INDEPENDENT OVERSIGHT
REVIEW OF THE
IDAHO NATIONAL LABORATORY
FUEL CONDITIONING FACILITY SAFETY BASIS

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U.S. Department of Energy
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Acronyms

ARF	Airborne Release Fraction
BEA	Battelle Energy Alliance, LLC
CFR	Code of Federal Regulations
CSE	Criticality Safety Evaluation
DOE	U.S. Department of Energy
DOE-ID	DOE Idaho Operations Office
DR	Damage Ratio
DSA	Documented Safety Analysis
DU	Depleted Uranium
EBA	Evaluation Basis Accident
EBE	Evaluation Basis Earthquake
ECAR	Engineering Calculations and Analysis Report
EDF	Engineering Design File
ESS	Evaluation of the Safety of the Situation
ETL	Equipment Transfer Lock
FCF	Fuel Conditioning Facility
FHA	Fire Hazards Analysis
HEU	Highly Enriched Uranium
HFEF	Hot Fuel Examining Facility
HSS	Office of Health, Safety, and Security
HUP	High Throughput Uranium Product
INL	Idaho National Laboratory
JCO	Justification for Continued Operation
LCO	Limiting Condition of Operation
LPF	Leak Path Factor
MAR	Material at Risk
MFC	Materials and Fuels Complex
NE	DOE Office of Nuclear Energy
PC	Performance Category `
RF	Respirable Fraction
RSAC	Radiological Safety Analysis Computer Program
SAC	Specific Administrative Control
SAR	Safety Analysis Report
SER	Safety Evaluation Report
SES	Safety Exhaust System
SPC	Solid Cathode Process Crucible
SSC	Structures, Systems, and Components
STL	Small Transfer Lock
TEV	Technical Evaluation
TSR	Technical Safety Requirement

EXECUTIVE SUMMARY

This report presents the results of an independent review of the upgraded safety basis for the Fuel Conditioning Facility (FCF), a Hazard Category 2 nuclear facility at the Idaho National Laboratory, which is managed and operated by Battelle Energy Alliance, LLC (BEA) for the U.S. Department of Energy (DOE) Idaho Operations Office (DOE-ID). The present mission of the FCF is to demonstrate the technical feasibility of electrometallurgical technology for treating spent nuclear fuel from Experimental Breeder Reactor-II and other similar fuels. The review was conducted at the request of the Office of Nuclear Energy (NE) and DOE-ID by the Office of Health, Safety and Security (HSS) Office of Independent Oversight with assistance of the HSS Office of Nuclear Safety Policy and Assistance.

The facility safety basis consists of the safety analysis report (SAR) and the associated technical safety requirements (TSRs). The review focused on the following approval basis areas: hazard and accident analyses; safety structures, systems, and components (SSCs); specific administrative controls (SACs); derivation of the TSRs, including SACs; and attributes for criticality safety. The review also considered whether the hazard controls contained in the SAR are accurately translated into the TSRs. The safety basis review criteria and lines of inquiry were directly based on the requirements of 10 CFR 830 Subpart B, and were consistent with the guidance for preparing safety analyses in the safe harbor standard, DOE-STD-3009, and the guidance for reviewing and approving safety basis documents in DOE-STD-1104.

The review team concludes that BEA broadly followed the guidance in the DOE-STD-3009 and used a generally sound approach in developing the FCF safety basis. Based on an initial hazard evaluation, the FCF SAR analyzes a representative set of postulated accidents as a basis for selecting and classifying hazard controls. The SAR provides descriptions of the required safety functions and functional requirements, and includes evaluations of the ability of the SSCs or SACs to provide the required safety function. The SAR also addresses the derivation of the TSRs, including SACs.

However, the review team identified four significant issues that potentially affect the acceptability of the safety basis documentation. Resolution of these four significant issues is necessary to ensure compliance with the requirements of 10 CFR 830 Subpart B. These significant issues were promptly communicated to NE and DOE-ID and the SAR development team for timely resolution as they were identified during the review. The four significant issues relate to: (1) insufficient analyses of potential accidents and release path mechanisms involving elemental cadmium during seismic events; (2) insufficient analyses of radioactive release scenarios resulting from the postulated evaluation basis earthquake; (3) unanalyzed aspects of pyrophoric fires and fire hazards in the cask handling area; and (4) a collection of assumptions in the analysis of postulated accidents for which controls were not identified or not fully captured in the derived TSRs. In addition, the review team identified improvement items in most of the areas reviewed. The improvement items would add to the overall completeness of the safety basis documentation and should be addressed, as resources allow, as part of upgrading the safety basis.

NE line organizations are responsible for reviewing the results, including identification and tracking of any required actions using their issues management processes. The HSS review team has offered specific recommendations to address each of the significant issues and improvement items. The HSS team also provides certain broad recommendations based on its overall observations and conclusions regarding the FCF SAR. These recommendations pertain to enhancing the hazard evaluation and accident analysis processes; improving the quality and rigor in the documentation of hazard control identification, classification, and evaluation; and adopting a more balanced approach to hazard control strategy, which might include crediting an additional mitigative system, such as the FCF safety exhaust system.

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Review of the Idaho National Laboratory Fuel Conditioning Facility Safety Basis

1.0 INTRODUCTION

1.1 Background

The nuclear facilities at the Idaho National Laboratory (INL) Materials and Fuels Complex (MFC), including the Fuel Conditioning Facility (FCF), are managed and operated by Battelle Energy Alliance, LLC (BEA) for the U.S. Department of Energy (DOE) Idaho Operations Office (DOE-ID). Prior to MFC transitioning to the INL contractor DOE-ID jurisdiction (it had previously reported to the Chicago Operations Office and was managed by a separate contractor), and as part of the INL contract transition in February 2005, nuclear facility safety basis deficiencies were noted during the vulnerability assessment conducted by DOE-ID and the transition review performed by INL. INL issued a declaration of a potential inadequacy in the safety analysis associated with MFC safety bases, which resulted in an evaluation of the safety of the situation (ESS) and justification for continued operation (JCO). A work plan was developed to provide MFC with upgraded safety basis documents that are compliant with the DOE Nuclear Safety Management regulations in 10 Code of Federal Regulations (CFR) 830 Subpart B. In 2007, the DOE Office of Independent Oversight conducted an inspection of selected FCF safety systems and identified additional safety basis deficiencies. Subsequently, a revised work plan for upgraded MFC safety bases, as well as the ESS and JCO were approved by DOE through a safety evaluation report (SER).

The upgraded draft FCF safety basis prepared by BEA is a result of this effort. This safety basis is comprised of the FCF Safety Analysis Report (SAR) and Technical Safety Requirements (TSRs). DOE-ID and the DOE Office of Nuclear Energy (NE), which have line management responsibilities for FCF, are in the process of reviewing the draft FCF safety basis. When completed, the line management review will result in an SER documenting the review and approving the FCF safety basis.

The present mission of the FCF, a Hazard Category 2 nuclear facility, is to demonstrate the technical feasibility of electrometallurgical technology for treating sodium bonded spent nuclear fuel from Experimental Breeder Reactor-II and other similar fuels. The FCF was initially activated in 1963 for its original mission, performed from 1964 through 1968, of demonstrating fuel reprocessing and re-fabrication in a closely coupled facility.

1.2 Review Scope

This Office of Health, Safety and Security (HSS) independent review, conducted at the request of NE and DOE-ID, was performed in parallel with the DOE line management review. This HSS review focused on selected aspects of the upgraded safety basis using the requirements of 10 CFR 830, *Nuclear Safety Management*, and DOE technical standards, including DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented*

Safety Analyses, and DOE-STD-1104, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*, as the bases for the conduct of the review. The review focused on the following approval basis areas:

- Hazard and accident analyses
- Safety structures, systems and components (SSCs)
- Specific administrative controls (SACs)
- Derivation of TSRs, including SACs
- Attributes for criticality safety.

The independent review also evaluated selected hazard controls contained in the SAR to determine whether they are correctly translated into the TSRs.

During the course of the review, potentially significant issues (problems or concerns that affect the validity of the safety basis documentation) were documented to clearly and concisely describe the issue in detail and to provide an explanation of the significance of the issue. As they were identified, these issues (Attachment 1) were communicated to and discussed with NE, DOE-ID and BEA to ensure that they receive timely resolution. Attachment 1 provides the final revisions of four significant issue forms. In addition, specific problems or concerns that did not rise to the level of significant issues were identified and discussed as improvement items. This report provides the review team's recommendations to address each significant issue, as well as each improvement item (Section 3.0).

Further details on the review process, including the review criteria and lines of inquiry and the team composition, are provided in Attachment 2.

NE line organizations are responsible for the disposition of the review results, including identification and tracking of any required actions.

2.0 RESULTS

2.1 Hazard and Accident Analyses

The FCF SAR was prepared using the guidance provided in DOE-STD-3009 and NS-18104, *INL Guide to Safety Analysis Methodology,* which addresses the conduct of the hazard and accident analyses, selection of SSCs, and derivation of TSRs, including SACs. The SAR appropriately establishes the facility as Hazard Category 2. The hazard analysis used a hazards identification checklist from NS-18104 to guide the process and involved knowledgeable engineering and laboratory personnel. Considering the complexity of the facility and the extent of its prior operations, the documentation resulting from the hazard identification methodology used does not fully assure a comprehensive and systematic evaluation of hazards. Nevertheless, with the few exceptions discussed below, the SAR considers an appropriately representative set of postulated accidents that represent and bound the potential events that may result in radioactive or hazard chemical releases or subject workers to high doses of radiation. The SAR also includes risk matrices, which follow the guidance provided by DOE-ID, to guide the selection of safety SSCs and SACs for the protection of the public, facility workers, and collocated workers.

2.1.1 Hazard Analysis

As described in the introduction of DOE-STD-3009, the foundation for effectively preparing a documented safety analysis is the assembly and integration of an experienced preparation team that includes individuals experienced in process hazard and accident analyses, facility system engineers, and process operators to perform the key hazard analysis activity. The preparation process for the FCF SAR made use of appropriate personnel for hazards analysis, engineering analyses, and safety analyses, in accordance with the standard's guidance. The hazard analysis process included using a what-if/checklist format and outside facilitators to consider the hazards associated with facility operations. The hazard analysis was formally documented in a technical evaluation and subsequently incorporated into the SAR.

The initial hazard evaluation is documented in Technical Evaluation (TEV)-160, *Fuel Conditioning Facility (MFC-765) Initial Hazard Evaluation Report.* Data from this hazard evaluation were subsequently transferred to the SAR and are presented in Section 3.3.2. The hazards analysis results include a hazard identification table summarizing the potential material and energy hazards in the facility, tables illustrating the radioactive and chemical hazards present, and a table addressing the scenarios that represent consequences of interest. Non-routine material and energy hazard sources that have the potential to result in an uncontrolled release of radioactive and hazardous materials have been comprehensively identified and follow the safe harbor methodology. Gross radioactive material inventory has been conservatively estimated for end-of-life and the projection assumes that all radioactive material that enters the facility remains in the facility. Although Table 3-7 does not present the total radionuclide listings, as identified in Engineering Calculations and Analysis Report (ECAR)-307 and TEV-139, *Fuel Conditioning Facility Documented Safety Analysis Upgrade Radioactive Source Term Data*, the main dose contributing radionuclides have been listed for reference.

