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**DEFENSE NUCLEAR FACILITIES  
SAFETY BOARD**

Washington, DC 20004-2901



June 9, 2021

The Honorable Jennifer Granholm  
Secretary of Energy  
US Department of Energy  
1000 Independence Avenue, SW  
Washington, DC 20585-1000

Dear Secretary Granholm:

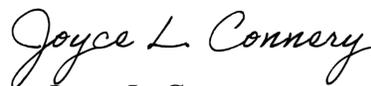
The Defense Nuclear Facilities Safety Board's staff performed a review of the reliability of ten credited safety systems at three facilities at the Los Alamos National Laboratory from October through January 2021. The staff concluded that these safety systems were able to reliably perform their credited safety functions; however, the team identified several safety observations that offer LANL an opportunity to strengthen the implementation of requirements that support safety system reliability.

These safety observations include: (1) evaluating the widespread practice of crediting safety systems with acknowledged vulnerabilities; (2) establishing the periodicity of required safety system design description updates; (3) strengthening the bases for technical safety requirement surveillance frequencies; and (4) improving the content of system health reports.

In addition to these observations, we are concerned with the rigor and level of safety system oversight being performed by the NNSA Los Alamos Field Office due to the lack of qualified safety system oversight personnel.

The enclosed report, provided for your information and use, further describes these opportunities for improvement and discusses additional staff observations on the selected safety systems.

Sincerely,

  
Joyce L. Connery  
Chair

Enclosure

c: Mr. Joe Olencz

# DEFENSE NUCLEAR FACILITIES SAFETY BOARD

## Staff Report

March 11, 2021

### Adequacy of Safety Structures, Systems, and Components Los Alamos National Laboratory

**Summary.** The Defense Nuclear Facilities Safety Board's (Board) staff performed a review of the reliability of ten credited safety systems at three facilities at the Los Alamos National Laboratory (LANL). These systems are listed below, organized by facility:

#### *Plutonium Facility (PF-4)*

1. Criticality Alarm System (CAS)
2. Chlorine Gas Delivery System (CGDS)
3. Electrical Distribution System (EDS)
4. Full-Scale Test Facility System (FSTF)
5. High-Efficiency Particulate Air (HEPA) Filters and Plenums Subsystem
6. Seismic Power Shutoff System (SPOS)

#### *Transuranic Waste Facility (TWF)*

7. Electrical Distribution System (EDS)
8. Seismic Power Cutoff System (SPCS)

#### *Weapons Engineering Tritium Facility (WETF)*

9. Oxygen Monitoring System (OMS)
10. Tritium Gas Handling System (TGHS)

The staff team concluded that these systems were able to reliably perform their credited safety functions; however, the team identified safety observations that offer LANL an opportunity to strengthen the implementation of requirements that support safety system reliability. These safety observations include:

- Evaluating the widespread practice of crediting safety systems with acknowledged vulnerabilities;
- Establishing the periodicity of required safety system design description (SDD) updates;
- Strengthening the bases for technical safety requirement (TSR) surveillance frequencies;
- Improving the content of system health reports (SHR); and

- Increasing federal safety system oversight (SSO) staffing levels.

The attached appendices discuss additional staff observations for each safety system identified during the review.

**Background.** In 2007, the Board conducted a review of the design, functionality, and maintenance of safety systems at LANL. The review identified a number of significant deficiencies, communicated in an October 16, 2007, Board letter [1]. In 2020, the staff performed a similar review with the objectives of evaluating the reliability of safety systems to perform their credited safety functions and the effectiveness of oversight of safety systems by both Triad National Security, LLC (Triad) and the National Nuclear Security Administration (NNSA) Los Alamos Field Office (NA-LA).

The staff selected 10 credited safety systems across three facilities at LANL, focusing primarily on systems that had not been recently reviewed by the Board, as well as two systems that had recently undergone major replacement activities. For each system, the staff reviewed the applicable sections of the documented safety analysis (DSA); the TSRs and their bases; the design of the system, including related drawings, diagrams, calculations, and analyses; and documents related to system maintenance, health, and performance.

In addition to agenda discussions for lines of inquiry developed through review of these documents, the staff held interviews with cognizant system engineers (CSE), discussions with Triad management, and discussions with NA-LA personnel, including SSO specialists. Due to the Covid-19 pandemic, the staff conducted the entirety of the review via teleconferences held in October and November 2020.

**Discussion.** While issues were not identified that would individually impact the ability of the examined systems to perform their specific credited safety functions, there were common issues across multiple systems, which collectively represent opportunities to strengthen the implementation of requirements that support safety system reliability.

*Crediting Safety Systems with Acknowledged Vulnerabilities*—Department of Energy (DOE) Standard 3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*<sup>1</sup>, allows for crediting safety systems with vulnerabilities for existing facilities. Specifically, it states “in cases where the designated SC [safety class] SSC [structures, systems, and components] are not capable of performing their required safety function without significant upgrade (i.e., backfit) other compensatory measures such as material-at-risk limits may be implemented in the facility and incorporated in the DSA” [2].

Two of the safety systems the staff reviewed have acknowledged vulnerabilities concerning their ability to meet their credited and approved performance criteria, specifically the SPOS at PF-4 and the TGHS at WETF. The staff performed a cursory extent of condition review

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<sup>1</sup> While DOE Standard 3009-2014 is the most current revision, the 1994 revision is the safe harbor that was used to develop the current PF-4, TWF, and WETF safety bases.

at WETF and PF-4 and identified an additional 21 systems with acknowledged vulnerabilities concerning their ability to meet their safety functions.

The TGHS is a safety significant control with a functional requirement to maintain containment during and following a Performance Category (PC)-2 seismic event. However, it is not expected to survive a PC-2 seismic event, which is an acknowledged vulnerability in the DSA [3]. As a compensatory measure at WETF, LANL reduced the facility material at risk. The safety basis does not explicitly credit the TGHS to reduce the frequency or mitigate the consequences to the public in the applicable accident scenarios.

