**OFFICE OF RIVER PROTECTION**
P.O. Box 450, MSIN H6-60
Richland, Washington 99352

DEC 10 2018

18-WTP-0128

The Honorable Bruce Hamilton
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, D.C. 20004

Dear Chairman Hamilton:

RESOLUTION OF DEFENSE NUCLEAR FACILITIES SAFETY BOARD ISSUE: CONCERNS REGARDING ELECTRICAL DISTRIBUTION SYSTEM IN THE WASTE TREATMENT AND IMMOBILIZATION PLANT

References:

1. DNFSB letter from P.S. Winokur from D. Huizenga, "DNFSB Staff Review of the Electrical Distribution System of the Waste Treatment and Immobilization Plant (WTP)," dated April 13, 2012.

2. DOE-HQ letter from D. Huizenga to P.S. Winokur, DNFSB, "Response to Technical Issues Identified in Defense Nuclear Safety Board Letter on Operability and Safety of the Overall Electrical Distribution System of the Waste Treatment and Immobilization Plant (WTP)," dated September 27, 2012.

3. *27th Annual Report to Congress*, Defense Nuclear Facilities Safety Board, Washington, D.C., dated April 27, 2017.

The Defense Nuclear Facilities Safety Board sent a letter (Reference 1) to the U.S. Department of Energy, Senior Advisor for Environmental Management regarding concerns associated with the electrical distribution system at the Waste Treatment and Immobilization Plant.

The purpose of this letter is to relay that commitments made in response to Defense Nuclear Facilities Safety Board concerns (Reference 2) have been completed as detailed in Attachment 1. Based on the work completed as summarized in Attachment 1, the DOE Office of River Protection considers the issue resolved. Bechtel National, Inc.'s position (Attachment 2) supporting resolution is also provided.

This letter also communicates a change in the commitment relative to implementation of IEEE 323, *Standard for Qualifying Class 1 E Equipment for Nuclear Power Generating Stations*, for environmental equipment qualification in the Low-Activity Waste Facility, Balance of Facilities, and Analytical Laboratory.

If you have any questions, please contact me, or your staff may contact Thomas W. Fletcher, Assistant Manager, Federal Project Director, Waste Treatment and Immobilization Plant, (509) 376-4941.

Brian T. Vance
Manager

WTP:KDT

Attachments (2)

cc w/attach:
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S.C. Petras, AU-1.1
P.K. Fox, DNFSB
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BNI Correspondence

Attachment 1
18-WTP-0128
(5 Pages Excluding Cover Sheet)

# Basis for Resolution of Defense Nuclear Facilities Safety Board Staff Issues with the Waste Treatment and Immobilization Plant Electrical Distribution System

Based on the below status in conjunction with the Defense Nuclear Facilities Safety Board (DNFSB) staff review held in June of 2017, the U.S. Department of Energy (DOE) considers DNFSB concerns related to the Electrical Distribution System to be resolved based on completion of the following actions:

Background:

The DNFSB identified the following concerns related to the Electrical Distribution System for the WTP (Reference 1).

> Although the WTP electrical distribution system meets many of the requirements of DOE orders and consensus industry standards, the review by the Board's staff raised concerns about the operability and safety of the overall electrical distribution system. Safety related electrical equipment for the Low-Activity Waste Facility is being procured without invoking requirements for equipment qualification. During a walk-down of the WTP construction site, the staff found evidence that 13.8 kV electrical cables had been submerged under water in a manhole. The staff identified numerous pieces of installed electrical equipment that have open gratings and are placed under the sprinklers of the fire protection system, resulting in hazardous conditions. The staff also found that the safety strategy for valve-regulated lead-acid batteries failed to address the credible hazards of battery fires and explosions, resulting from thermal runaway and hydrogen release scenarios.

From the DNFSB 27th Annual Report to Congress (Reference 3):

> Design and construction of the Electrical Distribution System – In an April 13, 2012, letter to DOE, the Board identified several issues related to the operability and safety of the electrical distribution system for WTP. Inadequacies in the design and construction of the electrical distribution system would inhibit the safety systems from performing their functions to protect the public and the worker. DOE's response to the letter included a plan to address these issues. DOE has made progress addressing the electrical issues; however, work remains to completely resolve the issue.

DOE responded to the ten specific concerns in a letter dated September 27, 2012, from D. Huizenga to P.S. Winokur (Reference 2). The letter outlined the remaining actions for resolving concerns with the WTP Electrical Distribution System. The remaining commitments were:

- **Adjustable Speed Drives Fed from Uninterruptible Power Supplies:** The project is already scheduled to develop Harmonic Analyses using ETAP Software to locate any buses which exceed the acceptability criteria defined in IEEE 519. Any buses with excessive harmonics will be evaluated and determined if equipment should be added to reduce harmonics to an acceptable level.

- **Valve-Regulated Lead-Acid Battery Charging System Safety Control Set:** BNI will perform a documented study of the Valve-Regulated Lead-Acid (VRLA) battery installations on WTP. The study will determine code and standard compliances, the adequacy of ventilation, and assess hazards to nearby safety equipment and workers. The study will include recommendations for any VRLA Battery installations or Design Criteria that requires improvements. Hazard analyses, accident analysis, and control decisions for VRLA battery installations for all plants will be developed using DOE-STD-3009 methodology using the conclusions of the study. PIER 12-0219 will track the development and issuance of these documents.

- **Valve-Regulated Lead-Acid Battery Installation Location:** Potential hazards associated with the Uninterruptible Power Supplies (UPS) system will be addressed in the issue commitment for VRLA Battery Charging System Safety Control Set.

- **Unprotected Electrical Equipment:** Bechtel National, Inc. (BNI) will perform a documented study as to the need to protect the Safety Significant (SS) and Safety Class (SC) electrical equipment from water intrusion consistent with IEEE 833. For all non-Safety plant electrical equipment the study will evaluate the need to provide spray shields based on the relevant importance to plant operations, scheduled down time to replace the electrical equipment and potential cost impacts to electrical equipment.

- **High Voltage Cables in Manholes:** ATS 12-0148 contains action(s) to implement a manhole inspection program and require supporting of power conductors so they are protected from submergence in water accumulation in the bottom of the manhole. There will also be an action to investigate and evaluate possible application of temporary protection over manholes that would effectively reduce water from entering them during the construction phase of the project, and prior to finished grade becoming flush with manhole covers.

