Department of Energy
Washington, DC 20585

September 27, 2012

The Honorable Peter S. Winokur
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, DC 20004

Dear Mr. Chairman:

We received your April 13, 2012, letter expressing concerns regarding the operability and safety of the overall electrical distribution system at the Department of Energy (DOE) Waste Treatment and Immobilization Plant (WTP) at the Hanford Site. In the letter, you identified that although the WTP electrical distribution system meets many of the requirements of DOE orders and consensus industry standards, review by your staff raised concerns about the operability and safety of the overall electrical distribution system. Your letter requested a response within 120 days addressing the issues related to the design and construction of the WTP electrical distribution system identified in the Defense Nuclear Facilities Safety Board Staff Issue Report provided as an attachment to your letter.

The enclosed response, developed by representatives from DOE and Bechtel National, Inc., addresses 10 areas of specific interest related to the electrical distribution systems.

If you have further questions, please feel free to contact me or Mr. Matthew Moury, Deputy Assistant Secretary for Safety, Security, and Quality Programs, at (202) 586-5151.

Sincerely,

David Huizenga
Senior Advisor
for Environmental Management

Enclosure

cc: Matthew Moury, EM-40

Waste Treatment and Immobilization Project Response to the Defense Nuclear Facilities Safety DNFSB Concerns: Electrical Distribution System

1. Electrical Equipment Qualification

DNFSB Concern:

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, Inc. (IEEE) Standard 323, *IEEE Standard for Qualifying Class 1E 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, (Correspondence Control Number: 214065) and ORP response to BNI dated March 30, 2010, (Correspondence Control Number: 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 Department of Energy's (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 Defense Nuclear Facility Safety Board's (DNFSB) 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 requirement of these IEEE nuclear standards, or clearly state and justify which portions of IEEE Standard 323 and IEEE Standard 344 remain applicable to the 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 function under expected operating and accident conditions.

Response:

The WTP Project will meet the requirements established by the Safety Requirements Document (SRD), as tailored, for the qualification of safety Structures, Systems, and Components (SSC). This includes IEEE-323 and 344. The referenced letters from BNI and DOE regarding relief from IEEE -323 requirements was explicit with respect to three pieces of LAW facility equipment; the Thermal Catalytic Oxidizer (TCO), the Carbon Bed Absorber, and the Exhauster. No other equipment, controls and instrumentation, or support systems were requested for exemption by BNI. The DOE letter only granted the exclusion to the IEEE-323 requirements for the three noted LAW facility systems. This approval did not relieve BNI from ensuring that vendor provided equipment was qualified to perform its safety functions in the environments it would operate in. Nor did DOE approval mean that BNI could not utilize requirements and provisions provided in IEEE-323 to an extent applicable. This is apparent by the fact that specification 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 LAW Facility) employs IEEE-323 requirements tailored for application to Chemical Toxicity Equipment. This was based on specific tailoring provisions provided in the SRD associated with the application of IEEE-323 which may be extended to SSCs designated SS that prevent or mitigate only chemical toxicity hazards. DOE's approval of the exclusion to IEEE-323 requirements was not contingent on BNI identifying "equivalent" standards. The DOE approval simply acknowledged the fact that some of the IEEE-323 requirements could not be met by certain vendors of the aforementioned equipment, particularly with respect to equipment qualification testing applicable chemical industry standard would have to suffice. Further, the specific chemical equipment would be procured to function as intended in the environments associated with the events for which they are intended to respond by the application of chemical industry codes, standards, and criteria in lieu of the IEEE-323 nuclear standard for this equipment.