The SPOS is designated as a safety class control to reduce the likelihood of a post-seismic fire through shutting down glovebox power in the lab areas in a seismic event. However, in the associated accident analyses for which the system is credited, the system does not provide any risk mitigation (i.e., lowering of consequence or frequency of the accident). DOE has defined performance criteria for safety class systems to ensure reliability in design commensurate with the importance of a safety class function. DOE Standard 3009-94 states that “[i]n determining performance criteria for safety-class SSCs, existing criteria traditionally associated with safety-class designation, such as *single failure criteria*, should be considered in the judgment process [emphasis added]” [2]. The PF-4 DSA acknowledges that the SPOS does not meet single failure criteria, as the 130 volt direct current control supply and the single safety significant breaker connected to each buss duct that provides power both represent single point failures [4]. A loss of the 130 volt direct current control power renders the seismic power shutoff system unable to meet its safety function. In addition, a failure of any one of the eight electrical buss duct circuit breakers can render the seismic power shutoff system unable to fully meet its safety function (to remove all power to the laboratory facilities). Due to these vulnerabilities, acknowledged in the PF-4 DSA, the staff questioned whether the system should be designated as safety class, as this designation implies the existence of redundancy in the design, which would provide a robust level of reliability.

Triad personnel informed the staff team that they decided to classify the system as safety class because they felt this would enhance the reliability of the system through the increased quality assurance measures required by LANL procedures for a safety class system. The staff notes that designating a system as less than safety class would not preclude performing these additional quality assurance activities. The safety basis does not explicitly credit the SPOS to reduce the frequency or mitigate the consequences to the public in the applicable accident scenarios. In addition, given the seismic upgrades and MAR reduction at PF-4, Triad personnel indicated they intend to downgrade the system to “other hazard control” in a future DSA update. This would not affect the calculated dose consequences because the SPOS is not explicitly credited.

While DOE Standard 3009-94 allows the practice of crediting safety systems with acknowledged vulnerabilities, because of the number of safety systems at PF-4 and WETF which do this, there is a need to evaluate how these systems are credited and to weigh the overall safety benefits of crediting multiple systems with known vulnerabilities.

*System Design Description Updates*—An SDD identifies the requirements associated with an SSC, explains the basis for those requirements, and describes the system design [5]. The main purpose of an SDD is “to collect system information to facilitate efficient design, maintenance, operation and training (because personnel will not have to review multiple documents in an effort to locate pertinent information)” [5]. To meet this purpose, SDDs must be kept up to date with changes in relevant documentation (e.g., DSA updates, revisions to calculations) and, more importantly, with changes to system design (e.g., design changes, system upgrades, replacements).

Various DOE directives contain requirements related to updating SDDs. For instance, DOE Order 420.1C states that “system design documents and supporting documents must be identified and *kept current* using formal change control and work control processes [emphasis added]” [6]. DOE Standard 3024-2011, *Content of System Design Descriptions*, states that an SDD “shall be maintained as an authoritative, *up-to-date* source of technical information on the system [emphasis added]” [5]. DOE Standard 1073-2016, *Configuration Management*, states that the CSE should “be responsible for ensuring documents related to the system are complete, accurate, and *up-to-date*, including SDDs [emphasis added]” [7].

Several SDDs had not been updated in years. For instance, SDDs at WETF related to the TGHS were dated 2008 and 2009 and referred to older versions of the safety basis and TSRs. In some cases, the current revision of the SDD was out-of-date with respect to actual implemented design changes. The current revision of the PF-4 EDS SDD incorporates the 2008 DSA and TSRs and does not reflect the current design of the EDS, which includes installation of a new uninterruptible power supply and backup diesel generator [8]. The associated SHRs for the EDS discuss the need to update the SDD. The 2017 SHR states that the SDD “will need to be revised to incorporate changes to the system, including the 480V Breaker Replacement, Bus Duct Breaker Replacement, and the Seismic Upgrades projects. This continues to be a hold over item from previous review periods” [9]. The 2018 and 2019 SHRs both contain the same statement and discuss the need for the SDD to be updated to reflect the replacement of the uninterruptible power supply [10] [11]. Subsequent to the staff’s review, in February 2021, Triad personnel updated the SDD to reflect the current design and safety basis. The staff noted similar issues with the SDD of the WETF OMS and the TWF SPCS (i.e., current design of the system).

Triad personnel and management were familiar with the concern regarding out of date SDDs, and the issue was tracked by the CSEs for several years in the SHRs. WETF management indicated that during vital safety system assessments, conducted every three to five years for each system, the assessment team would note the need for the SDD to be updated and would add it to the issues management system. Despite this tracking in SHRs and the action items from the assessments, Triad did not revise the SDDs. As a result, WETF management made the decision to track the needed revisions via a separate project.

During discussions with the staff, WETF management indicated there may be a need to develop a better set of requirements for updating SDDs, for instance after major system changes, and at least every three years if no major changes to the system occur. PF-4 and TWF management indicated they had revised their design change form in March 2020 to add a requirement to update SDDs prior to close out of the design, or to initiate an action item to do so

in their issues management system. Given the number of out of date SDDs, the staff concludes there is a need to establish a site-wide requirement for updating SDDs at a set periodicity, particularly with regard to completing timely updates following system design changes.

*Bases for Technical Safety Requirement Surveillances*—TSR surveillance requirements are defined as “requirements relating to test, calibration, or inspection to assure that the necessary operability and quality of safety structures, systems, and components is maintained; that facility operation is within safety limits; and that limiting control settings and limiting conditions for operation are met” [12]. These requirements are done on a set periodicity or frequency. DOE Guide 423.1-1B, *Implementation Guide for Use in Developing Technical Safety Requirements*, offers the following guidance for what surveillance requirement frequencies should be based on: “specific DSA assumptions, national and international codes, standards, and guides, reliability analyses, failure modes and effects analyses, instrumentation/equipment uncertainty analyses, manufacturer documentation, information from operating history, or engineering judgment” [13].

In reviewing the PF-4 FSTF surveillance requirement bases, the staff found the frequencies were based largely on operational experience. For instance, the bases of surveillance requirement 4.4.1.5, a requirement for an annual calibration of each flammable gas detector, states “[t]he frequency of annually is adequate based on operational experience and instrument drift,” with no further description [14]. In discussions with Triad personnel, the staff requested documentation on the operational experience referred to in the bases for all the FSTF surveillance frequencies to independently evaluate whether the operational experience supported the frequencies. However, Triad personnel informed the staff that the operational experience is not formally documented, and because the bases were written prior to current personnel employment, they were unable to speak to what operational experience was being referred to in the bases.

