DEVELOPMENT OF PROCESS TEMPLATES AS A PROJECT MANAGEMENT TOOL FOR THE PLUTONIUM FINISHING PLANT

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ABSTRACT

The mission of the Nuclear Materials Stabilization Project is to provide for safe stabilization; interim storage; repackaging; and shipment of the Plutonium Finishing Plant inventory of plutonium-bearing materials, spent nuclear fuel, and other nuclear material for reuse, long-term storage, and/or final disposition. In May 1994 (updated in 2000), the DNFSB issued recommendation 94-1 identifying a number of concerns regarding the storage of fissile materials and other radioactive substances. The DOE decided to implement a group of stabilization alternatives, including thermal stabilization, pyrolysis, calcination, and cementation. Pyrolysis and calcination are not currently planned for implementation at the Plutonium Finishing Plant. Integration of the remaining stabilization alternatives across a wide variety of material types and forms and a significant inventory of plutonium, presents numerous technical and management challenges. Integration of these alternatives and various materials are evaluated with the use process templates as means to analyze resource needs and improve project planning.

The analysis of resource needs discussed in this paper identified an existing disconnect between the approved baseline plan and the current DNFSB milestones (94-1/2000-1 implementation plan). The existing plan shows the milestones tied to completion of stabilization instead of at full compliance (stabilization and packaging) with DOE-STD-3013, where as the milestone description specifically requires full compliance for metals with the standard. An output of this analysis identified two significant management challenges that must be directly confronted in order for the Plutonium Finishing Plant to continue to succeed. First is completion of metal stabilization by the milestone of 3/31/2001. The second challenge is radiological dose management.

INTRODUCTION

An innovative integrated approach was developed to prepare a number of graphical and tabular presentations. This approach involved the use of templates to evaluate and analyze process parameters and constraints. This paper describes the following four templates that are used to evaluate several subprojects in an integrated manner to better optimize resource needs:

- Process Templates – stabilization process schedule duration is calculated based on process steps, cycle times, and concept of operation for several different processes

- Critical Stabilization Equipment Template – critical process equipment is shown graphically to support the stabilization schedules calculated in the process templates

- Critical Operating Staff Template – operating staff required to perform stabilization activities are shown graphically to support the stabilization schedules calculated in the process templates

- Radiation Exposure Template – exposure to operating staff is shown graphically to support the stabilization schedules calculated in the process templates

These templates were used to analyze the process parameters and the constraints on these parameters to achieve an optimized path forward. The purpose of the process templates is to integrate stabilization and disposition activities and establish a reality based schedule baseline. It may be necessary to refine the templates based on actual data as stabilization and disposition proceeds. The templates provide a significant advantage as a tool for resource estimating and project planning. A major benefit from developing the templates is the ability to perform off-line or "what if analysis" to evaluate changing or revised parameters.

Effective project cost management includes processes required to ensure that the project is completed within the approved budget. Along with cost estimating, budgeting and control, resource planning is crucial for successful cost management. Resource planning is used to determine the type and quantity of resources (people, equipment, and materials) that should be used to perform project activities. These resources are evaluated against the available critical process and operating parameters. Optimization of these resources is one key factor that leads to successful cost management.

BACKGROUND INFORMATION

Items to be stabilized and packaged include Plutonium metals and alloys, oxides and mixed oxides, plutonium residues, plutonium bearing solutions and polycubes. Metals and alloys are brushed to remove corrosion products (e.g. oxides) and repackaged to meet the DOE long-term storage standard. Certain alloys, based on low plutonium content, may be packaged in pipe overpack containers as TRU waste for eventual disposal at the Waste Isolation Pilot Plant. The corrosion products, oxides and mixed oxides are thermally stabilized in muffle furnaces. The stabilized product is repackaged to meet the DOE long-term storage standard. Plutonium residues which consist of ash, sand, slag and crucible components and miscellaneous materials are typically packaged in pipe overpack containers as TRU waste for eventual disposal at the Waste Isolation Pilot Plant. Solutions stabilization is primarily via the magnesium hydroxide precipitation process. Approximately 4300 liters of solutions require stabilization. Process equipment to convert solutions into solid hydroxide product has been installed in two new gloveboxes in the 234-5Z building. The process will use magnesium hydroxide to precipitate the plutonium, followed by filtering, manually scraping the material on the filters into boats, heating the boats on a hot plate to drive off most of the moisture, heating the material in a muffle furnace and repackaging the product for interim storage pending final packaging to meet the DOE long-term storage standard. Stabilization of polycubes involves thermally treating the polycubes in a muffle furnace at a low heat for eight hours to drive off volatiles followed by a 16-hour high heat cycle to stabilize the resulting material. The stabilized product is packaged to meet the DOE long-term storage standard.