Improvement Items

Although the overall guidance and approach are sound, several opportunities for improvement were identified during the review. For example, the current hazard evaluation document is similar in comprehensiveness to a facility-level design basis accident assessment associated with a conceptual design of a new facility, where little design detail is available on the processes and activities to be conducted in the facility. That is, it lacks the system-level and activity-level detail in hazard evaluation prescribed by DOE-STD-3009 for a facility that has been designed, constructed, and operated for several years. Also, as discussed in the standard, the what-if/checklist approach used for hazard evaluation may not be appropriate for the complexity of the facility or its operations and results in a lack of confidence that a comprehensive and systematic evaluation of hazards has been accomplished. For example, although several evaluation basis accidents (EBAs) have been analyzed in the SAR, the hazard and accident analyses documentation does not demonstrate that the possible interactive effects among the separate analyses have been sufficiently recognized. When possible interactions are considered, it may be found that the individual EBAs are not bounding, and thus the hazard controls identified in the FCF SAR and their classifications may not be complete and consistent.

Although the hazards analysis addresses the hazards relevant to the facility, the evaluation was not documented during its conduct by site personnel and contractors, and consequently, important information about the review (e.g., a record of the options considered for preventing or mitigating a hazard and the rationale for their acceptance or rejection) is not available. In addition, the hazards evaluation does not document the consideration of potential events resulting from process or utility system upsets, such as: loss of control of heating in the electrorefiners, loss of argon recirculation, loss of power (either partial or total), or programmable logic controller failures.

Although chemical hazards are identified, a number of concerns were identified with the documentation of these materials. For example:

- In some cases, quantities of materials are not included for the identified chemical hazards. Without the quantities listed, a determination of whether or not the materials were of concern cannot be made.
- Some sources of potential fire or explosion are identified in Table 3-6 (acetylene is identified as a flammable gas and acetone, alcohol, and gasoline are identified as flammable liquid hazards), but the designations are not carried forward to Table 3-8 or to the final hazards analysis.
- Ten pounds of beryllium are listed with the disclaimer that the quantity is "significantly less than reportable quantity." However, the reportable quantity is 10 pounds.
- Sodium hydroxide is identified (quantity of 1,000 pounds obtained from site personnel) with the disclaimer that the quantity is "significantly less than reportable quantity." However, the reportable quantity is 1,000 pounds.

2.1.2 Accident Analysis

Accident analyses were conducted for five EBAs. These include a pyrophoric material fire in the argon cell, cask breach, direct radiation exposure, release of non-radioactive hazardous material, and an evaluation basis earthquake (EBE). The SAR presents summary descriptions of each of the accidents, including the scenario, source term, consequences, comparison to guidelines, and safety SSCs and TSR controls. Details of the accident scenarios are typically provided by a set of referenced documents; including ECARs, engineering design files, and TEVs. The accident analyses were conducted using an adequate computer program and calculation methodologies. The Radiological Safety Analysis Computer Program (RSAC), modeling software developed by the site, was used to determine χ/Q values (release quantity dispersion) for 100 meter and greater distances used in all calculations identified in the various ECARs. The χ/Q values for facility workers were hand-calculated. RSAC was also used to calculate external gamma dose consequences.

During the HSS review, consequence analyses were independently reproduced and confirmed to be accurate using the same input assumptions. A newer version of RSAC (7.0.2), which now allows modeling consequences as close as 10 meters, was obtained. The newer version of RSAC was used to confirm that the χ/Q values used for facility worker dose consequence calculations are conservative (RSAC χ/Q values are less than the hand-calculated values).

Improvement Items

Some of the assumptions used for determination of airborne release fraction (ARF) and respirable fraction (RF) values are not adequately justified and do not ensure that the results conservatively assess dose or exposure consequences at receptor locations representing facility workers, onsite workers, and the public. For example, a combined ARF and RF value of 1E-5 for a cask container drop, drop of samples during transfer, and damage to storage racks in the air cell was said to be per the ARF and RF values documented in DOE-HDBK-3010-94 for a free-fall spill and impaction stress for nonmetallic or composite solids. However, these values could not be verified against the handbook, and the method for determining the combined value is not documented. In addition, the ARF value used in the accident analyses for cadmium releases and the ARF and RF values used in the analyses for the EBE may need to be re-evaluated, as discussed in the significant issues below.

The following significant issues were identified relating to the accident analysis. Additional details characterizing each significant issue are provided in Attachment 1.

Significant Issue 1

Potential accidents and release path mechanisms involving elemental cadmium during seismic events are not adequately identified and analyzed.

SAR-403, Section 3.4.2.4, describes the bounding event for nonradioactive hazardous material as a release due to the spill of liquid cadmium metal (at 500°C) to the argon cell floor as a result of a load drop. However, an EBE scenario resulting in the concurrent loss of electrorefiner and argon cell confinements, and involving burning pyrophoric uranium interacting with molten cadmium, has the potential for a greater airborne release than the load drop event (caused by equipment failure/human error). Such a scenario has not been analyzed.

ECAR-292, Section 8.2, states that a release of cadmium resulting from ignition of pyrophoric material in the argon cell is not considered credible; however, neither ECAR-292 nor HAD-238 provide evidence that a seismic event was considered as a common mode initiator causing failure of both the electrorefiner and argon cell confinements and resulting in interaction of burning pyrophoric uranium and molten cadmium. In addition, ANL-IFR-133 discusses experiments to determine the potential for cadmium combustion during a seismic event. These studies provided assurance that cadmium combustion was minimal under the controlled conditions of the experiments; however, the studies did not simulate the significant splashing and stalactite formation that would be expected in a seismic event with molten cadmium at 149°C above its melting point. Finally, the existing spill scenarios in ECAR-292 do not consider the interaction of molten cadmium with other combustibles in the argon cell.

Significant Issue 2

The analysis of the postulated EBE in SAR-403 does not adequately develop the scenario and the release source term, and does not appropriately justify the controls selected to mitigate the consequences of the event.

The material form (powder) used for determining the RF for analysis is not present in FCF, and the assumed conditions do not clearly bound the expected conditions. Also, the ARF value of 2E-3 used for the analysis may not be conservative because the argon recirculation system is to be assumed shutdown. The postulated event does not consider the possibility that argon recirculation could produce air flows that would exacerbate the concurrent fire and also increase the ARF over the analyzed value. In addition, the fires (described in ECAR-315 and a cadmium fire) have the potential to affect the accident progression and the analysis described for the EBE and ECAR-307. The argon cell structure is classified as safety significant, and the adequacy of this control is based on an asserted reduction of the accident damage ratio (DR). This assumption is not supported by analysis in the SAR and is not likely to be supportable (see further discussion in the significant issue form). If the potential consequence mitigation is credited to a reduced leak path factor (a suggested correction to the SAR in discussions with site personnel), rather than a reduced DR, this reduction needs to be justified and explained.

In addition, the effects of adverse system interactions (two-over-one) as a result of an EBE are not fully incorporated in the event description and analysis. For the EBE, the argon cell structure and argon cell confinement systems are classified as safety significant, and therefore are required to meet performance category (PC)-2 criteria. The safety analysis indicates that the argon cell structure is designed to the more stringent PC-3 criteria. The basic structures themselves are described as adequate to survive the event and are therefore credited with providing the needed mitigation. Further, the accident analysis (Table 3-9, event 1.12) considers a loss of argon cell confinement due to a failure of a non-safety in-cell bridge crane, and analyses show that the crane performance is acceptable for the current horizontal and vertical response spectra.

However, there is no SAR description of the system interaction analysis that would support either the unmitigated event scenario or the mitigation strategy. Especially vulnerable argon cell components include, in part, the penetrations (including the Safety Exhaust System [SES] penetration), cell windows, and viewing ports. Also, the argon confinement system boundaries extend from the argon cell SES penetration through the equipment tunnel and up to the seal pot assembly located in the Safety Equipment Building and therefore, two-over-one analysis is also necessary in the Safety Equipment Building well. The boundary of the confinement system following an earthquake is not always clearly described in the analysis. Without a complete description of the system interaction analyses (two-over-one), the ability of the argon cell to perform its preventive and mitigative functions cannot be determined.

ECAR-315 describes the postulated stay time after a pyrophoric fire to be 60 seconds; however, this life safety assumption is not evaluated in the SAR or the fire hazards analysis (FHA). Based on engineering judgment, ECAR-315 assumes that "in most instances it would take much less than sixty seconds to egress an affected area; however, under other instances or circumstances egress time may require the full 60 seconds." The SAR also does not analyze the performance of emergency lighting during a design based earthquake, which may impact the anticipated 60 second egress time.

The radiological dose for the unmitigated consequences to the facility worker is 489 rem and 60.5 rem to the co-located worker. Based on comparison to the evaluation guidelines, the SAR identifies argon and air cell structures to be safety-significant. However, the mitigated consequences to the facility worker remain in the "moderate" category (see section 3.4.2.5.5), which indicates that the credited structures do not sufficiently mitigate the consequences of the postulated "unlikely" category EBE accident. The INL evaluation guidelines (NS-18104, Fig. 3-4 or SAR, Fig. 3-3) for "unlikely" events with "moderate" consequences to the facility worker call for identifying additional safety-significant SSCs. This insufficiently mitigated residual risk to facility workers is not explicitly stated in the SAR.

Significant Issue 3

The SAR analysis of fires is not sufficiently coordinated with the analysis in the FHA to consider the full implications of the accidents described.

The SAR (reference Section 3.3.2.3.1.2) considers a fire in the cask handling area as extremely unlikely, and based on the estimated consequences, determines that the fire requires no further analysis. However, the FHA for this fire scenario (diesel fuel spill) concludes that a potential failure of the structural steel that threatens the integrity of the overhead crane exists. The FHA also takes credit for the sprinkler system cooling effects to protect the integrity of the steel during the fire. The SAR analysis does not consider the potential for the crane to collapse and impact either the truck and cask or the air cell.

Additionally, the accident analysis in the SAR may not address potential SSC failures resulting from the pyrophoric fire that could affect either the event progression or the mitigation strategy. The SAR and ECAR-315 describe the bounding consequences for a pyrophoric fire inside the argon cell resulting from the uranium dendrites being vaporized and subsequent release of radioactive material. Based on a previous analysis referenced in the FHA, this fire is described as lasting for 20 minutes and reaching temperatures of 1,112 degrees F (600 degrees C). Although the FHA mentions the previous analysis of a pyrophoric fire involving cathodic material, it does not evaluate this fire scenario. For example, the effects of the fire on the progression of the event with the SES operating (e.g., the potential buildup of material and subsequent failure of the high-efficiency particulate filter) and the credited SSCs (e.g., argon confinement system) are not included in the FHA, and consequently are not used in the SAR to support the analysis of the event.

