Allen, Pam, NMENV

From:	Maestas, Ricardo, NMENV
Sent:	Thursday, April 09, 2015 10:01 AM
To:	Allen, Pam, NMENV
Subject:	FW: LANL TWA?
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From: Smith, Coleman, NMENV
Sent: Monday, August 18, 2014 4:38 PM
To: Kliphuis, Trais, NMENV
Cc: Maestas, Ricardo, NMENV; Holmes, Steve, NMENV
Subject: LANL TWA?

Trais,

Here is the document that describes the design and safety basis for the new LANL Transuranic Waste Facility.

Cole

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Independent Oversight Review of the Los Alamos National Laboratory Transuranic Waste Facility Safety Basis and Design Development

July 2014

Office of Nuclear Safety and Environmental Assessments
Office of Environment, Safety and Health Assessments
Office of Independent Enterprise Assessments
U.S. Department of Energy

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Acronyms

CFR	Code of Federal Regulations
CRAD	Criteria, Review and Approach Document
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
FMEA	Failure Modes and Effects Analysis
FSS	Fire Suppression System
HSS	Office of Health, Safety and Security
IEA	Office of Independent Enterprise Assessments
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Fire Code
ISA	Instrument Society of America
LANL	Los Alamos National Laboratory
NA-LA	Los Alamos Field Office
NFPA	National Fire Protection Association
NNSA	National Nuclear Security Administration
OFI	Opportunity for Improvement
PDSA	Preliminary Documented Safety Analysis
PFHA	Preliminary Fire Hazard Analysis
RAMI	Reliability, Availability, Maintainability and Inspectability
SBRT	Safety Basis Review Team
SDC	Seismic Design Criteria
SPCS	Seismic Power Cutoff System
SSC	Structure, system, and component
TA	Technical Area
TRU	Transuranic
TWF	Transuranic Waste Facility

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1.0 PURPOSE

The U.S. Department of Energy (DOE) Office of Independent Enterprise Assessments (IEA) was established in May 2014 and assumed responsibility for managing the Department's Independent Oversight Program from the Department's former Office of Health, Safety and Security (HSS). HSS conducted an independent review of the preliminary safety basis and associated design documents for the Transuranic Waste Facility (TWF) at the U.S. Department of Energy's (DOE's) Los Alamos National Laboratory (LANL) prior to the creation of IEA. As part of the DOE's self-regulatory framework for safety and security, DOE Order 227.1, *Independent Oversight Program*, assigns HSS the responsibility for implementing an independent oversight program. This report discusses the scope, background, methodology, results, and conclusions of the review, as well as items identified for further follow-up by Independent Oversight.

Independent Oversight performed the review within the broader context of an ongoing program of targeted assessments, which focus on the design and construction of high-hazard nuclear facilities and evaluates the principal products; such as the Safety Design Strategy, Preliminary Safety Design Report, Preliminary Documented Safety Analysis (PDSA), and the Documented Safety Analysis (DSA). The requirements and processes established in DOE Order 420.1B, *Facility Safety*; DOE-STD-1189, *Integration of Safety into the Design Process*; and DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Non-reactor Nuclear Facility Documented Safety Analyses*, are used to review the project's development of the safety basis. Specific review areas include identification and evaluation of hazards associated with the facility, analysis of postulated accidents, and derivation and adequacy of hazard controls, in particular, safety structures, systems, and components (SSCs), safety management programs and specific administrative controls.

2.0 SCOPE

Independent Oversight examined the integration of selected nuclear safety hazard controls (i.e. safety SSCs identified in the TWF PDSA) into the TWF design, by performing an assessment of pertinent aspects of the PDSA submittals, hazards analyses, and design documentation. Independent Oversight focused on active safety systems; specifically the fire suppression system (FSS) (designated safety-significant), seismic power cutoff system (SPCS) (designated as safety-class), and the associated supporting and interfacing systems.

3.0 BACKGROUND

The TWF is being designed and constructed by LANL. The National Nuclear Security Administration (NNSA) Los Alamos Field Office (NA-LA) provides line management oversight. The final design is complete (with exceptions as noted) and site clearing activities have been completed.

The overall mission of the TWF is to provide LANL with capability to stage and certify newly generated transuranic (TRU) waste prior to shipping to the DOE's Waste Isolation Pilot Plant. The TWF will be located at LANL's new Technical Area (TA)-63, which was established to support TWF.

The TWF processes involve only TRU waste container handling and non-invasive operations that certify the waste meets acceptance criteria of the Waste Isolation Pilot Plant. TRU waste containers will not be opened at the TWF. The existing TRU waste staging and certification capabilities are currently being performed at TA-54, Area G, nuclear waste management operations, which are targeted for closure in 2015 due to *Comprehensive Environmental Response, Compensation, and Liability Act* consent agreements with the State of New Mexico. Because of the consent agreement timing and ongoing generation of TRU waste from LANL operations, the TWF is considered a high priority nuclear facility project for NNSA.

Before approval of the PDSA Revision 3.1, the safety basis for the TWF was based on the Preliminary Safety Design Report and its approval by NNSA through a Preliminary Safety Validation Report. PDSA Revision 3.1 is supported by a number of technical documents, such as hazard analyses, calculations, accident analyses, and drawings, which have been updated and revised along with changes to the various PDSA submittals. The NA-LA Safety Basis Review Team (SBRT) reviewed a prior LANL submittal of the TWF PDSA (Revision 0) and identified a number of technical comments. Independent Oversight review activities were initiated after the SBRT transmitted their technical comments to LANL. LANL revised the PDSA and submitted PDSA Revision 1 to NA-LA for review in July 2013. Based on the SBRT and Independent Oversight technical comments, PDSA Revision 1 was not approved and PDSA Revision 2 was submitted in December 2013. Likewise, based on SBRT and Independent Oversight technical comments, PDSA Revision 2 was not approved. After further revision, the final PDSA (Revision 3.1) submittal in March 2014 was approved by NA-LA.

4.0 METHODOLOGY

Independent Oversight performed a concurrent review of PDSA Revisions 1, 2, and 3.1 with NA-LA, which focused on:

- Hazard and accident analysis and identification of hazard controls, including safety SSCs and specific administrative controls.
- Translation of hazard controls into safety SSC design, safety functions, functional requirements, and performance criteria.

The review was based on applicable review criteria and lines of inquiry for safety SSCs in HSS Criteria, Review and Approach Document (CRAD) 45-59, *Review of Safety Basis Development for the Los Alamos National Laboratory Transuranic Waste Facility.* The review also used, as appropriate, selected criteria and lines of inquiry from HSS CRAD 45-34, *Fire Protection.* These CRADs were applied to active safety systems, which for TWF comprises the FSS and SPCS and their components.

Independent Oversight initiated its review with a scoping visit in July 2013. The visit included tours of the planned TWF site and operational areas at TA 54, Area G, and technical discussions with TWF Project management, nuclear safety, and engineering personnel. Concurrently, Independent Oversight requested and received documents in support of its review, including PDSA Revision 1 and salient supporting documents. Following offsite review of the documentation provided by the TWF Project and a series of tri-party teleconference calls (involving TWF Project, NA-LA and Independent Oversight personnel) to discuss questions raised by the review, Independent Oversight submitted its final comments to the SBRT at the end of August 2013. These comments were subsequently transmitted to LANL. In early September 2013, NA-LA formally submitted the SBRT comments to LANL and requested that PDSA Revision 1 be revised and resubmitted. LANL provided a response to the Independent Oversight comments at the end of September and in early October another conference call was held to determine comment resolution. At the end of October 2013, the TWF Project formally submitted an updated response to the Independent Oversight comments, including a summary of the comment resolutions.