Each of these stabilization processes was modeled using the process templates. Although many different types of materials and items are to be stabilized and the competing processes integrated, this paper focuses on metals as the example to depict the templates. The following example depicts the process used to integrate metals and alloys stabilization activities with other stabilization and packaging activities at the Plutonium Finishing Plant.

PROCESS TEMPLATES

The process flow for stabilization of metal and alloy items is shown in Figure 1. These items are first brushed to remove corrosion products (e.g. oxides), then repackaged to meet the DOE long-term storage standard, and placed into interim storage pending final shipment offsite. The brushed corrosion products, along with items that cannot be stabilized via brushing, are thermally stabilized in muffle furnaces at high temperatures, then verified to meet the "loss-on-ignition" moisture criteria, repackaged, and placed into interim storage.

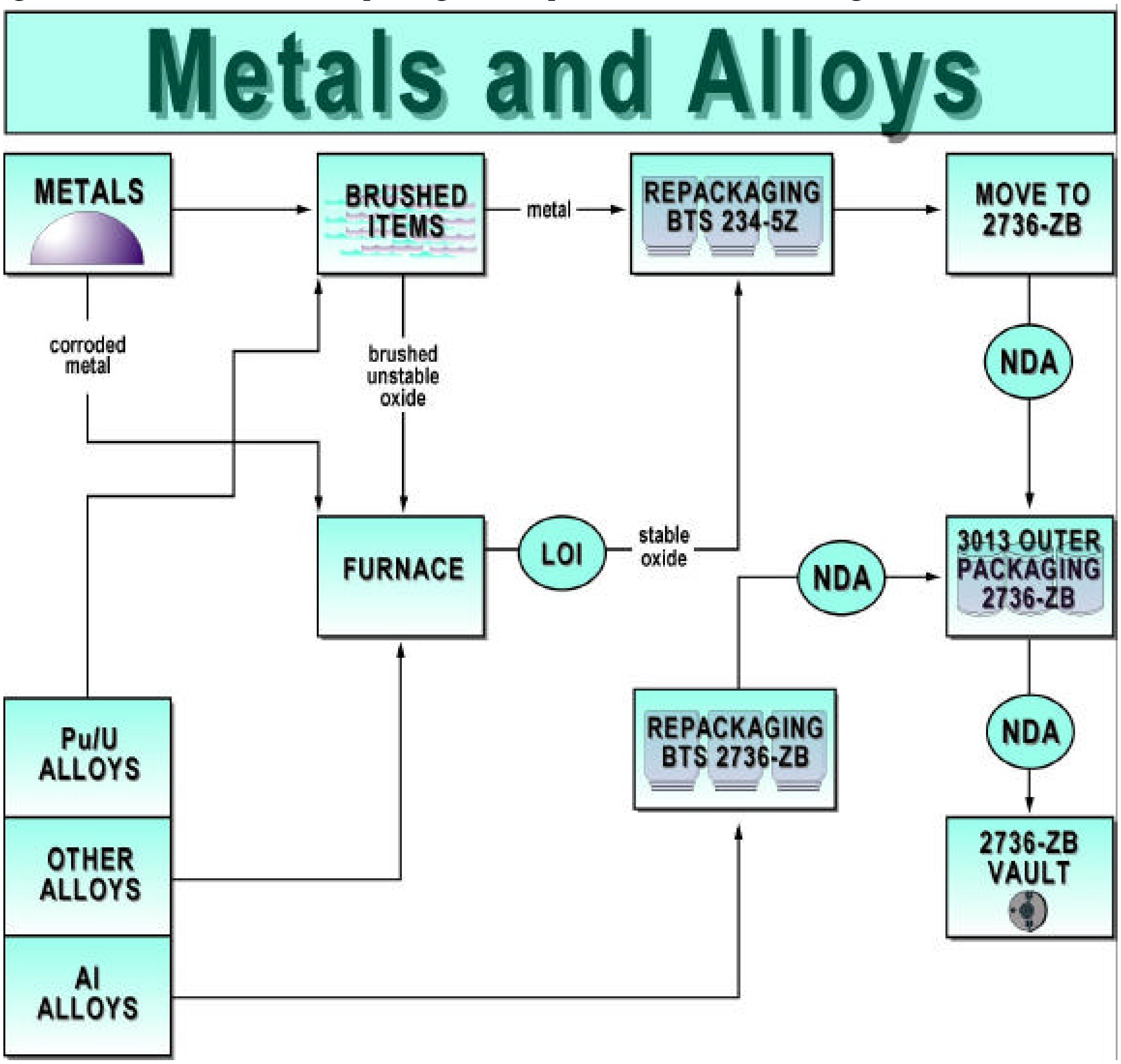

Fig. 1. Metals and Alloys Stabilization Process Flow

Based upon the process flow shown in Figure 1, process templates were developed for each material stabilization process category (i.e. metals, alloys, etc.). The process template for metals stabilization is shown in Table I, organized by the seven rate-limiting process steps. They include:

1. Brushing – Metal items are brushed in a 4-hour cycle time to remove surface oxides.

2. Furnace – Muffle furnace used to stabilize material by heat. Metal items have a cycle time of 24 hours.

3. LOI – Loss on Ignition technique used to verify stabilized material meets the DOE-STD-3013 criteria for moisture content of less than 0.5 percent. Cycle time is 8 hours.

4. BTS – Inner Bagless Transfer System for canning material in welded stainless steel cans. Cycle time is 2 hours.

5. NDA (BTS) – Non Destructive Assay technique with a 6 hour cycle time used to determine plutonium content in BTS inner cans.

6. 3013 Outer – Outer canning process with a 1.3 hour cycle time to seal inner BTS cans in outer welded stainless steel cans.