Actions Taken and Basis for Resolution:

1. **Electrical Equipment Qualification**

- In November 2017, a collaborative team consisting of DOE-HQ, DOE Office of River Protection (ORP), WTP, Waste Treatment Completion Company, and BNI and AECOM corporate staff conducted a systems-focused review to establish an optimized approach to the completion of the WTP Project portion of the Direct-Feed Low-Activity Waste (DFLAW) project. The team concluded that, because there are no SC structures, systems, and components (SSC) and no radiological SS SSCs in the Low-Activity Waste (LAW) Facility, Balance of Facilities, and Analytical Laboratory (otherwise known as LBL), there is no requirement to perform IEEE Standard 323 equipment environmental qualification in LBL. To address this decision, a Safety Requirements Document Change Notice was initiated. The proposed change was reviewed further by ORP and BNI staff, and the proposed approval of the change results in SS SSCs in mild environments not being required to be qualified to the requirements of IEEE Standard 323. LBL equipment qualification for mild environment shall be met through compliance with the

DOE O 420.1B through the design process. Equipment environmental qualification to IEEE 323 will continue to be performed for LBL SS SSCs credited for radiological and/or chemical hazards and required to perform an active safety function in harsh environments. A harsh environment is further defined by the SRD as environments significantly different from its mild environment (i.e., a design basis event environment [e.g. temperature, humidity, etc.] beyond the rated capability of the component in which the component is required to operate during/following the design basis event), environmental room conditions created by steam line breaks and from exposure of equipment to spray, flooding, or submergence that is not protected by credited safety features.

**2. Cable Ampacity Derating**

- IEEE Standard 848 methodology was not used because it was determined to be impractical to stage and test the large number of different combinations, quantities, and configurations of cables with different WTP design loads in a laboratory. Calculation 24590-WTP-E1C-LVE-00001 was revised to add the fire penetration seal impacts to cable ampacities that were determined from the analysis performed in report 24590-WTP-RPT-E-14-002. The Electrical Design Criteria, 24590-WTP-DC-E-01-001, has been revised to clarify that cable ampacities need to be evaluated for additional derating beyond what is specified in Calculation 24590-WTP-E1C-LVE-00001 if the cables are fire-wrapped, or if more than 12 inches of cable is contained within a single fire barrier penetration.

**3. Adjustable Speed Drives Fed from Uninterruptible Power Supplies**

- The approach of performing a harmonic analysis and, where necessary, mitigating harmful levels of harmonics, is included in WTP Project processes and procedures for future design work in the LAW Facility in report 24590-WTP-RPT-E-14-004, Performance of A.C. Adjustable Speed Drives Fed from an Uninterruptible Power Supply System (Reference 12). In addition, 24590-LAW-ES-E-16-001, WTP Harmonic Analysis Study – DFLAW Operation Configuration, has been issued to determine (voltage) total harmonic distortion on buses in LBL. Together these analyses verified that the harmonic interactions between the connected equipment are within acceptable limits of industry standard and the acceptable limits set by the manufacturers of UPS and adjustable speed drive equipment. These completed analyses of the UPS-ASD-Motor combination for the LAW Facility off-gas exhauster concluded that the system will perform its intended safety-related function without any issues associated with harmonics.

**4. Fast Reclosing of Power Supply Breakers**

- The WTP Project design strategy will prevent damage to large induction motors as a result of fast reclosing of electrical breakers and operation of the automatic bus transfer switches. Additional detail on how this issue is being addressed in the design was provided in the response to issue four of Memorandum 12-WTP-0276. The detail of the

memorandum was provided to DNFSB (letter from D. Huizenga, DOE to P. Winokur, DNFSB) on September 27, 2012.

**5. Valve Regulated Lead Acid Battery Charging System Safety Control Set**

- The WTP design aligns with the requirements of IEEE Standard 1187 and other applicable codes and standards. Project calculations of battery hydrogen generation rates, under a worst-case scenario, compared to air changes in the ventilation system, will prevent hydrogen concentrations in the room from exceeding 1% by volume (25% of the lower flammability limit), with significant safety factors. In addition, rooms with batteries will have local and remote alarms if there is an indication of ventilation system failure or overcharging of the batteries. As the WTP Project design matures, revisions to WTP Project design calculations for hydrogen concentrations in battery rooms will be provided to the DNFSB and/or DNFSB staff upon request. Calculation 24590-WTP-E1C-DCE-00001 is the first such calculation. This calculation addressed the concern in Balance of Facility Building 87 and Building 91.

**6. Valve Regulated Lead Acid Battery Installation Location**

- The VRLA battery installations at the WTP Project are compliant with IEEE NESC C2-2012 and other applicable codes and standards. The installations are only accessible to qualified personnel and the live parts of the batteries are guarded and/or insulated to prevent inadvertent contact with live parts.

**7. Unprotected Electrical Equipment**

- The WTP Project electrical installation designs comply with all applicable code and standard requirements for protecting electrical equipment from water hazard. No applicable codes or standards, including IEEE Standard 833, require protection or shielding of electrical equipment from fire-water spray. The main WTP Project CM electrical distribution buildings (B87 and B91) and all electrical rooms with safety electrical distribution equipment have interlocked pre-action fire water sprinkler systems that prevent water spray from contacting electrical equipment unless there is an actual fire event.

**8. High Voltage Cables in Manhole**

- The follow-on action has been completed. Permanent plant medium-voltage cables will be supported in manholes. Manholes will be periodically inspected for water accumulations and proper functioning of French drains. Permanent plant medium-voltage cables will be Hi-Pot tested prior to energization.

**9. Past Due Calibration of Protective Devices**

- The A6 Substation breakers have been set to their design settings, have been field calibrated, and have current up-to-date calibration stickers applied.

## 10. Emergency Turbine Generator Design Change

- No technical issues remain at this time. As the design matures, safety requirements and design information will be provided to the DNFSB and/or DNFSB staff as requested. The WTP Project acknowledges that there will be a delay between a postulated loss of offsite power and the availability of emergency power. If a safety analysis determine that specific motors present a safety hazard if they lose power for the duration of the transfer to ETG power, they will be provided with UPS power. The analysis of the performance of these motors on a UPS would be added to 24590-WTP-RPT-E-14-004, Performance of A.C. Adjustable Speed Drives Fed from an Uninterruptible Power Supply System, discussed in response to concern 3.

Attachment 2

18-WTP-0128

(18 Pages Excluding Cover Sheet)

Attachment to CCN: 304086, Resolution of Defense Nuclear Facilities Safety Board Concerns Related to the Waste Treatment and Immobilization Plant Electrical Distribution System

Attachment to
CCN: 304086

# Resolution of Defense Nuclear Facilities Safety Board (DNFSB) Concerns Related to the Waste Treatment and Immobilization Plant Electrical Distribution System

## Concern 1: Electrical Equipment Qualification

**Statement of DNFSB Concerns**

By Reference 1, the DNFSB identified its concerns as follows:

*The Waste Treatment Plant (WTP) Safety Requirements Document (SRD) requires that safety-related electrical equipment meet the service and environmental qualification requirements of Institute of Electrical and Electronics Engineers (IEEE) Standard 323, IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations. However, per Bechtel National, Inc.'s (BNI) letter to the Office of River Protection (ORP) dated March 29,2010, (CCN 214065) and ORP's response to BNI dated March 30, 2010, (CCN: 216355), the project team is procuring Safety-Significant (SS) electrical equipment for the Low-Activity Waste (LAW) Facility that has been exempted from these requirements. BNI cited and DOE agreed with three reasons for this exemption: (1) the SS classification is due to chemical toxicity hazards; (2) the equipment will be procured from chemical industry vendors that lack experience with some IEEE nuclear industry specific standards; and (3) the LAW Facility has minimal radiological hazards. BNI's request and DOE's approval of this exemption were predicated on BNI adopting equivalent chemical industry codes and standards for the design, specification, and fabrication of electrical components to ensure that the equipment can perform its intended safety function in the anticipated environment. However, the project team has not identified any chemical industry codes and standards, or developed a process to compare the requirements of these standards to nuclear industry IEEE standards.*

