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SIMULATION MODEL FOR SHIPMENT OF WASTE TO THE WASTE ISOLATION PILOT PLANT

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ABSTRACT

The United States Department of Energy has agreed to ship 15,000 drums of cold war legacy waste from the Idaho National Engineering and Environmental Laboratory (INEEL) to the Waste Isolation Pilot Plant (WIPP). This waste must undergo characterization and certification prior to shipment. The processes required to characterize and certify waste for shipment to WIPP are extremely complex. A simulation model was developed to analyze drum throughput in these various processes. Inputs to the model include process start and stop dates, machine upgrade dates, process times, and process rejection rates. Outputs include machine utilization, buffer storage statistics, truckloads shipped per month, drums shipped per month, and drum inventory by facility. The simulation model continues to facilitate the INEEL strategic and tactical planning needed to accomplish the agreement within the required time frame.

1 INTRODUCTION

1.1 Background

The United States Department of Energy (DOE) entered into the Spent Nuclear Fuel Settlement agreement with the State of Idaho and the Department of the Navy in October of 1995. This agreement allows for continued receipt and management of spent nuclear fuel at the Idaho National Engineering and Environmental Laboratory (INEEL). The agreement also establishes the conditions for managing approximately 65,000 cubic meters of contact-handled (CH) transuranic (TRU) waste currently stored at the INEEL Radioactive Waste Management Complex (RWMC). CH-TRU waste is material contaminated with alpha-emitting transuranium (atomic number greater than 92) radionuclides with half-lives greater than 20 years, in concentrations exceeding 100 nanocuries per gram of waste with an external container surface dose rate not exceeding 200 millirem per hour. One of the milestones identified in the settlement agreement is the shipment of 3,100 m^3 (15,000 drum equivalents) of CH-TRU waste to the Waste Isolation Pilot Plant (WIPP) located in Carlsbad, New Mexico by December 31, 2002 (hereafter, the "3,100-m^3 milestone"). CH-TRU waste must undergo many processes to prepare the waste for shipment and disposal at WIPP: storage, retrieval, examination, characterization, treatment, and shipping. These processes are managed at INEEL as the 3,100-m^3 Project. Many of these processes are similar to processes performed in a manufacturing plant except that they are regulated by ever-changing DOE orders and applicable federal, state, and local regulations.

1.2 Objectives

The objective for the INEEL TRU Waste Program is to meet the 3,100-m^3 Project interim and final milestones on or ahead of schedule and within budget. Missing a milestone on the 3,100-m^3 Project enforces suspension of spent nuclear fuel shipments to INEEL. The INEEL managing and operating contractor may also be penalized by a reduction in their cost plus award fees.

Therefore, program managers implemented computer modeling and simulation early in the life of the project to aid in strategic and tactical planning. The purpose of simulation analysis of the 3,100-m^3 Project is to test effects of planning assumptions on desired goals and objectives. These goals and objectives include target or mandatory milestones, throughput or output goals, maintenance projections, equipment needs, etc. The analytical processes are focused first on identifying operational bottlenecks, discontinuities in material flow, and incompatible assumptions or sequences, and then on potential enhancements or corrective actions. The purpose of the model is to determine what keeps the project from success, rather than to explore various paths to alternative futures.

1.3 Paper Organization

This paper describes development of the INEEL TRU Waste Stream Model for analysis and simulation of the 3,100-m^3 Project. Section 2 summarizes the processes necessary to prepare CH-TRU waste for disposal at WIPP. Section 3 describes the model and Section 4 draws conclusions about this modeling effort.

2 TRU WASTE WIPP CERTIFICATION PROCESS DESCRIPTION

The CH-TRU waste WIPP certification process is labor intensive because it involves handling and transporting thousands of 55-gal waste drums. Successful completion of this project requires availability of facilities, equipment, procedures and personnel to produce CH-TRU waste characterization and certification data with sufficient quality for disposal at the WIPP. Primary activities include:

- CH-TRU Waste Container Storage and Management
- Container Retrieval
- Waste Characterization
- Waste Certification
- Transportation.

