DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

October 7, 2019

The Honorable James Richard Perry
Secretary of Energy
US Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Secretary Perry:

The Defense Nuclear Facilities Safety Board received a letter from the Department of Energy's Office of River Protection on December 10, 2018, regarding ten open issues related to the electrical distribution system at Hanford's Waste Treatment and Immobilization Plant. DOE said in the letter that it had resolved all ten issues.

The Board agrees that DOE has documented acceptable strategies for resolution on the majority of these issues. However, the Board has identified two issues, related to equipment qualification and the battery charging control set, which require additional development and technical analysis. The Board will review the relevant technical documentation when it becomes available as DOE and its contractor continue the design process.

Please refer to the attached report for further details regarding the Board's position on each of the ten issues. The Board is providing this information for your information and use during the design and commissioning process.

Yours truly,

Bruce Hamilton
Chairman

Enclosure

c: Mr. William I. White
Mr. Brian T. Vance
Mr. Joe Olencz

DEFENSE NUCLEAR FACILITY SAFETY BOARD

Staff Report

July 28, 2019

Waste Treatment and Immobilization Plant (WTP) Electrical Distribution System Issues

Summary. The WTP project has made significant progress on addressing the majority of the issues, including those identified in the Board's previous letter [1], regarding the design of electrical distribution equipment. The staff review team's independent analysis of these concerns concludes that the project has adequately addressed eight of the ten open issues. The two remaining issues, titled *Electrical Equipment Qualification* and *Valve-Regulated Lead-Acid Battery Charging System Safety Control Set* do not have a sufficiently documented path forward at this time. Additional information on each of the ten issues is captured in individual Discussion sections in this report.

Background. This report documents the Defense Nuclear Facilities Safety Board's (Board) staff position as of July 2019 on the status of ten open issues related to the WTP electrical distribution system. The Board transmitted its issues to the Department of Energy (DOE) in a letter with a reporting requirement dated April 13, 2012 [1]. DOE responded with a path forward on all the documented concerns on September 27, 2012. The Board's staff continued to follow the project's resolution of these concerns, most recently with an onsite review in the summer of 2017. On December 10, 2018, DOE transmitted a letter [2] capturing the progress on each of the open safety issues. In that letter, DOE stated that the work completed to date was sufficient to resolve each of the issues.

For reference, WTP is a large capital construction project that will vitrify waste currently stored in underground tanks across the Hanford site. The construction includes four primary nuclear facilities with unique functions: a pretreatment facility, a high-level waste vitrification facility (HLW), a low-activity waste vitrification facility (LAW), and an analytical laboratory. A number of non-nuclear facilities containing utility and operational equipment support these facilities. In order to accelerate the vitrification of low-activity waste onsite, the project is focusing on the direct-feed LAW (DFLAW) campaign, which will allow the facility to process waste prior to completion of the pretreatment facility.

The DOE field office managing this project is the Office of River Protection (ORP) and the primary WTP design and construction contractor is Bechtel National, Inc. (BNI). Corporate partners BNI and AECOM have formed a separate subcontractor, the Waste Treatment Completion Company (WTCC), to focus exclusively on aspects of the DFLAW project including all commissioning activities. For ease of reference in this report, all contractor work will be attributed to BNI as it is the primary contractor for the project.

Discussion. For consistency, this report documents the issues in the same order as the 2018 letter from DOE [2]. Each section will have a brief summary of the issue as originally

communicated by the Board [1], a summary of the current status as communicated by DOE [2], and the staff review team's analysis of that status.

Electrical Equipment Qualification. The 2011 staff review team noted a number of concerns with the equipment qualification of electrical systems and components. Specifically, BNI discussed its intention to seek an exemption from IEEE 323, *Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations*, with regard to LAW, the analytical laboratory, and the support facilities. In addition, BNI discussed its intention to tailor IEEE 323 for application to HLW and the pretreatment facility.

While the team agreed that neither harsh nor high radiation environments are present in LAW, the analytical laboratory, or the support facilities, the remaining requirements in IEEE 323 and its associated daughter standards (e.g., IEEE 344, *Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations*) are critical to ensuring the adequate qualification of safety-related equipment. As a result, the team stated that any tailoring or exemption request must clearly capture what parts of the standard are being omitted and how equivalent chemical industry standards will address the resulting gaps.

