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ABSTRACT

The Idaho National Laboratory (INL) currently does not have the necessary capabilities to process all remote-handled wastes resulting from the Laboratory's nuclear-related missions. Over the years, various U.S. Department of Energy (DOE)-sponsored programs undertaken at the INL have produced radioactive wastes and other materials that are categorized as remote-handled (contact radiological dose rate > 200 mR/h). These materials include Spent Nuclear Fuel (SNF), transuranic (TRU) waste, waste requiring geological disposal, low-level waste (LLW), mixed waste (both radioactive and hazardous per the Resource Conservation and Recovery Act [RCRA]), and activated and/or radioactively-contaminated reactor components. The waste consists primarily of uranium, plutonium, other TRU isotopes, and shorter-lived isotopes such as cesium and cobalt with radiological dose rates up to 20,000 R/h. The hazardous constituents in the waste consist primarily of reactive metals (i.e., sodium and sodium-potassium alloy [NaK]), which are reactive and ignitable per RCRA, making the waste difficult to handle and treat. A smaller portion of the waste is contaminated with other hazardous components (i.e., RCRA toxicity characteristic metals).

Several analyses of alternatives to provide the required remote-handling and treatment capability to manage INL's remote-handled waste have been conducted over the years and have included various options ranging from modification of existing hot cells to construction of new hot cells. Previous analyses have identified a mobile processing unit as an alternative for providing the required remote-handled waste processing capability; however, it was summarily dismissed as being a potentially viable alternative based on limitations of a specific design considered. In 2008 INL solicited expressions of interest from Vendors who could provide existing, demonstrated technology that could be applied to the retrieval, sorting, treatment (as required), and repackaging of INL remote-handled wastes. Based on review of the responses and the potential viability of a mobile hot cell technology, INL subsequently conducted a technology evaluation, including proof-of-process validation, to assess the feasibility of utilizing such a technology for processing INL's remote-handled wastes to meet established regulatory milestones.

The technology evaluation focused on specific application of a mobile hot cell technology to the conditions to be encountered at the INL and addressed details of previous technology deployment, required modifications to accommodate INL's remote-handled waste, ability to meet DOE safety requirements, requirements for fabrication/construction/decontamination and dismantling, and risks and uncertainties associated with application of the technology to INL's remote-handled waste. The large

capital costs associated with establishing a fixed asset to process INL's remote-handled waste, the relatively small total volume of waste to be processed when compared to other waste streams though the complex, and competing mission-related needs has made it extremely difficult to secure the necessary support to advance the project. Because of this constraint, alternative contract structures were also explored as part of the technology evaluation wherein the impact of a large capital investment could be lessened. This paper presents the results of INL's technology evaluation of a mobile hot cell technology to the processing of INL's remote-handled waste and application of such a technology within the DOE system.

INTRODUCTION

The INL currently does not have the necessary capabilities to process all remote-handled wastes resulting from the Laboratory's nuclear-related missions. Over the years, various DOE-sponsored programs undertaken at the INL and other DOE facilities across the United States have produced radioactive waste and scrap that is classified as remote-handled (contact radiological dose rate > 200 mR/h). These materials include SNF, TRU waste, waste requiring geological disposal, LLW, mixed waste (both radioactive and hazardous per RCRA), and activated and/or radioactively-contaminated reactor components. The waste consists primarily of uranium, plutonium, other TRU isotopes, and shorter-lived isotopes such as cesium and cobalt with radiological dose rates up to 20,000 R/h. The hazardous constituents in the waste consist primarily of reactive metals (i.e., sodium and NaK), which are reactive and ignitable, making the waste difficult to handle and treat. A smaller portion of the waste is contaminated with other hazardous components (i.e., RCRA toxicity characteristic metals).

INL Remote-Handled Waste

Over 700 containers of remote-handled materials and waste at the INL are presently stored at the Materials and Fuels Complex (MFC) Radioactive Scrap and Waste Facility (RSWF), a RCRA-permitted waste storage facility (Figure 1). The waste originated from the operation of thee major hot-cell facilities at MFC and Experimental Breeder Reactors I and II (EBR-I and EBR-II). In many cases, the SNF and the various waste types are co-mingled within the same storage container necessitating the capability to remotely segregate SNF from the waste and segregate the various waste types to meet disposal facility waste acceptance criteria. Much of the waste is contaminated with sodium or NaK, also necessitating a remote treatment capability; bulk sodium will also be encountered during management of the remote-handled wastes.

