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Rev. 3

# Safety Design Strategy for the Remote-Handled Low-Level Waste Disposal Project

June 2012

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**DISCLAIMER**

# ABSTRACT

In accordance with the requirements of U.S. Department of Energy (DOE) Order 413.3B, “Program and Project Management for the Acquisition of Capital Assets,” safety must be integrated into the design process for new or major modifications to DOE Hazard Category 1, 2, and 3 nuclear facilities. The intended purpose of this requirement involves the handling of hazardous materials, both radiological and chemical, in a way that provides adequate protection to the public, workers, and the environment. Requirements provided in DOE Order 413.3B and DOE Order 420.1B, “Facility Safety,” and the expectations of DOE-STD-1189-2008, “Integration of Safety into the Design Process,” provide for identification of hazards early in the project and use of an integrated team approach to design safety into the facility. This safety design strategy provides the basic safety-in-design principles and concepts that will be used for the Remote-Handled Low-Level Waste Disposal Project.

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# ACRONYMS

| | |
|---|---|
| ATR | Advanced Test Reactor |
| CIC | core internal changeout |
| CD | critical decision |
| CDR | conceptual design report |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CSDR | conceptual safety design report |
| CVAS | cask-to-vault adapting structure |
| DOE | Department of Energy |
| DSA | documented safety analysis |
| EA | environmental assessment |
| FHA | fire hazard analysis |
| FONSI | finding of no significant impact |
| HC | hazard category |
| INL | Idaho National Laboratory |
| IPT | Integrated Project Team |
| LLW | low-level waste |
| NEPA | National Environmental Policy Act |
| NRF | Naval Reactors Facility |
| PDSA | preliminary documented safety analysis |
| PEP | project execution plan |
| PHA | preliminary hazard analysis |
| PSDR | preliminary safety design report |
| RHLLWDF | Remote-Handled Low Level Waste Disposal Facility |
| RMP | risk management plan |
| RWMC | Radioactive Waste Management Complex |
| RSWF | Radioactive Scrap and Waste Facility |
| SDC | seismic design category |
| SDIT | safety design integration team |
| SDS | safety design strategy |
| SSC | structure, system, and component |
| TFR | technical and functional requirement |
| WAC | waste acceptance criteria |

# Safety Design Strategy for the Remote-Handled Low-Level Waste Disposal Project

## 1. PURPOSE

In accordance with Department of Energy (DOE)-STD-1189-2008, "Integration of Safety Into the Design Process," this safety design strategy for the Remote-Handled Low-Level Waste (LLW) Disposal Project at the Idaho National Laboratory (INL) describes the overall safety strategy; describes the strategy for certain high-cost, safety-related design decisions; identifies key assumptions or inputs that may represent potential risks to design decisions; and identifies expected safety deliverables through the project. In accordance with the requirements of DOE Order 413.3B, "Program and Project Management for the Acquisition of Capital Assets," safety must be integrated into the design process for new or major modifications to DOE Hazard Category (HC) 1, 2, and 3 nuclear facilities. Safety analysis documentation will meet the requirements of 10 CFR 830, "Nuclear Safety Management," Subpart B, "Safety Basis Requirements."

This revision (Revision 3) to the safety design strategy (SDS) will be incorporated into the project critical decision (CD)-2/3 documentation and incorporates a number of updates to the overall project since the last revision (Revision 2, October 2010):

- Final site selection as documented in the finding of no significant impact (FONSI) documented in the environmental assessment (EA), DOE/EA-1793, "Environmental Assessment for the Replacement Capability for Disposal of Remote-Handled Low-Level Radioactive Waste Generated at the Department of Energy's Idaho Site" (DOE 2011).

- Decision to proceed with a design-build project delivery method as outlined in DOE/ID-11368, "Acquisition Strategy for the Idaho National Laboratory Remote-Handled Low-Level Waste Disposition Project" (DOE-ID 2011) and described in DOE/ID-11466, "Project Execution Plan for the Remote-Handled Low-Level Waste Disposal Project" (DOE-ID 2012).

- Development of performance specifications for design-build subcontractors documented in SPC-1437, "Design-Build-Operate Performance Specification for the Remote-Handled Low-Level Waste Disposal Project."

- Development and approval of the conceptual safety design report (CSDR) documented in INL/EXT-09-17427, "Conceptual Safety Design Report for the Remote-Handled Low-Level Waste Disposal Project" (INL 2010d).

- Development and submittal for DOE approval of the preliminary safety design report (PSDR) documented in INL/EXT-10-19054, "Preliminary Safety Design Report for the Remote-Handled Low-Level Waste Disposal Project" (INL 2012).

- Development of a reconciliation plan that addresses differences between the reference design evaluated in the PSDR and any design optimization of the vault/canister configurations.

- Specifications for waste streams documented in the technical and functional requirements (TFRs), TFR-483, "Remote-Handled Low-Level Waste Disposal Facility Technical and Functional Requirements."

# 2. DESCRIPTION OF PROJECT

As part of ongoing cleanup activities at INL, closure of the Radioactive Waste Management Complex (RWMC) is proceeding under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC 9601 et seq. 1980). Disposal of remote-handled LLW in concrete disposal vaults at RWMC will continue until the facility is full or until it is closed in preparation for final remediation of the Subsurface Disposal Area (approximately at the end of Fiscal Year 2017).

The continuing nuclear mission of INL, associated ongoing and planned operations, and Naval spent nuclear fuel activities at the Naval Reactors Facility (NRF) require continued capability to appropriately dispose of remote-handled LLW. Development of a new onsite disposal facility for the disposal of INL and tenant-generated remote-handled LLW has been identified as being needed to provide continued, uninterrupted INL remote-handled LLW disposal capability. The need for this proposed Remote-Handled LLW Disposal Project is to have replacement disposal capacity in place by the end of Fiscal Year 2017.