Moreover, relief from IEEE-323 was approved by DOE for the aforementioned equipment based specifically on the following SRD provision; "Where SS or SSCs are required to perform a credited safety function in a harsh environment, IEEE-323 will be used as appropriate." The ORP approval clarified what was meant "as appropriate" for the LAW TCO, CBA, and exhausters given in SRD, Appendix C, C.23, IEEE-323, *Qualifying Class 1E Equipment for Nuclear Power Generating Stations*, for the LAW TCO, CBA, and Exhausters. DOE SER 09-NSD-030 approved Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS-09-0013, *Applicability of 10 CFR 50.49 and IEEE-323 on the WTP Project, dated March 2, 2009 (CCN 192381)* requesting the tailoring of IEEE-323 for SS electrical equipment to apply IEEE-323 "as appropriate." Specifically from 09-NSD-030 Safety Evaluation Report (SER), *"as appropriate" means "to be in accordance with IEEE-323, unless the required testing/analysis information cannot be reasonably provided and its unavailability is not critical for the demonstration of the items Environmental Qualification (EQ) to perform its intended SS function. The requirement and criteria for the technical justification of "as appropriate" will be described in 24590-WTP-DC-ENG-06-001...and the documentation of technical justification will be in the component's respective EQ packages."*

The "as appropriate" was a limited clarification related to the ability to perform EQ testing only and not a complete abeyance of IEEE-323 for SS electrical equipment regardless of whether the classification is driven by toxicological consequences only. Therefore, the electrical system in all facilities must demonstrate compliance with IEEE-323 and IEEE-344/ACI in accordance with SRD Appendix C.23 "as appropriate." As stated in the SER, technical justification, including applicable industry codes, guides and standards, for the environmental qualification requirements will be documented in the EQ data packages.

Instrumentation and controls associated with the aforementioned equipment that is determined to have an active safety function is to be separately procured and will be qualified in accordance with IEEE-323 (1983) (i.e., the exclusion does not apply).

Based on the above explanation, there are no corrective or follow-up actions required.

2. Cable Ampacity Derating

DNFSB Concern:

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 DNFSB'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:

WTP has no current design, or anticipates any future designs which requires fire-wrapping of power cables. However, if there is a scope change that requires fire-wrapping of power cables, the ampacity of these cables will be determined either by testing or by analysis. WTP prefers the analytical method, because it has a shorter turn-around time to obtain results, and new configurations can be quickly analyzed and implemented into the designs. The ETAP software program, currently used at WTP, has the capability to calculate ampacities of cables that are fire-wrapped.

The Service Requisition for LAW/LAB Penetrations and Joint Seals is forecasted to be awarded by March 2013, and submittals for the Firestops are forecasted to be received by June 2013. After receipt of the Firestop submittals, which will include technical details related to the Firestop thermal conductance and/or Ampacity Derating Factors (ADFs), WTP will perform a documented evaluation to determine what impacts the firestops could have on cable ampacities listed in 24590-WTP-E1C-LVE-00001, Cable Ampacity Limitations Calculation.

A primary supplier of cable to WTP advised that, when requested by a customer, they calculate fire-wrapped cable ampacities using CYMCAP Software, which is a similar software to ETAP used by WTP.

The use of software to calculate ampacities for fire-wrapped cables is a preferred methodology. Determining cable ampacities using the IEEE 848 test procedures would be a hardship to the project due to the delay between identifying cable/fire-wrapping configurations and getting the test results. It would require the project to competitively bid and obtain the services of a testing laboratory, provide them with the actual fire-wrapping materials, cables (of all types and sizes) and define the cable configurations, prior to the lab running tests for each variation. Administration of the Services Subcontract with the testing Lab would introduce additional delays, where each new cable configuration requiring testing would initiate a new cycle of scoping, pricing, and acceptance of a new Task Order prior to running the new tests.

In summary, the DNFSB makes two key points, which are addressed by:

a) DNFSB Key Point: 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.

Once the Firestop information is available in 2013, WTP will perform a documented evaluation to determine if the reduction in margin caused by the Firestops, will be offset by the surplus margin embedded within the current Cable Ampacity Limitation calculation. The results from this evaluation will be included in the Cable Ampacity Limitation calculation.

WTP has no current design, or anticipate any future designs which requires fire-wrapping of power cables. However, if there is a scope change that requires fire-wrapping of power cables, the ampacity of these cables will be determined by analysis seal.

b) DNFSB Key Point: The DNFSB's staff found that neither IEEE Standard 848 nor equivalent requirements are included in either the WTP SRD or the BOD.

If future design changes result in the need to derate cable due to fire-barrier penetrations or fire wrapping, the effect on cable ampacities will be determined by analysis, utilizing the project ETAP software, and the derated ampacities would be added to existing Cable

Ampacity Limitation calculation. If fire-wrapping of power cables is introduced into WTP design, the BOD will be revised to address the requirement of de-rating of these cables.