2.2 Safety Structures, Systems and Components (SSCs)

The INL Guide to Safety Analysis Methodology, which has been used in developing the FCF SAR, contains detailed guidance for the evaluation and selection of safety SSCs and SACs. The guide addresses both radiological and non-radiological hazards and provides qualitative risk matrices to implement the guidance provided by DOE-ID for selecting safety class and safety-significant SSCs as well as SACs. The methodology also contains detailed guidance for selecting both safety SSCs and SACs and identifies the need to consider TSRs to protect key assumptions in the hazard and accident analysis. It appropriately indicates that multiple barriers should be identified, if necessary, to arrive at acceptable risk or to significantly decrease risk, and it addresses the evaluation of criticality safety and criticality controls.

The FCF safety basis development process includes the identification and classification of hazard controls according to classification criteria in Chapter 3 of the SAR. Chapter 4 of the SAR describes each of the selected safety-significant SSCs. The chapter identifies nine passive safety-significant SSCs and Table 4-1 provides a summary of the SSCs, including the accident mitigated, safety function, functional requirements, and performance criteria. Subsections address each of the SSCs and provide additional detail on the safety function, system description, and functional requirements along with a statement of the performance criteria and an evaluation of performance. A short description of the TSR controls is also provided for each SSC. The identified functional requirements reflect those assigned in the hazard and accident analysis, and the performance criteria and evaluation sections generally provide adequate discussion of the expectations along with references to detailed supporting calculations. However, the documentation does not always contain sufficient detail to support assertions and some improvements are necessary as described below.

Improvement Items

Some cases were identified in which the documentation of hazard control identification, classification, and evaluation in the SAR needs improvement. A prime example of this is related to the EBE. In Chapter 3 of the SAR (Section 3.4.2.5.5), the argon cell structure is classified as safety significant on the basis that the structure justifies a reduction in DR from 1.0 to 0.1. In Chapter 4 (Section 4.4.6), the structure's function is described such that it shall meet PC-2 seismic criteria (which is not a safety function), and the evaluation is unrelated to a reduction in DR as claimed in Chapter 3. Instead the evaluation of the structure is that the structure "provides a tortuous path for release of radioactive material." However, no analysis is provided or described that demonstrates that the structure and release path would be effective in mitigating the release and consequences to affected populations. In addition, there are conflicting discussions of the seismic criteria of the argon cell structure in the EBE discussions in Chapter 3 and Chapter 4.

In selecting hazard controls, a more balanced strategy using active mitigative systems, such as the SES, would be prudent and could lead to an improved set of hazard controls. There is considerable reliance on preventive measures using SACs and on mitigative measures using passive SSCs to control the hazards identified and evaluated in the SAR when an active system is available to mitigate the accidents that result in large doses to the facility worker. In particular, the proposed strategy has only one credited means of confinement for the EBE (safety-significant argon cell structure). A consideration in evaluating SSC classifications is the difficulty in establishing the reliability of a passive confinement in protecting the public and collocated worker, which is not addressed sufficiently in the current SAR. The analysis of the leak path factor for a damaged confinement is difficult and characterized by significant uncertainties. In addition, the discussion of the confinement boundary in SDD-252, *Argon Cell Confinement Boundary*, implies that the SES is necessary for the response to the expected breaches in confinement following an earthquake and should be classified as safety significant, as a minimum, in order to support the safety-significant function of the argon cell confinement boundary. Indeed, it serves as a defense-in-depth system to mitigate a number of postulated events, where mostly preventive measures and SACs have been credited to meet the evaluation guidelines. In addition, DOE Order 420.1B requires multiple means to ensure critical safety functions (such as confinement of hazardous materials from accident releases).

In some instances appropriate in-service tests and inspections are not specified for the TSRs to ensure safety SSCs continue to meet their functional requirements. For example,

- Periodic inspection of the casks, e.g., welds on the trunnions and lifting lugs, are not discussed in the SAR, although the system design descriptions include the periodic maintenance inspections performed on the casks.
- Periodic inspections and/or vacuum tests to ensure the small transfer lock (STL) door seals, equipment transfer lock (ETL) lid gasket, and platen "J" seal remain operable (so the doors can perform their intended function) are not identified.
- Periodic verification is not required to ensure that the equalization valve position indicating lights function properly (i.e., remote indicators match the valve position). (Note: This also applies to the remote indication that the platen safety restraint is preloaded – if that is used for the verification.)

- Although the STL doors are identified as safety features for load drops onto the STL, design calculations have not been completed to verify their ability to withstand the impact.

Significant Issue 4

A number of instances were identified in which the assumptions in the hazard and accident analysis and supporting calculations were not fully captured in the SAR or TSR.

A clear description of the controls that protect the assumptions made in the accident analyses is necessary to ensure that the facility is not operated outside the analyzed safety basis. In addition, the potential to make changes in the facility without accurately assessing the impact of those changes on the safety basis is increased when the controls are not fully described. In several instances, the discussions of the hazard controls in the SAR may be insufficient to completely identify and implement the controls necessary for safe facility operation.

Examples of such instances include:

- Although the anticipated end-of-life quantities of material at risk are not expected to be approached for some time, the consequence analyses depend on maintaining this assumption, which is not included as an administrative control.
- The processes for monitoring the continued effectiveness of the argon cell confinement system are described briefly in the SAR, but they are not addressed in an administrative control (designed to ensure that the program is implemented and the assumed functions of the confinement system are maintained).
- The operational configuration of the casks assumed in the analyses (ECAR-230 & -286), e.g. doors captured by bolts and weight of contents, is not described and included in the TSR controls to ensure that the casks are in the analyzed condition prior to lifting and handling within the building (though some are included in LST-337, *Approved Container/Payload List for Inter-facility Transfer Operations at MFC*).
- The cask and criticality analyses assume/calculate that the outer container retains its shape, thereby preventing an inadvertent criticality or a more significant radiation exposure to the workers, but this component is not explicitly identified as a safety SSC.
- The load drop analysis for the ETL assumes that the load is dropped from a height of 9 feet above the platen, and although discussed in the SAR, this assumption is not identified as an administrative control or otherwise discussed as the highest physically possible drop.
- The need to control access to the cask tunnel and the subcells as a preventive measure for criticality accidents in the air cell is not discussed in Section 4.4.5, and the planned modifications to address this need are not included in the planned improvements section of the SAR.

2.3 Specific Administrative Controls (SACs)

Guidance for the use of SACs is provided in DOE-STD-1186, the DOE-ID supplemental guidance letter, and the TSR section of the INL Guide to Safety Analysis Methodology. Chapter 4 provides adequate descriptions of those SACs necessary to protect the workers and the environment, and includes descriptions of each of the SACs identified in the hazard and accident analysis. The identified safety functions are generally appropriate. The descriptions of the SACs, their functional requirements, and explanations of the performance criteria are also generally appropriate. TSR controls are identified for the SACs.

Improvement Items

Most SACs were specified without providing a description or rationale for choosing administrative controls over engineered controls, such as safety SSCs. For example, the SACs for STL door and equalization valve operation and those for the ETL door and equalization valve operation rely on administrative checks of door positions and status instead of engineered controls such as door and limit switch interlocks. In another example, the personnel access restrictions for specific basement areas use evacuations instead of addressing the planned or existing design features such as walls, barriers, or locked doors, which assist in preventing overexposures. Although these and other SAC choices may have justifiable reasons (over engineered controls), these choices are not defended as specified by DOE Standards 3009 and 1186, which state that engineered controls are preferable over administrative controls and SACs, and the SAR should include a discussion regarding why SSCs are not plausible or practical for accomplishing the safety function.

Additional improvement items in the discussion of a few SACs were also identified.

- The discussion of the STL and ETL operations does not address the interfaces with the support systems necessary to perform the functions (e.g., position indications, operation of the doors and valves, and verification of platen safety restraint preload).
- The administrative control limiting lifting operations over an STL door is not worded to apply to the conditions when a door would be open for maintenance or testing.
- The SAC that addresses loads lifted during transfer using the ETL does not address the assumption in the engineering calculation that the load is dropped from an elevation of nine feet.

Finally, in some instances the criticality controls to be specified through the SAC would use dimensional controls when the individual components should have been designated as design features.

2.4 Derivation of Technical Safety Requirements (TSRs)

The SAR adequately derives the TSRs for the facility and follows the format and content guidance in the DOE-STD-3009. Interfaces with other TSRs include both TSR-400 for general requirements and TSR-413 for requirements related to inter-facility transfers of material. A summary of the controls derived in SAR chapters 3 and 4 is included in a table. The SAR identifies two defined modes, operation and standby, which are used in the implementation of the TSRs. The derivation of TSRs appropriately follows the safety information derived in the hazard and accident analysis and the discussions of SSCs and SACs in the previous chapters.

Improvement Items

The previously identified improvement items in chapter 4 of the SAR are also relevant to the derivation of TSRs in this section. In addition, some opportunities for additional surveillances were identified for Limiting Conditions of Operation (LCOs) and SACs and are discussed below.

The safety significant STL and ETL and associated equalization valves have an associated LCO identified in that these SSCs must be operable, however there is no surveillance test specified to demonstrate operability. The safety function of the STL and ETL and equalization valves is to prevent air from entering the argon cell thereby maintaining argon cell confinement. The SAR defines the safety significant STL doors' functional requirements such that one door is capable of being closed and latched at all times. The associated transfer lock equalization valves shall be capable of being shut to maintain a barrier between the argon cell and other areas. The SAR states that TSR level controls include an LCO that requires the STL and equalizing valves operability in the operations mode. However, only a visual periodic surveillance test is performed to confirm operability of these safety-significant SSCs. The same requirements apply to the defined ETL safety function, but the discussion states only that active components shall be operable and does not specify a surveillance test to demonstrate operability. For example:

- The operability of STL, ETL, and equalization valves is not clearly defined; that is, operability is said to include the "capability of being" closed and latched in some instances and as "being" closed and latched in other instances.
- Leak tests on STL and ETL door seals to verify operability are not identified.
- Specific surveillance tests with defined quantitative acceptance criteria are not included.
- Equalization valves are not identified by tag number as they should be given their significance.

The SAR does not include a requirement to maintain the argon cell oxygen concentration below the minimum value needed to initiate a pyrophoric fire or otherwise address an administrative program to monitor air leakage into the argon cell, STL, and ETL and take corrective actions, when necessary. The argon confinement structure is credited with prevention of pyrophoric fires, which are radioactive release initiators in the hazard and accident analyses, and the argon cell structure and argon confinement system are important for accident mitigation. Overall, the assumption of the integrity of the confinement system is important to the maintenance of the facility's safety basis. For example, a fundamental assumption is that oxygen is maintained below the concentration needed to initiate a pyrophoric fire, and oxygen monitoring and alarms are listed as non-safety design features for preventing/mitigating a pyrophoric fire in several scenarios. Several methods are available to monitor the leakage rate into the confinement and verify that confinement integrity is maintained. However, no TSR controls or administrative programs to monitor oxygen concentration or confinement in-leakage are discussed, and TSR actions are not included to correct an identified problem or protect pyrophoric material in the event of rising oxygen levels. (See Significant Issue 4.)

