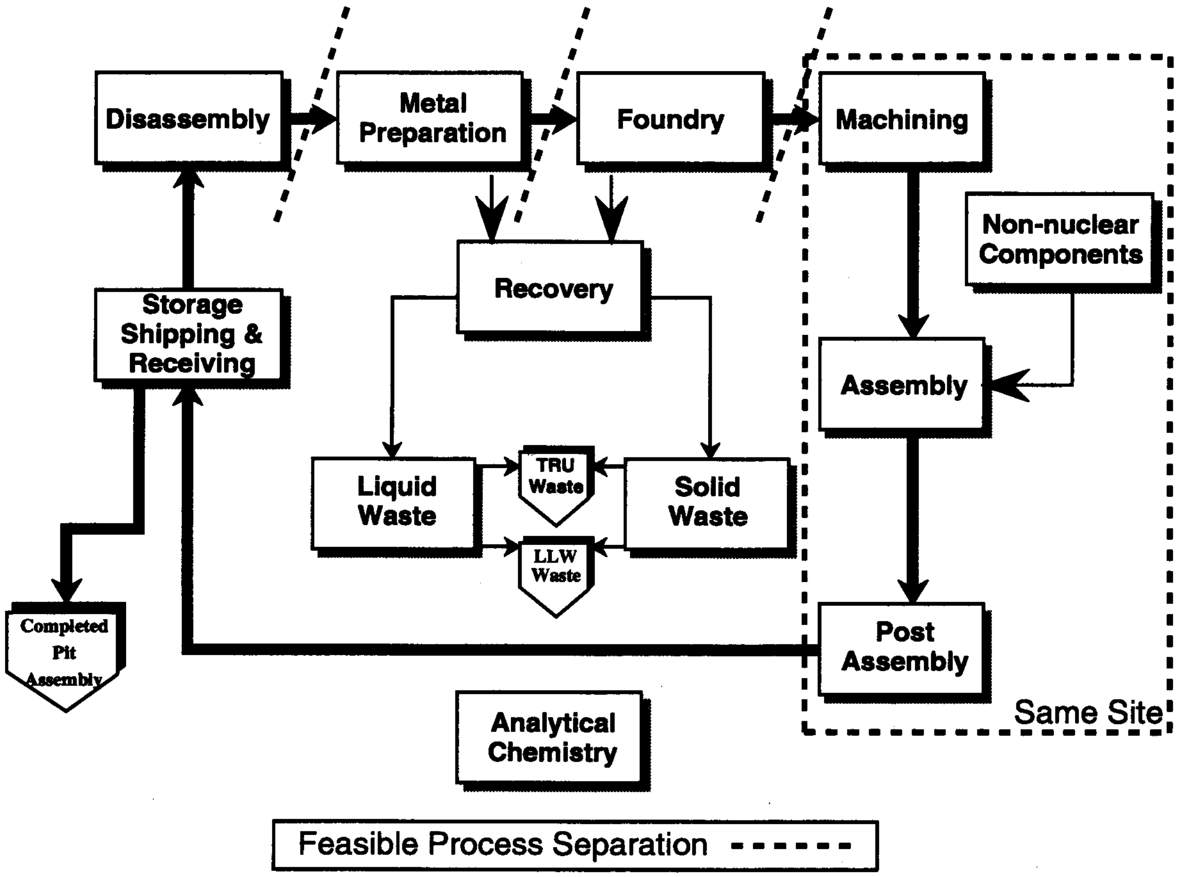

Figure 2

Laboratory Recommendations

The following processes can be completed at one site and handed off to another site without jeopardizing product quality:

- Pit dismantlement
- Hydride and oxidize to plutonium oxide
- Hydride and reduce to plutonium metal
- Reduction of plutonium oxide to metal
- Plutonium purification
- Americium extraction
- Foundry - cast plutonium feed ingots
- Foundry - cast plutonium components

To ensure product quality, the following processes must be completed sequentially at the same site:

- Machining of plutonium components
- Non-nuclear components coating
- Assembly & welding
- Bonding
- Post assembly

Though this analysis is not directing how the processes be located among sites, it can be seen that there is an advantage to locating processes requiring like support operations either at one site, or sites already possessing those capabilities. For example, economies would be achieved by locating operations requiring analytical chemistry and plutonium recovery (those operations listed in Table 1, footnoted 1 and 2 in the third column) at a single site or at sites possessing those capabilities.