DOE Response—As a result of a "system-focused review to establish an optimized approach to the completion of the WTP Project portion" [2] of the direct feed LAW project, BNI has concluded that IEEE 323 requirements are only necessary for safety-class systems and safety-significant systems located in harsh environments[1]. This conclusion was captured through Safety Requirements Document Change Notice [3] in late 2017. While previous equipment was procured under the tailoring/exemption captured by the 2011 review, any equipment procured going forward will use this new formulation on requirements.

DOE considers the documentation of this approach on equipment qualification adequate to resolve the Board's issue.

Current Staff Analysis—There is currently insufficient technical detail to support the newly expanded scope of the IEEE 323 exemption. While BNI has captured the extent of the exemption and the rationale for the decision, there does not appear to be a detailed discussion of how the mild/harsh environment dichotomy for safety-significant equipment was reached or how the chemical industry standards replace the requirements in IEEE 323 (i.e., a detailed requirements crosswalk).

The use of IEEE 323 for the WTP project is driven by the guide [4] associated with DOE Order 420.1B, *Facility Safety*. While the IEEE standard more closely aligns with safety-class equipment (Class 1E in the nuclear power industry), the typical tailoring of the requirements simply removes the requirement for redundancy and independence. In other words, the most common design of a safety-significant electrical system is a single train of a safety-class system. The equipment qualification requirements between the two remain largely the same unless there is a compelling technical reason that less rigorous requirements are acceptable.

[1] IEEE 323 defines a harsh environment as one resulting from a design basis event and typically consisting of high temperature, humidity, and pressure. The standard also discusses equipment in mild environments, which are defined as those that will never be significantly more severe than that of normal plant operation.

The selected chemical industry standards may provide equivalent guidance for electrical equipment used in mild environments; however, without some documented analysis, this equivalence is difficult to validate. Given the extensive requirements database used by the WTP project, this type of analysis would both ensure compliance with the newly invoked standards and allow the transparency necessary to ensure that BNI has adequately addressed the more comprehensive nuclear requirements.

Cable Ampacity Derating. As noted in the Board's 2012 letter [1], cable sizing criteria at WTP were, at the time, based only on planned electrical loading and environmental conditions and did not consider effects of cable fire-wrappings or other equipment protecting cables from potential nearby fires (e.g., firestop material in wall penetrations). These features can reduce cable heat transfer characteristics and result in elevated operating temperatures (i.e., hotspots) near those features. Hotspots can cause cables to fail prematurely and present a potential fire hazard themselves. Derating the ampacity (reducing the permitted electrical loading) of procured cables to ensure localized temperatures do not exceed the design specifications of the cables can prevent this hazard. However, the WTP basis of design did not explicitly discuss ampacity derating. Consequently, it was not clear if the associated hazards were appropriately controlled.

DOE Response—DOE has stated that the WTP design does not currently require the fire-wrapping of cables [2]. For firestop material, the response references a report concluding that for penetrations up to 12 inches, a 15 percent ampacity derating factor is sufficient. As a result, all power cabling will include this derating and the project design specifications have been updated. In the future, if either fire-wrapped cables or penetrations in excess of 12 inches are necessary, suitable cable ampacity derating will be calculated and applied. As a result of this analysis and commitment, DOE considers this issue resolved.

Current Staff Analysis—After reviewing the referenced BNI report, the staff review team concludes that the broad ampacity derating plan addresses the Board's original concern. The 15 percent derating factor, combined with BNI's commitment to evaluate further derating should design modifications require more than 12 inches of fire barriers for a single cable, should adequately control the hazard.

Adjustable Speed Drives Fed from Uninterruptible Power Supplies. During a loss of offsite power, uninterruptable power supplies (UPS) feed safety-related adjustable speed drives (ASDs) that control many of the large safety-significant and safety-class loads. The effect of high frequency harmonics and other UPS output waveforms on the ASD power conversion electronics may be difficult to predict and control. As the Board noted in 2012, these harmonic interactions could lead to overheating of electrical components or mechanical failures due to high vibration conditions.