Revision 2 of the PDSA, incorporating resolutions to most comments, was submitted for SBRT and Independent Oversight review in early December 2013. The submittal also included a re-design of several facility systems, including the FSS and associated electrical support system. Independent Oversight focused its review on the implementation of actions to resolve comments on PDSA Revision 1 and provided review results to TWF Project personnel and SBRT in mid-January 2014. Subsequently, TWF Project personnel provided Independent Oversight with an updated comment resolution matrix with additional actions to resolve the remaining open comments requiring closure in the PDSA. The SBRT review of this revision also identified a significant number of comments. In January 2014, NA-LA directed LANL to address the comments and submit a third revision to the PDSA.

The TWF Project submitted Revision 3.1 of the PDSA in March 2014. Independent Oversight reviewed the submittal in parallel with the SBRT. NA-LA approved the PDSA through a Safety Evaluation Report on March 18, 2014. Subsequently on March 31, Independent Oversight provided comments on PDSA Revision 3.1 to the SBRT and received the TWF Project's responses on April 8.

The principal Independent Oversight results, including identified strengths and potential improvements, are summarized in Section 5. The results of the review are arranged to flow from discussion of the safety analysis assumptions and supporting calculations, which establish the hazard controls and safety functions, to the active safety SSC. Section 5.1 covers the review of the PDSA, and Sections 5.2 and 5.3 cover review of the FSS and SPCS, respectively. Based on the results, Independent Oversight identified both findings (Section 8.0) and opportunities for improvement (OFIs) (Section 9.0) to consider in the development of the TWF DSA, Technical Safety Requirements and final facility design. Section 10.0 identifies potential areas for Independent Oversight follow-up. Supplemental information on the review, including the Independent Oversight reviewers, the Quality Review Board, and HSS management is provided in Appendix A. A list of documents reviewed is provided in Appendix B.

5.0 RESULTS

Independent Oversight focused on the integration of selected safety functions for facility design defined in the TWF safety basis by evaluating pertinent aspects of the submitted PDSA (Revisions 1, 2, and 3.1); hazards analyses; supporting calculations; and design, procurement, and configuration management documentation. Specifically, Independent Oversight focused on the TWF active safety systems (i.e., the safety significant FSS and the safety class SPCS). To ensure clarity, Independent Oversight identified deficiencies that were resolved by the TWF Project are termed "concerns." Deficiencies that are not resolved pending development of the DSA are termed "issues" and are tracked as OFIs.

5.1 Safety and Design Basis

Independent Oversight reviewed the Revision 1 PDSA submittal (August 2013) and found that overall the PDSA identified and analyzed an appropriate set of hazards and accidents for the expected operations and operating environment at the facility. The hazards analysis considered internal events (e.g. fires, explosions, and spills), external events (e.g. aircraft crash, natural gas pipeline explosion, and vehicle impact), and natural phenomena events (e.g. building collapse, wild-land fire, and earthquake followed by fire). The design basis accidents appropriately include both those that are representative of the types of events identified in the hazard analysis and unique events with specific sets of controls. The analysis was consistent with the guidance contained in DOE-STD-3009, DOE-STD-1189, and DOE-STD-5506, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*, and, generally included conservative estimates of the radiological material-at-risk, frequency of event, and event consequences.

With some exceptions, the PDSA analysis and designation of nuclear safety hazard controls appropriately focused on elimination of hazards, design of engineered controls, or use of specific administrative controls, which is consistent with Departmental expectations for hierarchy of controls. Independent Oversight concerns on the PDSA were satisfactorily resolved either through changes to the revised PDSA or LANL commitments to address these deficiencies (i.e. issues) in the DSA.

The Preliminary Fire Hazards Analysis (PFHA) generally identified all the fire hazards and selected appropriate controls. With exception of the analysis for combustible loading, the PDSA (Revision 1) analyzed fire hazards that were consistent with the PFHA and chose appropriate design basis accident fire scenarios. Appropriate fire protection controls were also selected to prevent and/or mitigate fire-based design basis accidents.

Review/Inspection Criteria:

Hazard (and accident) analyses are consistent with the DOE safe harbor methodologies; and they provide systematic and complete results for the selected hazards/accidents, consistent with the current design stage, to facilitate developing controls and their design and functional requirements. (10 Code of Federal Regulations (CFR) 830 Subpart B, DOE O 420.1B, DOE-STD-1189 - CRAD 45-59)

The PFHA conclusions are incorporated into the PDSA and demonstrate the adequacy of controls provided by the system to eliminate, limit, or mitigate identified hazards, and define the process for maintaining the controls and controlling their use. (DOE O 420.1B - CRAD 45-34)

The safety authorization basis is consistent with the PFHA; demonstrates the adequacy of controls provided by the system to eliminate, limit, or mitigate identified hazards; and defines the processes for maintaining controls at all times and controlling their use. (DOE O 420.1B - CRAD 45-34)

Independent Oversight reviewed a subset of the PDSA Revision 1 hazards and accident analyses that had the potential to affect the safety functions and controls for the FSS and SPCS (such as fires, explosions and seismic events), as well as the analyses relating to criticality safety and the use of the safety significant pipe overpack containers. The review did not result in concerns affecting the safety functions of the FSS and SPCS, but it did identify a number of concerns with the analyses. These included:

- Missing technical justification for the conclusion that the controls for the radiological hazards would also be sufficient for the other hazardous material present in the TRU waste at the facility.

- Lack of criticality safety technical analysis on the impact of fire suppression water, insufficient discussion of the mechanism for meeting the double contingency principle, and unclear disposition of a preliminary criticality safety evaluation recommendation in the PDSA.

- A number of concerns in the analysis of events involving acetylene operations and the selection of controls for these events.

- The need for a transparent technical basis related to frequency and material-at-risk estimates for external explosion events.

- A lack of transient combustible analysis in the PFHA to support the PDSA.

- A concern in the applicability of TA-54, Area G, storage drum array configuration used in the TWF pool fire calculation.

- Use of a non-conservative respirable fraction, airborne respirable fraction, and damage ratio that is not consistent with the anticipated form of the material-at-risk in the dispersion analysis of safety significant pipe overpack container failure.

Subsequently, the TWF Project revised the PDSA (Rev.1) in parallel with implementing a number of changes to the facility design, including the classification of the diesel generator and supporting electrical safety system components as safety significant. Following receipt of PDSA Revision 2, Independent Oversight completed a review to verify that the agreed upon resolution of the Independent Oversight comments had been effectively implemented, and found that most of its comments had been satisfactorily resolved. However, PDSA Revision 2 did not sufficiently address two comments (regarding pool fire calculation errors and lack of identified safety significance for the pipe overpack container internal seals), and the LANL actions to resolve some comments were found to be only partially implemented in the PDSA. The Independent Oversight verification comments were provided to the SBRT and the TWF Project, and were discussed during a tri-party teleconference call in mid-January 2014.

Review of PDSA Revision 3.1 (issued on March 13, 2014) determined adequate implementation of actions to resolve most Independent Oversight safety analysis comments. The remaining LANL actions are expected to be completed during the development of the DSA. These actions include clarifying the rationale for determining radiological hazards controls are sufficient for the other hazardous material, revising drum storage array pool fire calculations and other supporting analyses to address the specifics of the TWF storage configuration and fuel pool characteristics (including revisions based on the type of material addressed in the pipe overpack container analysis), and refining the criticality analyses technical basis.