7. NDA (3013) - Non Destructive Assay technique used to determine plutonium content after canning in 3013 outer cans. Cycle time is 6 hours.

Development of each processing activity requires it to be fully defined in terms of cycle time, number of cycles, number of process units required, and the number of operating shifts to be worked per day. The process template then calculates the expected duration for each processing activity in terms of operating hours, number of shifts required, number of scheduled days required, and number of expected days required to complete the activity.

The number of expected days is calculated from the total number of operating hours required to complete the processing activity, converted into shifts, adjusted to account for expected process efficiency to obtain the number of scheduled days required, then adjusted again to account for expected time efficiency to obtain the number of expected days. The historical process efficiency factor for PFP is 60% and the time efficiency factor is 93%, 90%, or 80%, depending upon the number of shifts worked per day. Total operating efficiency is the product of these two efficiency factors.

The resulting equipment utilization rate is then calculated to determine the rate limiting processing activity, which can then be evaluated and adjusted to reduce the duration. In many cases, additional process units and/or working shifts can change the rate limiting processing activity. All processing activities are balanced to the extent possible based on these two primary constraints to achieve the best possible operating scenario.

The method of resource planning presented in this paper begins with accurate modeling of the processing activities. From the process templates developed in this first step, all other templates are generated and utilized to evaluate the project, including the critical stabilization equipment template, the critical operating staff template, and the radiation exposure template. These other three templates are described and shown graphically in the following sections.