The staff performed an extent of condition review of the bases of all TSR surveillance requirements at PF-4, TWF, and WETF, and found that more than a third were based solely on operational experience or analyst judgment. Basing frequencies on operating history or engineering judgment is permissible, as discussed in Guide 423.1-1B, and can be effective. However, the lack of explanatory detail in the TSR bases on precisely what operational experience a frequency was based on, or the technical basis of the analyst judgment, impacts the ability of facility personnel to fully understand the reason for a selected frequency or determine the appropriateness of the frequency. Further, surveillance requirements are occasionally extended, and the lack of detail impedes the ability of personnel to analyze the impacts and appropriateness of proposed frequency extensions. Therefore, the staff concludes that adding supporting detail and data regarding operating experience and analyst judgment would improve the utility of TSR bases.

*System Health Reporting*—As part of the CSE program, DOE Order 420.1C requires CSEs to perform system assessments that must include “periodic reviews of system operability, reliability, and material condition” [6]. These reviews must assess the system for its “ability to perform design and safety functions; physical configuration as compared to system documentation; and system and component performance in comparison to established performance criteria” [6]. LANL utilizes SHRs in part to meet these requirements, and the content of SHRs is defined in the Triad procedure AP-341-802, *System Health Reporting*. The

procedure notes that the SHR aids the CSE and facility management in “developing an effective maintenance strategy... and efficient use of resources to mitigate the effects of material degradation and equipment obsolescence” [15]. During interviews with CSEs, they indicated their primary formal mechanism to document long-term concerns with the reliability of their systems was through the SHRs.

Per AP-341-802, SHR metrics are based on trends, rather than specific thresholds. The staff questioned the utility of this practice, as trends can mask unacceptable performance. The staff found several examples where this appeared to be the case. For instance, the PF-4 heating, ventilation, and air conditioning SHR reported a “stable” trend for “hundreds” of equipment/components reaching the end of their life or becoming obsolete and had strong language on the negative impact on the effect of obsolescence on the reliability of the system [16]. As another example, the PF-4 EDS SHR reported an “improving” trend for the parameter on corrective maintenance performed. However, the total number of open corrective maintenance actions had increased from 49 to 117 [17]. Finally, the TGHS SHR has a parameter for the “number of unincorporated pending changes” against the SDD [18]. It is reported as “3”, with a note that “3 indicates there are 3 SDDs associated with the TGHS” [18]. This has been stable since at least the fiscal year 2014 reporting period. However, as discussed earlier in this report, this metric represents SDDs which have not been updated for more than 10 years.

Based on these examples, there is an opportunity for improvement of the quality of SHRs at LANL. Metrics could be developed that are based on system specific absolute thresholds defining acceptable and unacceptable performance, rather than trends from one reporting period to another. This would prevent masking unacceptable performance over multiple reporting periods with a trend of “stable” or “improving.”

Per AP-341-802, an overall SHR rating of acceptable, marginal, or unacceptable is assigned for each system. An unacceptable rating is assigned if the system is not operable, while a marginal rating would indicate “significant deficiencies that need to be corrected,” such as “degraded or obsolete components,” “adverse trends for important parameters,” or “negative operability or availability trends” [15]. The vast majority of the SHRs reviewed by the team had an overall rating of acceptable. The staff found examples where the rating of acceptable did not reflect the data or narrative within the report. For example, the CGDS SHR, for the reporting period September 2018 through August 2019, had an overall rating of acceptable despite the fact that three of the four trends in the system operability section were degrading, the system availability was only 23 percent for the reporting period, and the system performance discussion indicated that concerns had been raised about the age of the system [19]. Additionally, the system was replaced in the following reporting period. As another example, the TGHS SHR, for the reporting period January 2018 through December 2018, had an overall rating of acceptable despite declining trends in operability and availability, with a declining trend in the number of facility service requests, and the majority of the remaining indicators either stable or declining [20].

Additionally, the staff noted inconsistencies between major system replacements and upgrades, and the overall health rating of the system in associated SHRs. System replacements and upgrades are typically planned and executed for systems with unreliable performance or

where there is a concern that, due to age or degradation, system performance would be impacted going forward. The goal of SHRs is to document a concern with long-term system performance. Thus, there should be a link between a rating of marginal or unacceptable and major system upgrades and replacements. However, the SHRs the staff reviewed did not reflect this.

As discussed above, Triad recently replaced the CGDS, and while the data and narrative in the SHRs prior to the replacement indicated reliability concerns, the overall rating was acceptable [19]. As another example, the CAS was also recently replaced. However, the SHRs prior to the replacement had ratings of acceptable, and the metrics within the report indicated reliable performance [21] [22]. Additionally, the SHRs for the OMS reviewed by the team contained discussion that WETF “continues to pursue an upgrade or redesign of the OMS,” despite the fact that the metrics indicated reliable performance, and the rating of the system was acceptable [23]. In discussions with the staff, Triad personnel indicated this project was a very low priority, and they were satisfied with the performance of the OMS. The staff believes there is an opportunity to reconsider overall system health ratings to better inform facility management in decisions related to prioritization of replacement and upgrade projects for safety systems.

*Field Office Safety System Oversight Staffing*—Currently, NA-LA lacks a sufficient number of fully qualified safety system oversight personnel. As of November 2020, there were two fully qualified SSO specialists, with two additional in training. The last analysis of the federal technical capabilities program staffing for NA-LA was performed in 2015 and identified the need for four SSO specialists.

DOE Order 426.1A, *Federal Technical Capability*, contained an appendix that outlined the duties and responsibilities of SSO specialists [24]. The responsibilities of SSO specialists given in the appendix included requirements for oversight of the areas discussed in this report where the staff identified concerns. In March 2020, DOE released a revision to this order which removed the appendix, with a note that a functional area qualification standard was being developed to capture these items [25].

For instance, the order stated that SSO specialists were to “confirm configuration documentation, procedures, and other sources of controlling information are current and accurate,” which would encompass the out-of-date SDDs noted by the staff [24]. As another example, the appendix discussed the responsibility of SSO specialists to review SHRs. The appendix also stated that SSO personnel were to “maintain communication and oversight of systems and monitor performance of the contractor’s” CSE program [24]. During the review, CSEs indicated that they primarily interfaced with facility representatives, rather than SSO personnel.