Issues affecting the accuracy of the PDSA were noted in calculation SB-DO-CALC-12-001, *Numbers of Drums in Pool Fires as a Function of Fire Size.* Initial review of PDSA supporting documents revealed that this analysis utilized a TA-54, Area G, model scenario for a liquid pool fire that is based on a different drum storage array and aisle width than the expected array configuration in the TWF storage buildings. Various inputs in the calculation are unique to Area G storage characteristics, which included the difference in asphalt surface and controls limiting the quantity for flammable/combustible liquids which were not reconciled against TWF design criteria. In addition, the conditions in the calculation do not apply to potential pool fire events that may occur during truck unloading operations at the TWF. These inconsistencies are not fully reconciled in the final TWF design and supporting calculations. For example, PDSA Revision 3.1 refers to calculation 11-001-CCAL-002, *Storage Building Fire Flow Drainage Sizing*, to support the conclusion that the minimum slope specified for TWF is sufficient to drain away 20 gallons of fuel within 70 seconds, but this calculation does not evaluate fuel spills or support a conclusion that a postulated fuel spill at the facility could be drained away within 70 seconds. (See **OFI-LANL-1.**)

Independent Oversight also found that the PDSA Revision 3.1 is inconsistent with the PFHA in describing significant factors that contribute to a decrease or increase in the risk of fire. For example, the PDSA performance criteria/attribute for controlling combustible loading (found in PDSA Table 4-1, Control 4.5.2) indicates transient combustibles will be maintained per the site-specific fire hazards analysis, limiting the maximum allowable loading to 2.5 pounds per square foot. The PFHA derived this loading limit based on Class A combustibles and associated heat release rates. The PDSA Revision 3.1 modified the control of only "combustibles" to a broader control of "combustibles and flammables." Since flammable liquids have a much higher heat release rate than Class A combustibles, the PDSA control 4.5.2 and PFHA may not be sufficiently conservative. (See **OFI-LANL-2.**)

5.2 Design Basis of Selected Safety Systems

Overall, Independent Oversight observed that the TWF Project Team's design solutions for the FSS and SPCS were generally appropriate for the analyzed hazards, but the original design documents and supporting analyses did not demonstrate that the level of safety required by DOE Order 420.1B, *Facility Safety*, was met. The review of PDSA Revision 1 and the associated design documents resulted in a number of design-related issues that included examples where the PDSA did not provide sufficient details for the active SSC safety functions, functional requirements, and performance criteria to effectively support design completion. Several concerns were also identified with the FSS and SPCS designs as described in the PDSA Revision 1, including the absence of clear designation of the emergency diesel generator and its fuel oil system as safety significant and non-conservative fire water storage tank sizing calculation. Technical design description for other fire related support systems operability, including the fire alarm system and dry pipe sprinkler systems, was either lacking or incomplete. Other documents providing design input, including the PFHA and supporting calculations, were not fully consistent with the PDSA Revision 1.

Following the revisions to the PDSA and re-design of the FSS, a number of the concerns were resolved and the most significant design deficiencies were eliminated; however, some deficiencies remain. Additional analysis is required to accurately calculate the reliability and availability of the SPCS to meet PDSA Revision 3.1 reliability criteria. The alarms that are needed to support continued monitoring of safety system status are identified in the PDSA and design documents, but the associated instruments and the alarm panel are not included as required loads for the auxiliary emergency load power panel. Finally, a number of LANL TWF activities, including completion of safety SSC design details and revisions to safety SSC supporting calculations, need to be completed in order to finalize the TWF design.

Review/Inspection Criteria:

The bases for the design, functional, and performance requirements of the selected safety SSCs to prevent or mitigate the postulated accidents are adequately defined and described. (DOE O 420.1B, DOE-STD-1189 - CRAD 45-59)

Technical, functional, and performance requirements for the systems are specified in (or referenced in) the facility authorization basis documents consistent with the facility PFHA. (DOE O 420.1B - CRAD 45-34)

Safety/authorization basis documents identify and describe the system safety functions, and these criteria are translated into design calculations and procedures. (DOE O 420.1B - CRAD 45-34)

Items and processes are designed using sound engineering/scientific principles and appropriate standards. (10 CFR 830 Subpart A, DOE-STD-1189, DOE O 414.4D - CRAD 45-34)

Items are designed to assure they can satisfy the required safety functions under appropriately analyzed and plausible accident or incident conditions. (DOE O 420.1B, DOE-STD-1189, DOE O 414.4D - CRAD 45-34)

5.2.1 Fire Suppression System

System Design

The safety-significant, fixed fire water suppression system is designed to mitigate the risks associated with hazards that result from fires at TWF. The TWF PDSA (Revision 3.1) provides analysis of numerous scenarios involving fires resulting from waste container handling operations, stored combustible material, spills, pressurized oil lines, and propane tanks. The majority of these scenarios are mitigated by the credited fire water system, which limits the amount of radiological material-at-risk that is involved in a fire, and by specific administrative controls that limit the amount of combustibles in use in the facility. The functional requirement of the safety-significant FSS is to limit the size, temperature, and duration of fires in order to help the LANL Fire Department manage and suppress them. In part, by using a robust safety significant FSS and components, the associated performance criteria should provide a specified volume of water for a minimum of two hours to meet the worst case fire described in the PDSA.

The FSS consists of a pressurized 8-inch ring main connected to dry barrel-type fire hydrants, post indicator valves, and fire department connections designed in accordance with National Fire Protection Association (NFPA) requirements to aid the LANL Fire Department. The TWF buildings containing TRU waste containers are protected with automatic wet and dry sprinkler systems.

Independent Oversight reviewed the functional requirements and the performance criteria of the safety significant FSS in the PDSA (Revision 1) and supporting design documents. Overall, Independent Oversight observed that the TWF Project Team's design solution for the FSS was appropriate for the analyzed hazards, but identified several concerns, which were communicated to the TWF Project Team through the SBRT and included:

- Functional requirements and performance/criteria attributes were not clearly defined for some FSS sub-systems, such as the fire alarm equipment and components and freeze protection for the heater loop and its components.
- Inadequate FSS design with respect to determining the minimum volume of fire water tank and sprinkler system available pressure.
- Inconsistencies between PDSA and FSS design drawings with respect to the number and location of the fire alarm panels.
- Missing required isolation valves in the dedicated fire ring-main system to ensure separation of safety significant water supply and non-safety water supply systems.
- Unclear definition of safety-significant classification boundaries for the backup diesel generator and fuel oil supply subsystem, the nitrogen system, and the water tank and pump house temperature alarms interface to the Fire Alarm Control Panel (in relation to connected non-safety SSCs).

Revision 2 to the PDSA, FSS redesign, and associated calculation updates were intended to address these concerns. Following these revisions, Independent Oversight noted that the PDSA Revision 2 and the re-designed FSS addressed most of the concerns; however, a design description of safety significant FSS fire pump and associated emergency generator sequence of operation remained to be added to the PDSA. (See **OFI-LANL-3.**)

During review of PDSA Revision 2, Independent Oversight noted that the single failure criteria will be applied to safety significant controls as prescribed in Institute of Electrical and Electronics Engineers (IEEE) 379, *Application of the Single-Failure Criterion to Nuclear Power Generating Safety System* (See PDSA, section 4.3). This requirement is imposed on safety class systems and components by DOE Order 420.1B, but is an optional requirement for safety significant systems. A review of the FSS electrical single line diagram (drawing E-6000, Revision 2) determined that the design did not meet the single failure criteria (e.g., emergency power is provided by a single diesel generator that feeds a common bus for both electric fire pumps). Revision 3.1 of the PDSA eliminated this discrepancy by removing the requirement for the safety significant FSS to meet IEEE 379 single failure criteria.