APPENDIX A

EVALUATION OF PROS AND CONS ASSOCIATED WITH SPLITTING PIT MANUFACTURING OPERATIONS AMONG SITES

The following table provides more information on the technical advantages and disadvantages associated with locating pit manufacturing operations at more than one site. Based on the technical advantages and disadvantages, an assessment was made as to whether or not the manufacturing process should be split between particular operations.

A general con associated with splitting the manufacturing operations at any point is the need to transport the SNM between sites. This may result in higher costs due to the additional packaging, waste generation, and accountability measurements. The increased number of times that SNM is handled will increase worker population exposure to radiation.

Disassembly - Pit Dismantlement

PROS: Dimensional quality of dismantled pit is not important. No damage of any consequence should occur to the product during handling or transit.

CONS: None noted

EVALUATION: Acceptable - no effect on product quality.

Disassembly - Hydride and Oxidize to Plutonium Oxide (HYDOX)

PROS: No damage of any consequence should occur during handling or transit.

CONS: None noted

EVALUATION: Acceptable - no effect on product quality.

Disassembly - Hydride and Reduce to Plutonium Metal (HYDEC)

PROS: No damage of any consequence should occur to the product during handling or transit. Working with a metal product does not use calcination as a process step. There is no requirement for high purity at this stage.

CONS: None noted

EVALUATION: Acceptable - no effect on product quality, metal easily packed and measured.

Metal Preparation - Reduction of Plutonium Oxide to Metal

PROS: No damage of any consequence should occur to the product during handling or transit. Working with a metal product does not use calcination as a process step. There is no requirement for high purity at this stage.

CONS: None noted

EVALUATION: Acceptable - no effect on product quality. Metal easily packed and measured.

Metal Preparation - Plutonium Purification

PROS: Shipping of purified plutonium has taken place between the Savannah River Plant, Rocky Flats Plant, Lawrence Livermore, and Los Alamos in the past without incident.

CONS: None noted

EVALUATION: Acceptable - no effect on product quality. Metal easily packed and measured.

Metal Preparation - Americium Extraction

PROS: Shipping of purified plutonium has taken place between Savannah River Plant, Rocky Flats Plant, Los Alamos, and Lawrence Livermore in the past without incident.

CONS: None noted

EVALUATION: Acceptable - no effect on product quality. Metal easily packed and measured.

Foundry - Cast Plutonium Feed Ingots

PROS: Redundant foundry system and expertise will be present in the complex. This provides back-up capability.

CONS: Duplicate foundry and expertise in the complex increases costs.

EVALUATION: Acceptable - no effect on product quality. Metal easily packed and measured.

Foundry - Cast Plutonium Components

PROS: Cast parts have been shipped during R&D operations between Los Alamos and the Rocky Flats Plant. Also, facilities to support plutonium analytical chemistry and metallography should only be required at the foundry facility.

CONS: There is a need for a foundry and/or a calcining operation to handle plutonium turnings at machining site. Calcining of the turnings is the least desirable option because of the need for an additional recovery step to convert the oxide back to metal. Foundry operations must be able to accommodate handling oxide and crucible skull from the melt operations.

EVALUATION: Acceptable - no effect on product quality. Provisions must be made to pack the cast components in a manner that provides protection from damage due to physical impact or surface corrosion.

Machining

PROS: Machined parts have been shipped during R&D operations between Los Alamos, Rocky Flats Plant, and Lawrence Livermore.

CONS: Minor damage to high-tolerance parts will increase scrap.

EVALUATION: Machining is the first step in a series of processes that cannot be separated. It is unacceptable to have the following process located at another site. Product quality and process yield can be easily jeopardized. Very small changes in the dimensions of the finished machined part can cause scrap.

Non-nuclear Components Coating

PROS: None noted

CONS: Coating quality degrades with time.

EVALUATION: It is unacceptable to have assembly and welding located at another site. Product quality and process yield can be easily jeopardized.

Assembly and Welding

PROS: None noted

CONS: Interruption of process flow at point prior to sensitive operation.

EVALUATION: For applicable pits, completing the bonding process on a timely basis is of highest priority.

Bonding

PROS: None noted

CONS: Interruption of process flow at point prior to sensitive operation.

EVALUATION: Getting the pit to its final sealed configuration on a timely basis is of highest priority.

Post Assembly

PROS: Diamond stamped pits have been shipped between the Rocky Flats Plant and Pantex.

CONS: None noted

EVALUATION: It is acceptable to ship the finished pit to another site after completion of this operation.

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