The proposed Remote-Handled LLW Disposal Project will be designed and constructed similar to the remote-handled LLW concrete disposal vaults currently in use in the RWMC Subsurface Disposal Area. This will accommodate, to the maximum extent possible, uninterrupted operations at the generating facilities and will capitalize on the operations experience and cost efficiencies of current remote-handled LLW disposal practices. One example of a vault layout consists of reinforced, precast concrete cylinders stacked on end and placed in a honeycomb-type array (see Figure 1). Alternative designs may include the use of multiple concrete-formed cylindrical sleeves inside of a single precast concrete vault. A removable concrete plug will be set on top of the vault to serve as a radiation shield and water barrier once the vault is filled. Alternative designs utilizing multiple cylindrical sleeves inside a single vault may require a temporary vault plug to be placed on open vault cylinders while waste canisters are being placed in other cylinders.

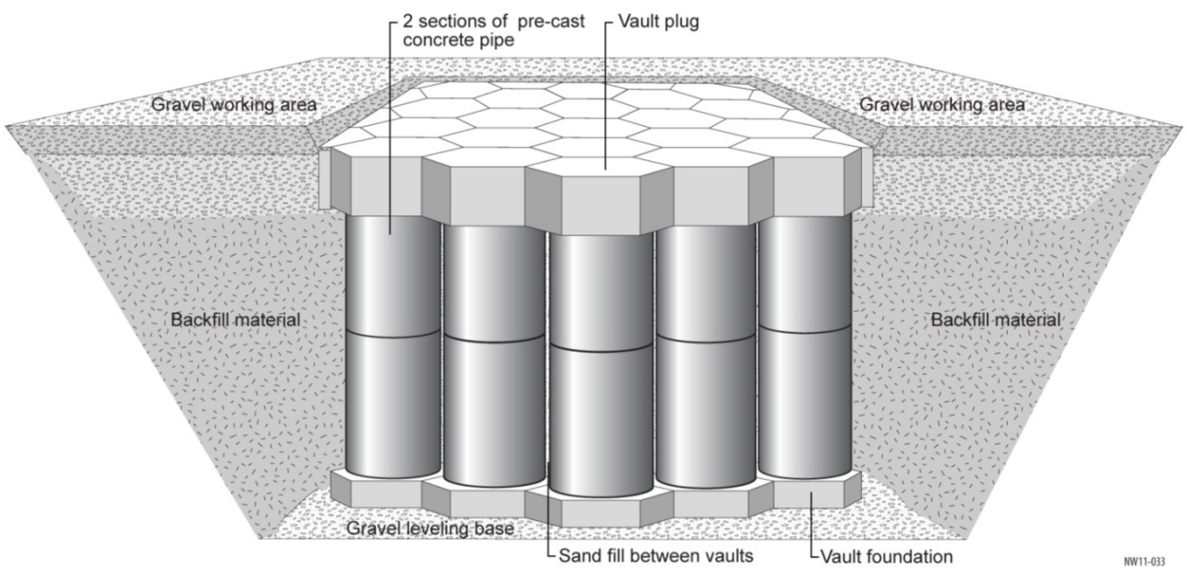


Figure 1. Reference concrete vault layout.

A siting study has been conducted to support the National Environmental Policy Act (NEPA) process that considered possible locations within the INL that are best suited for locating the facility. The siting study used a five-step process to identify, screen, evaluate, score, and rank multiple sites located across the INL (INL 2010b). The site selected for the Remote-Handled Low Level Waste Disposal Facility (RHLLWDF), as discussed in the FONSI documented in the EA is located approximately 0.5 miles southwest of the ATR Complex.

The Remote-Handled LLW Disposal Project will be designed and constructed using a design-build project delivery method. The design-build approach will be tailored, as appropriate, to integrate the requirements of DOE Order 413.3b with the DOE budget formulation process and the safety requirements of DOE-STD-1189-2008. The design-build method was chosen because the project has well-defined requirements based on current remote-handled LLW disposal operations at INL, the disposal facility is not complex, and there is limited risk with the design and construction phases of the project. However, as outlined in the project execution plan (PEP), DOE/ID-11466, there are uncertainties associated with the design-build project deliver method:

- Significant experience does not exist for the construction of a nuclear facility using the design-build delivery system.

- There are a limited number of design-build vendors familiar with DOE-related nuclear safety requirements.

- There may be differences in design between the reference design evaluated in the PSDR and advanced conceptual designs that may be developed by the design-build subcontractor.

- CD-2/3 documentation will be based on requirements in the TFRs, SPC-1437, and other design-build bridging documents rather than preliminary designs because preliminary design will not be available until after CD-2/3 approval.

In order to mitigate these uncertainties and ensure that safety is an integral part of the design process, the design-build subcontract(s) will be competitively bid to qualified subcontractors with nuclear facility experience. SPC-1437 requires the subcontractor to provide input to safety-basis documentation at all stages in the design and construction process through operational readiness. There are also specific requirements for the subcontractor(s) to provide design details, drawings, process flow diagrams, and other relevant deliverables in a timely manner according to project schedules to support safety basis development, also serving to ensure that nuclear safety is incorporated into design and construction.