*While the Board's staff concurs that the harsh environment and radiation safety requirements of IEEE Standard 323 may not be applicable to equipment in the LAW Facility, the remaining service and environmental qualification requirements of IEEE Standard 323 and the seismic qualification requirements of IEEE Standard 344, IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations, are applicable. The WTP project team needs to select and justify a suitable equivalent set of chemical industry codes and standards to replace the requirements of these IEEE nuclear standards or clearly state and justify which portions of IEEE Standard 323 and IEEE Standard 344 remain applicable to qualification of SS electrical equipment in the LAW facility. Qualification to environmental and seismic conditions is necessary to ensure that the electrical equipment will perform its credited safety functions under expected operating and accident conditions.*

**Response to DNFSB Concerns**

By Reference 2, DOE-HQ responded to the DNFSB staff concerns based on input jointly developed by DOE and BNI representatives. A summary of the submitted response, updated with current information, where necessary, is provided below.

The exemption from IEEE Standard 323 environmental qualification (EQ) requirements approved by ORP (Reference 3) was related to the ability to perform EQ testing on specific LAW Facility Safety Significant (SS) equipment only. This exemption has been included in the WTP engineering specification for environmental qualification of control and electrical systems and components (Reference 4). This

specification also includes IEEE Standard 323 tailored requirements for application to Chemical Toxicity Equipment. Equipment qualification packages for the exempted LAW Facility SS equipment have been prepared consistent with this specification (References 5, 6 and 7).

In November 2017, a collaborative team consisting of DOE-HQ, ORP, WTP, WTCC, and Bechtel and AECOM corporate staff conducted a systems-focused review to establish an optimized approach to the completion of the WTP Project portion of the DFLAW project. The team concluded that, because there are no Safety Class (SC) structures, systems, and components (SSC) and no radiological SS SSCs in the LAW, BOF, and Lab facilities (otherwise known as LBL), there is no requirement to perform IEEE Standard 323 equipment environmental qualification in LBL. To address this decision, a Safety Requirements Document Change Notice (SRDCN) has been initiated (Reference 8). Following the implementation of this change, SS SSCs in mild environments will not be required to be qualified to the requirements of IEEE Standard 323. The majority of the existing LBL procurements that require environmental qualification will be completed as currently specified; however, it is anticipated that some procurements will be modified to incorporate the new requirement (i.e., LAW Programmable Protection (PPJ) System). Equipment environmental qualification will continue to be performed for SC SSCs and SS SSCs required to perform an active safety function in harsh environments. A harsh environment is further defined as environments resulting from steam line breaks and from exposure of equipment to spray, flooding, or submergence that is not protected by safety features.

**Conclusion**

The exemption from IEEE Standard 323 EQ requirements was approved for specific LAW Facility chemical systems. Reference 4 includes IEEE Standard 323 requirements tailored for application to chemical toxicity equipment. The LAW chemical equipment has been environmentally qualified to this specification (References 5, 6, and 7).

BNI considers this DNFSB concern resolved.

## Concern 2: Cable Ampacity Derating

**Statement of DNFSB Concerns**

By Reference 1, the DNFSB identified its concerns as follows:

*BNI representatives stated that current cable sizing criteria are based only on planned electrical loading and environmental conditions and do not take the effects of penetration seals or fire-protected cable trays and conduits into consideration. Cable sizing and ampacity derating is especially important when electrical cable is installed through penetration seals in fire stops or in fire-protected tray and conduits, as is expected in the final design of some WTP facilities. These fire protection features cause a reduction in the heat transfer characteristics of electrical cables and result in localized hot spots where the cable's thermal limits may be exceeded at current levels below the cable's original ampacity rating. By derating the maximum current a cable can carry, these localized hot spots can be prevented. Cables that are sized without considering this can fail and become unable to perform their safety function. The design is approaching the maturity level where cable routes are soon to be finalized. Once cable routing has been finalized in the design the project team can calculate appropriate derating factors from testing in accordance with IEEE Standard 848, IEEE Standard Procedure for the Determination of Ampacity Derating of Fire-Protected Cables, or an equivalent*

*methodology. However, the Board's staff found that neither IEEE Standard 848 nor equivalent requirements are included in either the WTP SRD or the Basis of Design (BOD). This could lead to procurement of inadequately sized cables.*

**Response to DNFSB Concerns**

By Reference 2, DOE-HQ responded to the DNFSB staff concerns based on input jointly developed by DOE and BNI representatives. A summary of the submitted response, updated with current information, where necessary, is provided below.

The WTP Project has no current design, or anticipated future designs, which require fire-wrapping of power cables. If future design changes require derating of cable due to firestops in excess of 12 inches, or fire-wrapping of power cables, the effect on cable ampacity will be determined by analysis and the WTP Project basis of design (design criteria) will be revised to address the requirement to derate these cables.

BNI has prepared a report, 24590-WTP-RPT-E-14-002, *Impact Analysis to Power Cable Ampacities Penetrating Firestops* (Reference 9), using published formulas in IEEE transaction(s) to determine the impact to cable ampacities. This report concludes that for all power cables passing through up to 12 inches of firestop materials, a 15% ampacity derating factor (ADF) will be included in the design for all cables. Subsequently, Project calculation 24590-WTP-E1C-LVE-00001, *Cable Ampacity Limitations* (Reference 10), has been revised to include the 15% ADF. The *Electrical Design Criteria,* 24590-WTP-DC-E-01-001 (Reference 11), has been revised to note that if cables are fire-wrapped, or more than 12 inches of cable is contained within a single fire barrier penetration, cable ampacities will be evaluated for additional derating beyond what is specified in Calculation 24590-WTP-E1C-LVE-00001.

IEEE Standard 848 methodology was not used because it was determined to be impractical to stage and test the large number of different combinations, quantities, and configurations of cables with different WTP design loads in a laboratory.

**Conclusions**

Calculation 24590-WTP-E1C-LVE-00001 was revised to add the fire penetration seal impacts to cable ampacities that were determined from the analysis performed in report 24590-WTP-RPT-E-14-002. The *Electrical Design Criteria,* 24590-WTP-DC-E-01-001, has been revised to clarify that cable ampacities need to be evaluated for additional derating beyond what is specified in Calculation 24590-WTP-E1C-LVE-00001 if the cables are fire-wrapped, or if more than 12 inches of cable is contained within a single fire barrier penetration.

BNI considers this DNFSB concern resolved.