2.5 Criticality Safety

The sitewide criticality safety program is governed by LRD-18001, *INL Criticality Safety Program Requirements Manual*. The program is comprehensive and requires the performance of thorough criticality safety evaluations (CSE). Also, NS-18104, *INL Guide to Safety Analysis Methodology*, discusses the role of SACs in some detail, including items with relevance to criticality safety. Together, these documents form the basis for the CSEs and criticality safety related aspects of the facility SAR and TSR documents. For example, the SAR and TSR establish a SAC to mitigate consequences of a criticality to workers by requiring that areas with insufficient shielding be evacuated before conducting certain operations for which criticality is possible.

To support the development of the updated SAR, site personnel developed a set of CSEs to determine whether any components should be designated as design features (see further discussion below). As part of its overall criticality safety approach, personnel performed an overarching CSE to evaluate general FCF operations for normal and abnormal conditions, and thereby to determine the controlled parameters and limits for general operations in the argon and air cells. They also performed evaluations for large-scale storage of fissionable materials and for the fissionable material in the electrorefiners. The reviewed CSEs follow the format and content suggested by DOE-STD-3007. The CSEs include numerous useful graphical descriptions, as well as additional descriptive text to help the reader understand the evaluation. The assumptions for the most part are conservative and there are numerous, comprehensive parametric studies to determine worst cases. The calculations are based on appropriate, site-approved computer programs. The validation of the ability of the computer codes and data to accurately predict criticality is adequate for the cases evaluated. These evaluations establish the initial boundaries and scope of FCF criticality safety under the new SAR. Based on these evaluations, facility personnel determined that no safety SSCs were necessary. Although the completed CSEs define the initial boundary for ensuring FCF criticality safety, the analysis of potential criticality accident scenarios is incomplete and control selection is not finalized.

The SAR identifies a single SAC to implement the criticality safety controls. This SAC requires the development of a contractor-approved procedure list that establishes specific limits for controlled parameters as derived from the applicable CSEs. The contents of the list and the controls themselves are to be followed as "specific" requirements for the purpose of implementing the TSRs. This list will be developed as part of the SAR implementation. Discussion with site personnel during this review revealed that as part of the implementation, there is a concerted effort to perform new evaluations and to reuse information from existing ones to define and cover all credible cases. The personnel involved in this effort are experienced and disciplined, and there is an effective peer-review process.

Improvement Items

As discussed above, the effort on the analyses of potential accident scenarios continues. Review of the currently completed analyses performed indicates that they may not envelope some anticipated or unlikely events, and certain issues or weaknesses remain to be addressed to provide the assurance that a complete set of criticality safety controls has been identified. The potential weaknesses include the following:

- Dropping one crucible into an array of solid cathode process crucible (SPC) containers is not sufficiently analyzed. Site personnel indicated during this review that load drop calculations are now being performed. However, it appears that some calculations involve assumptions that may not be conservative. One example is dropped loads modeled as spheres, which is non-conservative in some cases. Also, the possibility that the crucible may shatter, dumping its contents into the central SPC container in the array, has the potential for this load drop to simultaneously add mass and graphite moderator, which may be an unanalyzed condition.

- Two high throughput uranium product (HUP) containers could fall over and roll together such that their bottoms are in contact unless they are in a rack that prevents such events. Dropping a HUP or other container onto a HUP or other container causing both to fall over is an anticipated event. However, discussions with site personnel during this review revealed that there is another calculation showing that three such containers can come together and this will be adequately subcritical.
- Another unanalyzed scenario, albeit unlikely, is a load or equipment drop that could be small enough that the dropped item or fallen piece of equipment could fall into the pit and thus compress, e.g., a stack of HUPs. However, discussions indicate that the facility intends to specify a control limiting pits to three or fewer HUPs. Such controls are not formalized and included or referenced in the SAR.
- The contingency analysis does not indicate the credible sources of moderator and why each is unlikely to become admixed with the fissionable material. The CSE does not indicate what checks and balances would alert workers before they added sufficient moderator (e.g., a single over batch of moderator) to be unsafe.
- The contingencies for erroneously substituting natural or enriched uranium instead of depleted uranium are not discussed in the CSE, and depleted uranium is poorly defined. It is noted that calculations conservatively assume natural instead of depleted uranium.

The analyses conclude that no components (e.g., graphite containers, HUPs) need to be safety SSCs or Design Features. INL plans to include certain hardware characteristics as part of the controls derived for the SAC. However, the draft procedures are not yet developed and the controls to be specified through those procedures remain undefined. In the absence of any description of how such administrative controls would be implemented, the safety basis remains uncertain. This review notes that limits established for criticality safety, such as container reflector thickness and geometry, are typically treated as Design Features, but this is not in the case for FCF. For example, due to the HUP container's shape, it should be a safety SSC/Design Feature. Changing the HUP dimensions could affect the ability of the rack and pit SSC features to perform their safety functions. Certain storage rack and pit components should also be Design Features because they are needed to ensure a safe geometry.

2.6 Technical Safety Requirements

With a few exceptions, the TSRs adequately implement the controls identified in Chapters 3, 4, and 5 of the SAR. Nevertheless, some opportunities for improvement were identified.

Improvement Items

TSR-403 LCO 3.403.1 action statements do not incorporate all of the immediate actions discussed in SAR 403, Sections 4.4.2.5 and 5.5.1. Section 5.5.1 of the SAR states, "When both doors of an airlock are inoperable, immediate actions are required to restore one door to operable status within 12 hours and to shut or verify shut the equalization valves. Otherwise, exposed pyrophoric materials must immediately be placed in closed metal confinement until the argon cell is in the argon cell standby mode within the following 36 hours." In addition, the SAR states "This same immediate restoration requirement applies in the event both STL doors are inoperable and is supplemented by also immediately placing the argon cell pyrophoric material inventory in closed metal confinement until the argon cell is in the argon cell standby mode." Although these paragraphs refer to immediate actions regarding restoring one door to operable status and immediately placing pyrophoric materials in closed metal containers, the LCO action statements and the associated Bases section (for both doors inoperable) do not require any action to be immediate and do not address placing the pyrophoric material in closed containers. It essentially allows no actions for 48 hours.

In several SACs, TSR-403 is not fully in accordance with DOE Guide 423.1-1, *Implementation Guide for Use in Developing Technical Safety Requirements*. The DOE Guide states that the LCO format should be used when the SAC is well defined, clear corrective actions are available, and conditions supporting the SAC can be easily surveilled, implying that surveillance requirements are to be used for this format. Nonetheless, LCOs for several SACs (for example, 3.403.5, 3.403.6, 3.403.8, 3.403.9) do not have associated surveillance requirements. In addition, LCO 3.403.8 specifies actions, rather than conditions, which does not meet the description of LCOs in the DOE Guide.

SAC 5.403.2 states that certain activities "be performed in strict accordance with documented approved procedures." This is a general conduct of operations statement that does not clearly specify which activities and under what circumstances these procedures would be used, leaving the purpose/basis unclear. It also does not add any specific requirements to those for maintenance, quality assurance, and other safety management programs that already apply to the designated safety-significant SSCs.

3.0 RECOMMENDATIONS

3.1 Significant Issues

The following recommendations are made concerning the significant issues. Additional details are included in Attachment 1.

Significant Issue 1

Fully analyze the effects of a seismic event causing a cadmium spill, including the effects of worst case splashing and spontaneous combustion within the cell and the effects of a simultaneous pyrophoric fire interacting with the cadmium spill.

Significant Issue 2

Reanalyze the EBE accident using reasonably conservative, applicable estimates of input parameters, specifically ARF and RF, and considering the possibility that system operations may exacerbate conditions at the time of the event. Based on the results of the reanalysis (including both radiological and chemical releases), re-evaluate and justify the classification of SSCs taking into account the need for multiple barriers to release and defense-in-depth, including the possibility of designating the SES as a credited safety system.

Two-over-one analyses should be documented for the confinement structures, and should be described in the SAR, in order to assure that the scenario is accurate, credit for cell structures credit is valid, and the analyzed prevention and mitigation strategies are adequate.

Perform a life safety egress calculation to validate the evacuation time used in the SAR, and analyze and verify that emergency lighting will be available in the aftermath of an earthquake.

Explicitly disclose the residual risk for DOE acceptance of the mitigated consequences of this accident (or any other unlikely category event), since the risk remains in the moderate category for facility workers and thus will not be reduced to meet the INL evaluation guidelines.

Use a more balanced hazard control strategy using active mitigative systems, such as the SES.

Significant Issue 3

Evaluate the potential for damage to the cask and breach of the air cell from failure of the overhead crane in a post-flashover condition. Integrate the analysis and conclusions in both the FHA and SAR for this fire event.

Fully evaluate the second category pyrophoric fire in the argon cell in the FHA and re-evaluate the pyrophoric fire scenario analysis in the SAR giving consideration to the FHA data.

Significant Issue 4

Review the assumptions that are fundamental to the accident analyses and identify those assumptions that are critical in defining the safety envelope of the facility. Based on this review, re-evaluate the TSR controls that are necessary to ensure that the facility is operated within the bounds of the analyses. As part of the review, consider the following:

- Develop a SAC that includes the sampling and total mass programs and periodically verifies that the assumptions regarding total material-at-risk and its constituents remain valid.
- Include a SAC that addresses monitoring the leak tightness of the argon confinement system, ETL, and STL, and correcting identified leaks to maintain the confinement integrity.
- Expand the identified controls for the casks to fully include the operational configuration of the casks assumed in the analysis (for example, doors captured by bolts and weight of contents) in LST-337.
- Reassess the need to identify the outer container as a safety-significant SSC based on its importance to the prevention of an inadvertent criticality or a more significant radiation exposure to the workers during cask drop events.
- Implement the 9 foot height limit, which is assumed in the ETL load drop analysis, as a SAC or provide evidence that higher drops are physically impossible.
- Include the access control preventive measures for criticality accidents in the discussions in Section 4.4.5, and identify the planned modifications to address this need in the planned improvements section of the SAR (alternatively, the modifications could be specifically directed in the SER).

3.2 Improvement Items

The following recommendations are included for consideration in addressing the identified improvement items.