As part of the tailoring strategy, CD-2 and CD-3 will be combined into a single CD-2/3 approval, currently scheduled for August 2012. Final design of components and/or systems requiring nuclear safety review are scheduled for completion commencing in August 2013, with construction hold points prior to the start of fabrication/construction of each of the applicable components or systems. These hold points ensure that the designs meet all nuclear safety requirements dictated by the preliminary documented safety analysis (PDSA). The PDSA will be re-evaluated at the 60% design milestone to ensure that safety-in-design is progressing as intended. In addition, the PDSA will be completed and evaluated at final design and will be part of the criteria for releasing the construction hold point.

The requirements of DOE Order 413.3B dictate that safety must be integrated into the design process for new nuclear facilities. Implementation of this requirement ensures adequate protection of the public, workers, and the environment. Requirements provided in DOE Order 413.3B, 10 CFR 830, and DOE Order 420.1B, “Facility Safety,” and the expectations of DOE-STD-1189-2008 provide for identification of hazards early in the project and use of an integrated team approach to design safety into the facility. The basic safety-in-design precepts include:

- Appropriate and reasonably conservative safety structures, systems, and components (SSCs) are selected early in the project designs.

- Project cost estimates include these SSCs.

- Project risks associated with selection of safety SSCs are specified for informed risk decision making by the project approval authorities.

The provisions of DOE-STD-1189-2008, when implemented in conjunction with DOE Order 413.3B and its guidance documents, are consistent with the core functions and guiding principles of the Integrated Safety Management System as described in DOE Policy 450.4A, "Integrated Safety Management Policy."

## 2.1 Operational Overview

Remote-handled LLW destined for disposal will be packaged into shielded transportation packages with stainless steel waste canister. The waste canisters will normally consist of cylindrical canisters designed specifically for the transportation package systems used. It is assumed that remote-handled LLW will be transported from NRF to the disposal facility in the 55-ton scrap cask, or similarly designed cask, that is currently used at RWMC. Operations involving this cask will be similar to those used at RWMC. The operational systems associated with transportation packages and transfer systems used by other INL generators will be determined once specific waste canister designs and transportation package systems are identified.

## 2.2 Anticipated Waste Streams

Anticipated waste for this project consists of remote-handled LLW from a variety of sources, nonhazardous activated metals, and resins. Descriptions of the waste streams from specific generating facilities and waste stream characterization data are provided in TFR-483 including DOE Order 420.1B "Facility Safety." A summary of these waste streams is provided in Table 1.

Table 1. Waste streams proposed for the Remote-Handled LLW Disposal Project.

| |
|---|
| **1. Activated metals** |
| • **ATR:** ATR produces activated metals during reactor core internal change-out (CIC) operations approximately once every 10 years. These components require time for decay before disposition and are in storage at the ATR Complex. Previous disposal of this waste stream was performed at RWMC using a cask that is no longer in use.<br>• **NRF:** NRF produces activated metals during routine operations. The activated metals waste stream also includes a limited volume of additional debris that qualifies as remote-handled LLW. Currently, waste is disposed of in the RWMC vaults in 55-ton scrap cask liners. Future shipments will also include large concept cask liners.<br>• **MFC:** Activated metals and debris will be generated from new missions. Legacy waste currently stored at MFC's Radioactive Scrap and Waste Facility (RSWF) will also be disposed. |
| **2. Ion-exchange resins** |
| • **ATR:** ATR produces ion-exchange resin waste during routine pool and reactor operations. This waste is currently disposed of in NuPac 14-210L cask liners at the Nevada National Security Site.<br>• **NRF:** NRF produces resin waste during routine operations. Currently, the waste is |

disposed of in Type VII demineralizer tanks in the RWMC vaults.

Ion-exchange resins from pool and reactor operations are generated at the Advanced Test Reactor (ATR) Complex and from pool operations at NRF. ATR ion-exchange resin is generated approximately four to six times annually from reactor loop and reactor ion-exchange systems. The generation rate depends on reactor operations and also varies during the years when CICs are performed. The ion-exchange resin waste streams have typical contact exposure rates up to 15 R/hour, although individual waste canisters may have higher contact exposure rates.

The ATR Complex also produces activated metals during reactor CIC operations, approximately every ten years. These components require decay time before they can be handled for disposal and are currently in temporary storage at the ATR Complex. NRF produces activated metals from examination of test components and during routine operations removing irradiated non-fuel components from spent nuclear fuel modules. The activated metals waste streams have typical contact exposure rates up to 30,000 R/hour (up to 60,000 R/hour for NRF waste streams), although individual waste canisters may have higher contact exposure rates.

In addition, activated metals and other remote-handled LLW streams are expected from new INL programs and from processing of remote-handled waste stored at the RSWF. These materials can contain a variety of radionuclides and can have contact exposure rates up to 30,000 R/hour, although individual waste canisters may have higher contact exposure rates.

Specific waste streams and one possible reference canister/vault configuration for each waste stream as described in TFR-483 are shown in Table 2; other canister/vault configurations may be developed during the preliminary and final design of the project.

Table 2. Waste stream and reference canister/vault configurations.

| Waste Stream | Canister Designation | Number of Canisters per vault |
|---|---|---|
| NRF activated metals | 55-ton cask liner | 2 |
| | New concept canister | 1 |
| NRF resins | Type VII RWDS module | 2 |
| | New concept RWDS module | 1 |
| ATR activated metals | HFEF-5 cask liner | 2 |
| ATR resins | NuPac 14/210L cask liner | 2 |
| MFC activated metals | HFEF-5 cask liner | 2 |
| MFC legacy waste (RSWF) | Modified stainless steel overpack in modified FTC cask | 1 |
| MFC legacy waste (SN cans) | HFEF-5 cask liner | 2 |
| MFC future (FCF) | HFEF-5 cask liner | 2 |
| MFC future (HFEF) | HFEF-5 cask liner | 2 |

## 2.3 Facility Layout

Facility configuration for the Remote-Handled LLW Disposal Project is similar to the existing vault design and configuration that is currently present at RWMC. This facility includes concrete vaults, vault plugs, access roads, and support infrastructure. Figure 2 shows an example layout for the new Remote-Handled LLW Disposal Project.

