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the Advanced Recovery and Integrated
Extraction System (ARIES) Facility

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Process Logic Flow Diagram for the ARIES Facility

Introduction

The Department of Energy Office of Fissile Materials Disposition (DOE-MD) is planning a facility to disassemble pits and convert the plutonium in the pits into a form suitable for international inspection. The facility, called the Advanced Recovery and Integrated Extraction System (ARIES) Facility, must handle much of the 38.2 metric tons of plutonium declared excess to national security needs in ten years of operation.

A process logic flow diagram for the ARIES Facility is presented here. This flow diagram is based on and supported by a library of fact sheets on topics that impact the design of the facility. Developing the flow diagram raised issues that significantly impact the design of the facility. These issues are discussed later in this document, and for some issues, discussed in greater detail in the appropriate fact sheets.

The flow diagram is designed to show requirements that dictate the need for space and/or equipment. In physically designing the facility, the same space or equipment may be used to meet several requirements. The flow diagram merely shows the activities that need to occur to meet requirements for the facility.

The flow diagram is not associated with any DOE site. The requirements shown on the flow diagram may be met by an existing facilities at a given site.

The flow diagram and this write up do not contain a great deal of detail on how each step in the diagram is performed. At this stage of design, the flow diagram merely identifies the need for the activity. Examples for some of the activities are given in the appropriate fact sheet. How the steps are performed becomes more defined as the design of the facility progresses.

Basic Assumptions

The process logic flow diagram assumes the facility

- will receive only whole pits and not pit parts or plutonium metal in other shapes,
- will produce both plutonium metal ingots or metal oxide,
- will can plutonium in double-welded cans suitable for long-term storage,
- can ship canned plutonium metal and oxide to another facility, and
- will be subject in part to inspection by the International Atomic Energy Agency (IAEA).

Pit Receiving

Pits are transported in FL containers (named for the container designer, Forest Lundburg) (see issue 14) attached to a Cargo Restraining Transport (CRT) fixture in a Safe Secure Transport (SST). The SST truck arrives at the site, the CRTs are unloaded from the truck, and the FL containers are removed from the CRTs.

A transfer check and material confirmation are done on the FL container. If the shipment is accepted, the FL container is moved to a short-term storage vault. If the shipment is rejected, the FL container is loaded back onto the CRT, which is loaded back onto the SST to be returned to the shipper.

The FL container is moved from the short-term storage vault and unpacked. The pit is surveyed for contamination. If the pit is not contaminated, a decision is made whether or not the pit can go directly to processing. If the pit can not go to processing, it is packed in a holder (referred to as a bird cage) and placed in a pit storage vault. If the pit is contaminated (see issue 8), the pit is closed in the inner FL pressure container and either moved directly to pit preparation or to vault storage.

Empty FL containers are surveyed, decontaminated if needed, certified clean, and repacked in CRTs for shipment for reuse.

Pit Vault

Clean pits in holders or contaminated pits in their inner FL pressure container are stored in the pit vault. The pit vault provides surge capacity between receiving and processing.

Pit Preparation

Pits from receiving and from the pit vault that are ready for processing are unpacked. Holders from uncontaminated pits are recycled back to receiving. The pits are tested for tritium contamination and sent to the special recovery line if they are contaminated. If the pit is not tritium contaminated, a decision is made to send the pit to either the bisector module for bonded bits or the parting lathe module for other pits.

Contaminated pits from pit receiving or the pit vault move through pit preparation in the inner FL pressure container. Tritium contamination should be found when the initial contamination is found, but confirmation techniques may be needed in pit preparation.

**Special Recovery
Line**

Pits with tritium contamination are disassembled in the special recovery line. Uncontaminated pits enter the glove-box line through a drop box. Contaminated pits moved to this line are unpacked from the inner FL pressure container and enter the line using equipment and techniques that control the spread of contamination.

Plutonium, highly enriched uranium (HEU), and nonspecial nuclear material (non-SNM) are separated in the special recovery line. Plutonium metal is processed in a vacuum furnace that drives off tritium and produces a metal ingot. The tritium is captured, assayed, and sent to tritium packaging and storage. The plutonium ingot is assayed to provide input information for accountability (see issue 4) and then sent to the in-process lag vault in the hydride/dehydride module if it is to be stored as metal or to the HYDOX reactor in the HYDOX module if the plutonium is to be stored as an oxide.

