

PERFORMANCE MEASURES IN THE OFFICE OF NUCLEAR MATERIAL AND FACILITY STABILIZATION AND THEIR DEPENDENCY ON SCIENCE AND TECHNOLOGY

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ABSTRACT

The Office of Nuclear Material and Facility Stabilization plays a key role in the Nation's nuclear weapons cleanup program. The mission of the Office of Nuclear Material and Facility Stabilization is to first achieve stabilization of the nuclear materials and spent nuclear fuel that our program is responsible for and then prepare both for eventual disposal. Deactivation of the buildings is also a major goal within our program since a building must be deactivated before it can be finally decommissioned. Effectiveness in these roles has become increasingly important to the Environmental Management (EM) program because stabilizing, monitoring, and maintaining the large quantity of nuclear materials and spent nuclear fuels and deactivating excess facilities, thereby reducing the risks and associated "mortgages," is one of the most urgent tasks in the EM Program. Nuclear material and spent nuclear fuel stabilization activities and deactivation activities support the Department of Energy (DOE) Environmental Quality strategic objective to, *"Reduce the most serious risks from the environmental legacy of the U.S. nuclear weapons complex first."*

The Office of Nuclear Material and Facility Stabilization's performance measures have been developed to clearly demonstrate the program results achieved for the resources requested. They also serve as a management tool and measure mission effectiveness. This paper describes current performance measures used in our program and demonstrates how science and technology plays a major role in contributing to the success of achieving the performance measures that have been developed to correlate to key areas of our mission--stabilization, disposition, and deactivation.

INTRODUCTION

The Department has tasked the Office of Nuclear Material and Facility Stabilization with stabilizing its nuclear materials and spent nuclear fuel (i.e., produce a safer chemical and/or physical form of the material) to reduce the level of potential risks from radiation exposure and contamination to personnel and the environment. Stabilization converts nuclear material to a stable form suitable for storage, either safe interim or long-term storage or disposal, depending on the programmatic need for the materials. Spent nuclear fuel is treated, when necessary, packaged suitably for eventual final disposal, and placed in safe interim dry storage. These activities are prioritized so the most serious risks are addressed first, and milestones and performance measures have been developed to track progress. As nuclear materials and spent nuclear fuel are placed in more stable forms, the buildings, production systems, machinery, and utilities can be deactivated. Timely deactivation is important to reduce risk associated with maintaining aged facilities as well as to reduce carrying costs (i.e., "Cold War Mortgage"); therefore, a performance measure was developed for "Facilities Deactivation." Money saved through deactivation is then available to accelerate other stabilization and deactivation activities.

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Achieving the goals of this Office is done in accordance with and support of Federal, State and Defense Nuclear Facilities Safety Board (DNFSB) commitments as well as key United States nuclear non-proliferation objectives.

To maximize progress towards achieving our stabilization and deactivation missions and the associated performance gains and cost savings, our Office must pursue new science and technology alternatives and aggressive technology deployment. The implementation of technology development is complicated somewhat by the fact that technical solutions are often needed to meet near-term compliance driven requirements, while the scientific advances needed may generally take longer. Our Office is working with the Office of Science and Technology to establish a program that capitalizes on the Department's past, present, and future scientific investments. Our Office also realizes that the development of good performance measures that reflect our mission, that change as our program changes, that are adequately and accurately defined, and that show our progress are important to this program's success.

Our performance measures for the Office of Nuclear Material and Facility Stabilization for Fiscal Year (FY) 1999 and FY 2000 are listed below. The spent nuclear fuel performance measures are being consolidated for the FY 2001 budget process.

- **Nuclear Material Stabilized (Plutonium, Uranium, other Nuclear Material)**
- **Nuclear Material Made Disposition Ready (Plutonium, Uranium, other Nuclear Material)**
- **Spent Nuclear Fuel in Stabilization Process, but Not Yet Stabilized**
- **Spent Nuclear Fuel Stabilized During Period**
- **Stable Spent Nuclear Fuel, Not Disposition Ready**
- **Spent Nuclear Fuel Made Disposition Ready during Period**
- **Spent Nuclear Fuel in Disposition Ready Storage**
- **Facilities Deactivation**

Not only does the use of new and alternative technologies assist us in meeting our performance measure goals and our mission, but these technologies are driven by compliance requirements, DNFSB, Federal, state, and local commitments and the desire to do things better, faster, or more cost-effectively, while at the same time reducing risk. Alternative and new technologies help us treat, stabilize, store, and transport our nuclear materials, deactivate in a safer and more efficient manner, meet Departmental and National nuclear non-proliferation goals, and will assist us with accelerated closure at our sites. New technologies will also assist us in developing disposition

strategies for nuclear materials that currently do not have disposition paths. Examples of new and alternative technologies instrumental in achieving progress in stabilizing nuclear material and spent fuel and assisting with facility deactivations and their linkage to our performance measures are discussed below.

