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INVENTORY DIFFERENCE INFORMATION AND CRITICALITY SAFETY

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ABSTRACT

Two examples are used to illustrate the natural relationship between inventory difference information and criticality safety as practiced at the Los Alamos National Laboratory. Both examples involve the unsuspected holdup of plutonium in furnace beakers. In the first example, material accumulated in a cavity between furnace beaker walls; in the second, material alloyed directly to the beaker wall. In each case, the holdup was detected during the preparation for semiannual inventories that included total shut down and cleanout. Holdup was confirmed by assay and detailed inspection. Criticality safety implications are discussed.

INTRODUCTION

The Los Alamos National Laboratory Plutonium Facility (TA-55, PF-4) has been operating for approximately 12 years. A multitude of plutonium processing activities incorporating over 100 unit processes in a single Material Access Area are housed in the facility, which occupies 100,000 sq ft of floor space.

This paper illustrates a natural relationship between nuclear material accounting practices currently being applied at TA-55 and criticality safety. Two examples of this relationship will be examined chronologically. In each case, an aspect of criticality safety was revealed by our accounting practice that may have been otherwise overlooked. Our narrative will avoid the larger issues of regulation and reporting requirements and of safeguards and computerized material accounting systems. Emphasis will be placed on accounting procedures, including assaying and adjustment of gram values. Our facility experience reveals that examples such as we discuss occur with moderate frequency because of the R & D nature of the work done at TA-55.

INVENTORY DIFFERENCE ACCOUNTING

For each unit process at our facility, an inventory difference (ID) is declared at the end of each month. The ID for a given process is the sum of the ID components, or material in process (MIP) differences, that have been declared for that month. Declarations of material in process may represent measurement differences, material holdup, cleanup, or other routine losses or gains experienced in nuclear materials processing. Each ID component (MIP) is evaluated as it is declared. At the end of each month, IDs are declared, evaluated, and reported. The ID gain or loss must be explained in a written statement.

For our examples, the nuclear material content of an item is defined as the gram value of plutonium as established by a destructive assay of a sample of an item with the result applied to the mass of the item, by a calculated factor times the mass of an item, or by a nondestructive assay (NDA) of the item. A MIP is defined as a difference in the assigned plutonium value of an item before handling or processing and the new assigned value after accounting for process side streams, waste, and product. Inventory differences of criticality safety concern are most often related to but not limited to holdup, process loss or gain, or remeasurements of items by superior techniques.

An ion exchange process presented us with two occurrences of unexpected holdup that resulted in inventory differences that in turn were identified as unanticipated infringements on the margin of criticality safety. These situations were revealed through the normal evaluation process, using the accounting system presently in place at the Los Alamos National Laboratory.

EXAMPLE 1

The ion exchange process we are discussing receives lean plutonium solutions from various sources throughout our facility. The solutions are combined, treated, and fed through ion exchange columns. The eluate (or plutonium-rich portion) then goes through oxalate precipitation and filtration steps. The wet oxalate cake is then calcined in a furnace beaker at 500°C with an end result of recovering 800-900 g of plutonium oxide of about 87% plutonium content. The calcination step used a double-walled furnace beaker composed of a stainless steel outer beaker with a platinum liner (see Fig. 1). These beakers typically receive NDA by thermal neutron counting (TNC) twice a year, when all processes are shut down and cleaned out for semiannual inventories. Normally, an assay by TNC would reveal a gain of <100 g on such an item. An ID would be declared and evaluated, and the beaker would become an inventory item on our books with a stated plutonium value.