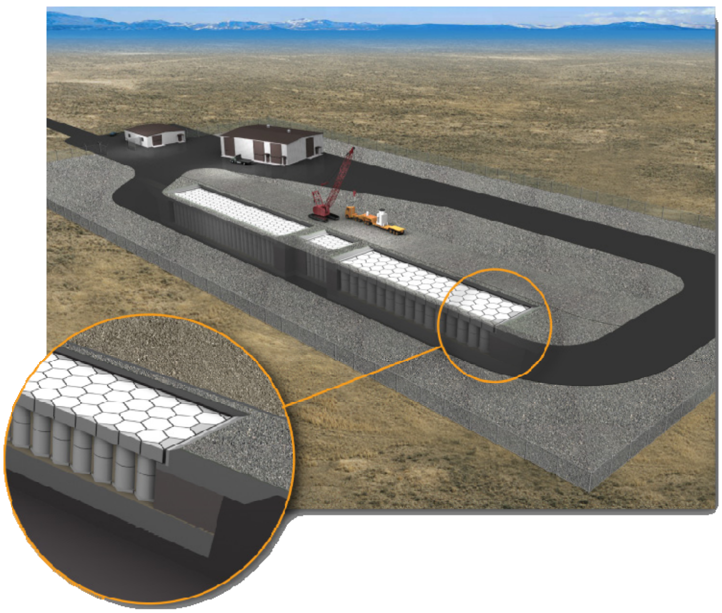

Figure 2. Example layout for the Remote-Handled Low-Level Waste Disposal Project.

The facility layout is based on the assumption that the facility that will be constructed and operated will be a stand-alone facility and will provide its own administration buildings and infrastructure to support disposal operations.

# 3. SAFETY DESIGN STRATEGY

The overall safety strategy for the Remote-Handled LLW Disposal Project is presented in the following sections.

## 3.1 Safety Guidance and Requirements

The reference design for the new Remote-Handled LLW Disposal Project is similar to the existing concrete disposal vaults in the RWMC Subsurface Disposal Area. This concept will accommodate uninterrupted operations at the generating facilities and will capitalize on operations experience and cost efficiencies of current remote-handled LLW disposal practices. The basic design of the facility and corresponding operations activities consider the high radiation levels associated with the remote-handled LLW streams and minimize worker radiological exposure. The major facility components, as described in SPC-1437 and TFR-483, are the vaults, vault shield plugs, crane, cask transfer system, and waste canister transfer system shielding. The waste canister transfer system shielding can include the existing cask-to-vault adapting structure (CVAS), shield bells for top-loading casks, or any other shielding system that might be developed for future cask/vault configurations. These components, coupled with the generator transportation packaging and waste canisters, provide for passive control of worker radiological exposure. Evaluations of these components, both existing and any that might be developed in the future, will be conducted throughout the design process to ensure that they meet appropriate shielding requirements. Requirements for the design-build subcontractor(s) to incorporate appropriate worker radiological exposure minimization SSCs as identified in facility safety-basis documentation are also specified in SPC-1437.

Design and construction of casks and cask transfer systems required for transporting remote-handled LLW canisters to the facility will meet the requirements of DOE Order 460.1C, "Packaging and Transportation Safety." In addition, any existing or new-designed cask must meet the same performance requirements as existing cask systems; adherence to these requirements will be assured by maintenance of a contractor-approved cask list that defines performance specifications for each cask and cask transfer system used at the RH LLW Disposal Project.

The design and safety evaluation of the facility and its operations will be completed in accordance with requirements delineated in DOE-STD-1189-2008. A tailored approach will be used where known facility hazards from the existing RWMC vaults were used to support the preliminary hazard analysis, the CSDR, and the PSDR. Because there are relatively no inherent radiological release hazards associated with confinement, ventilation, fire, or seismic releases from the facility, the associated hazards for this facility are few and result in low hazard accident scenarios, as addressed in the PSDR. Further review of the evolving design will be incorporated into development of the PDSA during the preliminary design. Development of the final DSA will be completed prior to start of operations. Based on requirements in SPC-1437, the design-build subcontractor(s) will be required to provide appropriate design information throughout the safety-basis documentation process.

The project will be designed in accordance with the requirements, codes, and standards identified in TFR-483 including DOE Order 420.1B "Facility Safety." Specifically, DOE Order 420.1B requires integration of design with safety analyses, adherence to nuclear facility design practices appropriate for the hazard category of the facility and operations, and implementation of a process that ensures that facility design and construction will be in compliance with the nuclear facility safety requirements of the order. This integration will be ensured by the requirements in SPC-1437 for the design-build subcontractor to provide appropriate design information to the safety-basis documentation process.