NUCLEAR MATERIAL AND SPENT FUEL STABILIZATION PROGRAM

An example of a technology transfer that will help achieve one of our main missions of nuclear materials stabilization is the installation of the Plutonium Stabilization and Packaging Systems (PuSPS). This system, adopted from British Nuclear Fuels, Inc., provides the capability for sites to stabilize and package plutonium metals and oxides in accordance with DOE packaging requirements. This technology transfer benefits the program because it minimizes radiation exposure, provides tamper-resistant containers, and eliminates organics inside the containers that can result in degradation of the container. PuSPS equipment is currently planned for the Savannah River Site (SR), Rocky Flats Energy Technology Site (RFETS), and the Hanford Site. This technology transfer helps us achieve progress towards our **“Nuclear Material Stabilized”** performance measure. Achievement of goals related to this performance measure and this technology transfer is also linked to the management commitment of accelerating closure of the Rocky Flats Plant, closure of Plutonium Finishing Plant at the Hanford site, and to DNFSB Recommendation 94-1 because it involves stabilization and packaging of plutonium metals and oxides .

Another stabilization technology being pursued is the blending down of off-specification highly-enriched uranium at the Savannah River Site canyons which is also linked to our **“Nuclear Material Stabilized”** performance measure. The project, referred to as the Off-Specification Fuel Project, involves DOE Headquarters, several DOE Field Offices, the Tennessee Valley Authority (TVA), and the commercial nuclear industry. The purpose is to blend down selected highly-enriched uranium (HEU) (from reprocessing) with low-enriched uranium (LEU), natural uranium, or depleted uranium to produce a low-enriched uranium product (1). This project's scope is to disposition all of the Nation's surplus HEU that is suitable for conversion to off-spec fuel, as directed by DOE's Office of Materials Disposition (MD). If this project is successful, then DOE will provide off-spec material to TVA for fabrication to commercial reactor fuel that will result in lower fuel costs, support the goals of the HEU disposition program by making surplus HEU non-weapons-usable and maximizing the amount of HEU that can be dispositioned as commercial reactor fuel, return the revenue to the U.S. Treasury through cost sharing arrangements with TVA, and provide assistance to other DOE programs in dispositioning their materials (1). MD is currently evaluating the use of DOE or commercial capabilities to blend the HEU to low-enriched uranium for use in the Tennessee Valley Authority's power reactors.

A new packaging technology called the pipe component is the baseline storage and transportation container for RFETS plutonium residues that meets requirements for disposal at the Waste Isolation Pilot Plant (WIPP). This technology is also linked to the performance measure **“Nuclear Material Stabilized”** and is critical to meeting the accelerated closure of RFETS. The pipe component is a flanged, stainless-steel pipe with a lid bolted to the flange, allowing the residue material to be sealed within the pipe. The pipe is fitted with a high-efficiency particulate air filter vent to prevent flammable gas buildup from radiolysis. This component is then placed inside a 55-gallon storage drum. The component would be used for packaging fissile gram equivalent-limited materials to achieve maximum loading of TRUPACT-II shipping containers while still preventing intermixing and criticality concerns in the event of a transportation accident. The pipe component would also block radiation emitted by high americium content materials at RFETS, allowing them to be classified as contact-handled transuranic waste. Even before processed plutonium residues are placed in the pipe component, they would be packaged in small sealed cans referred to as produce cans which are then sealed in bagout bags that are plastic bags used in removing containers from a glovebox (2). Use of this technology increases the amount of plutonium that can be safely transported in TRUPACT-II's providing a cost savings of about \$50M and a significant reduction in the number of shipments to WIPP (3).

Another area where we are using an emerging technology is in the stabilization of highly radioactive americium and curium solutions stored at SR which is also linked to the **“Nuclear Material Stabilized”** performance measure. In March 1998, SR began discussions on an alternate vitrification path called the “Batch Process Concept” since vitrification is the preferred alternative for stabilizing americium and curium. The Batch Process Concept will use a Cylindrical Induction Melter to vitrify these elements. This is a much simpler way to stabilize americium and curium than was previously being pursued using a bushing melter. Operation and testing of the new Cylindrical Induction Melter began in the April 1998 time frame. The benefits of this technology are risk reduction through the conversion of liquids to a more stable glass form and is critical to meeting the requirements of DNFSB Recommendation 94-1. The americium and curium elements, considered to be a National asset, will be processed in such a manner that they could be reused by DOE's Oak Ridge Operations Office and other DOE programs.