A variety of storage containers and shielding configurations have been used at the RSWF since 1965. Generally, materials stored at the RSWF pre-1978 were placed in 0.28-m (11-in.) diameter, 1.83-m (6-ft) long, thin-walled waste containers (commonly referred to as paint cans), which were placed in 0.41-m (16-in.) diameter, 3.76-m (12-ft, 4-in.) long, Schedule 10 sealed carbon steel pipes (RSWF liners) buried vertically in the ground. The paint can was then covered with gravel for shielding and the liner closed with a metal plate or the liner was closed with a 0.76-m (30-in.) concrete and metal shield plug. Post-1978 to present, the material is placed in a double-can assembly referred to as an HFEF-5 can. The inner carbon-steel cans have a diameter of approximately 0.29-m (11.5-in) and are 1.52-m (5-ft) long with a bolted lid. The outer can assembly is 0.32-m (12.75-in.) diameter stainless steel and is approximately 1.83-m (6-ft) long. This double container configuration is then placed in a 0.41-m (16-in.) RSWF liner and closed with a shield plug.

Pre-1990 most of the RSWF carbon steel liners were not protected from corrosion. In the early 1990s the original 0.41-m (16-in.) carbon steel liners containing material stored in the pre-1978 configuration were trans-located to new, cathodically-protected, 4.11-m (13.5-ft) long, 0.61-m (24-in.) diameter, Schedule 10 carbon steel liners; HFEF-5 cans were transferred from the 0.41-m (16-in.) liners to new cathodically-

protected 0.41-m (16-in.) liners. In addition to the storage configurations identified above, several variations of these configurations have been employed including a double-can configuration consisting of an outer 0.57-m (22.25-in) diameter, 3.43-m (11.25-ft) long outer can assembly; the associated inner can contains a payload of approximately 0.5 m^3 (5x that of the HFEF-5 can).

Fig. 1. Photograph of the Radioactive Scrap and Waste Facility at the Materials and Fuels Complex, Idaho National Laboratory.

The high radiation levels, the co-mingled nature, and various storage configurations of INL's remote-handled waste necessitate remote-handling and treatment capability not currently available at the INL. The purpose of the planned project is to characterize, segregate, treat (as necessary), and repackage INL remote-handled waste for shipment to a DOE-designated permanent disposal site(s) in accordance with established regulatory and legal milestones. Required capabilities include the ability to open the various storage configurations, extract the waste payload, sort and segregate the waste payload into the various waste types, treat sodium or sodium-contaminated components, package and disposition primary and secondary waste streams, and certify wastes for disposal. Spent fuel segregated from the waste during processing will be repackaged and returned to the RSWF for continued interim storage pending future processing or disposal at a permanent, geologic repository.

INL Remote-Handled Waste Processing Capability

Efforts to establish the required processing capability for INL's remote-handled wastes have been ongoing since at least 1980. During the past 25+ years DOE and its' operating contractors have pursued

development of the required capability several times; however, the project has not progressed beyond preliminary design (DOE Order 413.3A Critical Decision-2) due to lack of capital funds to support construction or modification of existing INL hot cells and competition with mission-related priorities. The project has also been hindered by the relatively small volume of waste to be processed when compared to other waste streams thoughout the DOE complex. However, recent project delays have resulted in negotiations between DOE and the State of Idaho on new INL Site Treatment Plan (STP) milestones and has placed the Department's ability to meet the Idaho Settlement Agreement milestone to remove all TRU waste from the State of Idaho by a target date of December 31, 2015 and in no case later than December 31, 2018 in jeopardy. Further significant project delays could result in additional missed regulatory and legal milestones. In addition to fines and penalties, further delays in addressing INL's remote-handled waste could have severe consequences to the relationship between DOE and the State of Idaho that could adversely impact the long-term viability and mission of INL.