Independent Oversight reviewed ability of the re-designed FSS to ensure that an uninterrupted flow path will be achieved (see PDSA Table 4-1, Control Summary for the TRU Waste Facility). The flow path starts from the fire water storage tank through the fire pump to the underground ring main and ends at the most hydraulically remote sprinkler head. Independent Oversight determined that the FSS flow path acceptably met the PDSA performance criteria. All the storage buildings containing radiological material-at-risk are protected throughout by safety-significant dry pipe sprinkler systems that are individually controlled with isolation valves designed to limit the number of systems being impaired due either to a potential pipe break or to support routine maintenance. Completed hydraulic sprinkler calculations were performed to meet the minimum flow and pressure requirements based on NFPA 13, *Standard for the Installation of Sprinkler Systems,* specified design density of ordinary hazard group 2 (see 11-001-FCAL-001, *Storage Buildings Dry Pipe Fire Protection Sprinkler System*, Revision 1).

FSS alarm outputs from safety-significant temperature element and level transmitters are routed into the safety-significant dedicated Fire Alarm Control Panel (later referred to as the Safety Alarm Panel) located in storage building TA-63-0152. Each sub panel located in the Waste Storage Buildings and Characterization and Waste Storage Building is routed back to this panel and connected to the alarm monitoring station located at the LANL Emergency Operations Center. PDSA Revision 3.1 provided additional details to the functionality of the FSS system and design basis. The alarm devices and the system boundaries are better defined with documented analytical limits for temperature and pressure for safety significant sensors.

Independent Oversight reviewed FSS components and their respective functional requirements to ensure the system was adequate for all anticipated environments. The functionality of the FSS depends largely on freeze protection to maintain the fire water supply tank temperature above 32°F. Safety significant controls for freeze protection to ensure the availability and reliability for the fire water storage tank and automatic sprinkler systems are appropriately included in the FSS design. The dedicated fire water storage tank will be insulated, and the dry pipe sprinkler risers will be located in the storage buildings and maintained at 60°F by commercial grade heaters.

Independent Oversight review of the design documents revealed several issues with the freeze protection design for the storage tank. Review of FSS drawing (C55446-F-6001) revealed that the safety significant temperature alarm setpoint for the above ground piping (40° F) does not match the setpoint in Tables 4-1 and 4-16 of the PDSA (45° F). Similarly, the safety significant temperature sensor for the storage tank (TE-002) has an alarm setpoint of 40° F, contrary to the alarm temperature of 45° F in PDSA Tables 4-1 and 4-16. The design drawing also indicates that the circulating pump and heater should be actuated at low temperatures by safety significant temperature elements in the above ground piping or in the storage tank, but the pump and heater have not been designated as safety significant controls and included as an auxiliary emergency electrical load. (See **OFI-LANL-4.**)

PDSA Revision 3.1 addressed most of the FSS design concerns originally identified by the Independent Oversight review of the PDSA Revisions 1 and 2; however, Independent Oversight identified the following new issues: (See **OFI-LANL-5.**)

- Lack of engineering analysis to demonstrate that the nitrogen supply cylinders are sized adequately to restore normal air pressure in the FSS within 30 minutes.

- The selected temperature rating for the Waste Storage Building sprinklers does not meet the NFPA 13 requirements based on the specific occupancy for the buildings.

- Inconsistencies exist among the PDSA Revision 3.1, NFPA 110, *Standard for Emergency and Standby Power Systems*, requirements and FSS design description regarding the safety alarms required for the diesel generator.

- The emergency diesel generator fuel tank sizing calculation (11-001-ECAL-015) appears to be conservative, but does not reference or demonstrate compliance with NFPA 110. The NFPA standard requires the sizing of fuel storage tanks to be a minimum capacity of at least 113% of either the low-fuel sensor quantity or the minimum run time based on the classification of the generator.

Supporting Analyses

Revised TWF engineering analysis and supporting calculations confirm that the fixed FSSs to the Waste Storage Buildings should operate as designed when supplied by redundant fire pumps that are both sized to meet the specified design criteria and specification requirements (see 11-001-FCAL-003, *Fire Protection Water Capacity*). The fire pumps, powered from the diesel generator upon loss of off-site power, are designed to operate for a minimum of two hours.

Independent Oversight reviewed design drawings, calculations, and PDSA event scenarios to evaluate the adequacy of the FSS design for the water supply and supporting systems. The design and supporting analysis as originally submitted by the TWF Project for the PDSA Revision 1 did not demonstrate a level of safety meeting the requirements of DOE Order 420.1B, *Facility Safety*, for highly protected risk. Analyses indicated that although two independent water supplies exist, without the boost from the safety significant fire pump, inadequate water pressure (to meet the required flow and pressure margin required by DOE-STD-1066-99, *Fire Protection Design Criteria*) exists from the fire water ring main alone. Additionally, as discussed below, the volume of the dedicated fire water storage tank did not meet the hydraulic requirements for the design basis fire (in accordance with the DOE standard). These concerns were addressed in Revision 2 to calculation 11-001-FCAL-002 and PDSA Revision 2, and incorporated in the FSS re-design.

As discussed below, Independent Oversight reviewed several calculations that serve to validate the FSS performance criteria as described in the PDSA. However, the Independent Oversight review identified concerns in the technical accuracy/validity of some calculations and in the TWF project implementation of the calculation process.

11-001-FCAL-002, *Fire Protection Storage Tank*, determines the required fire water tank capacity. As originally submitted (Revision 0A) to support PDSA Revision 1, this calculation did not consider the unusable water volume or the water volume required to achieve the International Fire Code (IFC) Appendix B Table B105.1 requirement for fire flow; when determining the tank size, the analysis must consider the unusable volume due to water level required to prevent vortex formation, tank required low water level, and pump net positive suction head requirements. For example, fire flow must consider a minimum flow of 1,500 gallons per minute for two hours duration as specified in the IFC. Independent Oversight determined that the dedicated volume of 143,004 gallons was inadequate to provide sufficient water supply for a two hour design basis fire scenario, since neither the unusable tank volume nor the IFC fire flow demand was considered in the calculation. During the FSS re-design, the tank was enlarged from 150,000 to 200,000 gallon capacity, which resolved the identified concern. A safety-significant low-level sensor will constantly monitor the fire water storage tank to ensure that the required water volume availability is maintained.