Our Office is also working with the Office of Science and Technology's Plutonium Focus Area to explore the possibility of using the Cold Ceramification Process to solidify residual ash. This process is an easily applied and highly effective waste stabilization technology and ties to the **“Nuclear Material Stabilized”** performance measure. Cold ceramification is basically a batch mix and set process similar to cement but with additional benefits. The products derived from the cold ceramification process have mechanical and leach properties almost equal to those of thermally-fused ceramics. It is based on the fact that similarly long-lived solids can be created through acid-based chemical reactions without heat or pressure. This process already occurs in nature with the formation of some long-lived minerals. The potential for this technology is just beginning to be realized. So far, cold ceramics appear to be extremely promising to stabilize hazardous metal containing mixed waste but, more importantly, it appears equally promising to

stabilize actinide residue including hot specimens of ash and ash heel from RFETS. The performance of cold ceramics in regards to leachability and internal gas generation is outstanding plus it results in an extremely sturdy waste form. Cold ceramics is proving to be a waste stabilization technology that is extremely cost-effective, nonthermal, does not produce offgases, and has the potential of meeting many DOE waste stabilization needs.

NUCLEAR MATERIAL AND SPENT FUEL DISPOSITION READY PROGRAM

Another focus of performance measurement for our program is packaging spent nuclear fuel and making it ready for disposal in a monitored geologic repository. Our Office is also exploring new technologies in this area and examples of these are discussed below.

For aluminum-clad spent nuclear fuel stored at SR, two alternate technologies are under development to make aluminum-based **“Spent Nuclear Fuel Disposal Ready.”** The preferred technology, called Melt-Dilute Treatment, melts aluminum research reactor fuel elements using an induction furnace and adds some depleted uranium and aluminum to dilute highly-enriched uranium (HEU) to low-enriched uranium (LEU). Melt-Dilute Treatment provides volume reduction of approximately 70% from a regular size fuel element (4) and, therefore, reduces the number of canisters that would go to permanent disposal. It also reduces criticality and proliferation concerns through isotopic dilution of HEU to LEU and provides flexibility to meet repository requirements. The resulting ingots from the treatment would be placed into canisters and co-disposed with high-level waste already destined for a permanent repository. Use of Melt-Dilute Treatment results in disposal of one canister of spent fuel in the middle of five canisters of vitrified high-level waste. The second backup approach, Direct Co-Disposal, also results in spent fuel co-disposed with high-level waste without any special treatment of the spent fuel (4).

Another technology our program is pursuing for spent nuclear fuel is the High-Integrity Can Concept being developed at our Idaho Operations Office which is linked to our **“Spent Nuclear Fuel Stabilized”** and **“Spent Nuclear Fuel Made Disposition Ready”** performance measures. This approach seals selected spent nuclear fuel within a multiple container system making it disposal ready. An inner high-integrity can (HIC) provides a substitute for spent nuclear fuel integrity by segmenting and further isolating problem materials, providing a long-term corrosion barrier and extra internal pressure barrier, delaying potential fission product release, and maintaining geometry control for extended periods (5). The HIC would be used when it is cost prohibitive to fully characterize diverse but limited quantities of spent nuclear fuel (such as sectioned fuels, sample and test materials, and scrap pieces) or used for individually packaged miscellaneous small lots of spent nuclear fuel in various shapes, sizes, or forms (5). This technology is expected to be used for a small percentage of the Department's spent nuclear fuel inventory for which additional protection is needed. The HIC will be used in a co-disposal configuration for direct disposal in a permanent repository.

FACILITIES DEACTIVATION PROGRAM

Facility deactivation mostly involves removing of all sources of non-fixed contamination from nuclear facilities that are no longer required to meet DOE's mission. This process can be time

and labor intensive. New and fundamental technologies will be required to increase the efficiency of remote operations and reduce deactivation costs. Discussed below are examples of technologies that will help us achieve the efficiency and cost reduction needed to reach our goals in the deactivation area. These technologies are linked to our **“Facilities Deactivation”** performance measure.