In discussing performance of these SSO duties and responsibilities, NA-LA indicated that due to the lack of qualified personnel, its oversight was mostly “ad-hoc,” and it did not cover all of these items. As a result, the staff concluded federal oversight of Triad’s CSE program is incomplete. NA-LA management indicated it intends to increase oversight as additional engineers complete SSO qualifications.

**Conclusion.** The staff evaluated the reliability of 10 credited safety systems at three LANL facilities. The staff concluded that these systems were able to reliably perform their credited safety functions. The staff identified several safety observations that, if addressed by Triad and NA-LA, would result in improvements to the implementation of requirements that support safety system reliability and the overall reliability of safety systems at LANL.

## Appendix A: Staff Observations on Safety Systems at the Plutonium Facility

The Defense Nuclear Facilities Safety Board's (Board) staff reviewed six safety-related systems at the Plutonium Facility (PF-4) as part of its review. Staff observations on each of these systems are provided below.

**Criticality Alarm System.** The criticality alarm system (CAS) is a safety significant control in the PF-4. The PF-4 documented safety analysis (DSA) [4] credits the CAS to mitigate radiological dose to workers by detecting high intensity radiation and providing an evacuation alarm signal to the emergency paging system. The CAS system design description (SDD) [26] states the CAS performs its safety function by monitoring all activities with fissionable materials on the main floor, in the basement, and vault. The CAS uses three parallel ring circuits comprising 35 detector clusters with three detectors in each cluster (one per ring circuit per cluster). The system uses a two-out-of-three logic, so that any two tripped detectors on different ring circuits or two different tripped detectors in the same cluster trigger a criticality alarm. Los Alamos National Laboratory (LANL) replaced the previous obsolete system with the current CAS in April 2017. The review team identified the following observations from its review of the CAS:

- *Discrepancy between DSA and CAS SDD*—The PF-4 DSA states that the CAS will initiate the evacuation alarm when “one or more detectors from at least two rings” are triggered [4]. The CAS SDD states that the system will generate an alarm and emergency evacuation signal when “the radiation levels exceed an alarm threshold at two or more detectors on at least two out of three ring circuits” [26]. Triad personnel indicated that the DSA provided a more clear description than the SDD. The review team notes that the SDD has not been updated since November 2017 and that the language in the SDD can be improved and made consistent with the DSA.
- *Measuring Decibel Level of CAS Alarm*—American National Standards Institute (ANSI)/American Nuclear Society (ANS) 8.3, *Criticality Accident Alarm Systems*, recommends a minimum decibel level for the audible alarm of the CAS [27]. Specifically, it states, “The audio generators should produce an overall sound pressure level of at least 75 dB, but not less than 10 dB above the maximum ambient noise level typical of each area for which audio coverage is to be provided.” While not required in the PF-4 technical safety requirements (TSR) [28] or standard test procedures [29] [30], the cognizant system engineer (CSE) for the CAS will occasionally measure the decibel level during the periodic test of the CAS. From their measurements, the CSE has found that the alarm meets the ANSI/ANS recommendation. Triad personnel indicated that they will consider including this recommendation as a step in the procedures for the periodic test.
- *Planned Improvement for CAS*—Triad has several efforts planned to improve the CAS and the supporting site public address system. These projects include replacing all of the detectors for the CAS (as required every five years per the TSR), replacing the batteries for the CAS internal uninterruptible power supply (UPS) system with

longer lasting batteries, replacing the rack for the site public address system, and replacing degrading speakers.

In addition to these observations, the review team also discussed the life expectancy of the detectors, internal UPSs, and CAS coverage in PF-4 with Triad.

*Life Expectancy of CAS Detectors*—The rated life expectancy of the CAS detectors is five to ten years. The life expectancy for the detector is determined in a Pajarito Scientific Corporation (the manufacturer of the detectors) calculation [31], which notes that the life expectancy is dependent on how many pulses are produced over time (due to the installed source and background radiation field) in the Geiger-Müller tube. This calculation supports the basis for the TSR surveillance requirement to replace each individual detector for the CAS every five years.

From its assessment of the system health reports for the CAS, the review team found five instances where detectors were replaced prior to five years. The review team noted that all of the detectors with fault alarms were located in the basement or vault, which is where radioactive waste and material are staged for extended periods of time. The gamma and neutron background radiation is typically higher in the vault locations than the first floor of PF-4.

Pajarito Science Corporation performed radiation tolerance testing on detectors using short bursts of high gamma and neutron radiation, but they did not study the effects of long exposures to slightly elevated radiation levels [32]. Of the detectors that needed to be replaced, Triad noted that only CAS-RE-18D-C had a failed Geiger-Müller tube [33]. Triad stated that it is expected that a Geiger-Müller tube, in a batch of over 100 detectors procured, would experience failure.

As for the remaining detectors, Triad could not explain why CAS-RE-18D-A failed. The diagnostic report for this detector indicated no issues with the internal circuitry or Geiger-Müller tube [33]. For clusters CAS-RE-3A and CAS-RE-3C, the fault alarms resulted when performing a test on a detector in a different cluster and location. Triad stated that after a detector trips during the periodic test of the system, all of the detectors in the same ring circuit will also trip. Triad noted that time is needed for the detectors to reinitialize and clear the fault alarm. Triad stated that all of the identified fault alarms were due to not allowing sufficient time to pass before proceeding with the test. Based on all of this information, the review team determined that there is not sufficient data to conclude that the background radiation in the vault or basement contributes to detectors failing in less than five years.

*CAS Internal Uninterruptible Power Supply*—The CAS contains two internal direct current (DC) UPS systems, DC-UPS-A and DC-UPS-B. If power is lost to the CAS, the internal UPS will continue to power the CAS for 10 hours (in quiescent) and 15 minutes (in alarm). Each internal UPS contains its own battery pack. The CAS SDD states, “every two years the CAS DC-UPS batteries will be replaced as needed.” From its assessment of the system health reports for the CAS, the review team found three instances where the batteries needed to be replaced earlier than two years.