Table I. Metals Processing Template

METALS

Processing Activity	Cycle Time (hrs)	No. of Cycles	Total Hours	Units Required	Shifts Required	Shifts Per Day	Scheduled Duration (days)	Expected Duration (days)	Utilization Rate (%)
Brushing	4	317	1,268	1	159	2	132	145	100
Furnace	24	88	2,100	3	58	2	49		
	16	75	1,200	2	75	2	63	123	85
LOI	8	37	296	1	19	1	31	39	27
BTS	2	354	708	1	89	2	74	82	56
NDA (BTS)	6	305	1,830	4	57	1	95	119	82
3013 Outer	1.3	354	460	1	58	2	48	53	37
NDA (3013)	6	354	2,124	3	89	2	74	82	56

Equipment Availability

Five furnaces are available. Three dedicated to support metal stabilization in CY 2000, two in CY 2001

One LOI unit (2 sample capacity) is available in the Lab.

One additional LOI unit (2 sample capacity) will be available by 6/15/00

NDA equipment available includes 6 small calorimeters (BTS can) and 2 large calorimeters (3013 Can)

One additional large calorimeter will be added by 4/01/01

BTS will be available by 9/30/00

3013 outer can welder will be available by 4/01/01

Concept of Operation

PQ Shift with 3 furnaces in CY00 and 2 furnaces in CY01. No ramp up assumed due to previous experience in FY00.

Brushing is rate limiting process.

TOE = Process efficiency x Time efficiency

Processing Efficiency of 60% is assumed.

Time efficiency is assumed as 93.3% for XYZ, 90% for PQ, and 80% for Day shift

Shift schedules are assumed on 8x9s

About 90% of metal will be brushed

About 10% of metal is corroded and will go directly to furnace

Furnace cycle time is 24 hr for metals and 16 hr for oxides

Metal items are assumed to require 2-3 furnace cycles to completely stabilize the material

Oxides from metal brushing are assumed to require 1 furnace cycle to completely stabilize the material

Furnace charge is 300 grams bulk for brushed oxides or 1 item for metals

LOI or SFE unit can process 2 samples simultaneous (equivalent to 2 units)

BTS cans produced prior to 4/01/01 will go to vault for interim storage

BTS cans will be loaded with the same number of metal items as existing convenience cans

BTS cans loaded with oxides from metals will be wattage limited (15 watts per BTS)

NDA only required prior to placing items into vault storage

CRITICAL STABILIZATION EQUIPMENT TEMPLATE

Each of the rate limiting process steps identified in the process templates involves critical operating equipment required to perform the specific processing activity, such as muffle furnaces, LOI, NDA, BTS, and 3013 canning equipment. As shown above, equipment utilization factors are developed for each processing activity, based on the number of units available and allocated to that activity. These equipment needs are input to the critical stabilization equipment template, where equipment utilization is integrated across all process templates and processing activities to determine the total equipment needs for the NMS Project. The equipment needs are arranged by month and by stabilization activity, then summarized by equipment type and compared to the equipment availability over the life of the project. Upgrades to equipment capabilities or addition of new units are reflected in the template and used to evaluate changes to the process templates.

The overall value of the critical stabilization equipment template is to integrate all equipment needs from the various stabilization activities and compare these needs to the availability of equipment. Based on total equipment utilization for the project, adjustments to schedule, equipment allocation, and/or the need for equipment upgrades can be made as part of the evaluation of project performance.

The resulting balanced equipment utilization was developed for the NMS Project and is presented in Table II at a summary level and in Figure 2 as a comparison for each of the major equipment types over the life of the project (the template itself is too large to present in this paper). In all cases, the number of units available is sufficient at maximum demand for the planned processing operations. For example, under the current baseline processing plan, the 234-5Z furnaces are utilized at a rate of 66 percent (maximum 3.3 units used out of 5 available). The template was also useful in identifying the need for on-time availability of specific stabilization equipment. For example, 3013 canning capability is not expected to be available until April 2001, whereas the equipment could be used today if available. Any slip in the schedule for equipment availability has significant adverse impact to the project schedule.