## Concern 3: Adjustable Speed Drives Fed from Uninterruptible Power Supplies

**Statement of DNFSB Concerns**

By Reference 1, the DNFSB identified its concerns as follows:

*The design of the WTP facilities relies on adjustable speed drives (ASD) fed from UPS systems to control many of the large (above 150 hp) motors. These large SS and SC motors, such as those of the SC 250 hp C5V exhaust fans in PTF, require electrical power during a loss of*

*off-site power event. UPS systems will provide emergency power for these safety-related ASDs until either the emergency generators are ready for SC loads or the loads are no longer required due to a process shutdown for SS loads. Typically, an engine-driven electrical generator, which has a purely sinusoidal output voltage waveform, is used to provide emergency power to ASDs and motors of this size. However, the output waveforms of UPS systems are not pure sinusoids and may contain high frequency harmonics. The effects of these harmonics and other voltage fluctuations on the ASD's power conversion electronics are difficult to predict and control. Without proper analysis and testing, this design approach may jeopardize the operability of safety-related systems.*

*The use of UPS systems to power ASDs has not been previously attempted in DOE defense nuclear facilities, but similar power electronics applications in other industries have often resulted in overheating of electrical components as well as vibration and mechanical failure of mechanical components. In these circumstances, the solutions required to address the problem were often expensive, labor intensive, and proprietary.*

*If an electric generator is required because UPS system cannot reliably supply electrical power to ASDs that drive safety-related equipment, significant design changes would be necessary. For example, the LAW Facility currently has no connection to a safety-related generator, and such a connection would have to be added.*

*A thorough knowledge of each UPS and ASD combination is fundamental to ensuring that the system can perform its safety function reliably. The WTP project will need to determine the potential voltage fluctuations and harmonics inflicted on ASDs due to switching to and operating on power from UPS systems, and the effects on the ASDs and the driven motor's performance. The project team will have to evaluate the potential for these phenomena to impact systems reliability and develop and implement requirements for filtering equipment for each UPS, ASD and motor combination that performs a SS or SC function.*

**Response to DNFSB Concerns**

By Reference 2, DOE-HQ responded to the DNFSB staff concerns based on input jointly developed by DOE and BNI representatives. A summary of the submitted response, updated with current information, where necessary, is provided below.

One follow-up action was included to perform an evaluation of buses in the design to determine if any have excessive harmonics and, consequently, will require equipment to be added to reduce harmonics to an acceptable level.

The WTP Project has performed an analysis of the UPS-ASD-Motor combination for the off-gas blowers in the LAW Facility in report 24590-WTP-RPT-E-14-004, *Performance of A.C. Adjustable Speed Drives Fed from an Uninterruptible Power Supply System* (Reference 12). In addition, 24590-LAW-ES-E-16-001, *WTP Harmonic Analysis Study – DFLAW Operation Configuration* (Reference 13), has been issued to determine (voltage) total harmonic distortion (THD) on buses in LBL. Together these analyses verified that the harmonic interactions between the connected equipment are within acceptable limits of industry standard and the acceptable limits set by the manufacturers of UPS and ASD equipment. Based on this analysis, it was concluded in the report that the UPS-ASD-Motor combination for the LAW Facility off-gas exhauster will perform its intended safety-related function without any issues associated with harmonics. The report also concludes that the design for the LAW Facility off-gas exhauster power system is acceptable without modifications.

Reference 12 will be updated to address other UPS-ASD-Motor combinations once the information required to perform the analyses is available. For any UPS-ASD-Motor combinations where potentially harmful levels of harmonics are identified, one or more of the following cost-effective design solutions will be implemented in the design:

- 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)
- Install active filters which generate opposing (canceling) harmonic waveforms

**Conclusions**

The approach of performing a harmonic analysis and, where necessary, mitigating harmful levels of harmonics, is included in WTP Project processes and procedures for future design work.

The completed analysis of the UPS-ASD-Motor combination for the LAW Facility off-gas exhauster concluded that the system will perform its intended safety-related function without any issues associated with harmonics.

BNI considers this DNFSB concern resolved.

## Concern 4: Fast Reclosing of Power Supply Breakers

**Statement of DNFSB Concerns**

By Reference 1, the DNFSB identified its concerns as follows:

> *The staff reviewed the project's strategy for preventing damage to large induction motors as a result of fast reclosing of electrical breakers and operation of the automatic bus transfer switches. As detailed in National Electrical Manufacturers Association (NEMA) MG-1-1993, Revision 2, Motors and Generators section 20.85; initially upon a loss of power, induction motors continue to rotate and retain residual magnetism; therefore, they develop generator action and induced voltages. When the motors are exposed to an automatic bus transfer or fast reclosing of the power supply breaker, there is a potential for the incoming voltage to be out of phase with that induced in the rotating machine. This can result in the development of a transient current and torque, the magnitude of which may range from 2 to 20 times the value rated for the machine, potentially causing damage to the motor. The severity of this damage is a function of the machine's construction, system inertia, operating conditions, and switching times. The project team will have to perform an evaluation of the magnitude and effects transient torques has on large induction motors during a rapid restoration of power in order to provide suitable protective devices for the protection of the connected motors, as required by NEMA MG-1.*

**Response to DNFSB Concerns**

By Reference 2, DOE-HQ responded to the DNFSB staff concerns based on input jointly developed by DOE and BNI representatives. A summary of the submitted response, updated with current information, where necessary, is provided below.

BNI agrees with the DNFSB concern that when motors are exposed to an automatic bus transfer or fast reclosing of the power supply breaker, there is the potential for the incoming voltage to be out of phase with that induced in the rotating equipment.

**Automatic Bus Transfer:**

There are no safety automatic bus transfers at WTP. The only automatic bus transfers are as follows:

- Non-safety, double-ended, low-voltage unit substations
- Non-safety, double-ended, medium-voltage (4.16 kV) switchgear in BOF building B91
- Non-safety, medium-voltage (13.8 kV) switchgear in the BOF and Lab facilities that will be supplied power from the standby diesel generator after loss of offsite power

**Fast Reclosing of the Power Supply Breaker:**

A temporary loss of power will cause most operating non-safety motors to drop out and not automatically restart. Restart of non-safety motors is manually initiated, except for some small horsepower motors that will automatically restart following transfer of supply buses to the standby diesel generators (significant delay between loss of power and restart). Safety motors are connected to adjustable speed drives (ASD) and will restart automatically on fast reclosing of power supply breakers following a temporary loss of power. 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 softly reaccelerate the motor to the required speed. These actions will prevent the development of a transient current and torque causing damage to the motor. Datasheets (typical) showing the requirement that ASDs are to be able to start a spinning motor, are provided for information (References 14 and 15).

**Conclusions**

The WTP Project design strategy will prevent damage to large induction motors as a result of fast reclosing of electrical breakers and operation of the automatic bus transfer switches.

BNI considers this DNFSB concern resolved.