HEU from the special recovery line is sent to HEU processing and classified shapes are sent to declassification processing.

Bisector Module

Bonded pits from pit preparation come to the bisector module. Uncontaminated pits enter the glove-box line through a drop box. Contaminated pits moved to this line are unpacked from the inner FL pressure container and enter the line using equipment and techniques that control the spread of contamination.

Pit tubes are cut off the pit and the pit is cut into two hemispheres using the pit bisector. The hemispheres are sent to the hydride/dehydride module if the plutonium from the pit is to be stored as metal or to the HYDOX module if the plutonium is to be stored as an oxide.

Parting Lathe Module

Nonbonded and nontritium-contaminated pits are sent to the parting lathe module. Pits that are not contaminated enter the glove-box line through a drop box. Contaminated pits moved to this line are unpacked from the inner FL pressure container and enter the line using equipment and techniques that control the spread of contamination

Pit tubes are removed and the pit is disassembled into plutonium, HEU, and non-SNM classified shapes with the parting lathe. The plutonium parts are assayed to provide input information for accountability (see issue 4) and sent to the in-process lag vault in the hydride/dehydride module if the plutonium is to be stored as metal or to the HYDOX reactor in the HYDOX module if it is to be stored as an oxide.

HEU from the special recovery line is sent to HEU processing and classified shapes are sent to declassification processing.

Hydride/Dehydride Module

Bonded hemispheres come from the bisector module to the hydride/dehydride reactor. Plutonium is separated from the HEU in the hemispheres in the reactor and the plutonium leaves the reactor as a metal ingot. The ingot is assayed to provide input information for accountability (see issue 4) and put into an in-process lag vault. Plutonium metal ingots from the special recovery line and plutonium metal shapes from the parting lathe are also received in the in-process lag vault. The ingots and shapes are cut up, mixed, and put into a casting furnace. The purpose of cutting, mixing, and recasting is to disassociate the cast plutonium in storage from the incoming pits. Metal shapes from the parting lathe may have to be pressed to fit into the casting furnace (see issue 13). The parts to be cast are weighed so that the final casting does not exceed the can limit for storage.

Because cutting and weighing is a blending operation, parts of the cut ingots and shapes are move back to the in-process lag vault for future blending needs.

Cast metal from the casting furnace goes to the primary canning module.

HEU from the hydride/dehydride reactor goes to HEU processing.

Sampling for destructive analysis is included in the hydride/dehydride module (see issue 12). Destructive analysis may be needed for to determine impurities that impact disposition processing that follows the ARIES Facility and to generate assay standards.

HYDOX Module

Bonded hemispheres from the bisector and plutonium metal from the special recovery line and the parting lathe that are to be converted to oxide come to the HYDOX reactor in the HYDOX module. The oxide powder leaving the reactor is assayed. For the oxide generated from bonded bits, this assay provides input information for accountability. For the other metals, this assay confirms that the metal entering the reactor leaves as oxide.

The oxide from the assay is blended to disassociate the oxide from the pit that was its source and weighed into batches for canning. An in-process lag vault is provided as was provided for metal blending.

The oxide is sampled for destructive analysis, and loss on ignition (LOI) testing is done on each batch (see issue 3). Oxide that fails the LOI testing is stabilized in a furnace and retested.

Oxide that passes LOI testing is mechanically sealed in a convenience can (food can) and sent to primary canning.

HEU from the HYDOX reactor goes to HEU processing and non-SNM classified shapes go to declassification processing.

Primary Canning Module

Plutonium metal from the hydride/dehydride module is moved to the primary canning module in a slip-top convenience can and oxide is moved from the HYDOX module to primary canning in a sealed convenience can. The convenience can is placed inside a stainless steel primary can that is seal-welded closed and leak tested. The can is rewelded if it fails the leak test. The can is moved to the electro-decon module when it passes the leak test.

Empty cans are laser marked outside of the module with a serial number that allows the can to be tracked.