Table II. Critical Equipment Utilization

Critical Equipment	Maximum Effective Demand	Units planned or expected
234-5Z Furnaces	3.3	5
2736-ZB Furnaces	4	4
Calorimetry	3	3
BTS 234-5Z	0.6	1
BTS 2736-ZB	0.8	1
Radioassay	1	2
3013 canning	0.7	1

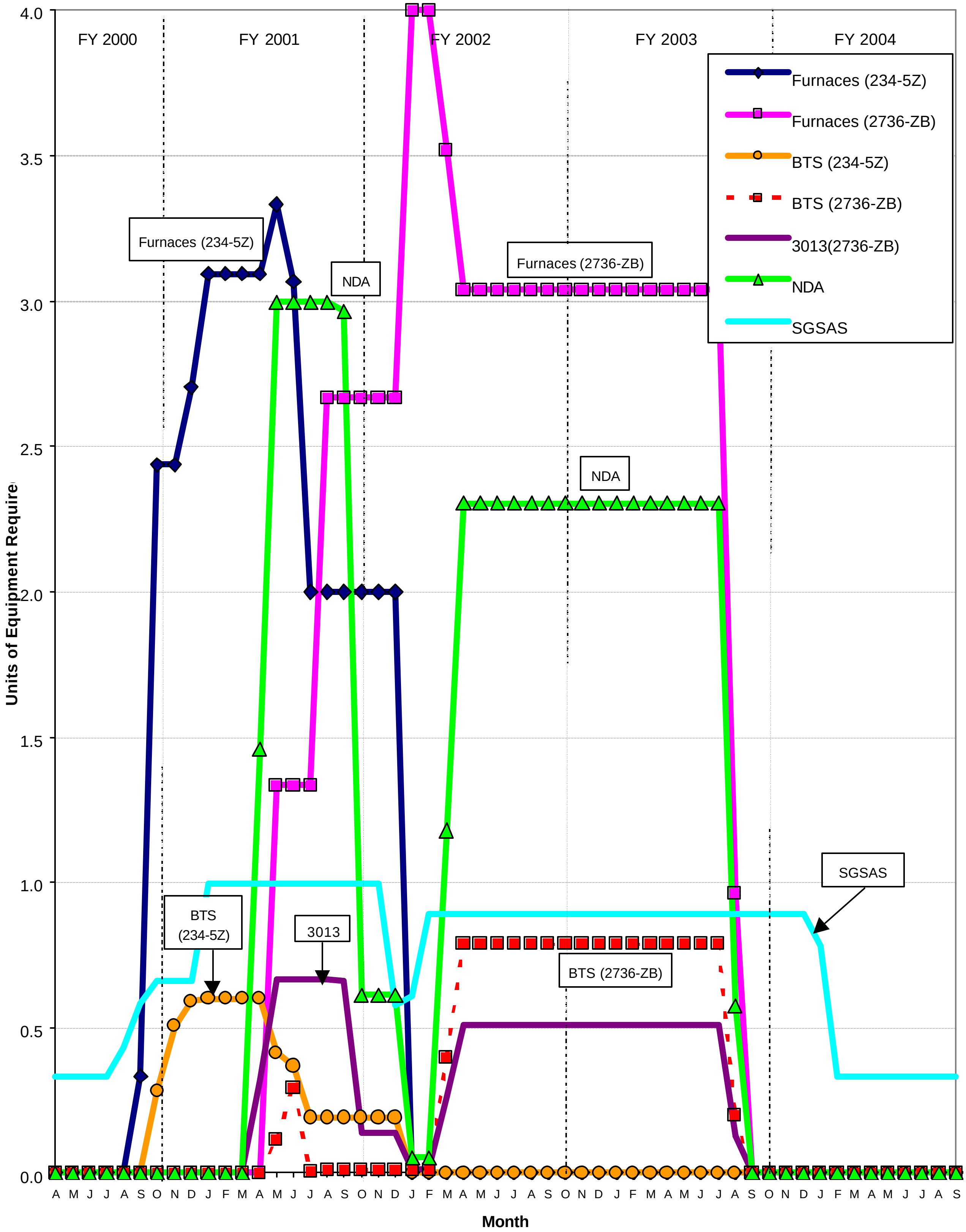

Fig. 2 Stabilization Equipment Utilization

CRITICAL OPERATING STAFF TEMPLATE

The critical operating staff required to perform all material stabilization processing activities is shown graphically in Figure 3 for the life of the NMS Project. Through the development and integration of the process and equipment templates, operating staff required to complete the associated processing activities were identified and input into the critical operating staff template, where operating staff are integrated across all process templates and processing activities to determine the total operating staff needs for the NMS Project. The staffing needs are arranged by month and by stabilization activity, then summarized by staffing type and compared to the staff available over the life of the project. Needs for additional staff are reflected in the template and used to evaluate changes to the process templates.