For the instance in January 2018, Triad noted that this was the first time LANL personnel performed preventive maintenance for the new CAS. Triad stated that while the system had only been in-service for less than a year, the batteries had to go through testing and were likely over two years old. Since this event, Triad safety basis personnel revised the PF-4 TSR to include a quarterly surveillance requirement to verify that one of the UPS systems supplying the CAS has an internal voltage greater than 46 volts direct current. The review team concludes that this surveillance requirement is sufficient for monitoring the health of the internal UPS batteries.

*CAS Coverage*—In 2018, LANL safety basis personnel revised the PF-4 TSR and changed the completion time to restore one detector when two out of three detectors in a cluster are declared inoperable from immediately to 14 days. Triad concluded that 14 days is acceptable and conservative given the low likelihood of a criticality accident and the overlapping coverage of adjacent detector clusters. However, the TSR at that time did not include a condition for multiple clusters having inoperable detectors.

On August 12, 2020, Triad declared a potential inadequacy of the safety analysis (PISA) related to a condition when two detectors in a cluster are inoperable and an adjacent cluster also has two inoperable detectors. As a result of the PISA, Triad submitted a revision to the TSR in October 2020 [14]. The revision includes a new condition and actions for this specific scenario. The TSR now requires Triad to immediately restore one detector in each affected cluster to operable or place one inoperable detector's ring circuit in each affected cluster in a tripped condition. In addition, Triad is required to transition to Mode 2 within two hours and not move material at risk into the applicable affected area(s). The review team agrees that these changes should allow the CAS to provide sufficient coverage and ensure that appropriate steps will be taken if certain conditions arise.

**Chlorine Gas Delivery System.** The chlorine gas delivery system (CGDS) is a newly designed safety significant system intended to replace the aging delivery system. CGDS consists of chlorine gas piping, valve manifolds, fittings, and couplings that deliver chlorine gas used in pyrochemical metal preparation processes. The PF-4 DSA credits the integrity of the CGDS to prevent leakage by providing confinement, as well as mitigate a potential leak by limiting the rate of flow of chlorine gas [4]. Two Department of Transportation-certified cylinders that contain up to 80 pounds of chlorine supply the gas to the system. These cylinders are located outside the PF-4 confinement boundary. The Chlorine Detection System (CDS) is installed in the same rooms as the CGDS for detecting and providing an alarm in the event of a chlorine gas leak. The safety basis does not credit the CDS for mitigating a chlorine leak from the CGDS components but classifies it as a contributor to the overall defense-in-depth strategy. The review team identified the following observations from its review of the CGDS.

*DSA Improvements*—There are some opportunities for improving the safety basis for the CGDS. The hazard evaluation assigns beyond extremely unlikely frequency to maintenance event MAINT-3-004c, in which a maintenance error results in the failure to install the restricted flow orifices (RFO). This hazard evaluation is not appropriate for events initiated by a human error [4]. Triad personnel indicated they may adjust the frequency during the DSA update. Additionally, the safety basis credits the RFO in the chlorine supply cylinders to mitigate the potential leak size. The gas supplier installs RFOs before delivering the cylinders to PF-4, and

PF-4 personnel verify the installation upon receipt via a TSR-level inspection. The description of the maintenance event in the hazard evaluation erroneously implies that RFOs may be removed and reinstalled.

*TSR In-Service Inspection*—The current TSR surveillance requirements identify an in-service inspection (ISI) requirement to visually inspect the CGDS components for signs of wear and degradation on an annual basis [28]. Triad personnel also normally perform a pressure test to demonstrate that the system is leak tight and provides confinement (i.e., able to perform its safety function) [34]. In cases where a partial ISI is performed (e.g., receipt of a bottle) the pressure test would not be completed. It may be more appropriate to credit the pressure test, as well as the visual inspection, in the TSR rather than just the visual inspection.

*Chlorine Detection System*—When the CDS detects 0.5 ppm of chlorine gas, it initiates the valves to isolate the chlorine supply, activates the evacuation alarm, and sends a warning signal to notify the TA-55 Operations Center personnel of a chlorine leak. The safety basis does not credit the CDS to mitigate a leak from CGDS components; rather it relies on the CGDS design for prevention and mitigation of leaks [4]. Triad personnel performed an analysis showing that, during a postulated pipe break, RFOs (with a functioning PF-4 ventilation system) greatly reduce the gas flow and prevent reaching the lowest lethal concentration of 430 ppm in the lab room [35]. The analysis also showed that it would take about five hours to reach the maximum chlorine concentration of about 400 ppm. Hence, it is reasonable to rely on RFOs for mitigating a chlorine leak. The odor threshold for chlorine in air is 0.2–0.4 ppm, whereas signs of irritation such as burning eyes, scratchy throat, and coughing would manifest themselves at 1 ppm. Therefore, a facility worker would be able to identify a chlorine leak well before it approached a lethal concentration.

**Electrical Distribution System.** The safety significant electrical distribution system (EDS) is credited to support the ventilation system, instrument air system compressors, the UPS, the site public address system, and the fire suppression system during normal operations and after a seismic event. The EDS includes equipment for both a primary configuration (normal power) and a secondary configuration (backup power), with additional redundant power equipment to manually modify either for common maintenance activities. The boundary of the system was recently expanded with the installation of the new safety significant UPS and uncredited backup diesel generator. The review team noted that all automated switching equipment is now within the boundary of the EDS, a significant improvement over previous revisions of the system.

*Age of EDS Equipment*—The majority of the EDS is original to the 1970s construction of PF-4 and therefore is at or approaching the end of its designed service life. As such, long-term reliability will become increasingly difficult to ensure due to the decreased availability of viable spare parts. Fortunately, the EDS does have several advantages that have contributed to its long operational life and reduce any immediate age-related concerns. Its components are almost entirely installed in clean, climate-controlled facilities, and the majority of electrical equipment is lightly loaded during normal operations (typically less than 50 percent of its prorated capacity). As such, as documented in the fiscal year 2019 system health report (SHR), the system continues to operate with essentially 100 percent availability [17].

However, while those positives are significant, the system is showing signs of its age. For example, during the most recent preventive maintenance cycle, an increasing number of minor/moderate corrective actions were identified. While none were significant enough to impact normal operation, there were more identified than could be corrected during the scheduled maintenance. In addition, obsolescence of both the existing power breakers and the motor control centers have led the contractor to go to extraordinary lengths to procure replacement and spare units. Triad personnel indicated they have been able to procure enough critical spare components to continue normal system operations until long-term replacement projects can be implemented.