In accordance with Section C.2.4.B of the INL Contract DE-AC07-05ID14517 (INL 2004), DOE's safety expectations of the INL contractor are as follows:

1. Establish clear safety, environmental protection, health, and quality assurance priorities and manage activities consistent with those priorities

2. Use a graded approach to the program and project safety integration process

3. Have an effective employee involvement program

4. Maintain an effective Integrated Safety Management System.

The specific requirement related to management of INL remote-handled waste is delineated in Part III, Section J, Attachment P of the INL Contract DE-AC07-05ID14517 (INL 2004), that states:

*The INL Contractor shall manage INL-generated LLW and, if directed by DOE, LLW generated by other tenants (e.g., NRF) upon closure of the RWMC LLW disposal operations…LLW management includes development of on/offsite LLW disposal capability and the supporting infrastructure.*

DOE expects the INL contractor to manage remote-handled LLW in a manner that is protective of both human health and the environment. These requirements are also specified in SPC-1437 for the design-build subcontractor(s).

## 3.2 Hazard Identification

Hazardous material inventories for construction and operation of the Remote-Handled LLW Disposal Project are very low in comparison to other nuclear operations and are commensurate with existing RWMC remote-handled LLW disposal operations. No chemicals found in the Occupational Safety and Health Administration substance-specific standards have been identified that would create a potential for exposure triggering medical surveillance during construction or operations. Additionally, no highly hazardous chemicals, as listed in 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals (Appendix A, List of Highly Hazardous Chemicals, or Toxics and Reactives)," will be generated, used, stored, or disposed of at this facility. The primary hazard associated with the facility is worker exposure to the high radiation levels associated with the waste through a variety of exposure scenarios.

The waste streams that will be accepted for disposal at the Remote-Handled LLW Disposal Project must meet the requirements for LLW as specified in DOE Manual 435.1, "Radioactive Waste Management." These requirements specify that the material must contain <100 nCi/g transuranic radionuclides. The strategy for developing material-at-risk for estimating inhalation dose consequences in subsequent hazard and accident analysis is based on the characteristics of each waste stream as documented in ECAR-1559, "Evaluation of Facility Inventory and Radiological Consequences to Support RHLLWDF Safety-Basis and NEPA Documentation."

In terms of direct radiation exposure consequences, a source term based on a 30,000 R/hr contact exposure rate specified in TFR-483 as the shielding design basis is used to determine consequences to the facility worker in the absence of appropriate shielding and/or handling procedures during transfer operations and vault storage. For NRF waste streams, up to 60,000 R/hr contact exposure rates are possible; therefore, in the case of NRF waste streams, the source term is based on a 60,000 R/hr contact exposure rate.

### 3.2.1 Preliminary Hazard Categorization

Based on the preliminary assessment of the anticipated remote-handled LLW streams and a comparison with DOE-STD-1027-92, "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports," the Remote-Handled LLW Disposal Project would have an initial hazard categorization of a HC-2 nuclear facility.

Operationally, the facility is designed to accept shipments of remote-handled LLW (including activated metals and resins) from NRF, ATR, and other INL generators. The total Remote-Handled LLW Disposal Project radioactive material inventory anticipated to be present in the facility at a given time will exceed the HC-2 threshold quantity values for several radionuclides per DOE-STD-1027-92. Although individual vaults may be considered separate facility segments per DOE-STD-1027 supplemental guidance and may have less than HC-2 threshold quantities as shown in ECAR-1559, the facility is designated as a HC-2 facility in order to provide maximum design and operational flexibility.

Waste canisters will be transported within the INL boundary to the Remote-Handled LLW Disposal Project and therefore will be compliant with the transportation limits specified in 40 CFR 173.424(h) for "Excepted packages for radioactive instruments and articles" as described in TEV-1119, "Assessment of Potential for Inadvertent Nuclear Criticality in the RHLLWDF." This requirement specifies a 15 g U-235 equivalent transportation limit. A mass limit of 15 g U-235 equivalent per canister would preclude potential criticality. Design optimizations developed by the design-build subcontractor will be reviewed as necessary for impacts on criticality safety.

It should be noted that waste acceptance criteria (WAC) will be developed for the Remote-Handled LLW Disposal Project to ensure that waste streams accepted for disposal will not exceed maximum established radionuclide content for each waste stream. These WAC will further ensure that waste streams do not have the potential to exceed evaluation guidelines due to inhalation dose consequences or direct radiation exposure. In particular, the WAC will identify those canisters that may require waste canisters transfer system shielding and/or specific procedures for transferring waste canisters with high contact exposure rates.

### 3.2.2 Preliminary Hazard Identification

With respect to nuclear safety, a hazard is defined as "a source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to personnel or damage to an operation or to the environment (without regard for the likelihood or credibility of accident scenarios or consequence mitigation)." To identify potential facility hazards, the following were examined:

- Quantity, form, and location of radioactive and hazardous materials that would be potentially releasable from the Remote-Handled LLW Disposal Project

- Potential energy sources and initiating events that could directly result in injury to workers or lead to release of radioactive or hazardous materials.

From review of the Remote-Handled LLW Disposal Project conceptual design report (CDR), INL/EXT-07-12901, "Conceptual Design Report for the Remote-Handled Low-Level Waste Disposal Project," (INL 2010a) and previous lessons learned, an analysis for potential hazards was performed and updated for the PSDR. The result of this analysis is found in Table 3, which presents hazards that should be considered as the design progresses and the safety basis documentation is being prepared. This table, which lists identified hazards and major safety concerns associated with these hazards, is not intended to be all inclusive and may be updated, as required.