- Consider the following to improve the hazard evaluation process and its documentation:
  - Include system-level and activity-level detail in the hazard evaluation.
  - Use a hazard evaluation approach that is more consistent for the complexity of the facility and its operations; such as a system level hazard analysis. Guidance is described in references such as the American Institute of Chemical Engineers *Guidelines for Hazard Evaluation Procedures.*
  - Ensure that the team meetings and decisions made during the hazard evaluation process are captured in notes and/or reports so that the records are available to support future efforts at the facility.
  - Verify that the documentation of the facility hazards is complete and accurate, in order that the future use or modification of the SAR can build on the analyses done to date without recreating them.
- To enhance the accident analyses, verify that events with a common cause are considered in a single scenario or that the analyses are coordinated so that possible interactive effects are recognized and the results of the analyses are consistent.
- To ensure that passive design features or remote indicators do not deteriorate and can continue to support their design functions, consider the need for periodic tests or inspections of these SSCs.
- Ensure that the discussion in the SAC section of the SAR provides appropriate justification for the use of an administrative control when an engineered control is also available.
- To improve the LCOs in the TSRs, evaluate the following improvements:
  - Clearly define operability as it relates to the STL and ETL doors and the related equalization valves.
  - Specify surveillances for those active SSCs (such as the ETL and STL doors) that are included in an LCO.
  - Improve the SACs by including surveillance requirements in those SACs that are suitable for using the LCO format.
  - Verify that action statements in LCO 3.403.1 correspond to those specified in the SAR
  - Re-evaluate the need for an SAC for passive penetration maintenance, and consider the incorporation of a control to periodically evaluate the integrity of the passive confinement systems.

- To ensure that the safety function of STL doors is accurately described, review the designations in Table 3-9, and verify that design basis assumptions are met and acceptance criteria for tested parameters are supported by calculations or other engineering documents.

- Ensure that analyses of criticality accident scenarios envelop the unlikely events, such as those in the examples given in Section 2.5 under improvement items.

- Consider designating the storage and processing devices for which dimensions are integral parts of the criticality controls as Design Features to ensure that their design is appropriately monitored and controlled.

- Specify the minimum staffing of the facility in the SAR and TSRs, or provide a justification for omitting this required section from the TSRs.

4.0 OVERALL CONCLUSIONS

The HSS review team concludes that BEA broadly followed the guidance in the DOE-STD-3009 in developing the facility's safety basis. Based on an initial hazard evaluation, the FCF SAR analyzes a representative set of postulated accidents as a basis for selecting and classifying hazard controls. The SAR provides descriptions of the required safety functions and functional requirements, and includes evaluations of the ability of the SSCs or SACs to provide the required safety functions. The SAR also addresses the derivation of the TSRs, including SACs.

While BEA has expended significant effort and implemented a generally sound approach to the development of the safety basis, limitations in the hazard analysis techniques and absence of analyses for some process upsets diminishes confidence that a complete set of hazard and accident analyses has been considered or that the hazard control set is comprehensive. The review identified four significant issues that potentially affect the acceptability of the safety basis documentation. Resolution of these issues is necessary to ensure compliance with the requirements of 10 CFR 830 Subpart B. These issues relate to: (1) insufficient analysis of potential accidents and release path mechanisms involving elemental cadmium during seismic events; (2) insufficient analyses of radioactive release scenarios resulting from the postulated EBE; (3) unanalyzed aspects of pyrophoric fires and fire hazards in the cask handling area; and (4) a collection of assumptions in the analysis of postulated accidents for which controls were not identified or not fully captured in the derived TSRs. In addition, improvement items were identified in most of the areas reviewed. Taken together, these issues and weaknesses indicate some revision and/or clarification of the hazard and accident analyses may be needed.

Attachment 1

Significant Issue Forms

Significant Issue 1

Subject: Potential Accident Involving Release of Cadmium during a Seismic Event

References:

- SAR-403, *Safety Analysis Report for the Fuel Conditioning Facility,* Section 3.3.2.3.5, "Nonradioactive Hazardous Material Release"
- TEV-160, *Fuel Conditioning Facility (MFC-765) Initial Hazard Evaluation Report*
- ECAR-292, *Cadmium Toxicological Exposure Evaluation for the Materials and Fuels Complex (MFC) Fuel Conditioning Facility (FCF)*
- ANL-IFR-133, *Investigation of Cadmium Combustion Potential*
- HAD-438, *Fire Hazards Analysis for MFC-765 Fuel Conditioning Facility (FCF)*

1. Issue: Potential accidents and release path mechanisms involving elemental cadmium during seismic events have not been adequately identified and analyzed.

Safety Analysis Report (SAR)-403, Section 3.4.2.4, describes the bounding event for nonradioactive hazardous material as a release due to the spill of liquid cadmium metal (at 500°C) to the argon cell floor as a result of a load drop. However, an evaluation basis earthquake (EBE) scenario resulting in the concurrent loss of electrorefiner and argon cell confinements, and involving burning pyrophoric uranium interacting with molten cadmium, has the potential for a greater airborne release than the load drop event (caused by equipment failure/human error). Such a scenario has not been analyzed.

Engineering Calculations and Analysis Report (ECAR)-292, Section 8.2, states that a release of cadmium resulting from ignition of pyrophoric material in the argon cell is not considered credible. This is based on a discussion in the Fire Hazards Analysis (HAD-238) that an unmitigated fire involving pyrophoric material in the argon cell would be isolated and contained within the immediate area of origination, and would not cause failure of the electrorefiner if the fire is outside the vessel nor penetrate the salt layer if inside the vessel. While this assumption may be acceptable, neither ECAR-292 nor HAD-238 provide any evidence that a seismic event was considered as a common mode initiator causing failure of both the electrorefiner and argon cell confinements and resulting in interaction of burning pyrophoric uranium and molten cadmium.

ANL-IFR-133, *Investigation of Cadmium Combustion Potential*, discusses experiments conducted in 1990 to determine the potential for cadmium combustion during a seismic event. The airborne release fraction used in ECAR-292 and SAR-403 for a cadmium release from an EBE accident involving the simultaneous loss of both electrorefiner and argon cell containments is assumed to be 1.6×10^{-5} based on high-efficient air particulate filter cadmium deposits from the bench-top scale studies described in ANL-IFR-133. These studies provided assurance that cadmium combustion was minimal under the controlled conditions of the experiments; however, the initial experiments demonstrated that splashed cadmium did indeed spontaneously combust, and in one case, there was a 1.5 minute fire involving a stalactite of frozen cadmium extending from the opening of the experimental melt vessel. In subsequent experiments, experimenters took positive actions to minimize splashes, aerosols from argon pressure, and formation of stalactites. While minimizing these types of effects provides better reproducibility in controlled conditions and a small airborne release fraction measurement, it does not simulate the significant splashing and stalactite formation that would be expected in a seismic event with molten cadmium at 149°C above its melting point. Additionally, the ANL report did not discuss or analyze the extrapolation of observed splashing, stalactite formation, and spontaneous combustion of the 1.7 kg of molten cadmium in the bench-top experiments to the 587.4 kg of molten cadmium in the electrorefiner.

The existing spill scenarios in ECAR-292 also do not consider the interaction of molten cadmium with other combustibles in the argon cell, specifically with the gallon quantities of lubricants in the argon cell cranes (as stated in discussions with Battelle Energy Alliance, LLC staff), which have the potential to spill in an EBE. Further, HAD-438 does not address the lubricants in the argon cell cranes and specifically states in Section 5.3.3.1 that “the combustible loading within the (argon) cell is extremely low, limited to electrical cabling between power sources and equipment.” Moderate quantities of hydrocarbons have the potential to become an accelerant for cadmium combustion.

With regard to the likelihood of an accident involving a spill and loss of confinement, ECAR-292, Section 8.1, states that a loss of containment of the Mk-IV electrorefiner and a simultaneous loss of containment of the argon cell is caused by an EBE. SAR-403 considers an EBE unlikely. The EBE should be considered the bounding accident for non-radiological hazardous material release and not the extremely unlikely load drop scenario currently described as the bounding accident.

2. Impact:

The potential interaction of burning pyrophoric uranium with molten cadmium during an EBE has not been analyzed. Consequently, releases of cadmium could be significantly worse than currently analyzed and have the potential to require safety structures, systems, and components.

3. Requirement/Standard:

- DOE Standard 3009-94, CN-3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Chapter 3, “Hazard and Accident Analyses”

- DOE Order 151.1, *Comprehensive Emergency Management System*

4. Recommendation:

Fully analyze the effects of a seismic event causing a cadmium spill, including the effects of worst case splashing and spontaneous combustion within the cell and the effects of a simultaneous pyrophoric fire interacting with the cadmium spill.

Significant Issue 2

Subject: Evaluation Basis Earthquake (EBE) Accident Analysis and Selection of Safety Measures

References:

- SAR-403, Sections 3.3.2.3.7.1, 3.3.2.3.10, and 3.4.2.5
- DSA-003-HFEF, Section 3.4.4.3.6
- ECAR-307, pp 9 & 10
- ECAR-315
- ANL-82-39
- ANL-IFR-133
- DOE-HDBK-3010, Section 3.2.3.1
- DOE Order 420.1B Chapter 1, Section 3.b(1) and Section 3.b(2)(a)3
- ECAR-8333, p 5
- Telephone conference call with site and NE headquarters personnel on 2/4/2010

1. Issue: The analysis of the postulated Evaluation Basis Earthquake (EBE) in Safety Analysis Report (SAR)-403 does not adequately develop the scenario and the release source term; and does not adequately justify the controls selected to mitigate the consequences of the event.

The Fuel Conditioning Facility (FCF) seismic design basis is performance category (PC)-3. The EBE is expected to severely damage the facility, but leave it standing. The material-at-risk (MAR) for the event is in the argon cell and is primarily the maximum end-of-life contents of the electrorefiners. These contents are assumed to be spilled by earthquake forces. A fire involving uranium on the cathodes is also assumed. Release of MAR is through breach of the cell walls (including failures of penetrations).

Respirable Fraction

SAR-403 Section 3.4.2.5.2 references DOE-HDBK-3010 in choosing the airborne release fraction (ARF) and respirable fraction (RF) values for the EBE used for the spilled salt portion of the source term. The analysis assumes a powder with an RF of 0.01; however, the DOE-HDBK-3010 value of RF for a powder spill is 0.3, which constitutes a factor of 30 reduction. As a basis for the 0.01 RF value used in the analysis, Engineering Calculations and Analysis Report (ECAR)-307 asserts that only 1.0 percent of the spilled salt is below 20 microns in size. This assertion is based on an analysis of the particle size distribution of a milled powder of the salt present in the Hot Fuel Examining Facility (HFEF) (see DSA-003-HFEF). The RF value is also supported by ANL-82-39, which is a report on brittle fracture studies of glasses and ceramics intended for radioactive waste forms. The applicability of these studies on materials for long term immobilization of high-level wastes is questionable given the lack of similarity of the materials (spilled molten salt versus hardened waste immobilization forms). SAR developers believe it is reasonable that a seismic event in FCF would not produce respirable salt particles with a finer particle size distribution than for salt that is intentionally crushed and ground.