## Concern 5: Valve-Regulated Lead-Acid Battery Charging System Safety Control Set

**Statement of DNFSB Concerns**

By Reference 1, the DNFSB identified its concerns as follows:

> *Chemical reactions in lead-acid batteries produce hydrogen and introduce explosion and fire hazards. To minimize this hazard, the project team selected VRLA batteries for use in the safety-related and non-safety-related portions of the UPS and DC electrical (DCE) systems. The design of VRLA batteries limits the release of hydrogen during normal operation and*

*reduces the hazard by containing and recombining hydrogen and oxygen in the battery. However, high ambient temperatures or high battery temperature caused by overcharging can increase pressure within the battery and cause significant hydrogen gas releases. To limit this hazard, most VRLA batteries use a temperature compensated charging system that helps limit battery temperatures and reduces the likelihood of battery overpressure. Additionally, to mitigate the hydrogen hazard, IEEE Standard 1187, IEEE Recommended Practice for Installation Design and Installation of Valve-Regulated Lead-Acid Storage Batteries for Stationary Applications, requires that areas containing VRLA batteries have dedicated ventilation systems to remove the heat generated by the battery charging process and to remove any hydrogen gas generated by the batteries.*

*The WTP project team recently modified the strategy used to control the hydrogen hazard associated with charging lead acid batteries. The control strategy now credits the temperature compensated charging system with preventing the generation of hydrogen gas as long as the safety-related cooling ventilation system maintains ambient temperature within an expected range. Using this control, the project team determined that battery fires and explosions are no longer credible events and thus eliminated a previous safety-related control requirement for ventilation flow across the batteries to prevent hydrogen gas accumulation while maintaining safety-related ventilation for battery cooling.*

*However, the staff notes that IEEE Standard 1187 considers battery fires and explosions to be credible events for systems that use temperature compensated charging. Consequently, the standard requires direct ventilation and recommends temperature compensated charging for mitigation of hydrogen hazards in addition to requiring ventilation for prevention of battery overheating. Thus there is a conflict between the standard and the current WTP safety strategy. The staff reviewed the justification provided for elimination of the requirement to provide ventilation to prevent hydrogen accumulation but determined it did not provide a compelling argument for failing to comply with IEEE Standard 1187.*

*The WTP project team has purchased the Alcad AT-30 series battery charger for use in the non-safety-related UPS and DCE installations in the WTP facilities. The staff's review of the Alcad AT -30 operating and service instructions revealed that the Alcad charger will allow battery charging to continue in a non-temperature compensated mode if the temperature compensating circuit fails. If the project team selected the same model of battery charger for the safety-related portions of the UPS and DCE systems, this mode of operation would represent a dangerous failure of an active safety control. The presence of a dangerous failure mode indicates that battery explosions and fires are a credible hazard. The relevant standards for the design of safety instrumented systems require methods to prevent or mitigate dangerous failure modes.*

**Response to DNFSB Concerns**

By Reference 2, DOE-HQ responded to the DNFSB staff concerns based on input jointly developed by DOE and BNI representatives. A summary of the submitted response, updated with current information, where necessary, is provided below.

A follow-up action was identified for BNI to perform studies of the valve-regulated lead-acid (VRLA) battery installations at the WTP Project to confirm code and standard compliance, adequacy of ventilation, and assess hazards to nearby safety equipment and workers.

The risk of accumulation of hydrogen in rooms with batteries is the greatest during equalization charge, near end of recharge, or during overcharge of the batteries. The most extreme abnormal condition is called thermal runaway where the battery reaches a high temperature while charging, which releases hydrogen gas at a higher rate. Thermal runaway is a rare event, and usually occurs as a result of poorly designed battery/charger and HVAC systems, and a lack of operational and maintenance oversight; however, these risks at the WTP Project are addressed as follows:

- Battery chargers include temperature-compensated charging systems which prevent the chargers from overcharging the batteries, preventing thermal runaway due to temperature rise. Temperature compensated charging raises and lowers the charging voltage in the opposite direction of the increase or decrease in temperature.
- Each battery cell has its own one-way valve that opens at a specific pressure to release excess gas in case of overcharging. The valve reseals after the pressure drops to a lower specified level. Flame arrestors prevent sparks or flame from entering the battery.
- Battery cases are designed to be self-extinguishing and meet minimum flammability standards of Underwriters Laboratories (UL) 94 V-0 and a limiting oxygen index (LOI) of 28.
- Live parts of batteries are guarded or insulated against inadvertent contact.
- The battery utilizes a highly porous and absorbent glass fiber mat that separates the plates and keeps the electrolyte and plates in contact with each other. These types of batteries do not leak electrolyte.
- Areas with safety class electrical distribution systems have two redundant fan coil units (FCU) with direct expansion (DX) condenser backups connected to emergency power to ensure the room remains within the design temperature during a loss of normal power.

The WTP Project installation described above and functional operational and maintenance oversight of the installations, will prevent the occurrence of any of the hazardous conditions described by the DNFSB and aligns with the codes and standards listed below:

- NFPA 70-1999 (NEC), *National Electrical Code*
- IEEE Standard C2, *National Electrical Safety Code*
- NFPA 70E-2012, *Standard for Electrical Safety in the Work Place*
- IEEE 1187-2002, *Recommended Practice for Installation Design and Installation of VRLA Storage Batteries for Stationary Applications*
- UFC, *Uniform Fire Code*
- IFC, *International Fire Code*

The DNFSB statement that IEEE Standard 1187 requires "direct ventilation and recommends temperature compensated charging for mitigation of hydrogen hazards in addition to requiring ventilation for prevention of battery overheating" does not align with the wording in the standard. IEEE Standard 1187 states that to mitigate hydrogen "either natural or forced ventilation can be used" and to prevent overheating, "Batteries should be installed so that they are protected from direct heating, ventilation, and air conditioning (HVAC) or other equipment airflows" and "The installation should provide for adequate air flow ... achieved by a combination of spacing between cells/modules and the design of the supporting structure." WTP Project designs are aligned with the IEEE Standard 1187 requirements.

In completing the design of these systems, BNI is performing hydrogen generation calculations for each room with VRLA batteries to confirm that there is sufficient ventilation (air changes) to ensure that the hydrogen concentration (by volume) does not exceed 1% (25% of the lower flammability limit [LFL])

under worst case scenario (thermal runaway) (References 16 through 20). These calculations have been completed for the rooms in the LAW, BOF, and Lab facilities containing VRLA batteries, and all results show that there is sufficient ventilation provided in the design. The calculations, in each case, conclude that there is a significant safety factor in the ventilation system above that which is required to prevent more than 1% hydrogen concentration. In addition, an alarm system is provided in rooms with batteries that will alarm if there is a failure of the ventilation system, or if there is a battery temperature increase indicating that there could be an overcharge condition. The alarm will be local to the room with batteries, remote to the Main Control Room (MCR), and by pager to Operations and Maintenance for the period between battery energization and MCR operation.

Hazard Analysis, accident analysis, and control decisions for VRLA battery installations have been performed for the LAW and HLW facilities using DOE-STD-3009 methodology.

**Conclusions**

The WTP design aligns with the requirements of IEEE Standard 1187 and other applicable codes and standards.

Project calculations of battery hydrogen generation rates, under a worst-case scenario, compared to air changes in the ventilation system, will prevent hydrogen concentrations in the room from exceeding 1% by volume (25% of the LFL), with significant safety factors. In addition, rooms with batteries will have local and remote alarms if there is an indication of ventilation system failure or overcharging of the batteries.

As the WTP Project design matures, revisions to WTP Project design calculations for hydrogen concentrations in battery rooms will be provided to the DNFSB upon request.

BNI considers this DNFSB concern resolved.