DOE Response—Using the ETAP® software package, BNI has generated a study detailing the harmonic interactions between the UPS and ASD for the LAW off-gas exhauster system [5]. Based on the criteria defined in IEEE 519, *Recommended Practice and Requirements for Harmonic Control in Electric Power Systems*, this study concluded that there were no harmful harmonics associated with this UPS-ASD combination. BNI committed to using this methodology as additional design information is developed for HLW and pretreatment

facility UPS-ASD combinations. Further, the response [2] listed several potential solutions should BNI discover harmful harmonic interactions for other UPS-ASD pairs, to include:

- Confirm that the connected equipment is immune to the calculated harmonics,
- Relocate loads to other buses,
- Install line reactors in circuits upstream and/or downstream from the ASD and motor,
- Install passive filters in ASDs (trap harmonics to ground), or
- Install active filters, which generate opposing (canceling) harmonic waveforms.

As a result of this response, DOE considers this issue resolved.

Current Staff Analysis—The staff review team has reviewed the referenced report [5] and concurs with BNI's analysis of the harmonic interactions between the LAW UPS and off-gas system. Given the data presented, the impact of harmonic interactions within this system should be minimal; as such, there should be no negative impact on the off-gas system's ability to perform its safety function. The analytical methods used in this report, if applied to other ASD-UPS combinations, should adequately identify any issues related to harmonic interactions. The staff review team also agrees, in principle, with the suggested set of potential design solutions should harmful harmonic interactions be identified. BNI has therefore documented an acceptable path forward to resolve the issues identified in the Board's 2012 letter. The staff review team plans to review future harmonic calculations for other UPS-ASD combinations in WTP as they are developed to assess the adequacy of the implementation.

Fast Reclosing of Power Supply Breakers. As of 2012, BNI had not yet developed a strategy to prevent damage to large induction motors that could result from rapid re-energization (i.e., the fast reclosing of electrical breakers). During a loss of power event, induction motors continue to rotate and retain residual magnetism, which can result in induced voltages on the motor leads. If the motor is re-energized before the induced voltage sufficiently decays (i.e., the motor rotation slows), the supplying voltage may be out of phase with that induced in the rotating machine. This can result in a transient current and torque being applied to the rotor, which can damage the motor and connected equipment if not adequately controlled.

DOE Response—Most motors in WTP are non-safety-related and therefore are not designed to automatically restart upon the loss of electrical power. They require manual restart, except in the case of a few smaller motor loads connected to the standby diesel generators. The delay between the loss of power and the potential restart of these non-safety loads is adequate to allow the motors to slow sufficiently before re-energization.

For safety-related electrical motors, the inclusion of ASDs in the design will resolve this issue. The ASDs are programmed to sense motor speed during coast-down, synchronize output with the speed and direction of rotation of the motor, and "catch the motor on the fly" to safely reaccelerate the motor to the required speed. These actions will prevent the development of a transient current and torque causing damage to the motor.

DOE consequently considers this issue resolved [2].

Current Staff Analysis—The staff review team agrees that the discussed design solutions should adequately protect the facility's large electric motors. The ASDs should prevent voltage phase differences from damaging the equipment, and subsequently, allow the motors to perform their safety function during electrical power supply transitions.

Valve-Regulated Lead-Acid (VRLA) Battery Charging System Safety Control Set. Lead acid batteries generate and release a significant amount of hydrogen gas during charging. As the accumulation of this hydrogen can present an explosive hazard, design standards for battery charging areas require adequate controls to ensure the hydrogen concentration remains below a fraction of its lower flammability limit (LFL). WTP selected VRLA batteries for both safety and non-safety systems as they are designed to limit the release of hydrogen by containing and recombining hydrogen and oxygen in the battery's cells under normal operation.

While a significant improvement over normal lead acid batteries in most applications, VRLA batteries are sensitive to temperature (both ambient and within the battery). If sustained internal heat generation exceeds the battery's ability to cool, the battery can enter a thermal runaway condition, substantially increasing the hydrogen generation and battery internal pressure. Most VRLA battery installations rely on temperature compensated charging and ventilation to mitigate this hazard.

The WTP control strategy for safety-related batteries relies on the temperature compensated charging circuit to prevent the buildup of heat and to minimize the generation of hydrogen gas. However, upon its review of the particular model of VRLA batteries selected for the non-safety systems, the 2011 staff review team identified that the charging circuit can fail in a non-conservative direction. If the same model of batteries are used for the safety-related systems, this failure mode could quickly challenge the system's ability to function as designed. The team pointed to additional guidance in IEEE Standard 1187, *Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Batteries for Stationary Applications*, capturing a number of recommended controls for VRLA charging areas including the assurance of adequate ventilation and heat dissipation. As this analysis is predicated on both normal and credible abnormal operating conditions, the reliance on this charging circuit alone does not adequately prevent the potential for battery fires and explosions.