Notwithstanding the above, the material form (powder) in the HFEF is not present in FCF and the assumed conditions do not clearly bound the expected conditions. The physical conditions of a powder spill at ambient temperature and a molten salt spill at 500 deg C bear no relation to each other. DOE-HDBK-3010 provides release fraction information on liquid spills and particularly, of heavy metal solutions (Section 3.2.3.1) that may be more relevant. In addition, consideration of the temperature of the solution and gas velocity (see below) over the spill may also alter the expected RF.

Airborne Release Fraction

The ARF value of 2E-3 may not be conservative inasmuch as the argon recirculation system is assumed shutdown. However, it is not clear from the accident description or other information that this is necessarily so for the unmitigated analysis. The postulated event does not consider the possibility that the argon recirculation could produce air flows that would exacerbate the concurrent fire and also increase the ARF over the analyzed value. On the other hand, the gas flow (air or argon) could quicken the solidification of the spilled salt and reduce the ARF. Overall, it appears that the ramifications of accident assumptions were not considered. The event should be reanalyzed using an ARF based on a worst-case estimate of the plausible conditions following the earthquake.

Scenario Development

An evaluation basis accident is intended to be a bounding accident involving facility MAR that can be involved in a representative event. Its purpose is to identify and classify preventive and mitigative measures for the event, based on the bounding accident consequences and their comparisons to evaluation guidelines for the classification of structures, systems, and components (SSCs). The EBE is defined as a spill of the contents of argon cell electrorefiners, breach of the cell structure and its penetrations resulting in the introduction of air in the cell, and a fire involving the cathodic materials, including uranium and retained salt.

The analysis of the EBE, documented in ECAR-307, focuses on the salt spill, with the undocumented assertion that the fire consequences are minimal compared to the salt spill. However, ECAR-315 contains an analysis of a fire from an equipment malfunction resulting in introduction of air in the argon cell involving uranium dendrites and salt laden cathodes. The consequences of this event are comparable to those of the EBE. It is not clear why this description of the fire component of the accident would not be bounding over that described in the EBE.

As discussed in significant issue 1, a cadmium fire with attendant chemical consequences is likely a part of the EBE event. Therefore it also needs to be considered as part of the EBE analysis.

Both fires (that described in ECAR-315 and a cadmium fire) have the potential to affect the accident progression and the analysis described for the EBE and ECAR-307. These analyses may have to be conducted separately, but they should be coordinated to recognize interactive effects and treat them consistently.

Adverse Interactions

The potential effects of adverse system interactions (two-over-one) as a result of an EBE have not been fully incorporated in the event description and analysis. For the EBE, the argon and air cell structures are classified as safety significant, credited design features. Although the safety analysis indicates that the argon cell structure and argon cell confinement systems need only meet PC-2 criteria, the argon cell structure is designed to PC-3 criteria. The basic structures themselves are described as adequate to survive the event and therefore, are credited with providing the needed mitigation.

Nevertheless, there is no clear SAR description of the system interaction analysis that would support either the unmitigated event scenario or the mitigation strategy. Especially vulnerable argon cell components include, in part, the penetrations (including the Safety Exhaust System (SES) penetration), cell windows, and viewing ports. Also, the argon confinement system boundaries extend from the argon cell SES penetration through the equipment tunnel and up to the seal pot assembly located in the Safety Equipment Building; therefore, two-over-one analysis is necessary in the Safety Equipment Building as well. Further, the boundary of the confinement following an earthquake is not always clearly described in the analysis. Without a complete description of the system interaction analyses (two-over-one), the ability of the argon cell to perform its preventive and mitigative functions cannot be determined.

Evacuation Time Analysis

ECAR-315 describes the postulated stay time after a pyrophoric fire to be 60 seconds; however, this life safety assumption is not evaluated in the SAR or the Fire Hazards Analysis. Based on engineering judgment, ECAR-315 assumes that "in most instances it would take much less than sixty seconds to egress an affected area; however, under other instances or circumstances egress time may require the full 60 seconds." The SAR also does not analyze the performance of emergency lighting during an EBE, which may impact the anticipated 60 second egress time.

Preventive and Mitigative Measures

In the summary of the safety SSCs for this event, the argon cell structure is classified as safety significant. The adequacy of this control is based on an asserted reduction of the accident damage ratio (DR). This reduction would have to be release of less than the contents of the electrorefiners. This is not supported by any analysis in the SAR and is contrary to the description of the accident and selection of the DR as described in ECAR-307, which states: "The DR is estimated based upon engineering analysis of the response of structural materials and materials-of-construction for containment to the type and level of stress/force generated by the event. Standard engineering approximations were used. These approximations include a degree of conservatism due to simplification of phenomena to obtain a useable model, but the purpose of the approximation was to obtain, to the degree possible, a realistic understanding of potential effects." In addition, as noted above, a system interaction analysis (two-over-one) would be necessary to support crediting the argon cell as a preventive and mitigative control.

Further discussions with site personnel indicate that accident mitigation should not be credited by a reduction in DR. Instead, a reduction in release results from a reduced leak path factor (LPF) due to the robustness of the structure and a "tortuous path" to release. This assertion needs to be explained and defended. Unless the structure and its penetrations are credited as PC-3 (i.e., no damage to the confinement), the passive confinement may not be credited without a defensible LPF calculation. The design flow capacity of the SES is an indication of the breach area expected for the confinement boundary system in the EBE and is relevant to an assessment of the LPF. In addition, the possibility that the concurrent pyrophoric fires might provide a driving force for the release would need to be taken into account.

Finally, the discussion of the EBE analysis in the SAR (Section 3.4.2.5) indicates that crediting the argon cell structure, even with the DR of 0.1, does not sufficiently mitigate the consequences of the postulated EBE accident. The mitigated consequences for the "unlikely" category EBE are "moderate" for the facility worker, which would call for additional safety-significant SSCs following the applicable Idaho National Laboratory evaluation guidelines for safety classification of SSCs (NS-18104, Fig. 3-4 or SAR, Fig. 3-3). This residual risk is not explicitly acknowledged in the SAR and is in conflict with SAR Section 3.3.2.3, which states, "…for all hazardous events where the estimated risk without controls challenged or exceeded established evaluation guidelines, safety SSCs, Technical Safety Requirements, and/or safety analysis commitments are identified to reduce the risk below risk evaluation guidelines."

2. Impact: The radiological doses for this accident quoted in the SAR are 489 rem for the in-facility worker; 60.5 rem for the 100 m collocated worker; and 1.96 rem at the 5000 m distance for the public. However, the RF used for the analysis is not relevant to the event and the ARF value used may be non-conservative as well. Chemical exposures to cadmium releases in the event may also support the need for additional safety measures. System interactions and evacuation times also need to be addressed. These issues raise the potential that the calculated doses may exceed the evaluation guidelines for safety-class and/or safety-significant SSC classification.

3. Requirement/Standard:

- DOE-STD-3009

    - Defense in Depth, page 7 - no one layer of defense by itself should be completely relied upon.
    - Accident Analysis, page 14 - all assumptions identified and justified.
    - Appendix A, section A-3, page A-3 - calculations should be based on reasonably conservative estimates of input parameters.

- DOE-STD-1021-93, *NPH Performance Categorization Guidelines for SSCs*, states in part that performance categorization shall be initially performed but that this preliminary PC shall then be modified by considering applicable system interaction effects, which are also known as "two-over-one protection."

4. Recommendations: Reanalyze the EBE using reasonably conservative, applicable estimates of input parameters, specifically ARF and RF, and considering the possibility that system operations and adverse system interactions may exacerbate conditions at the time of the event. Based on the results of the reanalysis (including both radiological and chemical releases), re-evaluate and justify the classification of SSCs, taking into account the need for multiple barriers to release and defense-in-depth ,and including the possibility of designating the SES as a credited safety system. If the facility SES were to be credited for mitigation of accident releases, all doses (facility worker, collocated worker, and public) could be significantly reduced.

Two-over-one analyses should be documented for the confinement structures, and should be described in the SAR, in order to assure that the scenario is accurate, credit for cell structures credit is valid and the analyzed prevention and mitigation strategies are adequate.

Perform a life safety egress calculation to validate the evacuation time used in the SAR analyze and analyze and verify that emergency lighting will be available in the aftermath of an earthquake.

A more balanced hazard control strategy using active mitigative systems, such as the SES, would be prudent and is recommended. The proposed strategy has only one credited means of confinement for the EBE (safety-significant argon cell structure). A consideration in evaluating SSC classifications is the difficulty in establishing the reliability of a passive confinement in protecting the public and collocated worker, which is not addressed sufficiently in the current the SAR. The analysis of LPF for a damaged confinement is difficult and characterized by significant uncertainties, as can be seen in the discussion of LPF in Chapter 4 of NUREG/CR-6410, *Nuclear Fuel Cycle Facility Accident Analysis Handbook*. In addition, the discussion of the confinement boundary in System Design Description-252, *Argon Cell Confinement Boundary*, recognized that, "Essential to the integrity of the confinement boundary is the structural and seismic design of the argon cell and its components that make up the confinement boundary system. The argon cell confinement boundary is designed to be structurally and seismically capable of withstanding a design basis earthquake to the extent that the total breach area from failed penetrations is no greater than the capability of the SES to maintain inward flow through the breach area." This implies that the SES is necessary for the response to the expected breaches in confinement following an earthquake and should be classified as safety significant, as a minimum, in order to support the safety-significant function of the argon cell confinement boundary. In addition, DOE Order 420.1B requires multiple means to ensure critical safety functions (such as confinement of hazardous materials from accident releases).

Significant Issue 3

Subject: **Safety Analysis Report (SAR) Analysis for Events Resulting from Fires**

Reference:

- SAR-403, *Safety Analysis Report for the Fuel Conditioning Facility*
- HAD-438, *Fire Hazards Analysis for MFC-765 Fuel Conditioning Facility (FCF)*
- TEV-160, *Fuel Conditioning Facility (MFC-765) Initial Hazard Evaluation Report*
- ECAR 315, *FCF DSA Upgrade Equipment Malfunction Accident Dose Consequence Analysis*

1. Issue: The SAR analysis of fires is not sufficiently coordinated with the analysis in the Fire Hazards Analysis (FHA) to consider the full implications of the accidents described.

The potential for the crane to collapse and impact either the truck and cask or the air cell has not been taken into account in the SAR analysis.

The SAR considers a fire in the cask handling area (Table 3-9, event 1.1) as extremely unlikely and based on the estimated consequences, determines that the fire requires no further analysis. The same fire scenario (diesel fuel spill) described in the FHA (HAD-438) results in flashover and states that "failure of the structural steel is probable and could potentially threaten the integrity of the overhead crane." When flashover does occur, the temperature of the smoke-layer in a compartment is between 932 and 1200 degrees F. Unprotected steel will begin to significantly lose structural strength around 1000 degrees F. The FHA also takes credit for the sprinkler system cooling effects to protect the integrity of the steel during the fire, even though the sprinkler system is described as not designed to protect against a diesel fuel fire.