Electro-Decon Module

Cans from primary canning are wiped clean then placed in an apparatus where they are electrochemically cleaned. The apparatus is mounted in a wall that separates two parts of a glove box. The glove box on one side of the wall is contaminated, the other side is clean. When the electro-cleaning cycle is done, the can is rinsed and dried inside that apparatus. When the can is dry, the door on the clean side of the apparatus is opened and the can is surveyed for contamination. If the can is still contaminated, the door is closed and the cleaning process is repeated. If the can is clean, it is removed from the apparatus and the glove box and sent to secondary canning.

The electro-cleaning and rinse solutions are recycled within the module. A portion of the solution is ultra-filtered to remove accumulations of metals. Sludge from the filter, worn electro-cleaning solution, and spent rinse water are periodically removed from the apparatus. The sludge and solutions are either evaporated or solidified. The waste generated from electro-cleaning is homogeneous and probably will contain sufficient transuranic (TRU) isotopes to be classified as a TRU waste. The waste must be sampled

and analyzed to meet the requirements of the Waste Isolation Pilot Plant (WIPP) waste acceptance criteria (WAC).

Secondary Canning

Cans from the electro-decon module are laser marked to add information about the can's contents. The primary can is placed in a secondary stainless steel can that is seal-welded closed and leak tested. The can is rewelded if it fails the leak test. After the secondary can passes the leak test, the secondary can is laser marked with information identifying the can and the contents. The secondary can is then moved to the nondestructive assay (NDA) module.

NDA Module

Detailed NDA is done for each product leaving secondary canning. Following the assay, the cans are moved to the product vault.

Product Vault

Cans of oxide and metal from the NDA module are accumulated in the product vault until the material is transferred to IAEA inspection.

Periodic inspection of the cans in the product vault may be needed to meet the surveillance and inspection requirements for long-term storage (see issue 10).

IAEA Safeguarded Vault

When ready for transfer to IAEA safeguards, the cans of metal and oxide stored in the product vault are moved to the IAEA safeguarded vault. The exchange is made in the presence of and verified by IAEA inspectors. Once the material is under IAEA safeguards, IAEA inspectors must have continuity of knowledge of the material and must be able to observe any handling or movement of the material (see issue 2).

Periodic inspection of the cans in the product vault may be needed to meet the surveillance and inspection requirements for long-term storage (see issue 10).

IAEA Inspection

The IAEA periodically removes a representative number of cans from storage to verify its contents (see issue 2). These cans are nondestructively assayed using equipment agreed to or under the control of the IAEA.

A representative number of the cans nondestructively assayed are selected for destructive assay. These cans are moved to IAEA sampling. The cans not sampled are returned to the IAEA safeguarded vault.

IAEA Sampling

Cans selected for destructive analysis sampling are separated based on whether they contain oxide or metal and moved to different glove box lines to open the secondary and primary cans and sampling. The oxides and metals are separated to prevent oxide contamination of the metal ingots.

Secondary can is opened and disposed of as low-level waste (LLW). The primary can is opened and a sample is taken. Samples are packaged and shipped to an IAEA laboratory for destructive analysis. The remaining contents of the can are weighed and placed in a new primary can. Oxides are first mechanically sealed in a convenience can so that the oxide can be canned in the same primary canning glove box as the metal without concern of cross contamination.

The primary can is sealed, electro-decontaminated, sealed in a secondary can, and non-destructively assayed in the same manner discussed for the primary canning module, electro-decon module, secondary canning module, and NDA module. This is shown as a separate function because the operation must be viewed by IAEA inspectors (see issue 2).

Product Shipping

Cans that are to be shipped from the facility are moved from the IAEA safeguarded vault to product shipping. The cans are surveyed by swiping to ensure they are not contaminated. Contaminated cans are decontaminated and resurveyed. After being surveyed, the cans are weighed and assayed to close accountability for the material. The cans are packed in a shipping container (see issue 14), the shipping container is packaged into a CRT, and the CRT is loaded onto an SST for shipment.

Lessor packaging for shipping may be used if the material is to be moved to another facility on site.

Once under IAEA safeguards, the material can only be moved to a location that has an agreement in place with the IAEA (see issue 2).