Table 3. Preliminary hazards identified for the Remote-Handled Low-Level Waste Disposal Project.

| Hazard | Hazard Source(s) | Concern |
|---|---|---|
| Fissionable materials | Fissionable materials in waste canisters | Preliminary evaluations indicate that waste streams for the facility do not contain significant quantities of fissionable material. |
| Radioactive materials | Radioactive materials in waste canisters | Potential radioactive material release hazard to the facility workers, the collocated workers, the offsite public, or the environment. Potential direct radiation exposure hazard to the facility workers. |
| Hazardous materials (e.g., toxic | Hazardous materials (e.g., ion-exchange resins) in waste canisters | Potential hazardous material release and subsequent chemical exposure hazard to the facility workers, the collocated workers, the |

| Hazard | Hazard Source(s) | Concern |
| --- | --- | --- |
| chemicals) | | offsite public, or the environment. |
| Fire and explosion | Combustible liquid (e.g., diesel fuel); hydrogen buildup inside waste canister; combustible waste inside waste canisters; and transient combustible materials | Potential fire and subsequent loss of confinement, resulting in a material release, which leads to a radiological or chemical exposure hazard to the facility workers, the collocated workers, the offsite public, or the environment. |
| Electrical energy | Batteries, battery charging stations, electrical panels, electrical utilities, generators, instrumentation and controls, motor control center, static electricity in radiation detector, switchgear, and low voltage (less than 600 volts) | |
| Kinetic energy | Moving loads: transport truck, transportation package, payloads of transportation packages, scissors lift, vehicle impact | Potential to cause a loss of confinement, resulting in a material release, which leads to a radiological or chemical exposure hazard to the facility workers, the collocated workers, the offsite public, or the environment. |
| Potential energy | Suspended loads: crane, hoist, lift | |
| Pressure | Compressed air, pressurized hydraulic systems | |
| External events | Range fire, plane crash, vehicle accident | |
| Natural phenomena | Earthquake, severe weather (e.g., extreme wind, flood, lightning, snow load) | |
| Potential asphyxiates | None | No asphyxiates anticipated. |
| Thermal energy | Lights, heated air in support buildings | Thermal energy does not pose a direct hazard but may cause injury to facility workers. |
| Radiant energy | None | No radiant energy hazards anticipated. |

## 3.3 Key Safety Decisions

Decisions will be made during the initial project life cycle that will affect the eventual design and construction of a new Remote-Handled LLW Disposal Project at INL. Those key safety decisions that could potentially result in significant cost are addressed herein along with the strategy justified consistent with the hazard categorization.

### 3.3.1 Seismic and Other Natural Phenomena Design Categorization

Based on an initial review of the applicable facility hazards and in accordance with ANSI/ANS-2.26-2004, “Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design,” the Remote-Handled LLW Disposal Project seismic design category (SDC) will be SDC-1. This determination is based on the assumption that failure of a vault will not cause radiological material to be brought to the surface and that it will remain in place without causing significant radiological exposure to workers, the public, or the environment. As stated in the standard, no limit state identification is required for SDC-1 SSCs; however, Limit State C was selected for the SDC classification. Seismic evaluation on the facility will be performed in accordance with the International Building Code (IBC 2009). In accordance with DOE-STD-1189-2008 requirements, other natural phenomena hazards and their impact on the Remote-Handled LLW Disposal Project design will be in accordance with DOE-STD-1020-2002, “Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities,” as applicable. In particular, the safety-significant SSCs have been designated as PC-2 in accordance with DOE-STD-1020-2002 and DOE-STD-1021-93, “Natural Phenomena Hazards Performance Categorization for Structures, Systems, and Components.”

### 3.3.2 Confinement Strategy

Conceptual design for the new Remote-Handled LLW Disposal Project is similar to the remote-handled LLW concrete disposal vaults currently in use in the RWMC Subsurface Disposal Area, including their associated confinement functional requirements. In addition to providing an overall confinement function of the radioactive waste materials discussed in Section 2.2, reliance on the existing design provides a fundamental basis for implementation of safety requirements for this new disposal facility.

As previously discussed in Section 2.1, the reference vault design consists of reinforced, precast concrete cylinders stacked on end and placed in a honeycomb-type array. Each stacked cylinder will be placed on a concrete base and will have a separate removable concrete plug placed on top of the cylinder. Alternative designs may include the use of multiple concrete-formed cylindrical sleeves inside of a single precast concrete vault. Alternative designs utilizing multiple cylindrical sleeves inside a single vault may require a temporary vault plug to be placed on open vault cylinders while waste canisters are being placed in other cylinders. The remote-handled LLW will be packaged into sealed stainless steel waste canisters at the generating facilities. One waste canister at a time will be shipped within a shielded transportation package from the generating facility to this disposal facility. Upon transportation package arrival at the appropriate vault array location, the waste canister will be transferred directly from a bottom-unloading transportation package into the concrete vault. If a top-unloading transportation package is used, then additional equipment will be required for lifting waste canisters out of the transportation package and transferring them into the concrete vaults. These waste canisters will function as a contamination barrier. A removable concrete plug will be set on top of the stacked precast concrete cylinders to serve as a radiation shield and water barrier to prevent surface water intrusion into the concrete vaults.

The basic design of this facility and corresponding operations activities consider the potential high radiation levels associated with the remote-handled LLW streams and will minimize worker radiological exposure by providing for an overall confinement function and passive control of worker radiological exposure.

### 3.3.3 Fire Mitigation Strategy

The Remote-Handled LLW Disposal Project will be considered as an unoccupied, below ground disposal facility. A preliminary fire hazard analysis (FHA) (HAD-474, “Remote-Handled Low-Level Waste Disposal Facility Preliminary Fire Hazards Analysis”) has been performed and will be finalized as part of the final design. The TFRs and SPC-1437 identify requirements for fire detection and suppression systems for this disposal facility. The lifting and handling of transportation packages and waste canisters at this disposal facility will require the use of diesel-powered trucks, tractor/trailer combinations, and a crane; these vehicles introduce the potential for a vehicle fire that is postulated to occur during transport or during transportation package/waste canister unloading evolutions. The FHA will specifically take this postulated fire scenario into account and identify appropriate preventative and mitigative features and administrative controls for implementation during these process operations.