The SHR does discuss equipment obsolescence and eventual replacement, but this analysis is buried in the body of the report with language that has been largely unchanged over the past three annual SHRs reviewed by the staff. During the interactions, both contractor management and the EDS CSE spoke clearly of the need to replace key EDS components through two large design and construction projects already in planning to ensure long-term system reliability.

While there do not appear to be any imminent age-related concerns with the EDS, the review team concludes that, given the age of the system, it would be beneficial for the CSE and Triad management to better document the aging management plan to maintain the health of the EDS going forward. As the most recent preventive maintenance cycle identified significantly more corrective actions than previous activities, the CSE may also need to reevaluate the periodicity of EDS preventive maintenance in the interim, especially considering the concerns documented with the age of some components.

*System Operability and Configuration Control*—The EDS does not have any specific performance criteria captured in the facility DSA [4]. As it is a support system for multiple active controls, the EDS functions are covered by the performance criteria for those controls. Therefore, the EDS does not have its own limiting condition of operation (LCO) statement in the TSRs [14]. Instead changes to the availability of the EDS would be evaluated for any impacts of the operability of the supported systems, and if necessary, LCO conditions for the supported systems would be entered. This is a common practice across the complex at many facilities. The EDS has significant redundancy built into the design that allows the facility to isolate sections of the system, while still providing sufficient power to the credited loads. This is a significant benefit as it allows personnel to perform some maintenance activities on the EDS without any impact to the operability of the supported systems. Additionally, the normal configuration of the EDS (illustrated in Figure 4-9 of the DSA [4]) is designed to allow all EDS equipment to operate at a lower power level (typically less than 50 percent) and provides alternate pathways if any equipment were to fail. This normal configuration design improves the reliability of the EDS, and thus, the reliability of the supported systems.

However, because changes can be made to the EDS normal configuration for maintenance activities without impacting supported systems and without entering any LCO conditions, there is a potential for the normal configuration of the EDS to not be restored after maintenance. Therefore, adding an LCO statement, with associated surveillance requirements,

that governs just the availability of the EDS would ensure that normal configuration (i.e., the additional reliability of the system) is maintained following maintenance activities or equipment degradation that does not impact the operability of supported systems. The review team understands that normal configuration of the EDS is currently maintained through normal maintenance practices and procedures (e.g., procedures following maintenance activities to restore the system). Nevertheless, an EDS-specific LCO statement would provide an additional mechanism to understand and govern the availability of the EDS.

*System Boundary*—The EDS boundary now includes all the automated switching equipment capable of transitioning credited loads between normal and backup power. This represents a significant improvement; however, the normal source of power (the grid) and the backup power source (the diesel generator) are not included within the system boundary. Following a seismic event, the EDS is expected to survive, but the grid and the backup diesel generator are not. The EDS-supported loads are designed to be able to perform their safety functions following a loss of power from the EDS. However, per Department of Energy (DOE) Standard 3009-2014, a control could be elevated to safety significant if it provides a “significant contribution to defense in depth” [36]. The review team concludes that including the new diesel generator within the EDS boundary warrants consideration, as it would offer a significant contribution to defense in depth, namely, continuing to provide power to the EDS-supported loads following an event which results in a loss of power from the grid.

**Full-Scale Test Facility Design Features.** The full-scale test facility (FSTF) is a safety significant system used for hydride compatibility tests of pits under simulated conditions. It includes the glovebox/reaction chamber, the chamber vacuum pump, the gas cabinet, the calibrated volume, the piping and fittings, the manual and automatic isolation valves, the hydrogen gas detector, the flammable gas control system, and the data acquisition/process control system. The PF-4 DSA credits the design features of the FSTF to prevent and mitigate the inadvertent release of radioactive material [4]. The reaction chamber provides primary confinement. The manual isolation valves prevent the transfer of hydrogen gas beyond the specified quantity, i.e., the calibrated volume. The automatic isolation valve is interlocked with the hydrogen gas detector and shuts off hydrogen gas flow to prevent a flammable concentration from developing in the gas cabinet in the event of a hydrogen leak. The pressure boundary associated with the piping and fittings inside the reaction chamber provide primary confinement of hydrogen gas when the test unit is in the reaction chamber. Hydrogen gas may be delivered to the experiment from a reservoir that simulates field conditions and has a limited volume. Another hydrogen gas source is from the flammable gas control system. In this case, hydrogen gas is routed from the gas cabinet into the intermediate vessels, i.e., calibrated volume, and then into the reaction chamber.

*Flammable Gas Control System*—The Flammable Gas Control System (FGCS) portion of the system has been out of service since late 2017, due to the need to replace the hydrogen gas control monitor. In reviewing the SHRs, the review team found that the monitor replacement has been delayed [37]. Programmatic testing utilizing the FSTF has continued during this time period, and the associated LCO 3.4.1 indicates this is permissible, as the condition requiring an operable flammable gas detector is only applicable if the lower flammability limit can be exceeded in the gas cabinet [28]. Nevertheless, operating for years with a portion of a safety

system out of service is not ideal. In response to this observation, Triad personnel described the FGCS as a “research and development programmatic vital safety system,” which is subject to, among other things, the needs of the program that operates it. Triad personnel further indicated that the monitor replacement would have received higher priority if the operating group had not been able to conduct its experiments without the FGCS.

*DSA Improvements*—The staff team identified an opportunity for improving the safety basis for the FSTF. The safety basis appendix states that the annual probability of a deflagration in the reaction chamber is 1E-10 per year [4]. This value is based on the results of a fault tree analysis that uses input parameters that lack adequate technical basis (e.g., a probability of 0.1 for the presence of ignition sources). Triad personnel stated that none of these values have been utilized in the FSTF hazard evaluations or control selection. Hence, the appendix includes unnecessary information that does not have adequate technical basis and may lead to misinterpretation of the safety basis. The staff team believes this information should be removed or corrected.