In calculation 11-001-FCAL-001, *Storage Buildings Dry Pipe Fire Protection Sprinkler System,* the 500 gallon per minute hose stream allowance in the calculation is assumed to occur at the closest hydrant (HYD-03) to the Characterization and Waste Storage Building modeled. However, a hydraulic analysis using a hose stream taken from the other safety significant hydrant (HYD-02), which may reveal a more limiting case, was not performed to support PDSA Revision 3.1 submittal. (See **OFI-LANL-5.**)

Calculation 11-001-MCAL-014, Revision A, *Storage Tank Thermal Mass Calculation,* determines the length of time that it takes for the fire protection water storage tank to reach 32 degrees F. The calculation used non-conservative calculation inputs, such as tank diameter and height, which are not consistent with the actual fire water tank physical characteristics as depicted in the tank specification 21-4100. This calculation was not updated during the FSS re-design. (See **Finding F-LANL-1.**)

Independent Oversight also identified issues with the calculation process related to some of the reviewed calculations. A number of these issues relate to the failure to verify calculations, when required by procedure, and to identify and track assumptions (either explicit or implied) in the calculations. For example, the tank sizing calculation (11-001-FCAL-002) was marked as no verification required (though the calculation procedure requires verification for safety-related SSC) and did not identify unverified assumptions as requiring follow-up. The pressure drop through the in-line circulation heater (15 feet) is an unverified assumption that will require validation following purchase of the heater; this is identified simply as "engineering judgment" in calculation 11-001-FCAL-002, Revision 1, *Fire Protection Storage Tank.* (See **Finding F-LANL-1.**)

Several unidentified assumptions require verification following construction. For example, the unusable volume of the tank is based on the anti-vortex plate being located 6 inches above the bottom of the tank. Specification 21-4100 (Part 2, Paragraph 2.4B), covering the water tank, requires the vortex plate to be a minimum of 6 inches above the bottom of the tank, but installation of the vortex plate may exceed 6 inches and the as-built configuration requires verification. Similarly, calculation 11-001-FCAL-003, *Fire Protection Water Pump Capacity*, uses piping lengths to determine leakage rate for sizing the jockey pump, and the installed piping will require verification to validate jockey pump sizing. Calculation 11-001-FCAL-001, *Storage Buildings Sprinkler System Hydraulic Analysis*, also uses assumed piping lengths to determine line losses, which will require verification of installed piping to validate required minimum pressure margin and flow requirements in the analysis. (See **Finding F-LANL-1.**)

Independent Oversight also reviewed two calculations related to the FSS electrical support system: 11-001-ECAL-001, *Load Summary*; 11-001-ECAL-012, *Coordination Study* (which supports the determination of electrical independence between the safety and non-safety systems); and one calculation for sizing the diesel generator (11-001-ECAL-014, *Diesel Generator Sizing*). These calculations were revised or prepared during the FSS re-design of the electrical system. The review found that the diesel generator sizing calculation, which describes the freeze protection loads as 20.5 kilowatts, does not match the PDSA Revision 3.1, which describes loading as 18.5 kilowatts for at least 22 hours. Also, the site load in the load summary calculation (a design input for several other electrical calculations, including the coordination study) did not match the load summary on the electrical power one-line diagram. Although the coordination study added analysis of the FSS system while operating on the diesel generator, the analysis of the normal power alignment had not been revised to fully reflect the changes to the electrical system design. TWF Project personnel indicated that several of the electrical calculations will require revision and this issue will be addressed at that time. (See **Finding F-LANL-1.**)

During the review, Independent Oversight noted that the coordination study was identified as requiring independent verification. However, the load calculation also supports safety significant SSC calculations, but was not identified as requiring independent verification as required by procedure. Also, the load calculation does not include a specific assumption relating to the "estimated lighting, mechanical, miscellaneous, and future loads" used in the calculation. (See **Finding F-LANL-1.**)

System Interrelationships

The design drawings and system descriptions associated with PDSA Revision 1 were reviewed to ensure the interfaces between the credited automatic sprinkler systems and other supporting systems (including freeze protection, nitrogen, and the fire alarm system) were consistent with the design basis. DOE-STD-3009 requires that any SSC necessary to ensure the availability of a preventive or mitigative safety class or safety significant SSC shall be likewise classified. Independent Oversight observed that several of the FSS support system interrelationships were not well defined in the supporting documentation, which did not adequately describe the respective system boundaries, system classifications, and functional performance requirements. Example concerns include:

- The safety classification and system boundary of the fire water tank low water level alarm (to the Fire Alarm Control Panel) and the fire pump house low temperature alarm were unclear.
- The (safety-significant) dry pipe fire water supply was not discussed in the PDSA Revision 1 or identified as safety significant on the FSS drawings.
- The piping and instrumentation drawing for the nitrogen system used to inert the safety significant dry pipe fire water supply did not indicate the safety functional classification as safety significant.
- The PDSA Revision 1 did not clarify that the fire water supply system is limited to operation of only one safety-significant pump (used for fire sprinklers) and that the other pump is manually placed in standby and classified as safety-significant for maintaining the system pressure boundary.

All of these concerns were addressed by revising the engineering drawings and the FSS system description in PDSA Revision 2.

Following the re-design of the FSS, a significant interrelationship exists between the electrical distribution system, the FSS diesel generator, and the FSS instrumentation and controls. As shown on the electrical power one-line diagram (C55446-E-6000 Revision 2), the facility electrical system provides power to the electrical fire pumps (through dedicated automatic transfer switches) and to the active support system loads, e.g., the jockey pump. Under the revised design, normal power to the fire pumps will be supplied directly from the output of the TWF utility transformer through breakers to the fire pump controllers, which include reduced voltage starters, automatic transfer switches, and isolation bypass switches. The necessary auxiliary loads (active support system loads) will be supplied from the auxiliary emergency load power panel (power panel-J) and a subordinate power panel. Under normal supply conditions, power panel-J will be supplied by the main Utility Building switchboard (switchboard A) through an automatic transfer switch. When the facility loses power, the diesel generator will supply a power panel (power panel-L) that services the electric fire pump automatic transfer switches and the automatic transfer switch for the auxiliary emergency load power panel.

11-001-TRPT-001, *Design Basis and Approach*, provides a description of the general design of the electrical support to the electric fire pumps. Both electric fire pumps, along with the active support system loads such as building heaters and heat trace, will be connected to a backup diesel generator via automatic transfer switches. To minimize the size of the generator, only one fire pump will be allowed to draw from the generator when the site loses normal power. This will be accomplished through the use of a mechanical (Kirk key) interlock on the breakers from the generator. The design basis includes an appropriate set of codes and standards to govern the design of the electrical subsystem, including NFPA 20 *Standard for the Installation of Stationary Pumps for Fire Protection* and 110 *Standard for Emergency and Standby Power Systems* for the diesel generator.

PDSA Revision 3.1 indicates that the electrical distribution system supports FSS operation with normal power and the diesel generator provides power in the event of loss of offsite power. The FSS instrumentation and control system supports FSS operation and provides alarm indication for the FSS subsystems. In general, the safety functions and performance requirements for these three subsystems are adequately addressed in the PDSA; however, Independent Oversight identified a number of issues, which were provided to the SBRT and TWF Project Team. For example, in PDSA Table 4-16 a performance criterion indicates that the "breakers" shall be safety design criteria (SDC)-2, but does not address a number of other safety significant components, such as the automatic and manual transfer switches. In addition, the Kirk key is identified as a manual switch, but Kirk keys are normally mechanical interlocks and are not capable of performing the PDSA described safety function, which demands that only one fire pump starts during a fire scenario concurrent with a loss of offsite power and prevents the simultaneous connection and use of both fire pumps. (See **OFI-LANL-5.**)

The PDSA Revision 3.1 also discusses the monitoring and alarm system and the associated safety alarm panel and identifies a number of "key switches" (or alarms) in Table 4-15. Although the PDSA discusses the need to maintain power to the freeze protection equipment, it does not identify the alarms that are needed to support continued system monitoring and the alarm panel as required loads for the auxiliary emergency load power panel. TWF design documents also do not address these potential safety-related electrical loads. Finally, PDSA Table 4-16 includes the functional requirements of these subsystems and provides additional information concerning the required subsystem performance criteria, but does not include specific design criteria or codes and standards (such as NFPA 20 and NFPA 110) for these support systems. (See **OFI-LANL-5.**)

5.2.2 Seismic Power Cutoff System

System Design

The overall design approach for the electrical system, which includes the SPCS, is discussed in 11-001-TRPT-001, *Design Basis and Approach*. As with a number of design documents, this document was revised following the initial Independent Oversight review in August 2013. Revision 1, issued in November 2013, discusses the safety class SPCS, which is required to prevent electrical fires following a seismic event by isolating electrical power from the storage buildings, the characterization trailers, and the exterior site lights. The design for the SPCS includes two redundant channels in order to satisfy the single point-of-failure requirement for safety class SSCs. Each channel of the SPCS includes a seismic switch, power cutoff contactor, and an isolation fuse enclosure, which houses the SPCS control circuit. Electrical power for the buildings is supplied through redundant, series power cutoff contactors, which are supplied from a step down transformer attached to the site's utility power system. Each seismic switch includes a seismic sensor, microcontroller and output relays which operate the power cutoff contactor. The branch circuits that supply control power to the seismic switches and power cutoff contactors are commercial grade (non-safety SSCs). The SPCS will be located outside and just north of the Utility Building in weather-tight enclosures supported by concrete inertia blocks and reinforced concrete walls.