In support of the Hanford Canyon Disposition Initiative, robotics staff at Pacific Northwest National Laboratory have been examining the use of a robotic vehicle called “Andros” for remote characterization within the Hanford U Plant railroad tunnel. This project has involved system checks of Andros, review of the tunnel itself to determine optimal deployment access, review of the characterization requirements and radiation sensor specifications for subsequent integration with Andros, testing and completion of the lifting platform for the robot, and actual deployment of Andros in the U Plant tunnel in late summer of 1998 (6). Andros’ mission, equipped with three cameras and lighting systems and radiation sensors, is to collect data on gross contamination levels, photograph the condition of the tunnel, and take smear samples of stains (7). Other options for deployment of Andros are likely to be the U Plant ventilation tunnel and a process cell. The main purpose of Andros is the characterization and final deactivation of Hanford’s U Plant which potentially could be used for another mission. For example, if surplus canyon facilities could be converted to low-level waste disposal facilities, potential cost savings and mortgage reduction for similar facilities at Hanford, Savannah River, and Idaho National Environmental Engineering Laboratory (INEEL) might exceed \$1 billion (7).

Various technologies being pursued through the Office of Science and Technology’s Deactivation and Decommissioning Focus Area are linked to the deactivation of the Savannah River Site’s 321-M Highly Enriched Uranium (HEU) Fuel Fabrication Facility. This facility is being deactivated because it currently has small quantities of HEU reactor fuel material and requires special material control and accountability procedures as well as ongoing surveillance and maintenance. Deactivation will make the facility less expensive to maintain by placing the facility in a long-term safe storage condition with residual hazards reduced to minimal levels. At least five improved technologies will be demonstrated at this facility relating to characterization, decontamination, dismantlement, and waste management. Three technologies that have already been implemented are: 1) a roof leak detector that quickly and safely identifies small roof leaks so an entire roof replacement is not necessary; 2) a new decontamination technology using a torch to melt sprayed glass frit which then becomes a liquid, impacts the surface, safely binds contaminants (chemically and mechanically) and then falls off the surface; and 3) an innovative small tool/component radiation monitor which literally “sniffs” the air around a tool and quickly gives an accurate measurement of total alpha activity (8). Another promising technology for demonstration at 321-M is the X-Ray, K-Edge Heavy-Metal Detector which can be used to identify and qualify levels of uranium held in 321-M system components, piping, and ductwork in situ, without disturbing the contaminants or the components, while reducing risk to workers (7). Potential cost savings and mortgage reduction with deactivation using alternate and new technologies is estimated to be \$20 million (8).

In order to accelerate facility deactivation, remote technology initiatives are needed for highly contaminated spaces and size-reduction of gloveboxes, tanks, and piping. With almost 2,000 gloveboxes and miles of process piping complex-wide, the increased efficiencies and safety margins gained through the application of robotics and improved size-reduction techniques (i.e., remotely operated equipment) would result in significant productivity and safety gains for our program. The Office of Science and Technology, through its Accelerated Site Technology Deployment (ASTD) Program, is funding a project at RFETS entitled, "Enhanced Deactivation and Decommissioning of Gloveboxes." This initiative includes a combination of technologies that provides in-situ radiological characterization of transuranic contaminated gloveboxes, improved mechanical size reduction techniques, and a WIPP-certified standard waste box (SWB) assay system. Currently, RFETS is focusing on new technologies involving mechanical tools such as the "crimper/cutter" which is capable of more efficient pipe cutting than baseline methods. Additional mechanical tool improvements are being investigated, including a "quarter-inch sheet cutter" that has significant safety and efficiency advantages over those currently being utilized (nibblers and reciprocating saws). Possible alternate in-situ size reduction technologies that might be applicable in the future include Plasma Arc Machining (PAM) with advanced fume control, the oxy-gasoline torch, laser-cutting torch, high-pressure water, and robotics techniques. The benefits of more efficient and easier-to-use technologies include reduction of labor costs, secondary waste generation, and occupational (industrial and radiological) risk to workers. The Office of Nuclear Materials and Facility Stabilization will continue to pursue these promising technologies in conjunction with the Office of Science and Technology.

CONCLUSION

The Nuclear Material and Facility Stabilization program is steering toward a new era of nuclear materials and spent nuclear fuel management and facility deactivation. Where the Department was **once** producing nuclear materials and operating production reactors, we are **now** looking to stabilize and make nuclear materials and spent nuclear fuel disposal ready and to deactivate DOE's excess facilities. Our program is dependent on science and innovative technology development to address stabilization and make materials disposition ready and to achieve an effective and cost-efficient deactivation program. This Office will continue to work with the Office of Science and Technology to pursue new and alternative technologies that help us achieve our mission and will continually strive to develop performance measures that will accurately track our progress.

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