2.1 CH-TRU Waste Container Storage and Management

TRU waste storage activities include waste container management practices and maintenance of the storage facilities as required by the RWMC Resource Conservation and Recovery Act (RCRA) Part B Permit. This includes weekly and monthly inspections of the waste containers and storage buildings. If drums are discovered to have severe rusting or apparent structural defects, they are overpacked in 83-gal containers. Problems with the storage facilities themselves, such as floor cracks, are noted and corrected by maintenance. Container management includes recording each container movement associated with the storage, retrieval, characterization, payload assembly, and Transuranic Package Transporter-II (TRUPACT-II) loading process. Barcode readers are used to input container status in the Transuranic Reporting Inventory and Processing System.

2.2 Container Retrieval

This process involves retrieving potentially WIPP-certifiable TRU waste containers from the inventory located in the RCRA compliant storage buildings. Selective retrieval operations are used to support the waste characterization and certification efforts. This is accomplished by identifying waste container populations with required waste codes from the appropriate database. Using container location coordinates, each drum is located and removed from the waste inventory. Approximately 22,000 drums have been identified from 33 waste streams to meet the 3,100-m^3 milestone. These drums were selected because of the probability that 15,000 drums from this population will successfully pass the rigorous characterization and certification requirements. Figure 1 shows RCRA compliant storage buildings containing CH-TRU waste.

Figure 1: RCRA Compliant Storage Buildings

2.3 Waste Characterization

Waste characterization includes establishing specific waste and container physical, chemical, and radiological parameters necessary to transport and dispose of the CH-TRU waste at the WIPP. These parameters include the waste physical form, weight, radionuclide content, RCRA data, and thermal wattage. A portion of the waste will be selected for intrusive examination and sampling. Container integrity and levels of confinement must also be evaluated. The following is a brief description of the characterization process:

Drums are transported from RCRA storage to a heated enclosure where they are stored for 72 hours at 18°C to 29°C. This temperature stabilization step is necessary during winter months to ensure that free liquids can be detected by the real-time radiography system, and to meet headspace gas sampling requirements. Each preheated drum is surveyed to measure radiation dose rates and detect surface contamination, and weighed. Drums with removable surface contamination are decontaminated before further processing.

Drums are transferred into the Stored Waste Examination Pilot Plant (SWEPP) where they undergo non-destructive examination and non-destructive assay. Non-destructive examination is performed by a real-time radiography system. This step is necessary to verify drum contents, establish the level of containment, and detect the presence of waste items (e.g., free liquids) that do not meet WIPP waste acceptance criteria. After real-time radiography, non-destructive assay is performed on each drum by a gamma-ray spectrometer and passive-active neutron assay. The gamma-ray spectrometer measures isotopic mass ratios for use by the passive-active neutron system to determine specific nuclear parameters and their associated total errors. After gamma-ray spectrometry, the passive-active neutron system determines the amount of plutonium in each drum.

The waste containers are then transferred from SWEPP to the drum venting facility (DVF), where each container is vented, its headspace gas is sampled, and a filter is installed in the vent opening. The gas samples are analyzed in real time by Fourier Transform Infrared Spectroscopy or Gas Chromatography-Mass Spectrometry for volatile organic compounds and flammable gases.

After drum venting, a representative sample of the waste drum population is selected for intrusive examination and/or sampling as required by the WIPP Quality Assurance Program Plan (QAPP). These drums are sent to Argonne National Laboratory-West for examination and sampling. Solidified waste form samples are transported to the INEEL Analytical Chemistry Laboratory for analysis. Argonne National Laboratory-West also performs visual examination of the waste for real-time radiography quality control checks. The visual examination consists of semi-quantitative or qualitative evaluation of the waste container contents. Results of the visual examination are used to determine sampling frequency requirements for future visual examinations.

2.4 Waste Certification

The WIPP QAPP requires three levels of validation for data generated by the waste characterization process: Level I review and validation by the data-generating operation, Level II review, validation, and reporting by independent reviewers, and Level III by WIPP reviewers. These data along with other related waste certification and transportation information are transferred to WIPP via the WIPP Waste Information System. Upon approval of the characterization and certification data, the waste containers can be assembled and loaded into TRUPACT-II containers for transport and disposal at the WIPP.

2.5 Transportation

Following final container disposition at the DVF, WIPP-certifiable containers are stored before shipment to Argonne National Laboratory-West for intrusive characterization or to WIPP for final disposal. The payload assembly area provides a location for overpacking containers that fail the container integrity requirements into standard waste boxes and an area for payload assembly in support of TRUPACT-II shipments. The payload assembly area is used to complete container labeling, identify compatible containers that can be combined into a payload and assemble payloads consisting of either 14 drums or two standard waste boxes.