A number of appropriate Instrument Society of America (ISA) standards are included in the design basis, but are not identified in the PDSA. The *Design Basis and Approach* includes appropriate electrical and instrumentation design standards for the SPCS, including those for seismic qualification, single failure criteria, independence, and setpoint calculations. In addition, some standards, such as ISA 84.00.01-*Application of Safety Instrumented Systems for the Process Industries,* would be invoked indirectly through the LANL Engineering Standards Manual. (See **OFI-LANL-6.**)

Independent Oversight identified several concerns in PDSA Revision 1 related to the SPCS design and the supporting calculations and analyses (which are discussed below). These issues related to:

- Omission of the functional requirements and performance criteria for the SPCS inertia block, including the coupling of the seismic switch to the ground motion, and for the enclosures housing the control circuits, seismic switch, and contactors.

- Insufficient description and evaluation of the interface and potential interactions between the safety and non-safety portions of the electrical system.

- Lack of documented analysis of the failure modes and effects related to the seismic switch and its microcontroller firmware and software.

- Uncertainty over the design response spectra to be used in designing and evaluating the performance of the SPCS (i.e., incomplete references to the LANL Engineering Standards Manual).

Following the submittal of PDSA Revision 2, review of the implementation of comment resolutions found that many concerns had been satisfactorily resolved, but some of the resolutions were only partially implemented. Subsequent discussions between Independent Oversight and the TWF Project personnel identified an acceptable resolution for each comment.

After the submittal of PDSA Revision 3.1, Independent Oversight conducted a review of the implementation of the agreed upon comment resolutions. Many of the resolutions of the design basis comments were found to be satisfactorily resolved, but some issues were not fully resolved. For example, the interface between the safety and non-safety electrical system is not evaluated sufficiently to establish the electrical independence of the safety class portion of the system. Likewise, the need to develop and identify the safety functions and performance requirements for the SPCS microcontroller software and firmware (as the design progresses) while completing the design and developing the DSA is not discussed. (See **OFI-LANL-5.**)

In addition, the SPCS must function by removing power to the TWF site for an SDC-2 event and must not allow the power cutoff contactors to restore power throughout an SDC-3 event. The discussion of the requirements for the SPCS to operate before a SDC-2 seismic event and remain in "safe mode" through a SDC-3 event is clearer in PDSA Revision 3.1, but references to the design spectra in the LANL Engineering Standards Manual (in Table 4-14) remain either incomplete or incorrect. The first requirement affects the setpoint and control function, while the second affects the design and testing required for seismic qualification. (See **OFI-LANL-5.**)

Supporting Analyses

Independent Oversight reviewed two calculations that were prepared to support the design of the SPCS. One of the calculations was found to appropriately assess the design of the support structure for the seismic switches, while the other calculation to determine the setpoint of the seismic switch was found to have a number of issues. Independent Oversight also reviewed the reliability, availability, maintainability and inspectability (RAMI) analysis and failure modes and effects analysis (FMEA) for the SPCS and identified design-related issues and open items related to each report.

The TWF Project prepared a calculation for the structural design of the support pads and anchorages for the two seismic switches. Review of the SPCS support pad calculation (11-001-SCAL-009) revealed that the foundation is very conservatively designed and, with the cruciform anchorage, the support pad will move responsively with the soil. Walls are included to protect the seismic switch and relay cabinet from wind-generated missiles, and are shown to resist the design basis earthquake and avoid "II/I interactions" with the switch and cabinet. The calculation concludes the pads and anchorages will adequately resist all the expected design loads and resist overturning or sliding under lateral loads. Independent Oversight found no concerns with the calculation.

Independent Oversight reviewed the initial issue of the seismic switch setpoint calculation (11-001-MCAL-010) and identified a number of concerns that adversely impacted its usefulness in establishing the seismic switch setpoint. Subsequently, the calculation was revised (Revision 1). This revision of the calculation recommends a conservative setpoint curve (using a uniformly adjusted version of the vendor's baseline setpoint curve), and resolves significant concerns; however, some issues remain. For example, the calculation does not identify the use of the ASCE 25-97 *Earthquake-Actuated Automatic Gas Shutoff Devices* response curve as representative of the sensor response as an unverified assumption. In addition, the calculation does not include an assumption related to the use of digital attenuation to the seismic sensor output (to preclude false activation), which would ensure the TWF Project action (in the specification) is tracked back to the calculation and the calculation revised, if necessary.

Independent Oversight also identified several process issues associated with the calculation. The calculation is marked "no" for design verification, although the calculation involves the design and purchase of safety class components. Also, the calculation does not discuss or provide the equations that were used to determine the calculated setpoint baseline and "must actuate" curve (i.e., the curve defining the ASCE 25-97 required actuation setpoint) or the method used to adjust the "must actuate" curve at short period. It is difficult to verify how the checker could conduct a "line-by-line" review of the calculation (no alternate calculation was provided). In addition, although the calculation's stated purpose is to support the specification for the seismic switch, the revised specification (26 2931) states (paragraph 2.4.H.1) that the seismic sensor will be "solid-state with tri-axial configuration with vector magnitude triggering from both horizontal and vertical primary and secondary waves," the calculation specifies only the requirements for horizontal motion. (See **Finding F-LANL-1.**)

Independent Oversight reviewed the RAMI analysis report for the SPCS (11-001-TRPT-0008), which was prepared by the TWF Project to evaluate overall system performance and guide design, engineering, and other analyses. Review of Revision 0 of the report resulted in the identification of a number of concerns directed toward improving the technical defensibility and accuracy of the analysis and the subsequent recommendations. These concerns were appropriately addressed in Revision 1 of the report. The RAMI analysis report includes a calculation of the probability of the system to fail to perform its safety function on demand and compares the result to an expectation that the probability of failure is beyond extremely unlikely ($< 1 \times 10^{-6}$). The SPCS system, as designed, does not meet this criterion. Consequently, the report includes recommendations to increase the expected reliability and availability of the system, such as the performance of periodic self-diagnostic tests on the seismic sensor and semi-annual inspection and functional test of the system. These recommendations are referenced in the design and functional requirements for the SPCS in the PDSA and will be finalized during construction.

TWF Project personnel determined that additional analysis should be performed to accurately calculate the reliability and availability of the system and select engineering methods to meet the reliability criteria for the SPCS. The RAMI will be revised to develop technically defensible criteria to assess reliability, address all the active components in the subsystem, appropriately justify the selected failure rates, and recalculate the reliability. Once the steps above are complete, the TWF Project intends to devise a new framework to evaluate the current design (calculated reliability against the revised reliability criteria) and to adjust the design and/or surveillance intervals, as necessary.