## Concern 6: Valve-Regulated Lead-Acid Battery Installation Location

**Statement of DNFSB Concerns**

By Reference 1, the DNFSB identified its concerns as follows:

> *During a walk-down of the WTP facilities, the Board's staff observed that many of the installed battery racks and associated charging systems are located in open areas near switchgear. In some cases, equipment located near the UPS systems and batteries is classified SS or SC. NESC C2-2012, National Electrical Safety Code, requires that storage batteries be located "within a protective enclosure or area accessible only to qualified persons." This requirement exists to protect equipment and personnel from the hazards and effects associated with battery fires and explosions. Additionally, DOE Standard 1027, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, requires that hazard controls to protect facility workers from the effects of operational accidents be considered. Based on applicable standards, the failure modes associated with VRLA batteries and the potential hazards to facility workers and safety equipment, the WTP battery units require enclosed and protected spaces away from normal personnel traffic and away from other safety related equipment.*

**Response to DNFSB Concerns**

By Reference 2, DOE-HQ responded to the DNFSB staff concerns based on input jointly developed by DOE and BNI representatives. A summary of the submitted response, updated with current information, where necessary, is provided below.

A follow-up action was identified to address potential hazards associated with the UPS system. This action was addressed in the response to DNFSB Concern 5.

The DNFSB contention that IEEE NESC C2-2012 requires storage batteries to be in a protected enclosure or area "to protect equipment and personnel from the hazards and effects associated with battery fires and explosions" is not accurate. IEEE NESC C2-2012 states that, "Storage batteries shall be located within a protective enclosure or area accessible only to qualified persons. A protective enclosure can be a battery room, control building, or a case, cage, or fence that will protect the contained equipment and limit the likelihood of inadvertent contact with energized parts." There are no words in the code regarding protecting "equipment and personnel from the hazards and effects associated with battery fires and explosions."

The WTP Project design complies with the IEEE NESC C2-2012 requirements. The live parts of batteries are guarded and/or insulated to prevent inadvertent contact, and the building areas with VRLA batteries are accessible only to qualified persons who have received specific training to work in those areas. Only qualified workers performing work under an approved work package, that includes a work hazards analysis, are permitted to work on the batteries.

As discussed in the response to Concern 5, the VRLA battery installation design does address mitigation of hydrogen generated by the batteries.

**Conclusions**

The VRLA battery installations at the WTP Project are compliant with IEEE NESC C2-2012 and other applicable codes and standards. The installations are only accessible to qualified personnel and the live parts of the batteries are guarded and/or insulated to prevent inadvertent contact with live parts.

BNI considers this DNFSB concern resolved.

## Concern 7: Unprotected Electrical Equipment

**Statement of DNFSB Concerns**

By Reference 1, the DNFSB identified its concerns as follows:

> *During a walk-down of the WTP facilities, the staff identified numerous pieces of installed safety-related and non-safety-related electrical equipment with open gratings on the top of the equipment. Examples include switchgear, UPS Systems, battery chargers, and power panels. These openings are located under the sprinkler heads of the fire protection system. Spray from activation of the sprinkler system or leakage from co-located fluid systems would likely penetrate this equipment and generate a short circuit that could damage the equipment and create hazardous conditions. The staff found this identical condition in the A-6 substation at Hanford during a 2004 review, as documented in the Board's letter to DOE dated August 26, 2004. The staff believes that if DOE had adopted an appropriate design standard such as IEEE*

*Standard 833, IEEE Recommended Practice for the Protection of Electrical Equipment in Nuclear Power Generating Stations from Water Hazards, this deficiency would have been prevented. IEEE Standard 833 addresses these issues and provides guidance for the protection of electrical equipment. Neither BNI personnel nor the Board's staff could readily determine the extent to which procured electrical equipment is affected by this problem. The Board's staff continues to believe that the WTP project should include IEEE Standard 833 or an equivalent standard in the WTP SRD and BOD and implement its requirements for the protection of electrical equipment from water hazards.*

**Response to DNFSB Concerns**

By Reference 2, DOE-HQ responded to the DNFSB staff concerns based on input jointly developed by DOE and BNI representatives. A summary of the submitted response, updated with current information, where necessary, is provided below.

A follow-up action was identified for BNI to perform a study to determine the need to protect the SS and SC electrical equipment from water intrusion consistent with IEEE Standard 833.

On further review of code and standard requirements, it was concluded that a study was not required to resolve this issue because there are no WTP Project implementing codes or standards that require protecting electrical equipment from fire-water spray. Implementing Code NFPA 70-1999 (NEC) Section 110-26(f)(1)(c) states: "Sprinkler protection shall be permitted for the dedicated space where the piping complies with this section." The dedicated space is the space immediately above the electrical equipment. NEC 110-34 states: "Protection shall be provided where necessary to avoid damage from condensation leaks and breaks in such foreign systems. Piping and other facilities shall not be considered foreign if provided for fire protection of the electrical installation." The WTP Project complies with these requirements.

Although not a WTP Project implementing standard, it is noteworthy that IEEE Standard 833 also does not require protecting electrical equipment from fire-water spray. IEEE Standard 833, Section 4.3, Sealing and Shielding, states:

> *It should be further understood that when water is to be applied directly to a specific item of electric equipment as a means of extinguishing a fire in or on that equipment, sealing or shielding should not prevent this; however, any other electric equipment in the vicinity should not be adversely affected by this action.*

The main WTP Project CM electrical distribution buildings (B87 and B91) and electrical rooms with safety electrical distribution equipment are fully compliant with WTP Project codes and standards and with IEEE Standard 833 requirements for fire-water. These buildings and electrical rooms have pre-action sprinkler systems to protect the electrical equipment from accidental fire-water spray. The pipes in these pre-action systems are normally dry and only fill with water in the event that smoke is detected by one of two detectors in the room and a sprinkler head(s) fuse melts from the heat of the fire. Water then only sprays from the sprinkler head(s) with the melted fuse. Sprinkler systems in non-safety electrical rooms are typically standard flooded water type systems, and only spray from the sprinkler head(s) with the melted fuse. Additionally, the following WTP Project design specifications and features are used to protect electrical equipment from inadvertent water sprays and spills:

- 24590-WTP-3PS-E00X-T0007, Rev 7, *Engineering Specification for Electrical Raceway System Installation*, requires exposed fittings for Q conduits shall be located above the maximum floodwater depth.

- 24590-WTP-3PS-E00X-T0001, Rev 6, *Engineering Specification for Electrical Equipment Installation*, Appendix D, prevents piping from being routed above electrical distribution equipment without protecting the equipment.

- 24590-WTP-3PS-E00X-T0004, Rev 12, *Engineering Specification for Installation of Cables,* requires hub openings to be sealed after cable installation in a manner that it completely fills the voids around all cables.

- Medium Voltage Switchgear are provided with factory supplied drip shields.

- Ventilation openings on top surfaces of safety electrical distribution equipment will be shielded if water spray, from other than fire water sprinklers, is determined to be a threat to the equipment.

**Conclusions**

The WTP Project electrical installation designs comply with all applicable code and standard requirements for protecting electrical equipment from water hazard. No applicable codes or standards, including IEEE Standard 833, require protection or shielding of electrical equipment from fire-water spray.