DOE Response—BNI is committed to performing studies of the VRLA battery installations at WTP to "confirm code and standard compliance, adequacy of ventilation, and assess hazards to nearby safety equipment and workers…" [2]. BNI has completed assessments for LAW, the analytical laboratory, and the support facilities, and will assess the HLW and the pretreatment facility as their designs mature.

In response to the staff's concern on thermal runaway conditions, BNI concluded that thermal runaway is a rare phenomenon and that a number of factors adequately protect the project, including:

- Temperature compensated charging,
- One-way pressure relief valves in the batteries to prevent overpressure,
- Battery compliance with Underwriters Laboratories minimum flammability standards,
- Safety-class equipment maintained at design temperature through loss-of-power, and
- Robust operational and maintenance programs.

The hydrogen generation assessments for LAW, the analytical laboratory, and the support facilities concluded that there is sufficient ventilation in battery charging areas to prevent hydrogen accumulation above 25 percent of the LFL. In addition, there are both local and remote alarms monitoring the ventilation and battery temperatures. BNI engineering concluded that the design and control strategy selected for WTP aligns with IEEE 1187 and other applicable codes and standards.

Therefore, DOE considers the Board concern resolved at this time.

Current Staff Analysis—The staff review team generally agrees with the methodology used in the hydrogen gas generation examples cited in the DOE response. However, the concern still remains when looking at safety-related equipment. As the credited control is the temperature compensated charging circuit, the hydrogen gas analysis is relying on uncredited equipment (e.g., climate control, alarms) for the room to remain below the LFL. The additional control of credited climate control for rooms containing safety-class VRLAs will reduce the likelihood of thermal runaway, but will not eliminate the possibility, as the condition can still occur at normal room temperatures. However, with credited airflow indication, this system could also provide sufficient ventilation to ensure that the battery charging areas remain below the LFL.

Overall, there is insufficient documentation at this time regarding the design of the safety-class systems (in HLW and the pretreatment facility) and no additional discussion about the non-conservative failure mode of the temperature compensated charging circuit.

Valve-Regulated Lead-Acid Battery Installation Location. During facility walk-downs, the 2011 staff review team noted that there are a number of locations within the support facilities and the primary electrical substation where battery racks appeared to be located in readily accessible locations. In addition, it was unclear at the time whether safety-related VRLAs would be collocated with other safety equipment, presenting a potential hazard to their operation due to hydrogen generation (as discussed in the previous issue).

DOE Response—All VRLA batteries are located in areas that are only accessible to qualified persons who have been trained to perform work in those locations. Either an engineered guard or insulated cover prevents inadvertent contact with live parts of the batteries. This is compliant with the IEEE NESC C2-2012, *National Electrical Safety Code*. In addition, any potential collocated safety equipment is adequately protected by the existing hydrogen generation control strategy (see the discussion in the previous issue). DOE therefore considers this issue resolved.

Current Staff Analysis—The staff review team agrees that controlling access to charging locations is sufficient to meet the shock hazard concerns captured in IEEE NESC C2-2012. The additional concern regarding collocated equipment remains if hydrogen generation is not adequately controlled (but is more closely associated with the previous Board issue).

Unprotected Electrical Equipment. During walk-downs in 2011, the staff review team noted several instances of electrical equipment exposed to potential intrusion of firewater or other liquids. Water spray from an activated sprinkler system or leakage from co-located fluid

systems would likely penetrate this equipment and potentially generate a short circuit that could damage the equipment or create other hazardous conditions.

DOE Response—In the response, BNI noted the inclusion of pre-action sprinkler heads into the design of the primary electrical distribution buildings (B87 and B91). The multi-step design used in the pre-action sprinkler system will prevent accidental activation of the system, by ensuring that pipes are dry unless smoke is first detected in the room. This will protect electrical equipment from accidental spray from the fire suppression system. BNI stated that most electrical equipment installations include features that would further protect them from accidental exposure to firewater and committed to providing additional protection if water intrusion "is determined to be a threat to the equipment…" [2]. BNI also committed to perform a documented analysis regarding the need to protect any safety-related equipment from water intrusion consistent with IEEE 833, *Recommended Practice for the Protection of Electric Equipment in Nuclear Power Generating Stations from Water Hazards*. DOE concluded that these design features and the commitment to future analyses are sufficient to resolve this issue.