Similarly, the effects of a pyrophoric fire in the argon cell on the event progression with the safety exhaust system operating (e.g. the potential buildup of material and subsequent failure of the high efficiency particulate filter) and the credited structures, systems, and components (SSCs) (e.g. argon confinement system) are not included to support the analysis.

The SAR and Engineering Calculations and Analysis Report (ECAR) -315 describe the bounding consequences for a pyrophoric fire inside the argon cell; based on the uranium dendrites being vaporized and the resulting release of radioactive material from the argon cell. This category of pyrophoric fire (events 1.6, 1.7, 1.8 and 1.9) results in the release of the entire inventory of the cathodes (uranium dendrites) located in the cell and is considered to be either anticipated or unlikely. In this event, air enters the cell during transfer operations, either through the equipment transfer lock or the small transfer lock. The same fire event is described in the FHA as lasting 20 minutes and reaching temperatures of 1,112 degrees F (600 degrees C). The FHA analysis also results in a risk of direct flame impingement or ember impingement on the first stage high-efficiency air particulate filter and eventually to the final filter bank, noting the lack of preventive controls such as fire screens at the first and final filter stage.

In calculating the collocated worker and public doses, the ECAR-315 assumes a ground-level release of material. Facility worker dose is evaluated with the assumption that facility ventilation is not operating or not effective and the released material migrates from the argon cell into the air cell, through the transfer tunnel, and eventually to the operating corridor surrounding the argon cell. The consequences to the facility worker have not been evaluated with the assumption that the Safety Exhaust System continues to operate.

2. Impact:

The failure of the (unprotected) steel and compromised integrity of the overhead crane could potentially breach the air cell or damage a cask being transported during this time, and has the potential to result in increased consequences to the workers and perhaps the public.

Adding the analysis of the pyrophoric fire to the FHA has the potential to affect the progression of the analyzed event in the SAR and the performance of the selected mitigating SSCs.

3. Requirement/Standard:

- DOE Standard 3009-94, CN-3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Chapter 3, "Hazard and Accident Analyses"

4. Recommendation:

Evaluate the potential for damage to the cask and breach of the air cell from failure of the overhead crane in a post flashover condition. Integrate the analysis and conclusions in both the FHA and SAR for this fire event.

Fully evaluate the second category pyrophoric fire in the argon cell in the FHA, and re-evaluate the pyrophoric fire scenario analysis in the SAR giving consideration to the FHA data.

Significant Issue 4

Subject: Accident Analysis Assumptions Requiring Technical Safety Requirements (TSR) Controls

References:

- SAR-403, *Safety Analysis Report for the Fuel Conditioning Facility*, Rev. 0, TBD
- ECAR-453, *Fuel Conditioning Facility Air Cell and Argon Cell Direct Radiation Shielding Calculations*, Rev. 0, 1/09
- SDD-252, FCF *Argon Cell Confinement Boundary & Argon and Air Cell Shielding Systems*, Rev. 0, 6/09
- EDF-6590, *Radiological Consequence Calculations for the HFEF-5 Cask*, Rev. 2, 11/06
- ECAR-230, *HFEF-5 Cask In-Facility Drop Analysis*, Rev. 0, 7/08
- INL-INT-08-146, *Criticality Alarm System Evaluation for the FCF*, Rev. 0, 8/08
- EDF-6509, *Low Temperature Accidental Drop Analysis of the HFEF-5 Cask*, Rev. 1, 6/06
- F5150-0067-EK, *Equipment Transfer Lock Platen and Platen Safety Restraint Structural Analysis & Design Report*, 3/92
- F5150-0147-EK, *Reassessment for Large Drop Load Weight on Equipment Transfer Lock Platen*, 5/96
- W0341-0020-ES, *System Design Description Air Cell Transfer System*, Rev. 2, 10/94
- SDD-252, *FCF Argon Cell Confinement Boundary & Argon and Air Cell Shielding Systems*, Rev. 0, 6/09
- ECAR-315, *FCF DSA Upgrade Equipment Malfunction Accident Dose Consequence Analysis*, Rev. 0, 9/08
- ECAR-286, *HFEF-14 In-facility Drop Analysis*, Rev. 0, 6/08
- TSR-413, *Technical Safety Requirements for Inter-facility Transfers*, Rev. 2, 8/09
- LST-337, *Approved Container/Payload List for Inter-facility Transfer Operations at MFC*, Rev. 4, 12/08
- SDD-201, *HFEF-5 Cask System Design Description*, Rev. 3, 10/09
- SDD-202, *HFEF-14 Cask System Design Description*, Rev. 3, 10/09

1. Issue: A number of instances were identified in which the assumptions in the accident analyses and supporting calculations were not fully captured in the controls identified in the Safety Analysis Report (SAR) and TSRs.

The discussions of the hazard controls in the SAR are mostly thorough, but in some instances the discussion may be insufficient to completely identify and implement the controls necessary for safe facility operation. For example:

- Although the anticipated end-of-life quantities of material-at-risk are not expected to be approached for some time, the consequence analyses depend on maintaining this assumption and the sampling and total mass programs that support it are not included as an administrative control.
- The processes for monitoring the continued effectiveness of the argon cell confinement system are described briefly in the SAR, but they are not addressed in an administrative control designed to ensure that the program is implemented and the assumed functions of the confinement system are maintained.

- The operational configuration of the casks assumed in the analysis, e.g. doors captured by bolts and weight of contents, is not described and included in the TSR controls to ensure the casks are in the analyzed condition prior to lifting and handling within the building (though some are included in LST-337, *Approved Container/Payload List for Inter-facility Transfer Operations at MFC*).
- The cask and criticality analyses assume that the outer container retains its shape, thereby preventing an inadvertent criticality or a more significant radiation exposure to the workers, but this component is not identified as a safety structure, system, or component (SSC).
- The load drop analysis for the equipment transfer lock (ETL) assumes that the load is dropped from a height of 9 feet above the platen, and although discussed in the SAR, this assumption is not identified as an administrative control or otherwise justified as physically limited to 9 feet.
- The need to control access to the cask tunnel and the subcells as a preventive measure for criticality accidents in the air cell is not discussed in Section 4.4.5, and the planned modifications to address this need are not included in the planned improvements section of the SAR.

2. Impact: A clear description of the controls whose implementation protects the assumptions and calculations performed as part of the accident analyses should be included in the SAR (Chapters 3, 4, and 5). Without this description and the identification of the controls necessary to maintain those assumptions, there is the potential to operate the facility outside the analyzed safety basis. In addition, the potential to make changes in the facility without accurately assessing the impact of those changes on the safety basis is increased.

3. Requirement/Standard: DOE-STD-3009

- "The quantified consequences are compared to the numerical Evaluation Guideline for the purpose of identifying safety-class SSCs and any accident specific assumptions requiring coverage by TSRs." – Accident Analysis, page 14
- Expected products of this chapter, as applicable based on the graded approach, include: "Identification of assumptions needing TSR coverage." – Purpose (of Chapter 4), page 55
- "This subsection identifies those assumptions requiring TSRs to ensure performance of the safety function." – 4.4.X.5 Controls (TSRs), page 61

4. Recommendations: Review the assumptions that are fundamental to the accident analyses and identify those assumptions that are critical in defining the safety envelope of the facility. Based on this review, re-evaluate the TSR controls that are necessary to ensure that the facility is operated within the bounds of the analyses. As part of the review, consider the following:

- Develop a SAC that includes the sampling and total mass programs and periodically verifies that the assumptions regarding total material-at-risk and its constituents remain valid.
- Include a SAC that addresses monitoring the leak tightness of the argon confinement system, ETL, and small transfer lock, and correcting identified leaks to maintain the confinement integrity.
- Expand the identified controls for the casks to fully include the operational configuration of the casks assumed in the analysis (for example, doors captured by bolts and weight of contents) in LST-337.
- Reassess the need to identify the outer container as a safety-significant SSC based on its importance to the prevention of an inadvertent criticality or a more significant radiation exposure to the workers during cask drop events.

- Implement the 9 foot height limit, which is assumed in the ETL load drop analysis, as a SAC or provide evidence that higher drops are physically impossible.
- Include the access control preventive measures for criticality accidents in the discussions in Section 4.4.5, and identify the planned modifications to address this need in the planned improvements section of the SAR (alternatively, the modifications could be specifically directed in the Safety Evaluation Report).

Attachment 2

Review Plan

Plan for the Review of the Idaho National Laboratory Fuel Conditioning Facility Upgraded Safety Basis

January – February 2010

U.S. Department of Energy
Office of Health, Safety and Security
Office of Independent Oversight

DEPARTMENT OF ENERGY
OFFICE OF HEALTH, SAFETY AND SECURITY
OFFICE OF INDEPENDENT OVERSIGHT
PLAN FOR THE REVIEW OF THE IDAHO NATIONAL LABORATORY
FUEL CONDITIONING FACILITY UPGRADED SAFETY BASIS

January – February 2010

Approved by:

Dr. Shivaji S. Seth — Date: 1/19/10
Senior Technical Advisor for Nuclear Safety
Office of Environment, Safety & Health Evaluations
Office of Independent Oversight

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U.S. DEPARTMENT OF ENERGY
OFFICE OF HEALTH, SAFETY AND SECURITY
OFFICE OF INDEPENDENT OVERSIGHT
PLAN FOR THE REVIEW OF THE IDAHO NATIONAL LABORATORY
FUEL CONDITIONING FACILITY UPGRADED SAFETY BASIS

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January – February 2010

I. INTRODUCTION

This document outlines the activities currently planned by the Office of Independent Oversight, within the Office of Health, Safety and Security, for reviewing the upgraded safety basis for the Fuel Conditioning Facility (FCF), a Hazard Category 2 nuclear facility at the Idaho National Laboratory (INL) Materials and Fuels Complex (MFC). The upgraded safety basis is part of an overall plan to provide MFC with safety basis documents that are compliant with the U.S. Department of Energy (DOE) Nuclear Safety Management regulations in 10 CFR 830 Subpart B. The safety basis upgrade plan for the MFC nuclear facilities, in turn, was part of the resolution of an unreviewed safety question resulting from reviews of MFC safety bases conducted by both Battelle Energy Alliance (BEA) and DOE during and following the Management and Operations contract transition in 2004. The Office of Independent Oversight also conducted an inspection of selected FCF safety systems in 2007.

The upgraded safety basis, comprising a documented safety analysis (DSA) and associated technical safety requirements (TSRs) prepared by BEA, is in the process of being reviewed by the Idaho Operations Office (DOE-ID) and DOE Headquarters line management, and will result in a safety evaluation report approving the FCF safety basis. As requested by the Office of Nuclear Energy (NE), the present Independent Oversight review of the DSA and TSR will be conducted in parallel with the DOE line management review. This review will focus on selected aspects of the upgraded safety basis using the requirements of 10 CFR 830, *Nuclear Safety Management*, and DOE standards, including DOE-STD-1104, *Review and Approval of Nuclear Facility Safety Basis and Safety Design Basis Documents*, as the basis for broad guidance for the conduct of the review. While this plan outlines projected review activities, changes to specific activities and review focus areas may be made in response to emerging concerns and requests from key Headquarters managers.