Based on the above explanation, there are no corrective or follow-up actions required.

3. Adjustable Speed Drives Fed from Uninterruptible Power Supplies

DNFSB Concern:

The design of the WTP facilities relies on Adjustable Speed Drives (ASD) fed from Uninterruptible Power Supply (UPS) systems to control many of the large (above 150 hp) motors. These large SS and Safety Class (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 it's 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:

Specifications, datasheets, and material requisitions for the UPSs, ASDs and motors provide the requirements to the respective supplier so that any technical difficulties can be addressed and mitigated. The design requirements, including ASD settings, are coordinated with the mechanical equipment and ASD, and motor suppliers to ensure the power supply and drive are matched to the motor load. The ASD and UPS combinations will be tested during Commissioning and Testing to confirm their compatibility, and that their performance meets project requirements.

The WTP baseline currently includes the development of a harmonic analysis of the WTP Electrical Distribution System using ETAP software to locate any busses which exceed the acceptability criteria defined in IEEE Std 519. Busses with excessive harmonics will be evaluated, and determined if equipment should be added to reduce harmonics to an acceptable level.

The possibility that UPSs may be used to power key safety loads during Emergency Turbine Generator (ETG) startup is documented in 24590-BOF-JCDPI-M-11-0001, *Implement Turbine Technology for the Purpose of Safety Class Emergency Power*. This Justification of Continued Design, Procurement, and Installation (JCDPI) commits the project to evaluating the increased starting time of the ETG (30 to 200 seconds) to determine if additional power source(s) are required to carry certain safety loads that cannot tolerate the ETG startup time. If the results of this evaluation indicate that additional power sources are required, it is likely that UPSs will be used to power these safety loads. The JCDPI recognized that the hazards of using UPSs would need to be evaluated by stating: *The hazards and requirements associated with UPS units and their support auxiliaries will be evaluated and documented.*

The operation of a motor via an ASD, that is in turn powered from an UPS, is recognized as a unique design feature that requires the coordination of the motor, ASD, and UPS suppliers. WTP specifications, datasheets, and material requisitions for the UPSs, and ASDs provide the requirements to the respective supplier so that any technical difficulties can be addressed and mitigated.

Additionally, the current scope of work includes performing a harmonic analysis to identify any busses in the electrical distribution system where harmonics are at a level where they could be harmful to equipment.

If interim power is required for critical motor-driven loads, the motors will be connected to and controlled through adjustable speed drives that will be fed from UPSs; no large-induction motor will be connected directly to a UPS. The advantages of ASD for controlling motors include:

- Soft start
- Reduction in thermal and mechanical stresses on motors and drive train
- Improve efficiencies
- Low starting currents (eliminates voltage drops from motor starting inrush current)
- High power factor
- Speed control based on the relationship between performance and system curves

The ETG Load List currently identifies the following SC large motors that will be powered via an uninterruptible power supply.

- HLW-C5V-FAN-00004A/B (350 Hp each)
- PTF-C5V-FAN-00001A/C (train A, 2 x 50 %, 250 Hp each)
- PTF-C5V-FAN-00001B/D (train B, 2 x 50 %, 250 Hp each)

In the LAW facility, the following motors for the SS offgas system exhausters are each powered from a UPS that is on the LAW normal power system.

- LVP-EXHR-00001A/B/C, powered from UPE-UPS-20301/20302/20303, via LVP-ASD-00001A/B/C.

In each of these cases the output from the UPS is routed through ASDs, which then power the respective motor.

In summary, the DNFSB makes four key points, which are addressed by:

a) DNFSB Key Point: 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.

UPS Specifications limit the UPS output harmonics to IEEE Standard 519, *Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems,* recommendations of not more than 5 percent (rms) harmonic voltage distortion, and 3 percent for any single harmonics. ASD Specifications require them to be rated to operate satisfactorily on buses with 5 percent harmonic voltage distortion. Motors are special inverter type with special design features, per NEMA MG-1 (Part 31), for connection to ASDs.

b) DNFSB Key Point: A thorough knowledge of each UPS and ASD combination is fundamental to ensuring that the system can perform it's safety function reliably.