STAINLESS STEEL/PLATINUM FURNACE BEAKER

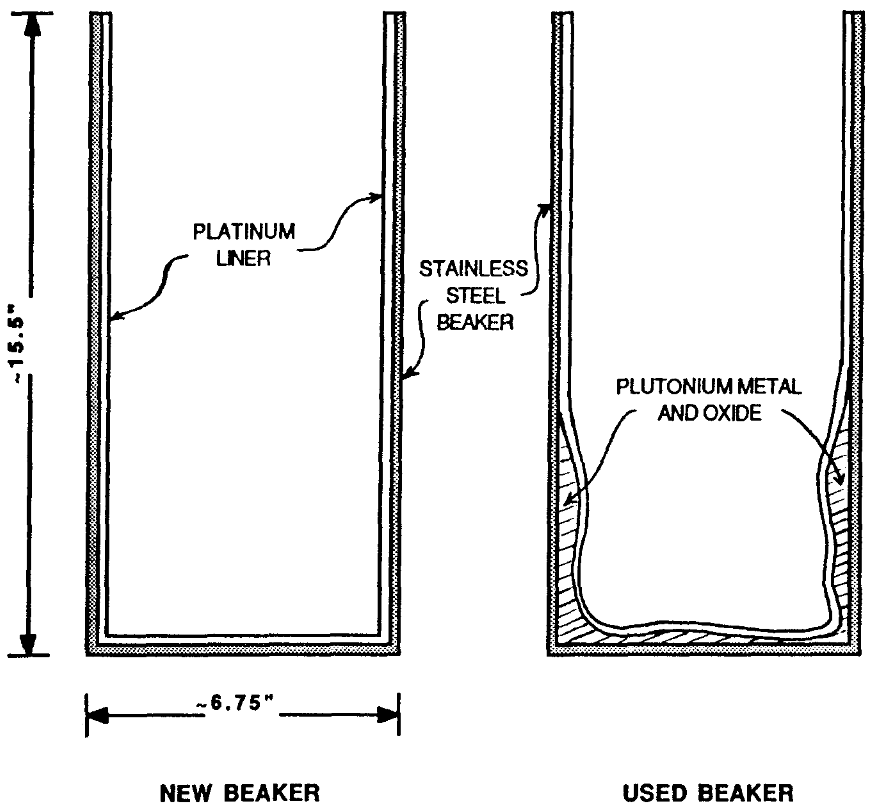

Fig. 1. Drawing of the stainless steel furnace beaker with platinum liner before and after continued use. Stainless steel wall thickness is about 1/16 in.

In this particular example, the TNC measurement resulted in a surprisingly high assay value of 490 g. An ID was declared, and the beaker was assigned the 490-g value. The operating group, which had years of experience in this area, immediately contested the measured gram value of the beaker and requested confirmation. The beaker received a second NDA by TNC, which agreed with the first. Because of the large physical size of the beaker, we were not able to perform calorimetry. The operations personnel continued to suspect the validity of the NDA measurements, particularly because the holdup was impossible to detect visually. A team from Mound Laboratory was in Los Alamos performing independent verifications, so we asked them to measure the beaker in their large diameter calorimeter. All of the various Los Alamos and Mound measurements had good agreement, and the beaker's assigned plutonium value remained unchanged at 490 g. The operating group, still skeptical, chose to sacrifice the beaker by removing the platinum liner for inspection. A hole was discovered in the liner, and a cavity between liner and outer shell was found to contain plutonium metal and oxide (Fig. 1). It is believed that the cavity was formed from the repeated beating of the outside of the beaker to dislodge material. The operating group's solution to the unsuspected holdup problem and possible criticality safety concern was to begin using a single-walled Inconel beaker with dimensions similar to the stainless steel beaker.

EXAMPLE 2

The Inconel furnace beaker (Fig. 2) cited in Example 1, above, was used for six months. Preparations were then made by the operating group for the next semiannual inventory. The beaker received an NDA measurement by TNC, and it assayed at an unexpectedly high 691 g. Although MIPs are evaluated as they are recorded, the precise locations within the process where holdup accumulates are not known until cleanup. It was noted, however, that accumulation in the beaker was consistent with normal holdup accumulations for the six-month period. The beaker was assayed several times by TNC and calorimetry, with a final accepted value of 682 g as assayed by calorimetry. It was then created as an inventory item, and the ID was declared, evaluated, and reported. The operating group challenged the NDA value on the basis that