Fire protection for the administration and maintenance buildings will adhere to requirements of the NFPA 101, “Life-Safety Code.”

### 3.3.4 Criticality

In the conceptual design stage of the Remote-Handled LLW Disposal Project, preliminary evaluations indicated that waste streams for the facility do not contain significant enough quantities of fissionable material to make nuclear criticality a credible accident. Waste canisters will be transported within the INL boundary to the remote-handled LLW disposal project and therefore will be complaint with the transportation limits specified in 40 CFR 173.424(h) as described in TEV-1119. This requirement specifies a 15 g U-235 equivalent transportation limit per canister. A mass limit of 15 g U-235 equivalent would preclude potential criticality. Further evaluation will be made on the need for criticality safety requirements (e.g., specific packaging configurations for high fissile materials) pertaining to this facility during development of the PDSA. Design optimizations developed by the design-build subcontractor will be reviewed as necessary for impacts on criticality safety.

### 3.3.5 Anticipated Safety Functions

Based on the results of the preliminary hazard identification, there are no safety-class SSCs identified or required for this facility. In the worst case design-basis accident identified for the Remote-Handled LLW Disposal Project, it was concluded that potential exists for an accident that could result in direct radiation exposure exceeding evaluation guidelines to the facility worker. The concrete vault plugs were identified as a structural component that provides a radiation shielding safety function that would protect the facility worker from these consequences after the waste canisters are placed in the vaults. Alternative designs utilizing multiple cylindrical sleeves inside a single vault may require a temporary vault plug to be placed on open vault cylinders while waste canisters are being placed in other cylinders; the temporary vault plug would also be required to provide the same radiation shielding safety function. In addition, shielding required during transportation package unloading and waste canister transfer operations is identified for protecting the facility worker from these consequences during placement of the waste canisters in the vaults. This waste canister shielding includes, but is not limited to, the existing CVAS, shield bells for top-loading casks, or any other shielding system that might be developed for future cask/vault configurations. Because the vault plugs and shielding during waste canister unloading and transfer provide a radiation shielding safety function, they are designated as safety-significant SSCs for design and facility planning purposes. As the facility design matures, further analyses will be performed evaluating the direct radiation exposure to the facility worker from specific material being stored.

# 4. RISKS TO PROJECT SAFETY DECISIONS

A risk management plan (RMP) for the Remote-Handled Low-Level Waste Disposal Project has been developed that defines the scope, responsibilities, and methodology for identifying, assessing impacts of, and managing risks that could affect successful completion of the project. The objective of risk management, as described in this plan, PLN-2541, “Risk Management Plan for the Remote-Handled Low-Level Waste Disposal Project,” is to enable project success by identifying project risks (i.e., programmatic, technical, cost, and schedule) and appropriate response actions to effectively manage the risks through project completion. Risk response plans (mitigations) are identified for highly ranked risks. The identified risks and mitigation strategies are incorporated into a risk register that is continually reviewed and updated throughout the project life cycle. The identified risks are reevaluated and expanded or updated and response plans identified, as necessary.

Because the Remote-Handled LLW Disposal Project is being planned based on the existing disposal facility design and operations, no significant changes to the remote-handled waste characteristics are anticipated. As previously discussed in Section 3.2.1, based on the preliminary assessment of the estimated inventory in the identified remote-handled LLW streams and comparison with DOE-STD-

1027-92, the Remote-Handled LLW Disposal Project will have a radionuclide inventory that results in a hazard categorization as a HC-2 nuclear facility.

In addition, further waste stream characterization and/or selection of new waste canisters may result in revisions to release factors and/or changes in the quantity and radionuclide distributions present in the waste canisters. In addition, advanced concept vault/canister configurations may result in identification of accident scenarios not previously evaluated, or revisions to material-at-risk for accidents already evaluated. These changes may impact calculations and analyses associated with the PDSA and final DSA, and may also result in identification of additional safety-significant SSCs.

Concrete shield plugs perform the safety function of shielding. As previously discussed in Section 3.3.5, direct radiation exposure from a vault with a damaged or missing shield plug may exceed evaluation guidelines to the facility worker. Therefore, the concrete shield plugs are identified as components that would protect the facility workers from those consequences. The shield plugs, both the permanent concrete shield plug placed on top of a vault after it is filled or a temporary shield plug that might be required for open vault cylinders while waste canisters are being placed in other cylinders, will be designated as safety-significant SSCs for design and facility planning purposes. The design of the shield plugs has been verified to protect facility workers from direct radiation exposure in ECAR-1263, “Remote Handled Low Level Waste Disposal Facility Vault Plug Shielding Requirements.” As facility design matures, further analyses may be performed, evaluating specific postulated exposure scenarios for the specific material/vault/canister configuration being stored beyond those already evaluated. Additional controls may be identified for a specific waste canister with contact exposure rates that exceed the shielding design parameters specified in SPC-1437 and TFR-483.

Further evaluation also will continue during the transportation package selection process. The current design for RWMC involves a bottom-unloading cask that is placed over a concrete vault with the waste canister lowered directly into the vault through the CVAS. This approach is proposed for NRF waste streams destined for disposal at the Remote-Handled LLW Disposal Project. If a top-unloading transportation package is selected for other waste streams, then additional equipment including shielding will be required for lifting waste canisters out of the transportation package and transferring them into the vault. Other shielding systems might be required for future cask/vault configurations. Additional shielding or administrative controls may be required to minimize worker exposure. Shielding for transportation package configurations currently anticipated for use has been evaluated in ECAR-1314, “RHLLW Disposal Facility Cask Dose Evaluation.” This evaluation will be updated as required if additional transportation package configurations are required.