Specifications, datasheets, and material requisitions for the UPSs, ASDs, and motors provide the requirements to the respective supplier so that any technical difficulties can be addressed and mitigated. The design requirements, including ASD settings, are coordinated with the mechanical equipment and ASD, suppliers to ensure the power supply and drive are matched to the motor load. The ASD and UPS combinations will be tested during Commissioning and Testing to confirm their compatibility, and that their performance meets project requirements.

c) DNFSB Key Point: 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 system reliability, and develop and implement requirements for filtering equipment for each UPS, ASD, and motor combination that performs a SS or SC function.

The WTP baseline currently includes the development of a harmonic analysis of the WTP Electrical Distribution System using ETAP software to locate any busses with excessive harmonic levels. The analysis utilizes IEEE Std 519 as a guide to determine acceptability of the calculated harmonic levels on busses.

d) DNFSB Key Point: In these circumstances, the solutions required to address the problem were often expensive, labor intensive, and proprietary.

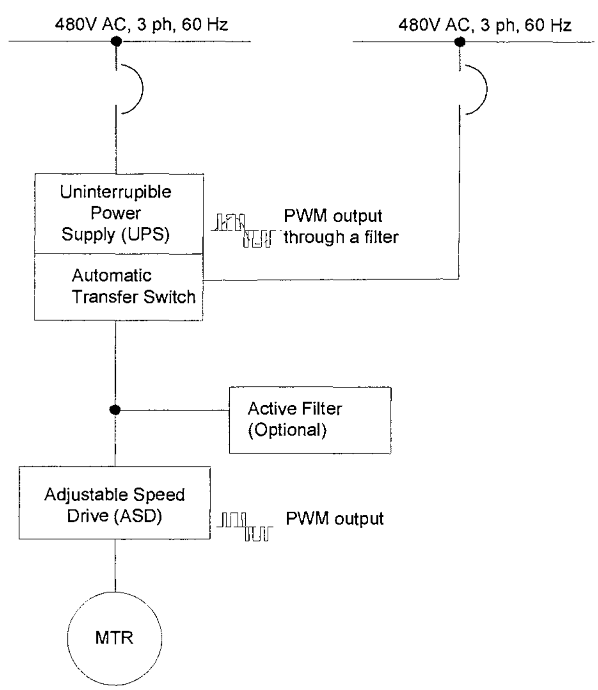
For any busses that are found as a result of the harmonic analysis to have potentially harmful levels of harmonics, typical cost-effective solutions to be taken by the project include one or more of the following:

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

The above process of design, harmonic analysis, and mitigation (if necessary) of harmful levels of harmonics is a normal design process for a large industrial facility like WTP. If problem areas are identified, the above are typical cost-effective solutions for any busses with harmful levels of harmonics.

The illustration shows the application of an active filter to offset harmful harmonics, if they were to occur between the UPS and ASD of a motor circuit.

Example of Single-line for UPS power to large motors with Active Filter Connected.



Follow-up Action: 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.

4. Fast Re-closing of Power Supply Breakers

DNFSB Concern:

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:

Fast Transfers are not a problem on WTP because the only motors with automatic restart after an interruption of power are connected to Adjustable Speed Drive's. The ASD's will be programmed to synchronize with and restart a spinning motor. All other motors must be manually restarted after an interruption of power.

On the project, WTP automatic bus transfers are limited to the following cases:

- Non-safety, double ended, low voltage unit substations
- Non-safety, double ended, medium voltage (4.16 kV) switchgear located in BOF building B91.

After a loss of power running non-safety motors drop out and their restart must be manually initiated. After a loss of power certain (running) safety-class motors, that have automatic restart controls, are connected to ASDs. After a power outage and restoration of power, these ASDs are programmed to sense motor speed during coast-down, synchronize its 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. Refer to (typical) Data Sheets 24590-HLW-EVD-C5V-30001 and 24590-PTF-EVD-C5V-10003 for the requirement that the ASD be able to start a spinning motor.