**HEPA Filters and Plenums Subsystem.** The high-efficiency particulate air (HEPA) filters and associated plenums form a part of the safety class passive confinement barrier for the facility and contain 22 safety class HEPA filter housings. The safety function of the confinement system is to mitigate the release of radioactive material to the environment, which is met by providing a controlled filtered pathway for release of air from the facility. In-place efficiency of HEPA filter plenums is required to be the equivalent of 99.95 percent or better, which is verified on the installation of new HEPA filters and tested every two years as a TSR surveillance requirement. The review team evaluated the HEPA filter plenum test procedures and test results for the latest installation of HEPA filters and the most recent periodic HEPA filter test. The results show that HEPA filters exceed performance requirements. The installation test data also provided evidence that LANL is meeting the recommended service life of 10 years for HEPA filters. Additionally, differential pressure across filter stages is required to be maintained at less than two inches water column, which is monitored daily during facility operator rounds as a TSR surveillance requirement.

*SHR Tracking of In-Service Inspections*—An annual ISI of the HEPA housings and associated plenums is required to ensure that the supply and exhaust ductwork from the plenums to the structure remain a functional confinement barrier during and after a basement fire. The SHR documents the results of these annual inspections; however, the results from the safety class and safety significant portions of the system were combined. This resulted in the appearance of a significant number of inspection findings that were being carried year to year, without clearly identifying that these findings did not adversely impact the safety class function of the system. In discussions with the CSE, the CSE noted that inspections did not identify any deficiencies that would impact the safety class confinement boundary; however, the CSE agreed that improvements to how the information is presented in the SHR would be useful for independent reviewers.

*HEPA Filter Inspection Programs*—Triad does not have a documented HEPA filter life program consistent with the confinement ventilation system design and performance criteria table in Appendix A of DOE Guide 420.1-1A, *Nonreactor Nuclear Safety Design Guide for Use*

with DOE O 420.1C, *Facility Safety*. However, the CSE stated that Triad follows the recommendations of the filter life program in DOE Handbook 1169, *Nuclear Air Cleaning Handbook*, and a review of the testing data validated that these recommendations are met. The HEPA filter receipt inspection procedure provides detailed instructions that meet the recommended inspection criteria of DOE Standard 3025, *Quality Assurance Inspection and Testing of HEPA Filters*. However, Triad does not have a specific procedure for the inspection of level B storage areas consistent with Nuclear Quality Assurance (NQA)-1, *Quality Assurance Requirements for Nuclear Facility Applications*. NQA-1 is invoked by American Society of Mechanical Engineers (ASME) AG-1, *Code for Nuclear Air and Gas Treatment*, and DOE Standard 3020, *Specification for HEPA Filters Used by DOE Contractors*, which include specific storage requirements for HEPA filters. Triad personnel stated that individuals who conduct the inspections are knowledgeable of the storage requirements and appropriately note any deficiencies. Therefore, while some of the HEPA filter inspection programs are not documented, the personnel responsible for program implementation demonstrated knowledge of the detail and purpose of the guidance in DOE directives and consensus standards during discussions with the review team.

**Seismic Power Shutoff System.** The DSA identifies the seismic power shutoff system (SPOS) as a safety class system with a safety function of mitigating the potential for post-seismic fire by shutting down glovebox power in the laboratory areas in the event of a seismic event [4]. The SPOS consists of two trip channels (or trains), one in each half of PF-4 (north and south). Each trip channel consists of three tri-axial seismic detectors. These seismic detectors are arranged using relay logic to produce a trip output signal when any two of the three seismic detectors have determined that a seismic event is in progress. The use of a two out of three logic permits the safety function to not be inhibited by a failure of a single seismic detector. It also permits operation with a single seismic detector out of service by latching the output of the failed seismic detector to a trip state, thereby converting the seismic detector trip logic from a two out of three configuration to a one out of two configuration, maintaining single failure criteria for the seismic detectors.

The output of the relay trip logic is provided to four trip solenoids that open buss duct circuit breakers that feed utilities and gloveboxes in half of the PF-4 laboratory facilities. This output signal is the application of 130 volts direct current (VDC) control power to each trip solenoid. To successfully meet its safety function, the SPOS must remove all power to the laboratory facilities, requiring each of the four electrical buss duct circuit breakers in the north half of PF-4 and each of the four electrical buss duct circuit breakers in the south half of PF-4 to open. The DSA also discusses an enable/disable key switch for each channel (north/south half) of PF-4. When in the disable position, the 130 VDC control power is removed, thus removing the capability for the relay trip logic to effect a power shutdown of the respective laboratory loads. This feature allows maintenance on each channel without the possibility of inadvertently removing power to the loads.

*Initial Functional Test*—Recommendation 2009-2, *Los Alamos National Laboratory Plutonium Facility Seismic Safety*, identified the need to reduce the risk posed by a seismic event at PF-4. On April 29, 2011, DOE notified the Board that Deliverable 5.4.3 of the implementation plan had been completed. An attachment to this completion letter noted that the

installation of the automatic seismic shutdown capability was complete and had passed functional testing [38]. A review of the individual test steps listed in these pages revealed that one set of tests was not included in the test instructions. Therefore, while all of the listed steps and verifications were properly and satisfactorily completed, the test did not completely satisfy its overall goal of confirming that any two of the three seismic switches will trip all required bus duct breakers. Later routine surveillance testing did confirm satisfactory performance of the scenarios that were missed.

## **Appendix B: Staff Observations on Safety Systems at the Transuranic Waste Facility**

The Defense Nuclear Facilities Safety Board's (Board) staff reviewed two safety-related systems at the Transuranic Waste Facility (TWF) as part of its review. Staff observations on each of these systems are provided below.

**Electrical Distribution System.** The safety significant electrical distribution system (EDS) at TWF is the small subset of electrical power equipment necessary to provide energy to the in-service fire water pump, which is part of the safety significant fire suppression system (FSS). The FSS is not credited to perform its safety function during or after a natural phenomenon hazard event (e.g., earthquake), and neither is the EDS.

*Upgrading EDS to Support the Fire Suppression System*—All physical modifications (as applicable) needed to upgrade the FSS and EDS to safety significant have been completed, as well as most of the critical paperwork. Therefore, the review team's conclusions were formed based on the implementation of the systems as documented in the current TWF documented safety analysis (DSA). While the boundary of the credited EDS is very narrow, it does appear to meet the key requirements described in Department of Energy (DOE) Order 420.1C for credited support systems. However, much like the more complicated PF-4 EDS, the system is designed to deliver energy from two uncredited sources, the electrical grid (normal power) and a general service diesel generator (backup power). Given that no single accident scenario appears to disable normal electrical power while starting a fire in the facility, this boundary is consistent with DOE Order 420.1C. However, the review team notes that crediting the backup diesel as part of the EDS would provide increased system reliability and defense in depth for numerous accident scenarios.