Current Staff Analysis—The documentation provided in BNI's response, in addition to facility walk-downs performed in 2017, demonstrate that the existing electrical distribution equipment in WTP is reasonably protected from potential water intrusion. The installation of pre-action sprinkler heads along with the specifics of equipment enclosure installation, provide additional assurance that minimal equipment (not already impacted by fire) will receive collateral damage from sprinkler operation.

High Voltage Cables in Manholes. During walk-downs in 2011, the staff review team found that multiple underground vaults housing electrical cables contained a significant amount of standing water. While BNI removed the water, the staff questioned how long the cables had been submerged, and whether submersion in water would impact the cables' durability and future long-term ability to function. At a minimum, the team recommended that modifications be made to ensure that cables are kept above the expected waterline in the event of future flooding.

DOE Response—The power cables identified during the facility walk-down were temporary installations to support facility construction. As discussed in its response, BNI will remove all temporary power cables when they are no longer required. BNI will install cable supports in the underground vaults prior to installing permanent plant cables. The permanent plant medium-voltage cables are approved for direct burial in the soil and for operation in wet locations, but not for permanent submergence. In addition, the project documentation [6] now captures requirements to perform "periodic inspections of the manholes for water accumulation, and for confirmation that the French drains are functioning properly prior to energization with permanent power." [2]

Current Staff Analysis—The staff review team agrees that BNI is adequately protecting temporary power cables that support construction activities. The staff team also agrees that engineered supports, French drains, and BNI's inspection program should ensure that the environment for permanent cables is controlled. Per the manhole layout plans referenced in BNI's response letter, the environment described for permanently installed cables should be adequate once those plans are implemented across the project.

Past Due Calibration of Protective Devices. During a walk-down of the switchgear room in the A6 substation, the 2011 staff review team observed that the posted calibration date for many of the protective devices was more than 10 years old. DOE field office personnel stated these postings may be from the original calibration at the factory; however, they could not provide the calibration check requirements or any records to support meeting those requirements. The A6 substation was not supplying any loads on the WTP site at that time, but the equipment in the switchgear building was energized. It was therefore unclear if this equipment had been adequately maintained during the construction process. The A6 substation is now in service and is supplying loads to support commissioning activities on site.

DOE Response—The calibration stickers in the A6 substation were applied at the factory prior to being shipped, and none of the mains of feeder breakers had been field calibrated or set to their WTP Project design settings at the time of the review. Since the walk-through in December 2011, these protective devices have been field calibrated and set to their design settings by a third-party laboratory. Therefore, DOE considers this issue resolved.

Current Staff Analysis—The staff review team is encouraged that the relays have been field calibrated and are ready to provide power to the project. There is a concern regarding the maintenance of these devices going forward as the DOE response does not address this topic. The staff team hopes that the project ensures that this equipment is maintained consistent with existing site electrical distribution equipment maintenance programs. This includes, but is not limited to, documenting the current status of all equipment calibration and any preventive maintenance activities (i.e., periodic instrumentation re-calibration) as recommended by the manufacturer. However, these ongoing maintenance activities are beyond the scope of the original review.

Emergency Turbine Generator Design Change. The project has elected to design and procure an emergency turbine generator instead of the more common reciprocating diesel. The selection of turbine generators for a safety-class control represents a risk in equipment procurement and qualification, given that the use of turbine generators is uncommon in nuclear applications. For instance, turbine generators typically require a significantly longer startup time and may therefore require significantly larger UPSs to provide power to safety-class loads as the turbine is brought on line.

DOE Response—Design engineers chose to move from emergency diesel generators to turbines due to the "significant cost savings and other technical advantages regarding size, cooling, efficiency, and reliability…" [2]. Safety basis personnel updated the project's safety basis to include this change. ORP approved this update in August 2013. BNI also committed to analyzing the hazard presented by the delay in the emergency turbine generators being brought on line and to provide UPS power as necessary. In the response, BNI documented that as "No technical issues remain at this time," and that it considers the Board issue to be resolved.

Current Staff Analysis—The staff review team agrees that there are no outstanding technical issues that cannot be overcome through the existing design process. As the generators are required to support HLW and the pretreatment facility, further progress on the system design

has been delayed. However, the project has captured and adequately addressed the concerns transmitted in the 2012 Board letter.