The overall value of the critical operating staff template is to integrate all staffing needs from the various stabilization activities and compare these needs to current staffing projections. Based on total staffing availability versus need for the project, adjustments to schedule, staffing allocation, and/or the need for new staff to support additional operating shifts, can be made as part of the evaluation of project performance.

The resulting balanced staffing profile was developed for the NMS Project and is presented in Figure 3 as a comparison for each of the critical operating staffing categories, focused on operators, over the life of the project (the template itself is too large to present in this paper). In all cases, the available staff is sufficient at maximum demand for the planned processing operations. The maximum need for operators peaks at 68 and can be compared with current staffing plans, which call for a maximum of 69 operators. Under the current baseline plan, operators are fully utilized. This template was used as a tool for identifying available staff that could be utilized to man additional operating shifts or to start other stabilization activities earlier than previously planned.

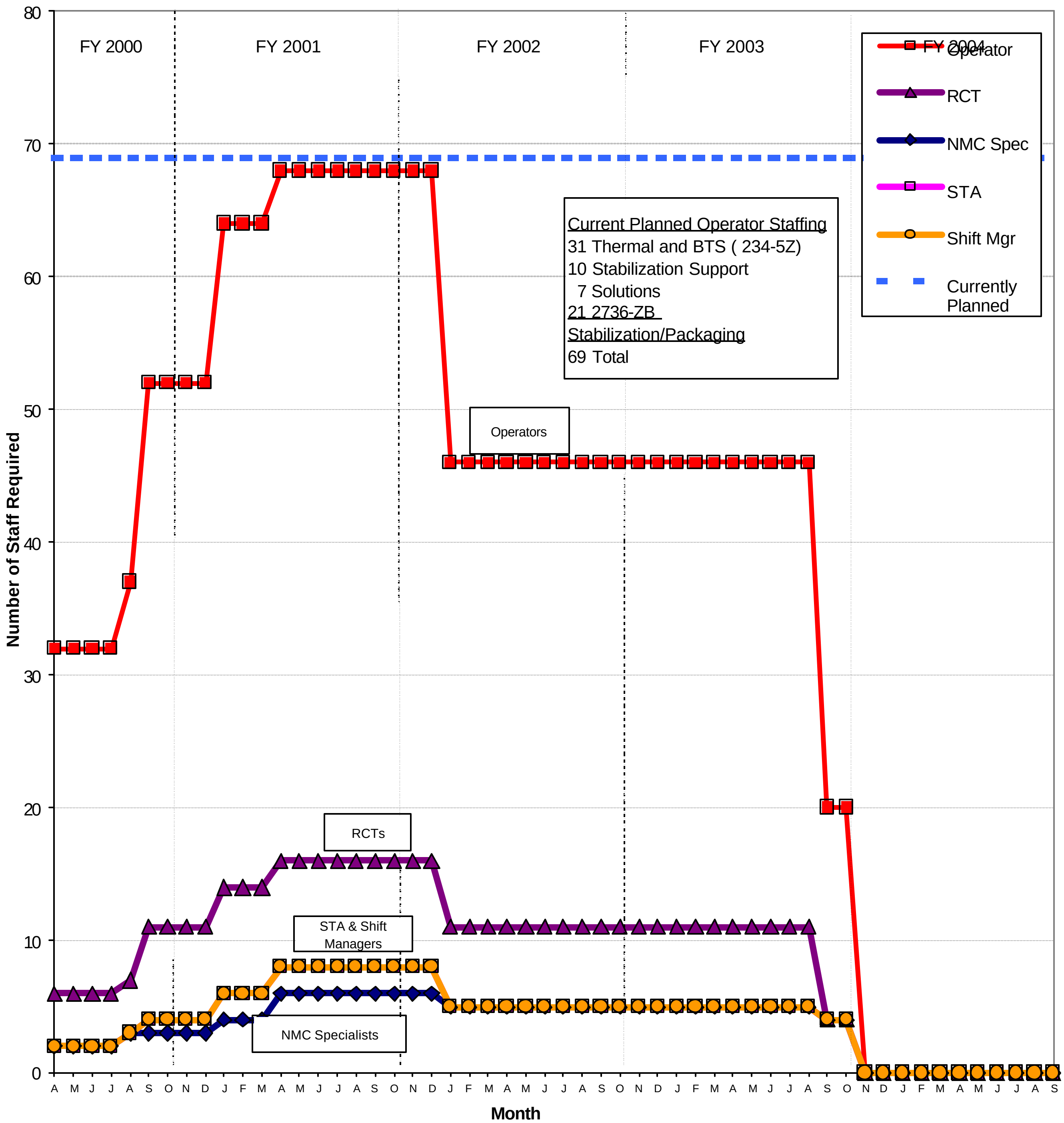

Fig. 3 Critical stabilization Staff

RADIATION EXPOSURE TEMPLATE

Radiation exposure projected to perform all material stabilization activities is shown graphically in Figure 4 for the life of the NMS Project. Projected project dose estimates have been based on a combination of calculated unit operations from ALARA design and operations reviews, field measurements, and other analyses. These estimates were projected based on monthly total exposures and monthly