# 5. SAFETY ANALYSIS APPROACH AND PLAN

As a HC-2 nuclear facility, the Remote-Handled LLW Disposal Project must meet specified nuclear safety requirements delineated in accordance with 10 CFR 830. The following requisite nuclear safety documentation will be developed as part of the project:

- SDS as updated periodically throughout the project.
- Preliminary hazards analysis (PHA), completed and documented in INL/EXT-07-12903, “Preliminary Hazard Assessment for the Remote-Handled Low-Level Waste Disposal Project” (INL 2010c) and incorporated into the PSDR.
- CSDR, completed and documented in INL/EXT-09-17427 (INL 2010d).

- PSDR, completed and documented in INL/EXT-10-19054 (INL 2012); submitted for DOE approval.

- PDSA to be developed and approved prior to start of construction.

- Final DSA to be developed and approved prior to start of operations.

This nuclear safety documentation will be developed in accordance with DOE-STD-1189-2008 and NS-18101, "INL Safety Analysis Process," nuclear facility safety requirements. Developing the required safety-basis documentation in accordance with these requirements will ensure that there is no risk to project completion due to delays in completing the appropriate documentation.

This project is following the requirements of DOE Order 413.3B to the extent practical. As such, the nuclear safety documentation identified above may be combined as part of tailoring for the project. Specifically, the PHA was used as input into the project CSDR that was prepared with the conceptual design. A PSDR has been developed and includes an updated hazards analysis. The development of the PDSA will be completed during preliminary design, followed by a final DSA prior to the start of operations.

Project safety basis document preparation will follow the guidance of DOE-STD-1189-2008, which is to integrate safety analysis throughout the design process. The standard is intended to implement safety-in-design philosophies listed in DOE Order 413.3B and facility safety criteria listed in DOE Order 420.1B. This approach is intended to ensure that hazards are identified early in the project and that a safety design integration team approach is used to design safety into the facility.

As the project design matures, generation of other necessary safety documents and analyses will be required. These supporting documents, other than operational procedures, will include the following as appropriate:

- Fire hazard analysis: Preliminary FHA documented as HAD-474 to be finalized during final design.

- Criticality safety evaluation: Documented as TEV-1119; may be reevaluated during preliminary and final design.

- WAC that ensure that waste streams accepted for disposal will not exceed maximum established radionuclide content for each waste stream and do not have the potential to exceed direct radiation exposure levels. In particular, the WAC will identify those canisters that may require transfer system shielding and/or specific procedures for transferring waste canisters with high contact exposure rates.

- Shielding evaluations for transportation systems and both temporary and permanent vault shield plugs.

- Transportation plans and contractor-approved cask control list that defines specifications for all cask/canister combinations that will be allowed at the Remote-Handled LLW Disposal Project.

- Hoisting and rigging plan

- Engineering design files

- As low as reasonably achievable reviews

- Radiation work permits
- Operational job safety analyses
- Industrial hygiene exposure assessments prepared in accordance with the associated INL procedures.

# 6. SAFETY DESIGN INTEGRATION TEAM – INTERFACES AND INTEGRATION

The purpose of the Integrated Project Team (IPT) is to provide cross-functional groups of individuals organized for the specific purpose of delivering a project where the technical, management, budgetary, safety, and security interests are met. Use of IPTs is the primary tool for breaking down the barriers that can exist between different organizations, different professions, and different levels within the command structure. A successful IPT brings the diverse elements together to form a unit that is willing to share information and balance priorities and ideologies in efforts to successfully execute the project mission while achieving the overall safety strategy.

The safety design integration team (SDIT) includes appropriate representatives from traditional worker safety disciplines, emergency management, and safeguards and security. The SDITs that will be used for this project include the Federal IPT, contractor IPT, and the local project SDIT. Each of these IPTs consists of individuals representing diverse disciplines with specific areas of expertise and the ability to support the Federal Project Director in successful execution of the project. Membership may be full time or part time and will change as the project matures through the various phases from initiation through closeout. Membership includes federal and contractor employees and consists of members, or designees, as specified in the PEP.

The responsibilities of the IPT include the following:

- Support the Federal Project Director
- Support preparation and submittal of funding request documents, as necessary, to secure project funding
- Support development of the project acquisition strategy
- Ensure interfaces are identified, defined, and managed to completion
- Identify, define, and manage implementation of environment, safety, health, and quality requirements
- Identify and define appropriate and adequate technical scope, schedule, and cost parameters
- Perform periodic reviews and assessments of project performance and status against established performance parameters, baselines, milestones, and deliverables
- Plan and participate in project reviews, audits, and appraisals, as necessary
- Review and comment on project deliverables, as appropriate

- Review change requests and support change control board actions, as appropriate
- Participate in readiness reviews or readiness assessments
- Support preparation, review, and approval of project completion and closeout documentation
- Ensure that safety is fully integrated into design, construction, and operations of the nuclear facility.

Security must also be addressed for the Remote-Handled LLW Disposal Project. The strategy for security design is based on the conclusions in INL/INT-11-21215, “Preliminary Security Vulnerability and Physical Protection Assessment of Proposed Remote-Handled Low-Level Waste Disposal Facility” (INL 2011). This assessment concluded that there are no radiological sabotage threats associated with the project and that physical protection requirements should be based on the classification level of the materials proposed for receipt and disposal at the facility.

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