The staff further notes that DOE has revised its design approach for emergency power generation and is no longer procuring the originally specified turbine generators [7]. Further design activity for this system is expected to continue with the resumption of HLW design activities.

Conclusion. The staff review team concludes that BNI has documented an adequate path forward on eight out of the ten issues captured in the 2012 Board letter. The team recommends that the Board's staff reassess the remaining two items in future reviews of the project as DOE and its contractor continue the design process. For reference, a bulleted summary of the status of each issue follows:

- **Electrical Equipment Qualification** – There is insufficient technical justification to exclude IEEE 323 requirements from WTP safety significant equipment located in a mild environment.

- **Cable Ampacity Derating** – The existing derating applied to all WTP power cabling appears sufficient for existing wall penetrations. In addition, the project has committed to analyze any larger wall penetrations for power cabling as necessary.

- **Adjustable Speed Drives Fed from Uninterruptible Power Supplies** – The methodology outlined in the report is consistent with IEEE guidance on managing harmonic content from power electric devices and BNI has committed to analyze additional ASD-UPS pairs as design information becomes available.

- **Fast Reclosing of Power Supply Breakers** – The ASDs used to control the operation of safety-related electrical motors are capable of adequately preventing damage to the equipment in the event of unplanned power cycling.

- **Valve-Regulated Lead-Acid (VRLA) Battery Charging System Safety Control Set** – The credited charging technology selected for the LAW facility still appears to be capable of failing in a non-conservative manner. The reliance on uncredited support systems to prevent a dangerous accumulation of hydrogen gas in BNI's analysis does not adequately ensure the operation of this safety system.

- **Valve-Regulated Lead-Acid Battery Installation Location** – Controlled access to the battery charging areas is sufficient to address the majority of this concern. Any remaining aspects associated with collocated equipment and hydrogen generation are more closely associated with the previous issue.

- **Unprotected Electrical Equipment** – The project's use of pre-action sprinkler heads in key electrical areas along with its commitment to analyze the vulnerability of equipment to inadvertent water intrusion should effectively address this concern.

- **High Voltage Cables in Manholes** – The commitment to install all permanent power cabling on engineered racks and the adoption of a manhole monitoring program should allow the project to adequately monitor the condition of underground power cables going forward.

- **Past Due Calibration of Protective Devices** – Adequate monitoring and maintenance of protective devices have become more critical now that electrical equipment has been energized and loaded. The project's commitment to these preventive maintenance practices appears sufficient to address the concern as originally documented.

- **Emergency Turbine Generator Design Change** – There are currently no outstanding design and qualification concerns that cannot be addressed by the existing WTP processes. In addition, DOE has recently revised its approach for emergency power generation.

Cited References

[1] Defense Nuclear Facilities Safety Board, *Review of the Electrical Distribution System for the Waste Treatment and Immobilization Plant, Hanford Site*, Letter to the Department of Energy containing staff issue report, April 13, 2012.

[2] Department of Energy, *Resolution of Defense Nuclear Facilities Safety Board Issue: Concerns Regarding Electrical Distribution System in the Waste Treatment and Immobilization Plant*, Letter to the Board, December 10, 2018.

[3] Bechtel National, Inc., *Contract Deliverable 9.1 - 24590-WTP-SRDCN-ENG-16-00022, Revision to SRD Safety Criterion 4.4-1 and Resubmits Contract Deliverable 9.1 – 24590-WTP-SRDCN-ENG-16-00022, Revision to SRD Safety Criterion 4.4-1, CCN 298234*, Letter from K. D. Irwin, BNI, to W. F. Hamel, ORP, December 21, 2017.

[4] Department of Energy, *Nonreactor Nuclear Safety Design Criteria and Explosives Safety Criteria Guide for use with DOE O 420.1, Facility Safety*, DOE Guide 420.1-1, March 2000.

[5] Bechtel National, Inc., *Performance of A.C. Adjustable Speed Drives Fed from an Uninterruptible Power Supply System*, 24590-WTP-RPT-E-14-004, Rev 0, October 22, 2014.

[6] Bechtel National, Inc., *Cable Raceway Manhole Inspections*, 24590-WTP-3PN-E00X-00037, Oct 2, 2013.

[7] Bechtel National, Inc., *BOF – Emergency Turbine Generator Vendor Buyback of Equipment*, Baseline Change Proposal, 24590-WTP-TN-PC-19-0147, May 22, 2019.