In order to meet DOE Order 413.3A requirements and ensure that scarce resources within the Department are best utilized, an alternatives analysis is being conducted by DOE to document the highest-ranked alternative for providing the required remote-handled waste processing capability for INL remote-handled waste. This alternatives analysis is focussing on: 1) the previously planned Remote Treatment Project (RTP; construction of a new annex to the Hot Fuel Examination Facility at MFC), 2) the current planned Remote-Handled Waste Disposition Project (RWDP; modification of the Fluorinel Dissolution Process hot cell at the Idaho Nuclear Technology and Engineering Center [INTEC]), 3) the applicability of a commercially-available mobile hot cell technology, 4) modification of the Hot Fuel Examination Facility at MFC, 5) modification of CPP-659 at INTEC, and 6) a yet to be defined alternative possibly consisting of a combination of the above-identified alternatives. Though engineering and design efforts, information on the previously planned RTP and the currently planned RWDP is available, including budgetary estimates and conceptual designs. Similar information has not been developed for the application of a commercially-available mobile hot cell technology.

Evaluation of Mobile Hot Cell Technologies

The original mission need statement for the capital project identified application of a commercially-available mobile processing unit as an alternative for providing remote-handled waste processing capability. The option was based on a specific design. Further exploration of this alternative was not conducted because the specific design of the identified capability did not treat hazardous waste or have non-destructive analysis capabilities other than visual examination. Although previously dismissed, INL personnel attending the annual Waste Management Conference identified this alternative as a potentially viable option for processing INL's remote-handled waste. Application of a commercially-proven mobile technology could result in substantial cost savings to the Department and warrants serious consideration to determine the viability of a mobile technology to INL's remote-handled waste.

The INL solicited Expressions of Interest (EOIs) from commercial vendors with proven, field-deployed mobile technologies that could be applied to INL's remote-handled wastes. Responses to the request for expression of interest were received from five (5) commercial vendors. Based on evaluation of subsequent proposals, a firm-fixed priced contract was issued to AREVA Federal Services, LLC, the lowest-priced responsive offeror.

AREVA Federal Services, LLC Background

AREVA Federal Services, LLC is leading a consortium of AREVA-affiliated companies formed to serve the U.S. Federal Government, specifically DOE and its contractors, by combining the capabilities, technologies, and resources from multiple AREVA companies. AREVA is the largest nuclear fuel cycle technologies and services provider in the world. With 50 years of experience and 71,000 employees

worldwide, AREVA offers a depth of resources in the nuclear industry that is unparalleled. AREVA offers international experience in all aspects of the nuclear fuel cycle and has experience and capabilities in waste management facilities and technologies.

AREVA has deployed mobile hot cells in France for the retrieval and processing of radioactive wastes similar to INL's remote-handled wastes. The mobile hot cell consists of a self-contained system designed specifically to the conditions where it will be deployed. While this technology has only been used to date for direct-buried, drummed waste, the system could be modified to accommodate the processing activities required for INL's remote-handled waste. If determined to be a viable alternative for processing INL's remote-handled wastes, substantial cost savings could be realized by eliminating the costs associated with a fixed Department asset though alternative contracting mechanisms (e.g., lease options), and by minimizing or eliminating shipments of remote-handled waste from MFC to INTEC.

PURPOSE

The purpose of INL's technology evaluation was to evaluate the technical viability of a commercially-available mobile hot cell to the processing of INL's remote-handled wastes and validate proof-of-process. Without this evaluation the viability of a mobile hot cell technology could not be adequately compared to the other, more significantly-developed alternatives for processing INL's remote-handled waste. The result of which could result in a flawed recommendation as to the most cost-effective and efficient means by which to address this critical legacy waste issue.

The purpose of this evaluation was *not* to perform initial design activities for a mobile hot cell, but to determine if it is a viable option that, pending results of the DOE alternatives analysis, should be advanced further. Though detailed discussions and tours of existing deployed technologies, INL personnel assessed the viability of a mobile hot cell technology with respect to INL conditions and validated proof-of-process. Resulting information will be used to support DOE's alternative analysis required to meet DOE Order 413.3A requirements.

