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# Application of PSA to Storage of Pu at SRS

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## Introduction

Pu is stored in a wide variety of physical forms and containers at the Savannah River Site (SRS). Probabilistic Safety Analysis (PSA) techniques are used to determine the risk associated with each of these storage modes and assist in identification of the controls necessary to minimize the risk. One storage method involves solids in exposed drum storage where the drums are vulnerable to external events, natural phenomena, and release of material due to weathering of the containers. Another storage method may involve liquids being processed inside the canyon facilities where the greatest risks are not from external events but from process upsets. PSA techniques have been particularly useful in the evaluation of criticality situations concerning Pu processing and storage. The applications include "normal" operating situations, problems following a seismic event, and the identification of potential problems during the decontamination and decommissioning of a facility.

In this paper I would like to discuss two specific examples of the use of PSA techniques. The first involves the analysis of potential accidents in a Pu receipt and storage facility. The second example involves processing solutions that have the potential for experiencing an uncontrolled "red oil" reaction.

## Pu Receipt & Storage Facility

The essential functions of receiving, storing, retrieving, and shipping dictate the basic requirements for the Plutonium Storage Facility (PSF), which is designed to accommodate a rapid turnover of inventory with minimal exposure of personnel to radiation. It may be necessary to handle incoming and outgoing shipments by a single truck. Upon receipt and completion of a contamination survey, the shipping containers are moved from the loading dock to the staging area within the vault. The incoming shipping containers inspected and placed in designated storage positions.

Each package is visually inspected upon arrival. Nondestructive Assay (NDA) measurements for accountability are made in the NDA laboratory portion of the PSF. All containers are required to have an accountability/quality nondestructive assay made within ten calendar days of receipt.

Nondestructive assay confirming measurements are made on all shipments of 30-gallon shipping containers. Confirming measurements are performed on receipts within two days. These measurements are made using a neutron coincidence counting technique. Records are maintained for quantities of nuclear material moved in or out of the facility.

Initiating events for accidents were systematically developed in the PSF analysis using the Savannah River Laboratory (SRL) incidents data bank,[3] facility-specific considerations, and the 200-Area Fault Tree data bank.[2] The results of the systematic determination of potential accidents were grouped into three categories based on accident initiators:

- Natural phenomena

- External events

- Process related events.

The PSF structure consists of concrete walls several feet thick. Thus, no accidents in the first two categories resulted in any significant consequences. The process related events included:

- Shipping Container Failure
- Fires
- Violent Reaction Due to Pressurization
- Nuclear Criticality
- Inner Package Penetration
- Impacts
- Package Corrosion

The results of the analysis did not identify any potential accidents with unacceptable consequences. However, a number of procedural revisions and administrative controls were instituted as a result of this safety analysis.

## "Red Oil" Explosion in a Processing Facility

Spent fuel from the reactors is reprocessed in the canyon facilities at SRS. The fuel is dissolved and then a solvent extraction process is used to separate the Pu from the waste material. This process is primarily an aqueous process using nitric acid to keep the Pu in solution. As a part of the solvent extraction process, Tri-Butyl Phosphate (TBP) is introduced into the processing stream. Thus, the potential for "red oil" type reaction is present from the point of introduction of TBP to the end of the process.

The initial PSA was performed to determine the areas of the canyon that presented significant risks. The logic for modeling a red oil explosion was developed with the assistance of knowledgeable facility personnel. To simplify the task, the canyon vessels were divided into 5 categories: feed tanks, sump receipt tanks, the mixer settlers, evaporators, and evaporator bottoms tanks.

The first three categories of vessels are normally at ambient temperature and therefore would have similar methods for providing the necessary heat to cause an uncontrolled "red oil" reaction. For these vessels the potential sources of heat that could heat the vessel above 100 $^{o}C$ are very limited. Heat removal mechanisms in the form of a combination of the agitator and either the cooling coils or the canyon ventilation are also available. The analysis indicated that if the agitators are available during transfers into these tanks no runaway "red oil" reaction would occur. Thus, the agitators were identified as safety related items.

As long as the material remains at ambient temperatures (< 100 $^{o}C$) the reaction does not produce enough heat to cause the reaction to runaway. For this reason, special attention was given to the evaporators and their bottoms tanks. The bottoms tanks were eliminated as a concern based on the fact that the material in the bottoms tanks would be at a lower temperature than the material in the evaporator (if it became uncontrollable in the evaporator, it would never reach the bottoms tank) and they also have agitators and surface cooling mechanisms to provide cooling to the vessel.

The evaporators proved to be of greatest concern. However, in order for an uncontrolled red oil reaction of sufficient magnitude to compromise the canyon containment to occur, it must involve at least 3,000 pounds of TBP. In addition, the organic must be heated to 120 C or above without an aqueous layer of at least one foot. Application of PSA to this problem indicated that the three main controls that prevent runaway red oil reaction: solvent inventory control, temperature control, and ensuring the presence of aqueous in the evaporator. Thus the minimum number of controls were identified which would result in a safe configuration for the processing system.

## Conclusion

These brief examples provide an indication of the strength and diversity of the PSA techniques used at SRS. Complex problems that previously would have been difficult or impossible to address, may now be addressed with a sound technical basis for decision making. The PSA techniques have given us the ability to address a wide variety of problems in cost effective and efficient manner. The use of the PSA techniques does not cost, it pays.

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