HEU Processing

HEU classified shapes from the special recovery line, the parting lathe, the hydride/dehydride reactor, and the HYDROX reactor are moved to HEU processing. The shapes are assayed to provide input information for accountability (see issue 4) then electro-decontaminated to remove any plutonium contamination. The HEU shape is surveyed for residual plutonium. The shape is bagged out or put into a convenience can, assayed to account for HEU loss during decontamination, and moved to the HEU vault for storage.

As for the can electro-decon module, the HEU electro-cleaning and rinse solutions are recycled within the module. A portion of the solution is ultra-filtered to remove accumulations of metals. Sludge from the filter, worn electro-cleaning solution, and spent rinse water are periodically removed from the apparatus. The sludge and solutions are either evaporated or solidified. The waste generated from electro-cleaning is homogeneous and probably will contain sufficient TRU isotopes to be classified as TRU waste. The TRU waste must be sampled and analyzed to meet the requirements of the WIPPWAC.

HEU Vault

HEU shapes from HEU processing are accumulated in the HEU vault to ship for further processing. The HEU is still in classified shapes and the vault must be partitioned from areas to which IAEA inspectors have access (see issue 6).

HEU Shipping

HEU is shipped as classified shapes to Y-12 (Oak Ridge National Laboratory). When sufficient HEU has accumulated in the vault, the HEU is moved to HEU shipping where the material is packed into DT-22 containers. The containers are certified for shipping, weighed and assayed to close accountability for the material, and loaded into CRTs. The CRTs are loaded onto an SST for shipment to Y-12.

Declassified Processing

Non-SNM classified shapes from the special recovery line, the parting lathe, the hydride/dehydride reactor, and the HYDROX reactor are moved to declassification processing. The shapes are declassified by melting them in one of several different furnaces, each furnace is designed to handle a different material. Size reduction of classified parts by cutting and/or pressing may be used to fit parts into the furnaces. The degree of preparation needed is a function of the furnace design.

The melted materials are cast into ingots, placed in convenience containers, and moved to waste assay.

The flow diagram does not show any decontamination of classified shapes before melting (see issue 11).

Waste Assay

Primary waste and secondary waste, such as worn tools, gloves, and wiping rags generated in the glove-box lines are assayed and weighed to determine if it is TRU waste (greater than 100 nCi/g) or LLW. The assay also serves to confirm that SNM is not being removed from the glove boxes in the waste. TRU waste is moved to TRU waste packaging and certification and LLW is moved to LLW packaging and certification.

The facility will generate some waste outside of the glove boxes that is administratively determined to be LLW. This waste is not assayed and goes directly to LLW packaging and certification.

TRU Waste Packaging and Certification

TRU waste is segregated and packaged into 55-gal. drums to limits set by the WIPP WAC. The drum is weighed and assayed to ensure that the final package meets WIPP WAC requirements. The assay also provides closure data for accountability. Drums that fail to pass the WIPP WAC are repacked, reweighed, and reassayed. If the drum meets the WIPP WAC, the drums are moved to TRU waste shipping.

**TRU Waste
Shipping**

TRU waste drums from TRU waste packaging and shipping accumulate in storage until there is sufficient waste to ship to WIPP. Just prior to shipping, the drum is tested for gas accumulation. If the drum fails, the drum is vented and retested. After gas testing, the drum is staged for loading. The contents of 2% of the drums are scanned using real-time-radiography to confirm the contents against the packing record. Drums ready for shipment are loaded into truck-mounted TRUPACT containers and shipped to WIPP.

**LLW Packaging and
Certification**

LLW is packed into a container compatible with the disposal option for the site. The package is assayed to ensure the package meets the WAC for the disposal option and to provide closure data for accountability.

LLW packages are stored until there is sufficient waste to ship to disposal. Containers are then loaded and shipped.

Shipping containers and the method of transport depend heavily on the disposal options available to the site.

Disposal of LLW includes discarding tritium-contaminated waste that may require special packaging and different disposal options.

**Tritium Packaging
and Storage**

Tritium captured in the special recovery line is packaged and stored until sufficient tritium is accumulated for shipment to xxxxx. When sufficient tritium has accumulated, the packages are assayed to provide closure data for accountability, loaded, and shipped.