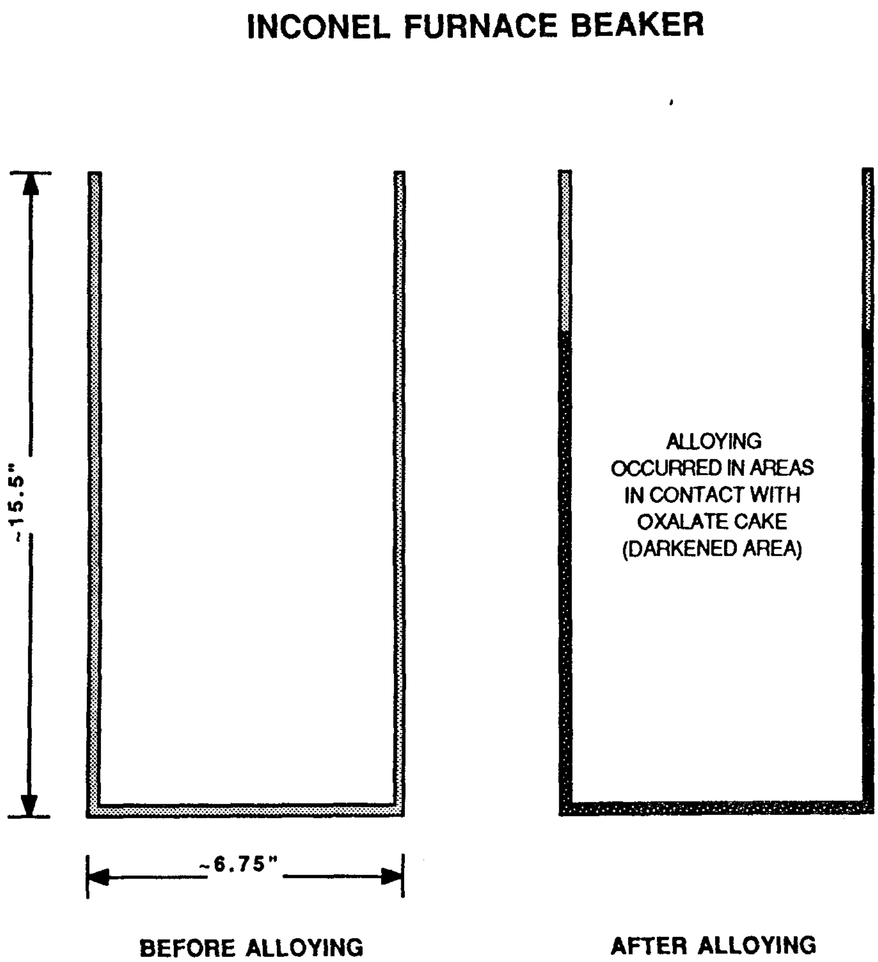

Fig. 2. Drawing of the Inconel furnace beaker before and after alloying with plutonium. Inconel wall thickness is about 1/16 in.

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Although the operating personnel were skeptical regarding the assay results of each item in the two examples, they were prompt in assigning the gram values to the items and including them in their criticality limit evaluation data. A follow-up criticality safety study was performed, with the conclusion that up to 1000 g of alloyed plutonium will be permitted in each Inconel furnace beaker in addition to the 1000-g batch limit established for each beaker. The operating group's criticality safety officer recommended that all process operating procedures dealing with furnace beakers be updated to include a bimonthly check sheet to document the weight of each beaker for tracking and evaluation.

CONCLUSIONS

As illustrated by these examples, at TA-55 we use inventory difference information to enhance criticality safety. Inventory difference components are evaluated on a daily basis for accountability and safeguards implications, but in addition, we have a practice of communicating any inventory difference component of a magnitude greater than 100 g to the operating group criticality safety officer and site criticality officer for their evaluation as to its criticality safety implications. We have thus taken steps to assure that we take full advantage of the insights that examples such as the above provide. We look upon the relationship between inventory difference information and implementation of criticality safety as a natural, meaningful one.

At present, we are examining systems to implement in our proposed SNM R&D facility that may enhance our ability to monitor inventory difference components as a daily, routine working component of criticality safety.