average staff exposures. The results of the radiation exposure template are compared against a monthly reference of 125 mRem per month - based on an administrative limit of 1,500 mRem per person per year. (These projected dose estimates are based on unmitigated exposure, prior to the application of shielding and other exposure reduction methods.) The analysis supporting these exposure results highlights solutions, metals/alloys and oxides/MOX as the most exposure intensive stabilization activities. If no ALARA mitigating actions were to be taken, radiation exposure to the nuclear operators are projected to be above the administrative limit during the entire stabilization period (2001 through 2003). However, the PFP ALARA Operations Group have applied the prescribed ALARA mitigating actions from the ALARA Design Review to the Magnesium Hydroxide Project and as expected, actual exposures during stabilization processing have been less than estimated – thus demonstrating the benefits of effective ALARA planning.

The overall value of the radiation exposure template is to integrate all radiation exposure estimates from the various stabilization activities and compare these against the administrative control limits. The radiation exposure template has identified the operator exposure during stabilization activities as a significant management issue, requiring aggressive ALARA management actions to implement exposure reductions. Radiation exposure to the critical operating staff remains as a potential limitation for performing stabilization activities, unless ALARA mitigating actions are applied. During FY 2000, radiation exposure was aggressively managed and maintained below the 1500 mRem administrative limit.