NEMA C50.4-14.21, *Polyphase Induction Motors for Power Generating Stations*, requires that:

> *". . . the system should be designed so that the resultant volts per hertz vector between the motor residual volts per hertz and the incoming source volts per hertz vector at the instant of transfer or reclosing is completed does not exceed 1.33 per unit volts on the motor rated voltage and frequency basis... "*

Safe (slow) transfers or re-closings can be accomplished by a time delay equal to or greater than 1.5 times the open-circuit alternating-current time constant of the motor (NEMA MG-1-20.33.1).

This is equivalent to the residual voltage of the coasting motor decaying to approximately 25 percent of normal system voltage. A typical 200 hp motor decays to 25 percent of normal system voltage in approximately 0.5 seconds. Therefore, a time delay of 0.5 to 1.5 seconds over the range of 25 to 200 hp would be sufficient. Motors larger than 200 hp require slightly longer delays. Generally even the largest motor under load has its residual voltage decay to 25 percent within 5 seconds of loss of power.

The Figures on the next page, from two different sources, show that the residual voltage for both (typical) 300 hp and 200 hp motors will decay to 0.25 per unit (volts) in less than 1.5 seconds. Therefore, the 5 seconds listed above is a conservative number. However, the time for residual voltage to decay during fast transfers is not relevant to WTP since non-ASD connected motors will shutdown on loss of power and require manual restart. ASD connected motors, with automatic restart, are designed to catch the (spinning) motors on the fly.

In summary, the DNFSB makes a key point, which is addressed by:

a) DNFSB Key Point: 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.

Fast Transfers are not a problem on WTP because the only motors with automatic restart after a loss of power are connected to Adjustable Speed Drives programmed to synchronize to a spinning motor.

Based on the above explanation, there are no corrective or follow-up actions required.

Typical Residual Voltage Decay of Induction Motors 200-300 HP

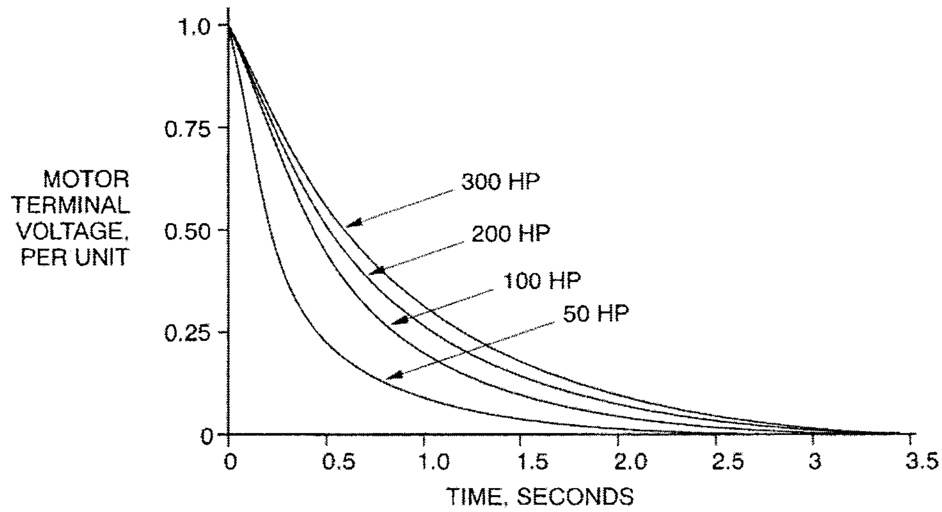


Figure 4-1; Induction Motor Open Circuit Voltage Decay

(Source: Cummins Power Generation Application Manual)