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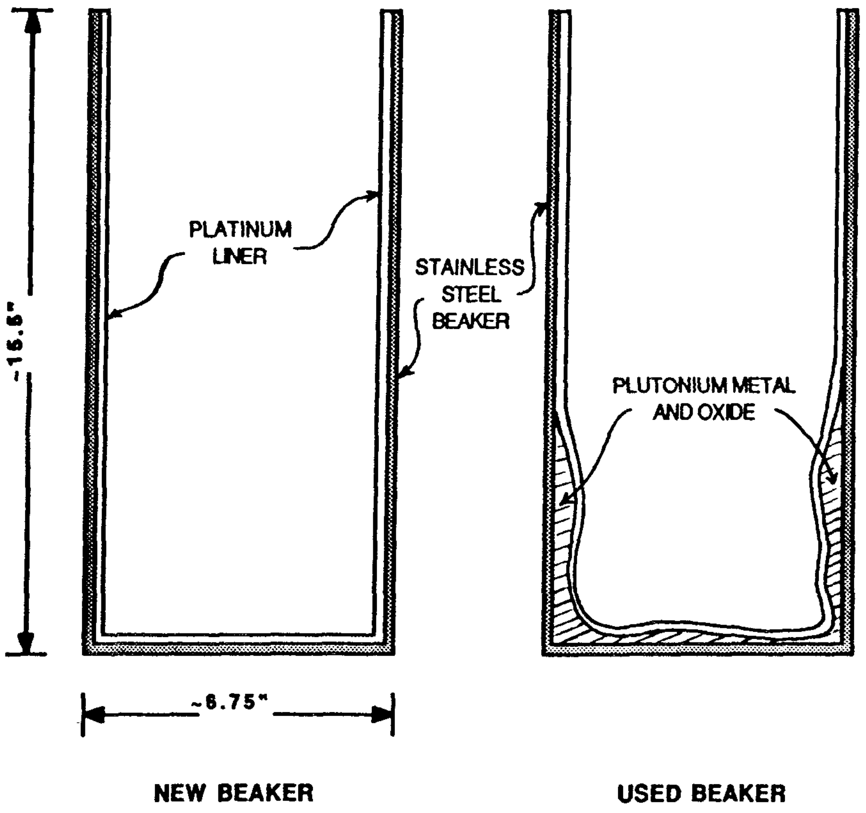

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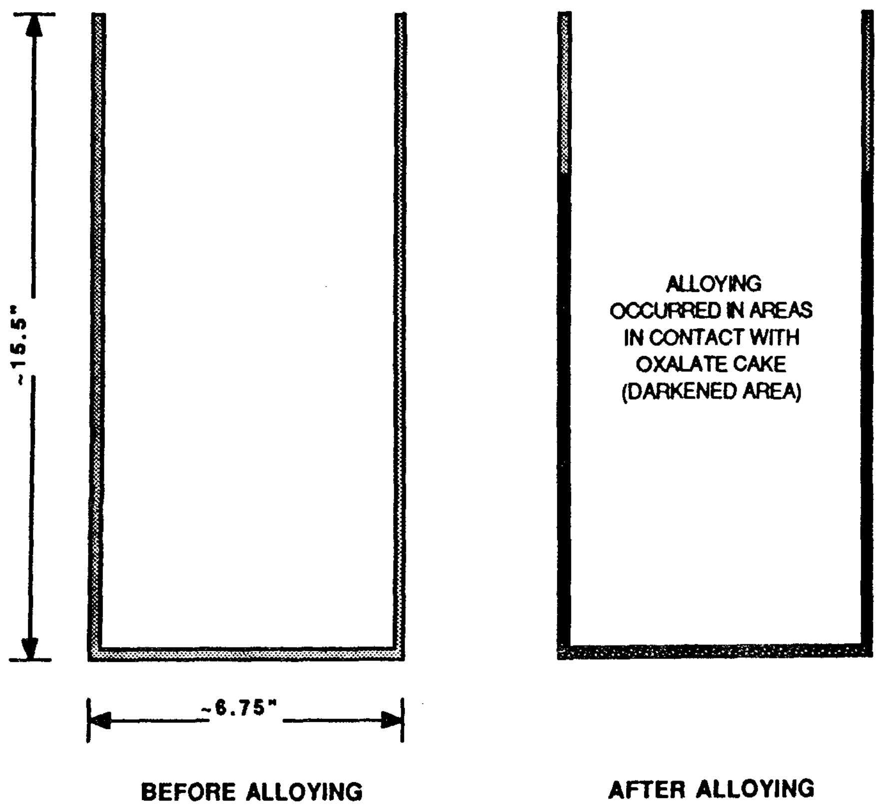

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