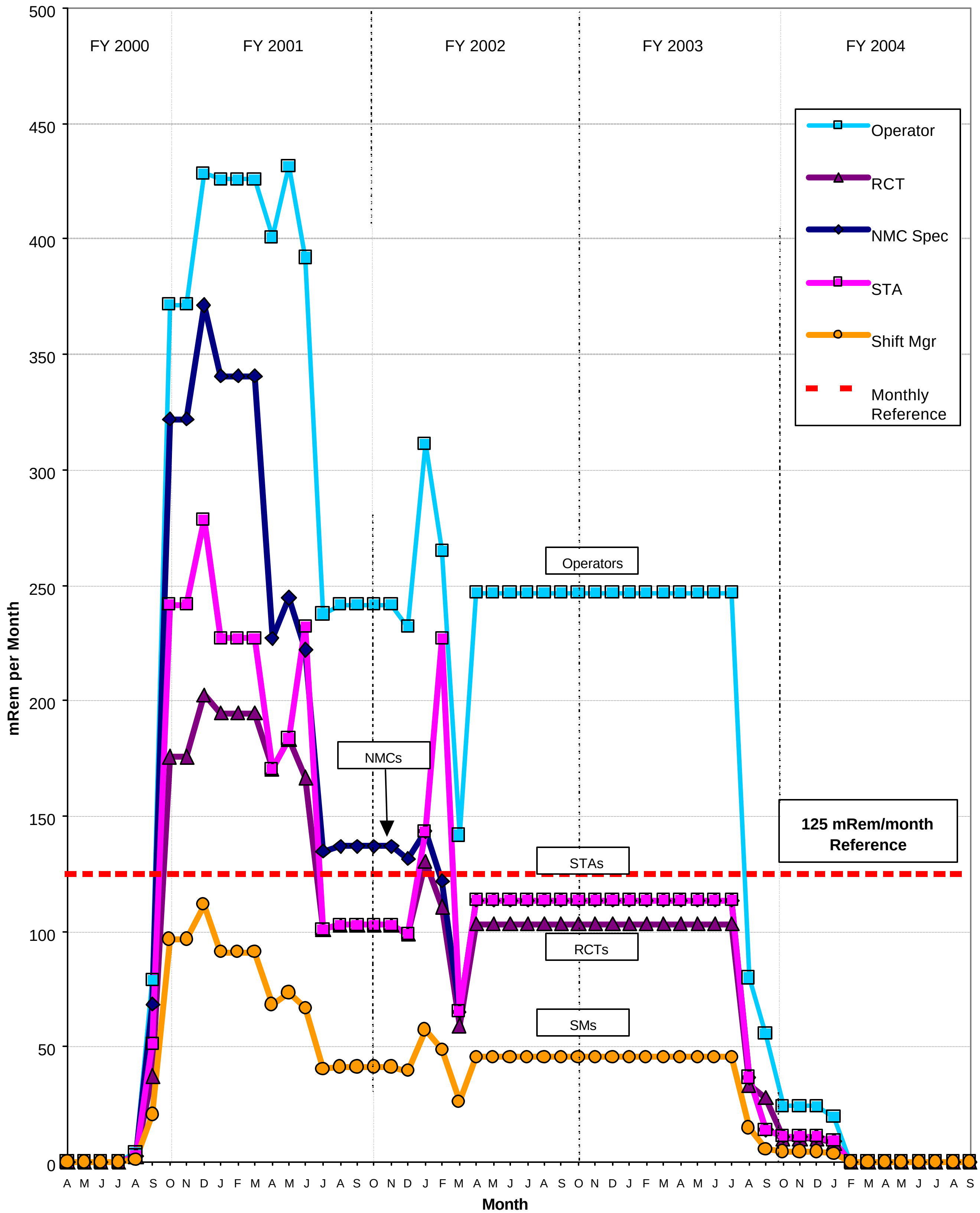

Fig. 4 Monthly Personnel Dose for Stabilization

CONCLUSION

Integrated project planning was the basis for strategizing changes to increase efficiency, and accelerate risk mitigation work associated with stabilization and disposition of nuclear materials at PFP. This paper describes the use of project specific templates as a project management tool to evaluate and analyze critical requirements, resources, and constraints affecting stabilization and disposition of nuclear materials. Processing capabilities, including cycle times and all of the detailed operational requirements, were factored into the development of these templates and utilized to compare need versus availability of critical equipment, critical operating staff, and available radiation exposure to provide the tools required for project managers at PFP to evaluate and optimize their project performance.

The results of this analysis identified two significant management challenges that must be resolved in order to achieve success. First, the on-time availability of stabilization and disposition equipment and systems required for timely completion of scheduled activities, and second, projected radiation exposure to operating staff must be reduced and managed closely to meet the proposed schedule dates. Current models project that the exposure to operators will significantly exceed the administrative limits. The templates developed for the NMS Project provide an additional project management tool for further evaluating the impact of issues and changes to the project. Given the early warning, project managers now have the opportunity to resolve identified issues and implement changes that will allow for on time completion of this project. Further refinement of these process templates is in progress to automate and simplify their use, and to incorporate actual data from ongoing stabilization activities.

REFERENCES

1. Integrated Project Management Plan for the Plutonium Finishing Plant Stabilization and Deactivation Project, HNF-3617, Rev. 0, April 1999.

2. DOE Standard - Stabilization, Packaging, and Storage of Plutonium-Bearing Materials, DOE-STD-3013-99, November 1999.