The payloads are loaded into TRUPACT-II containers. Once the TRUPACT-IIs are loaded, shipping information is loaded into the TRANSCOM satellite tracking system for continuous tracking during transport. Final radiological surveys are performed on the TRUPACT-II containers and transporter, then the shipment is released. Figure 2 shows a transporter carrying three TRUPACT-II containers.

Figure 2: Transporter with TRUPACT-II Containers

3 SIMULATION MODEL

Successful simulation of a complex system consists of two major aspects: accurate understanding of the system, and reasonable translation of the system concept into an appropriate simulation environment. An INEEL CH-TRU Waste Certification Process Flowsheet was used as the original basis for developing the model. Additional data not included on the flowsheet were obtained from other sources, such as site visits and interviews with Waste Management personnel. Development of the model began in fiscal year (FY) 1995, before establishment of the agreements and milestones now governing the 3,100-m^3 Project performance. Because of the long record of planning evolution, the model is now in its one hundred fortieth major revision. Model evolution is governed by:

- Planning revisions, including addition of process steps or modification of schedule.
- Incorporation of increased model detail
- Addition of features such as enhanced output

Two primary components comprise the model: the model itself and the spreadsheet used to supply the model with specific data. Extend™ software by Imagine That, Inc. is used for model development. The software uses an object-oriented approach to modeling using interconnected blocks to represent interaction between specific processes. The spreadsheet facilitates testing, modification, and documentation of assumptions, such as facility start and stop dates, processing rates or delay times, and capacities.

The ability to group blocks into larger hierarchical structures was used extensively during model development. The top level of the hierarchy is designed around three modules: the INEEL, the WIPP, and a transportation module. The next lower layer of hierarchy consists of facilities followed by specific functions performed within facilities. The individual processes performed within the INEEL TRU Waste Simulation model include the following:

- generation
- storage
- retrieval
- preheating
- real-time radiography
- gamma-ray spectroscopy
- passive-active neutron assay
- radiation control survey
- process quality control activities
- drum venting
- headspace gas sampling
- gas generation testing
- intrusive characterization
- repackaging or overpacking
- treatment
- payload assembly
- TRUPACT-II loading
- truck requests
- shipping.

Some facilities have so many functions that these functions within a facility are placed within another level of hierarchy. This hierarchical approach is beneficial because it allows multiple modelers to develop the system. The Extend™ package allowed for easy integration of modules.

The focus of the INEEL TRU Waste Simulation Model effort is the 3,100-m^3 Project milestone (and secondarily, other subsidiary milestones) rather than on general purpose performance measures such as operating efficiency, budget, manpower allocation, etc., all of which are means to achievement of the 3,100-m^3 Project milestone. The model is intended to be used in the following way: when Project Management is made aware of a change in a planning assumption, the model is revised to reflect that change. Analyses are then run to show the effect of the change on achievement of the 3,100-m^3 milestone. If the effect of the change is significant, other model assumptions may be revised to attempt to mitigate the effect. Alternatives can then be presented to Project Management for dealing with the changed planning assumption.

3.1 Model Inputs

Model inputs are read from an Excel™ spreadsheet via a custom Read Spreadsheet block created in Extend™. A subset of the type of input data used to drive the model is listed below:

- process start and stop dates
- machine upgrade dates
- process times (e.g., real time radiography, gamma ray spectroscopy), quality control sample frequency, and waste stream specific rejection rates
- storage capacity by process and building
- release dates for specific drum populations to be shipped
- number of drums per TRUPACT-II
- number of TRUPACT-IIs per shipment
- procurement of TRUPACT-IIs
- WIPP opening date for receiving non-mixed and mixed waste
- intrasite drum transfer
- drum inventory by waste stream and waste form.

Input data are based upon assumptions or process knowledge and are refined as assumptions or processes change.