EVALUATION OF MOBILE HOT CELL TECHNOLOGY

The evaluation team exchanged information with design engineers, subject-matter experts, and operations personnel regarding application of AREVA's mobile hot cell technology and UKAEA's sodium/NaK treatment technologies (AREVA teamed with UKAEA in response to INL's request for EOIs and the subsequent RFP). The evaluation team was provided access to sodium/NaK treatment systems at the Dounreay Site in northern Scotland and to mobile hot cells at the Marcoule Site in France. Specific emphasis was placed on lessons learned and the adaptability of deployed technology designs to INL-specific conditions.

Evaluation Criteria

Vendor information was gathered and verified/validated by working meetings and tours of the Vendor's facilities. The following criteria highlight the 19 criteria that were considered in evaluating AREVA's mobile hot cell technology for processing INL's remote-handled wastes. Following each criteria is an overview of key proof-of-process observations of the evaluation team.

Criteria 1 – *Details of previous technology deployment (waste configuration, waste types, processing rates, waste radiation levels, nuclear and facility safety requirements, visual examination capability, subcontract structure, etc.).*

AREVA currently has two mobile hot cells in operation at the Marcoule Site, France, with a third generation hot cell in construction by AREVA TA. Each unit includes visual examination capabilities and in-cell instrumentation, monitoring, and video capabilities. The hot cells have been designed to French nuclear safety requirements that, based on discussions with facility personnel, appear to be substantially similar to DOE requirements.

- The first generation unit (ERFB; Figure 1) has been deployed two times with first deployment in 1996 – 2006 for retrieval of approximately 6,200 aging, legacy mid-level and remote-handled, bitumized 55-gal waste drums; the second deployment, which is ongoing, utilizes the hot cell for the retrieval of ruptured drums and cleanup of the concrete vaults that were used to store the previously-retrieved bitumized waste drums.
- The second generation unit (ERCF; Figure 2), which was designed and constructed based on lessons-learned from deployment of the first unit, is more modular in design and is currently in use. Operations began in 2007 and focus on retrieval of remote-handled, bitumized 55-gal waste drums.
- The third generation hot cell, currently in the construction phase, will be deployed at the Cadarache Site in France for retrieval of remote-handled mixed waste from interim storage pits. The design and construction of the hot cell builds on the lessons learned from commissioning and operation of the first- and second-generation units at the Marcoule Site.

Fig. 1. Photograph of AREVA's first-generation mobile hot cell (ERFB) deployed at the Marcoule Site, France.

Fig. 2. Photograph of AREVA's second-generation mobile hot cell (ERCF) deployed at the Marcoule Site, France.

Criteria 2 – *Required modifications (conceptual) of Vendor's existing technology(ies) to accommodate the configuration and required processing of INL's remote-handled wastes; such processing shall include all processes required to package and certify waste for final disposition.*

The second-generation mobile hot cell is modular in design and can be engineered to accommodate the anticipated higher radiation levels and storage configuration of INL's remote-handled waste and to include all processes required to disposition INL's remote-handled waste (visual examination and sorting, sodium treatment, final waste packaging, waste certification). AREVA also has substantial, demonstrated experience in development of casks for shipment/handling of wastes.

Criteria 3 – *The ability to remotely handle and process containers with radiation readings up to 20,000 R/h and to maintain worker exposure As Low As Reasonably Achievable (ALARA) utilizing a mobile technology concept.*

AREVA has the technical expertise and demonstrated experience in modifying the existing mobile hot cell designs to provide required shielding capability, as demonstrated in evolving design from the first-generation hot cell to the third-generation hot cell that will accommodate significantly higher radiation levels. Concepts include utilization of both permanent and temporary shielding, in-cell and control room

continuous radiological monitoring, and source checks performed as part of commissioning to validate compliance with design shielding criteria. The mobile hot cell design could also accommodate mechanical installation of additional shielding, if required.

Criteria 4 – *Ability to observe and document repackaging process as required to meet disposal facility's waste acceptance criteria.*

The AREVA mobile hot cells are equipped with shielded windows to allow observation of processing activities, as well as, video capability to meet disposal facility waste acceptance validation and verification criteria. The existing mobile hot cells also have the capability to collect samples of waste for destructive analyses.