The main WTP Project CM electrical distribution buildings (B87 and B91) and all electrical rooms with safety electrical distribution equipment have interlocked pre-action fire water sprinkler systems that prevent water spray from contacting electrical equipment unless there is an actual fire event.

BNI considers this DNFSB concern resolved.

## Concern 8: High Voltage Cables in Manholes

**Statement of DNFSB Concerns**

By Reference 1, the DNFSB identified its concerns as follows:

> *The staff requested that two underground manholes housing electrical cables be opened for inspection. These cables supply power to nuclear facilities in the area. BNI personnel found several feet of water in manhole number 45, which houses several 13.8 kV cables, indicating that the current drainage system is not functional and that the design is inadequate to prevent wetting cables. BNI had the water removed prior to the staff's arrival; however, the cables still showed signs of being submerged, and the staff questioned how long they had been submerged, the impact to their durability after being submerged, and their long-term ability to function underwater. The insulation material of submerged electrical cables will gradually lose its dielectric strength, which can lead to electrical faults, potentially resulting in explosions. This phenomenon was observed in manholes at the Y-12 sites in the 1990s. Protecting the cables will require that the WTP project team develop a program to routinely survey manholes containing power cables for water and make modifications as necessary to keep electrical cables dry. These modifications include installation of cable supports such as those detailed in*

*the American Electrician's Handbook, which provides guidance on meeting the requirements of the National Electric Code. These modifications should ensure that cables are kept above the expected waterline in the event of manhole flooding.*

**Response to DNFSB Concerns**

By Reference 2, DOE-HQ responded to the DNFSB staff concerns based on input jointly developed by DOE and BNI representatives. A summary of the submitted response, updated with current information, where necessary, is provided below.

A follow-up action was identified for BNI to implement a manhole inspection program and to require supporting of power conductors so that they are protected from submergence in water accumulation in the bottom of the manhole.

WTP permanent plant manhole designs include cable supports and are provided with a French drain at the bottom of each manhole to prevent water accumulations. Cable supports will be installed in the manholes prior to permanent plant cables being installed. 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. Currently, construction also uses some of these manholes to distribute temporary power throughout the WTP Project construction site.

At the time of the DNFSB site visit, there were no permanent plant cables installed in manhole number 45 (MH-45). The observed cables were installed for temporary construction power use only and were not supported since supports had not been installed yet. The French drains in MH-45 were clogged with mud and not functioning properly at the time of the inspection. These temporary power cables will be removed by Construction when they are no longer required for temporary power.

Permanently installed cables are designed to be supported and secured in accordance with code and industry standards and Hi-Pot tested for insulation integrity prior to energization. Project documentation has been revised to require periodic inspections of the manholes for water accumulation, and for confirmation that the French drains are functioning properly (Reference 21) prior to energization with permanent power. Manhole cable support details are provided in Engineering Manhole Layout Plans (References 21 through 27).

**Conclusions**

The follow-on action has been completed. Permanent plant medium-voltage cables will be supported in manholes. Manholes will be periodically inspected for water accumulations and proper functioning of French drains. Permanent plant medium-voltage cables will be Hi-Pot tested prior to energization.

BNI considers this DNFSB concern resolved.

## Concern 9: Past Due Calibration of Protective Devices

**Statement of DNFSB Concerns**

By Reference 1, the DNFSB identified its concerns as follows:

> *During a walk-down of the switchgear room in the A6 substation, the Board's staff observed that the posted calibration date for many of the protective devices was more than 10 years ago (August 2001). DOE-RL personnel stated that these postings may be from the original programming and installation of the switchgear and that the switchgear is not calibrated on site, but sent back to the manufacturer in the event that it fails a calibration check. DOE-RL personnel could not provide the calibration check requirements or any records to support meeting these requirements. The A6 substation is currently not supplying any loads on the WTP site, but the equipment in the switchgear building is energized. The substation is scheduled to enter service in 2012 when some WTP buildings begin commissioning. It is not clear why DOE-RL is not requiring the contractor to maintain and calibrate electrical protective devices at the manufacturer's recommended intervals, or formally remove the equipment from service.*

**Response to DNFSB Concerns**

By Reference 2, DOE-HQ responded to the DNFSB staff concerns based on input jointly developed by DOE and BNI representatives. A summary of the submitted response, updated with current information, where necessary, is provided below.

The A6 Substation was constructed to provide 13.8 kV power to the WTP Project. At the time of the walkthrough, although the substation equipment was energized, the WTP Project main switchgear was not receiving power from the A6 substation. The calibration stickers observed during the walk-down 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. Since the walk-through in December of 2011, these protective devices have been field calibrated and set to their design settings by a third-party laboratory.

**Conclusions**

The A6 Substation breakers have been set to their design settings, have been field calibrated, and have current up-to-date calibration stickers applied.

BNI considers this DNFSB concern resolved.

## Concern 10: Emergency Turbine Generator Design Change

**Statement of DNFSB Concerns**

By Reference 1, the DNFSB identified its concerns as follows:

> *The project team's recent decision to replace the SC reciprocating diesel driven generators with SC emergency turbine generators (ETGs) and large SC UPS systems affects the WTP safety basis. Since the startup time requirements for ETGs exceed those of reciprocating diesels, the WTP project team is adding large SC UPS units to the design to power safety equipment during ETG startup. This emerging issue introduces new safety requirements and it is unclear how they will be incorporated into the safety basis. Additional staff reviews will be*

*necessary after this portion of the design matures to determine the adequacy of the design changes and the selected safety requirements.*

**Response to DNFSB Concerns**

By Reference 2, DOE-HQ responded to the DNFSB staff concerns based on input jointly developed by DOE and BNI representatives. A summary of the submitted response, updated with current information, where necessary, is provided below.

The WTP Project initiated a change from emergency diesel generators (EDG) to emergency turbine generators (ETG) due to the significant cost savings and other technical advantages regarding size, cooling, efficiency, and reliability. Because this change impacts the existing safety basis, 24590-BOF-JCDPI-M-11-0001, *Implement Turbine Technology for the Purpose of Safety Class Emergency Power*, (References 28 through 33) was developed to justify continued design and procurement of the ETGs and ETG Building in advance of completing the hazard analysis and approval of the Authorization Basis (AB) Amendment request. The JCDPI does not allow installation of the ETGs, nor does it allow excavation or construction for the ETG Facility at the WTP Project. The AB Amendment to incorporate the ETGs was approved by ORP in August 2013 (CCN 260410) (Reference 33).

The WTP Project acknowledges that there will be a delay between a postulated loss of offsite power and the availability of emergency power. If a safety evaluation determines that specific motors present a safety hazard if they lose power for the duration of the transfer to ETG power, they will be provided with Uninterruptible Power Supply (UPS) power. The analysis of the performance of these motors on a UPS would be added to 24590-WTP-RPT-E-14-004, *Performance of A.C. Adjustable Speed Drives Fed from an Uninterruptible Power Supply System*, (Reference 12) discussed in the response to Concern 3.

**Conclusions**

No technical issues remain at this time. As the design matures, safety requirements and design information will be provided to the DNFSB as requested.