3.2 Model Outputs

The model has been used continually throughout the 3,100-m^3 Project. Project managers use the model to test effects of changes to assumptions. Some assumptions that have changed include the WIPP opening date for mixed and non-mixed waste, WIPP waste acceptance criteria, process quality control requirements, and facility availability. Based on changing assumptions, the model was revised to determine what changes needed to the system to ensure the 3,100-m^3 Project milestones were met. For example, the model predicted the need to add extra shifts per week and buy additional equipment (e.g., gamma-ray spectrometer and real time radiography systems). The model took the fear out of making bold planning revisions to achieve project success. The types of information of interest to the Project Managers include:

- equipment utilization
- buffer storage statistics

- truckloads shipped per month
- drums shipped per month
- drum inventory by facility

Model results based on FY 2000 assumptions are shown in Table 1 and depicted graphically in Figure 3. Figure 3 is a graphical output from Extend™.

3.3 Model Verification and Validation

Model results and assumptions are regularly distributed to the Project Management team for review and comment. Assumptions and model inputs or design are revised as new data becomes available. The model inputs and design are verified and validated by comparing model results with process performance. Extensive reviews with project staff allow continual re-verification of the model in the changing 3,100-m^3 Project environment.

4 CONCLUSIONS

The INEEL TRU Waste Simulation Model was used in establishing the Project Baseline for the 3,100-m^3 Project. The baseline documented the expected conditions for executing the project. These conditions were used to detect, measure, and/or identify technical, operational, or programmatic deviations from the baseline. As the project grew in complexity, the Project Baseline had to be revised. The model was and still is a valuable tool for these planning efforts. The process of model design detected inconsistencies in planning that would not have been realized by other means. In addition, model outputs and analysis identified process bottlenecks that would have been impossible to recover from if not detected early in project planning.

The processes to characterize and certify drums for shipment to the WIPP are complex, but compounding that complexity with evolving DOE orders and applicable federal, state, and local regulations makes for interesting project planning. The INEEL TRU Waste Simulation Model is essential in determining what is keeping the project from success and how to change the system in response to changes to baseline assumptions.

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Table 1: Production Summary by Fiscal Year

	FY98	FY99	FY00	FY01	FY02	FY03	Total
SWEPP	2,503	1,803	4,674	9,792	3,248	0	22,020
DVF		860	4,144	8,330	2,672	0	16,006
Shippable Drums		390	2,030	9,056	3,846	0	15,322
TRUPACT-IIs per Week		—	0.84	14.04	14.41	0	—
Shipments per Week		—	0.28	4.68	4.80	0	—
Shipments		4	14	234	221	0	473

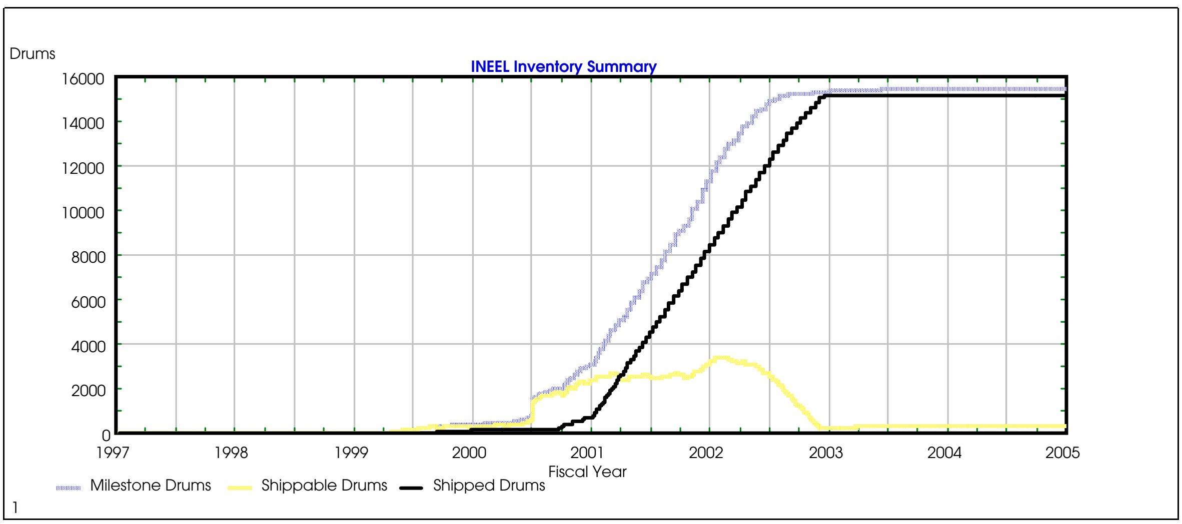

Figure 3: INEEL Drum Certification and Shipping

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