Criteria 5 – *Ability to perform radiological measurements to meet disposal facility waste acceptance criteria (e.g., dose-to-curie measurements).*

The second-generation mobile hot cell has in-cell radiological monitoring capability to fully scan 55-gal waste drums. AREVA is currently incorporating an imaging passive-active neutron (IPAN) system and high resolution gamma spectroscopy (also part of ERFC deployment) into its' third-generation mobile hot cell currently being prepared for deployment at the Cadarache site.

Criteria 6 – *Anticipated processing rates based on current experience in deploying mobile technology and corresponding ability to meet established INL regulatory and legal milestones.*

Based on operating experience at the Marcoule Site (ERFB and ERFC are currently processing approximately 40, 55-gal drums per week using two 8 h operating shifts), a mobile hot cell could conservatively support the processing rates required to process all "known TRU" by December 31, 2018. The inherent flexibility of the second- and third-generation mobile hot cells would accommodate redundant process systems for those activities determined to limit overall waste processing thoughput.

Criteria 7 – *Sodium treatment capabilities and integrated approach to treatment with waste segregation and repackaging. Obtaining UKAEA's feedback*

AREVA's teaming partner, UKAEA proposed various pre-conceptual design concepts based on extensive sodium treatment and handling experience at the Dounreay Site that is directly relevant to waste stored at the RSWF. Experience has proven that small alkaline metal-contaminated components can be achieved using water, sodium hydroxide solution, and alcohol baths in conjunction with physical techniques such as ultrasonic baths. These methods could be utilized in conjunction with more extensive treatment systems for bulk sodium/NaK.

UKAEA personnel also stressed the importance of keeping the process simple and pragmatic, while ensuring that the inherent safety issues associated with sodium and NaK treatment are proactively addressed (e.g., utilization of argon gas cover during waste segregation activities) during all pertinent steps of the process.

Criteria 8 – *Requirements for decontamination and dismantling of mobile equipment following processing of all INL remote-handled wastes.*

AREVA has proven experience decontaminating hot cells, as necessary, to support their relocation for other uses. The first-generation hot cell has been moved within the facility multiple times. The second-generation hot cell can be moved by disassembly and reassembly of the modular units or by moving monoblocks. Each unit has been designed to be transferred on road by truck.

Criteria 9 – *Ability to 1) Design and fabricate mobile technology to DOE Order 414.1C, Quality Assurance, and NQA-1 quality requirements, 2) Meet safety design requirements of DOE Order 420.1B, Facility Safety; specifically, ability to satisfy Hazard Category 2 nuclear facility requirements and meet applicable seismic category requirements, and 3) Meet applicable requirements of DOE Manual 470.4-2, Physical Protection, and DOE Manual 470.4-6, Nuclear Material Control and Accountability.*

The AREVA Federal Services QA Program commits to compliance with the following Codes, Standards, and Regulations:

- 10 CFR 21
- 10 CFR 72, Subpart G
- 10 CFR 50, Appendix B
- 10 CFR 63, Subpart G
- 10 CFR 70
- 10 CFR 71, Subpart H
- 10 CFR 72, Subpart G
- 10 CFR 820
- 10 CFR 830.120
- DOE O 414.1C
- ASME NQA-1.

AREVA, in support of the MOX Fresh Fuel Facility currently being constructed for DOE at the Savannah River Site by Shaw AREVA MOX Services, has evaluated numerous U.S. and French requirements and is experienced in developing interface documents that address facility safety and other technical requirements. A mobile hot cell would be designed (and constructed) in accordance with all applicable DOE requirements, utilizing to the maximum extent practicable, analyses and design elements already completed for the mobile hot cells deployed in France. In addition to the technical expertise and experience in meeting DOE requirements, AREVA's operations experience adds additional credibility to the safety of the deployed mobile hot cell systems. No overpack contamination, no atmospheric contamination, and no surface contamination outside the retrieval cell has occurred during the retrieval of over 6,200 bitumized waste drums using the mobile hot cell process, further validating the safety design features of the mobile hot cells and demonstrating AREVA's capabilities to effectively meet applicable safety requirements.

Utilizing the mobile hot cell technology would allow placement of the modular facility immediately adjacent to the RSWF. As such, existing security measures could be extended by INL to encompass the mobile facility and reduce requirements associated with transport of the waste outside the physical protection area. The hot cell visual and measurement capabilities could support required nuclear material control and accountability.