BNI considers this DNFSB concern resolved.

**References**

1. Letter from P. S. Winokur, DNFSB, to D. Huizenga, *DNFSB Staff Issue Report – Review of the Electrical Distribution System for the Waste Treatment and Immobilization Plant, Hanford Site*, DOE-HQ, CCN 247098, dated April 13, 2012.

2. Letter from D. Huizenga, DOE-HQ, to P. S. Winokur, DNFSB, *Waste Treatment and Immobilization Project Response to the Defense Nuclear Facilities Safety DNFSB Concerns: Electrical Distribution System,* CCN 252583, dated September 27, 2012.

3. Letter from S. J. Olinger, ORP, to F. M. Russo, BNI, *Approval of Application of the Institute of Electrical and Electronics Engineers (IEEE)-323 for Structures, Systems, and Components (SSC) Classified Safety Significant (SS) for Protection from Chemical Hazards Only*, CCN 216355/10-NSD-023, dated March 30, 2010.

4. 24590-WTP-3PS-JQ06-T0005, *Engineering Specification for Environmental Qualification of Control and Electrical Systems and Components, Appendix E "Environmental Qualification Requirements for SS-Chemical Toxicity Equipment in the LAW Facility,"* dated June 5, 2014.

5. 24590-WTP-EQP-ENG-14-0023, Rev 0, *Equipment Qualification Package (EQP) for LAW Thermal Catalytic Oxidizer and Ammonia Air Dilution Skid*, dated August 11, 2016.

6. *24590*-WTP-EQP-ENG-14-0015, Rev 0, *Equipment Qualification Package (EQP) for Activated Carbon Bed Absorbers,* dated May 25, 2016.

7. 24590-WTP-EQP-ENG-14-0029, Rev A, *Equipment Qualification Package (EQP) for Secondary Off-Gas System (LVP) Exhausters,* dated March 6, 2015.

8. Letter from K. D. Irwin, BNI, to W. F. Hamel, ORP, *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, dated December 21, 2017.

9. 24590-WTP-RPT-E-14-002, Rev 0, *Impact Analysis to Power Cable Ampacities Penetrating Firestops*, dated October 14, 2014.

10. 24590-WTP-E1C-LVE-00001, Rev 5, *Cable Ampacity Limitations*, dated May 19, 2016.

11. 24590-WTP-DC-E-01-001, Rev 18, *Electrical Design Criteria*, dated August 29, 2017.

12. 24590-WTP-RPT-E-14-004, Rev 0, *Performance of A.C. Adjustable Speed Drives Fed from an Uninterruptible Power Supply System*, dated October 22, 2014.

13. 24590-LAW-ES-E-16-001, Rev 0, *WTP Harmonic Analysis Study – DFLAW Operational Configuration*, dated February 23, 2017.

14. 24590-HLW-EVD-C5V-30001, Rev 0, *Electrical Data Sheet Adjustable Speed Drive,* dated July 29, 2008.

15. 24590-PTF-EVD-C5V-10003, Rev 0, *Electrical Data Sheet Adjustable Speed Drive,* dated July 30, 2008.

16. 24590-WTP-E1C-DCE-00001, Rev 0, *Hydrogen Emission of Valve Regulated Lead Acid Batteries,* dated March 12, 2014.

17. 24590-LAW-E1C-UPE-00003, Rev 0, *LAW VRLA Batteries Hydrogen Emission Calculation*, dated August 16, 2017.

18. 24590-LAB-E1C-UPE-00002, Rev A, *Hydrogen Emission of Valve Regulated Lead Acid Battery in Lab UPS*, dated September 3, 2015.

19. 24590-BOF-E1C-UPE-00007, Rev 0, *Hydrogen Emission of Valve-Regulated Lead-Acid Battery in BOF Building 21S*, dated November 10, 2017.

20. 24590-BOF-E1C-UPE-00010, Rev A, *Hydrogen Emission of Valve-Regulated Lead-Acid Battery in LAW Effluent Electrical Building (B27) Battery Room*, dated November 2, 2016.

21. 24590-WTP-3PN-E00X-00037, *Cable Raceway Manhole Inspections,* dated Oct 2, 2013.

22. 24590-BOF-E0-E54T-00051, Rev 0, *13.8 kV Electrical Manhole Layout Plans*, dated April 14, 2006.

23. 24590-BOF-E0-E54T-00052, Rev 0, *13.8 kV Electrical Manhole Layout Plans*, dated April 14, 2006.

24. 24590-BOF-E0-E54T-00053, Rev 0, *13.8 kV Electrical Manhole Details and Bill of Materials,* dated April 14, 2006.

25. 24590-BOF-E0-E54T-0061, Rev 0, *13.8 kV Electrical Manhole Layout Plans – 'A' Train,* dated April 14, 2006.

26. 24590-BOF-E0-E54T-0062, Rev 0, *13.8 kV Electrical Manhole Layout Plans - 'B' Train (Q)*, April 14, 2006.

27. 24590-BOF-E0-E54T-0063, Rev 0, *13.8 kV Electrical Manhole Details and Bill of Materials 'A' & 'B' Train*, dated April 14, 2006.

28. 24590-BOF-JCDPI-M-11-0001, Rev 0, *Implement Turbine Technology for the Purpose of Safety Class Emergency Power*, dated May 26, 2011.

29. Letter from F. M. Russo, BNI, to S. L. Samuelson, ORP, *For Approval: Justification for Continued Design, Procurement, and Installation 24590-BOF-JDCPI-M-11-00001, Revision 0, Implement Turbine Technology for the Purpose of Safety Class Emergency Power,* CCN 230464, dated June 3, 2011.

30. Letter from D. E Knutson, ORP-WTP, and S. Charboneau, ORP, to F. M. Russo, BNI, *Approval of Justification for Continued Design, Procurement, and Installation (JDPI) to Implement Turbine Technology for the Purpose of Safety Class Emergency Power, 24590-BOF-JDCPI-M-11-00001, Rev 0,* CCN 236243/11-NSD-043, dated June 16, 2011.

31. Letter from F. M. Russo, BNI, to S. L. Samuelson, ORP, *Request for Extension of Justification for Continued Design, Procurement, and Installation (JCDPI) 24590-BOF-JDCPI-M-11-00001, Revision 0, Implement Turbine Technology for the Purpose of Safety Class Emergency Power,* CCN 247941, dated June 11, 2012.

32. Letter from S. L. Samuelson, ORP, to F. M. Russo, BNI, *Approval of Request for Extension of Justification for Continued Design, Procurement, and Installation (JCDPI) to Implement Turbine Technology for the Purpose of Safety Class Emergency Power, 24590-BOF-JDCPI-M-11-0001, 'Implement Turbine Technology for the Purpose of Safety Class Emergency Power',* CCN 251439, dated August 15, 2012.

33. Letter from K. W. Smith, ORP, to M. McCullough, BNI, *Approval of Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-12-0171, Revision 1, 'Incorporate Emergency Turbine Generator in Lieu of Emergency Diesel Generator into the WTP Safety Basis'*, CCN 260410, dated July 31, 2013.