The review team also noted that the boundary and specific components of the EDS are now captured in the updated FSS system design description, and as such, the FSS cognizant system engineer (CSE) is responsible for both the EDS and FSS. While not a concern given the simplicity of the electrical components, responsibility for such electrical power components are typically outside the duty of a fire protection engineer. The FSS CSE acknowledged this concern, but discussed that the TWF engineering team has sufficient electrical expertise to support the system

**Seismic Power Cutoff System.** The seismic power cutoff system (SPCS) is a safety class system designed to isolate electrical power to the TWF waste storage area to minimize the likelihood of an electrically induced fire during a significant seismic event [39]. It consists of two independent and redundant channels (or trains) of equipment, each capable of performing the safety function. Each channel includes solid state, tri-axial seismic sensors, threshold detection logic, automatic test circuitry, and an electrical contractor that opens when the measured seismic motion exceeds a specified set point. The two electrical contractors are connected in series such that the electrical loads of the TWF waste storage area are de-energized when a significant seismic event is detected by either of the two trains. The design includes

provisions for bypassing either of the two trains, under a limiting condition of operation action, to permit continued operation during test and maintenance activities.

*DSA Functional Diagram*—In 2017, an error was identified with the software of the seismic sensors. This error precluded the seismic sensors from detecting some internal hardware and software faults as required by the system design. The Los Alamos National Laboratory management and operating contractor designed and fabricated a replacement seismic sensor capable of detecting faults associated with both internal hardware and software failures, which successfully addressed the error. This redesign affected the TWF safety basis and required revisions to various chapters of the DSA and the control language in the technical safety requirements. This design change also resulted in the addition of a “Test/Bypass” enclosure as part of the system modification. Revision 3 of the DSA does not contain an up to date functional diagram depicting this new enclosure. Triad indicated that a corrected diagram would be included in revision 3.1 of the DSA.

## Appendix C: Staff Observations on Safety Systems at the Weapons Engineering Tritium Facility

The Defense Nuclear Facilities Safety Board's (Board) staff reviewed two safety-related systems at the Weapons Engineering Tritium Facility (WETF) as part of its review. Staff observations on each of these systems are provided below.

**Oxygen Monitoring System.** The oxygen monitoring system (OMS) is a safety significant system with the safety function of providing early warning to facility personnel, such that action can be taken to prevent a deflagrable gas mixture in the tritium gas handling system (TGHS), the tritium gas containment system, and the tritium waste treatment system (TWTS) low-pressure receiver [3]. The system provides a local audible alarm when oxygen concentration reaches or exceeds its set point, which is set to be lower than the limiting oxidant concentration (LOC) [3].

*Maximum Allowable Oxygen Concentration*—The staff found an example of an incorrect non-conservative system parameter for the OMS, specifically the maximum allowed oxygen concentration by volume in the OMS. This LOC is driven by the national standard, National Fire Protection Association (NFPA) 69, *Standard on Explosion Prevention Systems*. A revision to NFPA 69 reduced the published LOC for oxygen from 5 to 4.6 percent [40], directly affecting the limits for the OMS in the WETF technical safety requirements (TSR) [41]. Taking into account instrument uncertainty, the acceptance criterion of 3 percent in the WETF TSR is non-conservative. Based on the instrument uncertainty calculation, if the OMS indicates the maximum allowed concentration of 3 percent, the actual concentration could be as high as 4.91 percent, which exceeds the NFPA LOC of 4.6 percent [42]. Following discussions with the staff, Triad personnel declared a potential inadequacy of the safety analysis, resulting in a positive unreviewed safety question determination.

*Alarm Response Procedures*—The staff's review identified that some of the OMS alarm response procedures, specifically those related to the oxygen monitors in the gloveboxes, do not have an action for personnel evacuation, although this action is included in the documented safety analysis (DSA). Triad personnel stated they would revise these alarm response procedures to include the evacuation of non-essential personnel, similar to the action in the alarm response procedure for the tritium waste treatment system.

**Tritium Gas Handling System.** The TGHS is designated safety significant. Its safety functions are to “provide primary containment during tritium-processing activities” and to “reduce the frequency of air in-leakage” [43].

*Fire Accident Scenarios*—Per the DSA, the gas pressure in the TGHS is required to not exceed the maximum allowable working pressure (MAWP). Sections of the system are assigned a MAWP and given overpressure protection per the site engineering procedures for pressure safety [44]. However, not all portions of the system have a certified MAWP; the DSA identifies this as a vulnerability. These portions of the system are out-of-service and physically blanked

off from the in-service portions of the system. The assigned MAWP values for the in-service portions of the system are based on normal operating temperatures, and the maximum operating pressure for typical tritium gas handling operations is less than 90 percent of the MAWP. As the system is credited to maintain confinement during a glovebox fire, it may be more appropriate to evaluate, and potentially assign, MAWP values based on the anticipated fire temperatures.

*Set Points for Over-temperature*—Heaters are used throughout the TGHS, and for any heated portions, “over-temperature protection is required unless an operator continuously monitors the component temperature during heating operations, or the heater at full power cannot cause a loss of containment” [43]. In previous versions of the WETF DSA, this over-temperature protection was a key element of the pressure safety program. At the direction of National Nuclear Security Administration Los Alamos Field Office this was removed as a key element, as it was considered an inherent part of the site pressure safety program. As over-temperature protection devices are an active control, it may be more appropriate to flow into the TSRs as part of a system limiting condition of operation (LCO), with associated surveillance requirements to periodically verify the operability of the devices, rather than maintaining them within a site engineering program. The staff reviewed the procedure for operational testing of over-temperature protection devices and verified these devices are appropriately tested on an annual basis [45]. Nevertheless, covering the TGHS over-temperature protection devices within the pressure safety program, rather than in a TSR surveillance requirement associated with the system LCO, is inconsistent with the treatment of other over-temperature devices in the facility. Therefore, Triad should consider revising this in a future DSA update.

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