The TWF Project prepared an FMEA for the SPCS to confirm through analyses of component level failures that the design meets the single failure criterion of the IEEE Standards 379 and 384 *IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits*. The FMEA results are summarized in discussions of loss of function of a single channel and loss of function in both channels (common cause failures); appropriately many of the anticipated failures result in "safe" failures because of the system's fail safe design. The FMEA also includes a discussion of the critical characteristics of most, though not all, of the SPCS components, including the inertia block, electrical enclosures, seismic switch, and power cutoff contactor. Independent Oversight reviewed the FMEA and provided comments to LANL. The FMEA was not revised, but TWF Project personnel indicated that Independent Oversight comments are to be considered in completing the critical characteristics determinations and commercial grade dedication plan. (See **OFI-LANL-5.**)

System Interrelationships

The SPCS interfaces with the non-safety electrical supply system. The SPCS safety function removes power from the Waste Storage Buildings, Characterization and Waste Storage Building, characterization trailers, and associated exterior lighting in the event of a design basis earthquake. To perform this function, two power cutoff contactors (A and B) are wired in series to the electrical power supply to the buildings, trailers, and associated exterior lighting and provide a way of removing power during a seismic event. The contactors are shown on design drawings, including the electrical one-line drawing for the site (C55443-E-6000), and are inserted in the facility's electrical supply between the main incoming power switchboard (switchboard-A) and the power panel that supplies the buildings, trailers, and lighting (power panel-B).

The SPCS is designed to receive control power from the facility electrical supply system to support its safety function. Following the re-design of the electrical system to support the changes made to the FSS and the standby diesel generator supply, the SPCS control power circuits are to be supplied by power panel 11, which is supplied directly by the non-safety Utility Building main power panel (power panel-A) through a step down transformer.

As previously noted, the design approach for the electrical system is discussed in 11-001-TRPT-001, *Design Basis and Approach*. The electrical design (Section 7) includes a discussion of the SPCS and a brief list of the applicable codes and standards. The abbreviated list of codes does not include IEEE 379 and 384, though both are included in the Code of Record for the project. The design basis and approach for the electrical system states that the isolation fuse enclosure provides the "required separation between the safety and non-safety wiring" for the control power circuits, but does not include a detailed discussion of the methods used to implement IEEE 379 or 384 or discuss the physical separation or electrical isolation (which would require further discussion and justification) of the redundant contactor circuits and main electrical supply. (See **OFI-LANL-6.**)

Independent Oversight review of PDSA Revision 1 resulted in two concerns. The Interface Design paragraph in Section 4 did not describe the system boundaries and interfaces sufficiently to support an understanding of the interactions between the SPCS and site electrical power system (e.g., whether the non-safety system is sufficiently isolated from the safety system). Also, the interconnection of the seismic switch (control power) circuits through the normal and ground lines and the potential effects of short circuits and open circuits on the seismic switch actuation relays was not specifically addressed.

Revision 2 of the PDSA partially addressed the identified concerns; first by expanding the discussion of the control power circuit interface (see PDSA Section 4.2.12.4) to specifically address the fuse isolation device and then by revising the Table 4-15. The revised Table 4-15, Section 4.2.12.3, included performance criteria for "electrically and physically isolated components" with associated design criteria and appropriate references to IEEE 384. However, the system evaluation and interface design discussion did not describe how the electrical isolation would be achieved and implemented in the design or the function of the surge suppressor devices. Although the design drawings indicated that the boundaries of the SPCS are confined to the components on the pad, there was no specific description in the design documents of the surge suppressors or the components that provide electrical isolation in the main power supply circuit and no specific description whether these components perform a safety function.

Revision 3.1 of the PDSA and the accompanying design changes did not address these remaining open issues. For example, the calculations necessary to support this evaluation, such as the load summary and coordination study, have not been revised to address coordination of the main power circuit following the re-design of the system to provide safety significant power to the electric fire pumps. (See **OFI-LANL-5.**)

6.0 CONCLUSIONS

Independent Oversight determined that the safety analysis in the PDSA identified and analyzed an appropriate set of hazards and accidents for the expected operations at the TWF. The hazards analysis considered a suitable range of events, including internal, external, and natural phenomena events. The design basis accidents correctly address accidents that are representative of the types of events identified in the hazard analysis and unique events with specific sets of controls. The analysis was consistent with accepted methods contained in DOE standards and, for the most part, included conservative estimates of the material-at-risk, frequency of the event, and event consequences. The designation of controls appropriately focused on elimination of hazards, design of engineered controls, or use of specific administrative controls, which is consistent with Departmental expectations for hierarchy of controls. Review of PDSA Revision 3.1 showed that actions to resolve Independent Oversight comments on the safety analysis requiring resolution prior to approval of the PDSA had been satisfactorily implemented and that actions to resolve the remaining comments during preparation of the DSA were appropriately identified.

The review of the initial PDSA submittal found that the identification of the safety controls for the prevention and mitigation of the analyzed accidents was generally adequate and the selected safety SSCs appropriate for the required safety functions. However, Independent Oversight and the SBRT identified a number of significant concerns with the identification of the required safety functions and performance criteria for all safety SSCs. In addition, a significant issue item related to the design of the FSS involving selection of the safety significant fire pumps was unresolved. Correction of the review concerns and resolution of the open design item resulted in significant changes to the PDSA and re-design of the FSS and the supporting portion of the electrical distribution system late in the project and led to a further round of revisions following review of the submittals. Review of final PDSA submittal (Revision 3.1) confirmed that the safety analysis adequately identified the required safety functions for the safety SSCs in the review scope. Nevertheless, some areas for improvement in the identification of safety functions and performance requirements remain and the LA-00-LA SER identifies a number of design-related actions to be completed along with resolution of issues in the DSA.

Independent Oversight review of the initial design documentation established that the design solutions for the FSS and SPCS were generally appropriate for the analyzed hazards, but the original design documents and supporting analyses did not fully demonstrate an appropriate level of safety in the design. Independent Oversight identified a number of design-related concerns with the FSS and SPCS designs as described in the PDSA, including a non-conservative fire water storage tank sizing calculation. Technical information that explained the operability for other fire related support systems, including the fire alarm system and dry pipe sprinkler systems, was either missing or incomplete. Following the revisions to the PDSA and re-design of the FSS, a number of the concerns were resolved and the most significant design deficiencies eliminated; but some concerns remain and are identified as issues to be resolved during DSA development. Additional analysis is needed to accurately calculate the reliability and availability of the SPCS to meet PDSA reliability criteria. The alarms, required to support continued monitoring of safety system status, are identified in the PDSA and design documents, but the associated instruments and the alarm panel are not included as required loads for the auxiliary emergency load power panel. Finally, a number of design activities necessary to finalize the design, including revisions to a number of calculations, remain to be completed.

Independent Oversight's initial review of the supporting calculations revealed issues in the technical content of the calculations and the calculation processes, resulting in one broad finding. Most calculations in the initial sample had significant technical errors that adversely affected their conclusions, and several of these had not been independently verified as required by LANL procedures. In addition, Independent Oversight identified a number of examples where assumptions were not specified in the calculation so that they could be captured and tracked to closure as required by LANL procedures. The final calculation(s) reviewed by Independent Oversight were improved and appropriately verified; but a number of calculations remain to be revised or completed. Actions should be taken to re-evaluate and identify the assumptions imbedded in the calculations and establish a method to track them to closure.