EVALUATION SUMMARY

Based on personal observation of actual mobile hot cell technology deployment, discussions with operations and technical personnel, and the operational and technical expertise of the INL team who conducted the site visits, it is the conclusion of the INL technical evaluation team that a mobile hot cell technology is a technically feasible alternative for providing the required capability to process INL's remote-handled wastes. AREVA's first generation mobile hot cell technology has been in operation for 10+ years. Based on the success of this first deployment, the first-generation unit has been modified to conduct additional cleanup activities and the technology has been incrementally improved upon, though

construction of the second- and third-generation units for the retrieval of other highly-radioative wastes, to meet increasing technical challenges in the French nuclear complex. The ability of the technology to safely process remote-handled wastes has been demonstrated though the production rates and safety record realized at the Marcoule Site.

This technology provides the following advantages:

- Existing, proven technology in operation that is not based solely on development of a design concept and/or references
- The mobile hot cell developed by AREVA is currently in its third generation, with each generation building on the design, construction, commissioning, and operations lessons learned of previous deployments
- The mobile hot cell provides flexibility for location of the facility to minimize waste handling
- The mobile hot cell requires minimal onsite fabrication and can be qualified in cold tests
- The modular design of the mobile hot cell system is versatile, providing for deployment flexibility based on specific INL conditions to be encountered (e.g., several cells can be constructed for process thoughput limiting steps or several hot cell systems could be deployed, with each designed specifically to accommodate a specific liner configuration).

Risks

While it is the conclusion of the evaluation team that the mobile hot cell technology is a viable alternative for processing INL's remote-handled waste, there are several inherent risks that would need to be further evaluated and quantified prior to deployment. While these risks have been identified, it is not possible at this stage to quantify these risks in that sufficient information to assess the impact of these risks on the project is not available without further development of this alternative though conceptual design. These risks include:

1. Equivalency of French and DOE requirements and activities that may be required to demonstrate such equivalency and/or modifications to design analyses that must be conducted to meet DOE requirements
2. Processing rates that can be realized in the mobile hot cell to meet project regulatory and legal requirements, including management of all secondary waste streams. It should be noted that this risk is inherent to all alternatives being considered for processing INL remote-handled waste.

Application to Idaho National Laboratory Remote-Handled Waste

Based on evaluation of AREVA's mobile hot cell and an assessment of INL's remote-handled waste inventory, two applications of the mobile hot cell technology are considered by the evaluation team to be most feasible: 1) deployment of a mobile hot cell to process all INL remote-handled waste and 2) deployment of a mobile hot cell for the reconfiguration of wastes stored in 24-in. liners for further processing at an existing INL hot cell facility.

Under the first application, a mobile hot cell system would be utilized to process all INL remote-handled waste. All processing activities would be completed utilizing the modular mobile hot cell system, with the final segregated (and treated) waste being dispositioned directly to the final disposal facility. Under this

application, the mobile hot cell would be placed adjacent to the RSWF to provide for continous on-demand feed of RSWF liners and real-time placement of segregated SNF in continued interim storage at RSWF.

Under the second application, the mobile hot cell technology would be utilized in conjunction with retrieval activities to size reduce the pre-1978 storage configuration (i.e., 0.41-m [16-in.] liners overpacked in 0.61-m [24-in.] liners) to simplify transport and downstream processing requirements. Under this scenario, an existing INL hot cell would be utilized for segregation and sorting, treatment (as necessary), and final packaging and certfication of wastes for disposal. Waste currently stored in double containers (i.e., HFEF-5 cans or SLSF cans) would be transported directly to the onsite hot cell, bypassing the mobile hot cell facility. Within the mobile hot cell, which would be located immediately adjacent to RSWF to provide on-demand supply of RSWF liners, sizing and overpacking activities could include removal of the 0.41-m (16-in.) liner from the 0.61-m (24-in.) liner (if allowed based on physical condition of the original 0.41-m [16-in.] liner), cutting of the 0.61-m (24-in.)and 0.41-m (16-in.) liners immediately above the inner paint can (reducing the length by approximately 2.13 m [7 ft]), and removal of gravel shielding greatly reducing the required capabilities of a fixed hot cell.

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