II. SCHEDULE

The review process is divided into several stages, including offsite planning, onsite review activities, report writing, and closeout. The planning activities include team orientation, preliminary document reviews, and interviews with selected BEA and DOE staff. Preliminary areas for follow-up and discussion during the initial site visit will be developed.

An onsite review visit will be conducted in January with a second visit in February 2010 if necessary for follow-up. During the initial visit, review activities such as facility and process walkdowns, interviews, meetings, and document reviews, are planned.

Additional supporting documentation may also be collected during this visit. Following completion of the initial visit, team members will finish the review of their assigned areas and develop comments and issues. Significant issues identified during the review will be forwarded to NE as they are identified. If needed, the second site visit will include interviews, meetings and discussions necessary to address the significant comments and questions developed by the team. Finally, a report documenting the results of the review will be prepared and provided. The overall schedule is provided below.

Team Orientation/Initial Document Review	January 4-15, 2010
Initial Site Visit	January 18-22, 2010
Document Review	January 25 – February 12, 2010
Follow-up Site Visit (if necessary)	February 15-19, 2010
Report Preparation	February 15-26, 2010
Report for Review	February 26, 2010

III. REVIEW TEAM RESPONSIBILITIES AND ASSIGNMENTS

Dr. Shivaji Seth, Senior Technical Advisor for Nuclear Safety, Office of Environment, Safety and Health Evaluations will be the senior DOE official managing the review activities and the senior Independent Oversight point of contact. He will be assisted by a staff of technical specialists and administrative support personnel. The review team leader and his staff will ensure that the review is conducted in accordance with approved standards.

The team list is provided on page 4 of this plan.

IV. SCOPE OF THE REVIEW

The review will determine if sufficient documentation and bases exist to satisfactorily conclude that the lines of inquiry are addressed. The DSA review will focus on the following approval basis areas:

- Hazard and accident analyses
- Safety structures, systems and components (SSCs)
- Specific Administrative Controls (SACs)
- Derivation of TSRs, including SACs
- Attributes for criticality safety and other selected programs, as necessary

The review will also consider that the hazard controls contained in the DSA are accurately translated into the TSRs.

V. REVIEW PROCESS

Independence

Independent Oversight is charged with the independent oversight of nuclear facilities and operations throughout the Department. Independence is assured by its direct reporting relationship through the Office of Health, Safety, and Security to the Secretary of Energy (i.e., outside any line management reporting chain). Further, Independent Oversight does not have any direct responsibility for site operations, policy formulation, or environment, safety, and health and emergency management program implementation.

Comments and Significant Issues

During the course of the review, reviewers will document comments and emerging issues. Comments will be used to document important deficiencies identified during the review (i.e., it is not the intention to document minor typographical or administrative errors). As comments are identified, reviewed, clarified and/or resolved, significant issues that may be identified will be documented to ensure that they receive timely resolution. Significant (or potentially significant) issues will be further documented as discussed below. Interactions with site personnel for follow-up questions; additional information; or to clarify observations, comments, or issues will be conducted by the Senior Review Group.

A significant issue identifies a problem or concern that affects the validity of the safety basis documentation. Significant issues generally involve: (1) potential release of hazardous material or energy with significant consequences to the public, worker, or environment that will otherwise be left without coverage in the DSA; (2) technical errors or omissions that invalidate major conclusions relevant to the safety basis; or (3) failure to cover topical material required by DOE regulations, directives, and guidance on DSAs.

Significant issues will be further documented using the Significant Issue Form (see Appendix B). Reviewers will identify the issue in detail and provide an explanation of the significance of the issue on the form. The significant issue will be reviewed by the Senior Review Group and revised as necessary to validate the significance (the impact of not resolving the issue) and to ensure it is clearly and concisely expressed. Following review, the Significant Issue Form will be provided to the team leader for approval and then forwarded to NE.

At the completion of the project, the comments and significant issues will be collated and provided to NE with the draft/completed report.

Report

A report will be issued as the formal product of the review. The report will describe the general process used to perform the review, discuss the overall conclusions, and identify and discuss any significant issues and associated recommendations (as well as status of resolution, if known). The report will also include attachments containing the significant issues and comments identified during the review. This independent review is being performed at the request of NE and DOE-ID and disposition of the review results, including identification and tracking of any actions, is the responsibility of these organizations using their issues management processes.

Office of Independent Oversight
Office of Environment, Safety, and Health Evaluations
Review Team for Idaho National Laboratory
Fuel Conditioning Facility Upgraded Safety Basis

January – February 2010

Team Leader

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Senior Review Group

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Team Members

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Laura Crampton, Administrative
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APPENDIX A

APPROVAL BASES AND REVIEW ACTIVITIES

HAZARD AND ACCIDENT ANALYSIS (Chapter 3)

- The Hazard and Accident Analysis comprehensively presents the hazards of the facility and is based on a consistent, substantiated logic.
- The Hazard and Accident Analysis follows the safe harbor methodology provided in the DOE standards (e.g. DOE-STD-3009) and guides (e.g. DOE G 421-1.2).

Review Activity: Review the hazard and accident analysis.

Review Lines of Inquiry:

- Does the hazard analysis include hazard identification that specifies or estimates the hazards relevant for DSA consideration (i.e., both natural and man-made hazards associated with the work and the facility)? The hazard analysis presents a systematic, comprehensive identification of:

    - Hazardous materials and energy sources present by type, quantity, form, and location
    - Natural phenomena hazards, including design basis and beyond-design-basis events
    - Sources of external hazards, such as nearby airports, railroads, or utilities such as natural gas lines

- Is the final hazard category for the facility consistent with DOE-STD-1027-92, Change Notice No. 1, and any differences between the final hazard category and the initial hazard category are explained?

- Does the hazard analysis include a hazard evaluation that covers the activities for which approval is sought?

- Is the hazard analysis consistent in approach with safe harbor methodologies?

- Does the hazard analysis identify preventive and mitigative features for the spectrum of events examined?

- Does the hazard analysis identify dominant accident scenarios through ranking or an equivalent structure?

- Are normal, abnormal, and accident conditions (including consideration of natural and man-made external events, identification of energy sources or processes that might contribute to the generation or uncontrolled release of radioactive and other hazardous materials, and consideration of the need for analysis of accidents that may be beyond the design basis of the facility) evaluated?

- Does the accident analysis clearly substantiate the findings and delineations of hazard analysis for the subset of events examined and confirm their potential consequences?

- Are results clearly characterized in terms of public safety, defense in depth, worker safety, and environmental protection (i.e., the consequence results represent a significant hazard to safety of workers or the public, or represent a significant uncontrolled release of hazardous material to the environment, or challenge or exceed applicable evaluation guidelines)?

- Are the consequences used appropriately to classify safety SSCs and SACs in accordance with DOE guidance?

- Is the logic behind assessing the results in terms of safety-significant SSCs, SACs, and designation of TSRs understandable and internally consistent?

- Have safety-class and safety-significant SSCs, SACs and associated TSRs been identified for preventing and/or mitigating events potentially exceeding evaluation guidelines?

SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS (Chapter 4)

- The identified safety SSCs are adequate to mitigate or prevent the analyzed accidents with potential to exceed evaluation guidelines.
- The DSA satisfactorily documents the basis for determining the safety SSCs and their required functions.

Review Activity: Review the appropriate DSA chapters.

Review Lines of Inquiry:

- Are the safety SSCs identified and described consistent with the logic presented in the hazard and accident analyses?

- Are safety functions for safety SSCs defined with clarity and consistent with the bases derived in the hazard and accident analyses?

- Are the boundaries of safety SSCs, including the support systems, clearly defined?

- Do the functional requirements and system evaluations derive from the safety functions and provide evidence that the safety functions can be performed when called upon?

- Was a system evaluation performed to assure functional requirements are met?

- Is the control of safety SSCs relevant to TSR development clearly defined?

SPECIFIC ADMINISTRATIVE CONTROLS (Chapter 4)

- The identified SACs are adequate to mitigate or prevent the analyzed accidents with potential to exceed evaluation guidelines.
- The DSA satisfactorily documents the basis for determining the safety SACs and their required functions.

Review Activity: Review the appropriate DSA chapters.

Review Lines of Inquiry:

- Are the SACs identified and described consistent with the logic presented in the hazard and accident analyses?

- Are safety functions for SACs defined with clarity and consistent with the bases derived in the hazard and accident analyses?

DERIVATION OF TECHNICAL SAFETY REQUIREMENTS (Chapter 5)

- The TSRs derive from the most significant preventive and mitigative features identified in the hazard and accident analyses.
- The DSA and TSR Bases satisfactorily document the bases for determining the controls necessary to ensure that safety SSCs, SACs or safety management programs will perform their required functions.

Review Activity: Review the appropriate DSA chapters and TSR sections.

Review Lines of Inquiry:

- Are identified TSRs adequate to preserve the functional and administrative requirements necessary to ensure protection of workers, the public, and the environment (as identified in the hazard and accident analyses?

- Have the bases for deriving TSRs been identified and described in the hazard and accident analyses, safety SSC, and SAC chapters?

- Is the logic for the derivation consistent with the logic and assumptions presented in the analyses?

- Are the bases deriving safety limits, limiting control settings, limiting conditions for operation, surveillance requirements, and administrative controls provided and technically accurate?

- Is the process for maintaining the TSRs current at all times and for controlling their use defined?

APPENDIX B

SIGNIFICANT ISSUE FORM

SIGNIFICANT ISSUE FORM USE AND SAMPLE

Independent Oversight will notify line management promptly when review activities indicate the potential for a significant issue. A significant issue identifies a problem or concern that affects the validity of the documentation in establishing the safety basis for the facility. Significant issues generally involve:

- Potential release of hazardous material or energy with significant consequences to the public, worker, or environment that will otherwise be left without coverage in the DSA
- Technical errors or omissions that invalidate major conclusions relevant to the safety basis
- Errors or omissions in identifying or establishing hazard controls in the hazard and accident analysis
- Failure to cover topical material required by DOE regulations and directives on DSAs

Significant Issue Form

The purpose of the significant issue form is to provide potentially important information from the ongoing safety basis document review to the Office of Nuclear Energy and solicit feedback. The information on this issue form is preliminary and is not meant to communicate conclusions of the team. Consequently, this form should be provided only to those who have a need to know the information, and used only in the context of ensuring effective communications between NE and the review team.

SUBJECT:

REFERENCE: <u>(Section/Paragraph/etc.)</u>

1. Issue:

2. Impact:

3. Requirement/Standard:

4. Recommendation

Approval:

Originator ______________________________ Date ____________________

Team Leader ____________________________ Date ____________________