Overall, the review revealed issues in the translation of safety functions (identified in the hazard and safety analyses) into a coherent set of safety functions, performance requirements, and design criteria in Chapter 4 of the PDSA. The SER directed actions and the completed actions in revising the PDSA and design provide an acceptable approach under which the PDSA can satisfactorily support continued design, procurement, and construction. The maturity of the design has progressed to a point where procurement of SSCs can begin, and although the proposed designs for the FSS and SPCS are not complete, the designs are acceptable based on commitments to fully meet appropriate safety design criteria in the DSA. Management attention during the procurement and construction phase of the project is warranted to ensure that ongoing engineering activities adequately resolve the remaining open items and ensure the completed SSC design and as-built configurations will support the required safety functions. In addition, LANL management should review the Safety Basis Improvement Plan and confirm that the Plan's corrective actions appropriately address the results of this review and that near term actions support the expectations for safety-in-design for the TWF project. (See **OFI-LANL-7.**)

7.0 FINDINGS

Findings indicate significant deficiencies or safety issues that warrant a high level of attention from management. If left uncorrected, findings could adversely affect the DOE mission, the environment, the safety or health of workers and the public, or national security. Findings may identify aspects of a program that do not meet the intent of DOE policy, DOE orders, or Federal regulation. Corrective action plans must be developed and implemented for Independent Oversight appraisal findings. Cognizant DOE managers must use site- and program-specific issues management processes and systems developed in accordance with DOE Order 227.1 to manage these corrective action plans and track them to completion.

Los Alamos National Laboratory

Finding F-LANL-1: Several engineering calculations contained technical errors and failed to identify and track assumptions used in the calculation, and some calculations were not independently verified, as required by 10 CFR 830 Subpart A, DOE Order 414.1D, and AP-341-605.

8.0 OPPORTUNITIES FOR IMPROVEMENT

As discussed above in the results, this Independent Oversight review identified seven OFIs. These potential enhancements are not intended to be prescriptive or mandatory. Rather, they are suggestions offered by Independent Oversight that may assist site management in implementing best practices, or provide potential solutions to minor issues identified during the conduct of the review. In some cases, OFIs address areas where program or process improvements can be achieved through minimal effort. It is anticipated that these OFIs will be evaluated by the responsible line management organizations and either accepted, rejected, or modified as appropriate, in accordance with site-specific program objectives and priorities.

Los Alamos National Laboratory

OFI -LANL-1: Establish appropriate design inputs and assumptions for the pool fire scenarios at TWF and complete a unique analysis based on the expected drum configurations, fuel spill sizes, and facility operational configuration.

OFI -LANL-2: To ensure that the analysis of flammable combustibles and liquids in the DSA and PFHA are consistent with each other and encompass the full spectrum of potential fires at the facility, perform a combustible loading analysis that is consistent with the controls documented in the PDSA.

OFI -LANL-3: Provide a sequence of operation for the fire protection pumps during normal power operation and during a loss of offsite power, including a description of pump lead/lag setpoints during normal power operation.

OFI -LANL-4: Clarify whether the temperature elements that start the heater loop pump and heater should be safety significant. Alternately, reclassify the heater loop pump and heater as safety significant and credited controls. Also, examine the temperature controls for the fire water tank to ensure that temperature elements have appropriate setpoints and that installed locations are appropriate and have an analytical basis. Reevaluate the safety significant tank temperature alarm elements with regard to their setpoints and location.

OFI -LANL-5: Resolve design related comments on PDSA Revision 3.1 in a timely manner to support procurement and construction.

OFI -LANL-6: Verify that all the design standards applicable to the design of safety systems are appropriately identified in the PDSA, DSA, and project Code of Record and available to the responsible engineers.

OFI -LANL-7: Review and update the LANL Safety Basis Improvement Plan based on identified issues from TWF PDSA review.

9.0 ITEMS FOR FOLLOW-UP

Prior to submittal of the DSA, Independent Oversight will conduct an operational awareness visit to determine the status of the identified open design issues. When the TWF DSA is submitted for review and approval, Independent Oversight will conduct a review of the DSA and implementation of nuclear safety requirements in the final design for active safety SSCs. The operational awareness visit and the DSA review will also assess the closure status of issues associated with the finding and OFIs.

10.0 REFERENCES

Plan for the Independent Oversight Review of the Transuranic Waste Facility Safety Basis and Design Development, May 2013

HSS CRAD 45-59, *Review of Safety Basis Development for the Los Alamos National Laboratory Transuranic Waste Facility*, Revision 0, May 2013

HSS CRAD 45-34, *Fire Protection,* Revision 1, October 2012

DOE Order 420.1B, *Facility Safety*, Chg. 1, April 2010

DOE-STD-1066-99, *Fire Protection Design Criteria*, July 1999

DOE-STD-1189, *Integration of Safety into the Design Process*, March 2008

DOE-STD-3009, *Preparation Guide for U.S. Department of Energy Non-reactor Nuclear Facility Documented Safety Analyses*, CN-3, March 2006

DOE-STD-5506, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*, April 2007

ASCE 25-97, *Earthquake-Actuated Automatic Gas Shutoff Devices*

IEEE 379, *Application of the Single-Failure Criterion to Nuclear Power Generating Safety System*

IEEE 384, *IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits*

IFC – International Fire Code Appendix B Table B105.1 *Fire Flow Requirements for Buildings*

ISA 84.00.01, *Application of Safety Instrumented Systems for the Process Industries*

NFPA 13, *Standard for the Installation of Sprinkler Systems*

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*

NFPA 110, *Standard for Emergency and Standby Power Systems*

Appendix A
Supplemental Information

Dates of Review

Onsite Review: July 29-31, 2013
Offsite PDSA Reviews: August and December 2013, March 2014

Office of Health, Safety and Security Management

Glenn S. Podonsky, Director, Office of Independent Enterprise Assessments
William A. Eckroade, Deputy Director, Office of Independent Enterprise Assessments
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Appendix B
Key Documents Reviewed and Observations

Documents Reviewed

- 102335-ECC-13-63-0000-0008, *Power Cutoff Contactor*, Rev. 0, 5/13
- 102335-T13-00013, Memorandum from TWF Project Manager to Federal Project Director, Subject: *Transuranic Waste Facility (TWF) Project HSS Comment Responses*, 9/23/13
- 102335-T13-00014, Memorandum from TWF Project Manager to Federal Project Director, Subject: *Transuranic Waste Facility (TWF) Project HSS Updated Comment Responses*, 10/21/13
- 102355-ECC-13-63-0000-0003, *Seismic Switch*, Rev. 0, 5/13
- 102355-ECC-13-63-0000-0009, *Isolation Fuse Enclosure*, Rev. 0, 5/13
- 102355-HA-00001, *Preliminary Fire Hazard Analysis for the Transuranic Waste Facility*, Rev. 4, 7/13
- 102355-HA-00001, *Preliminary Fire Hazard Analysis for the Transuranic Waste Facility*, Rev. 5, 12/13
- 102355-PDSA-001, *Preliminary Documented Safety Analysis for the Transuranic Waste Facility*, Revision 1, 7/13
- 102355-PDSA-001, *Preliminary Documented Safety Analysis for the Transuranic Waste Facility*, Revision 2, 12/13
- 102355-PDSA-001, *Preliminary Documented Safety Analysis for the Transuranic Waste Facility*, Revision 3.1, 3/14
- 102355-SDS-00001, *Safety Design Strategy for TWF*, Rev. 5, 11/13 (Unapproved)
- 11-0001-SPEC.001, Section 26 2830, *Enclosed Contactors – Low Voltage*, Rev. 0, no date
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Observations

- Walk down TA-63 TWF Site and Tour TA-54, Area G, nuclear waste management operations