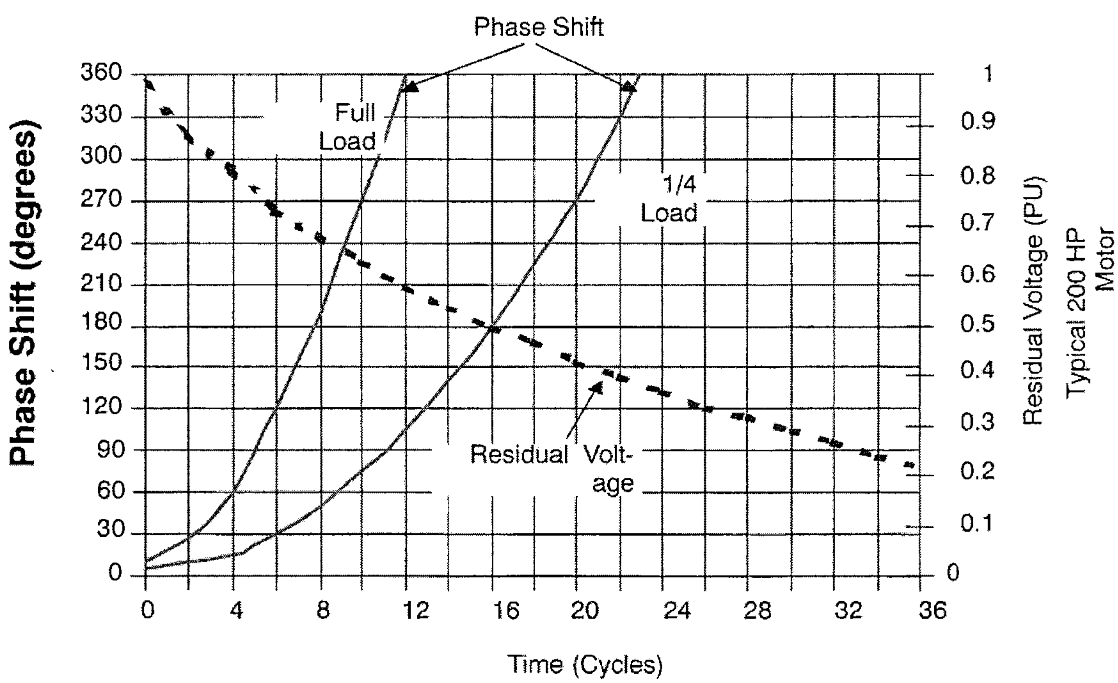


Figure 4-2; Motor Voltage and Phase Shift

(Source: GE Industrial Power Systems Data Book)

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

DNFSB Concern:

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 staffs 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:

The WTP project acknowledges that fires and explosions associated with UPS battery operation are "credible events." It is incumbent on the WTP project to evaluate all hazards, including those of the UPS, in accordance with DOE-STD-3009. The (updated) hazard analysis of the UPS has not been completed at this time, but will evaluate hydrogen generation and accumulation hazard and control features. The hierarchy of controls to address UPS hazards will be established consistent with DOE-STD-3009 standard, including selection of passive over active barriers and engineered over administrative controls as appropriate.

BNI will perform a documented study on all of the VRLA battery installations. The analysis will determine if:

- Current Design is compliant with Codes and Standards.
- Current Design provides adequate ventilation to prevent hazardous accumulations of Hydrogen gas.
- If unenclosed batteries expose nearby Safety Equipment or workers to blast or fire.

The above analysis will include a room-by-room evaluation, and will include recommendations for any changes to existing VRLA Battery Installations Design Criteria or battery installations.

The purpose of the study is to ensure that VRLA batteries can perform their intended functions, and that safety equipment and personnel are adequately protected from explosions originating from VRLA battery hydrogen generation.

In summary, the DNFSB makes two key points, which are addressed by:

a) DNFSB Key Point: 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.

WTP's interpretation of IEEE Standard 1187 is that it does not require that VRLA batteries have dedicated ventilation systems. The standard recommends that ventilation be provided to prevent the possible accumulation of hydrogen of reaching 2 percent of the total volume of the battery area/cabinet. It further states that either natural or forced ventilation can be used. The adequacy of natural ventilation immediately around the batteries to prevent hydrogen accumulations will be evaluated as part of the hazard, accident analysis, and control strategy development process.

b) DNFSB Key Point: 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.

WTP's interpretation of IEEE Standard 1187 is that it does not require directed air flow across the tops of the batteries. The HLW PDSA has been revised to credit temperature compensated charging (a preventive control) in lieu of directed air flow across the tops of the batteries (a mitigative control) addressing thermal runaway conditions. This control methodology is compliant with IEEE Std 1187. The other provisions of IEEE Std 1187 are still applied. The Hazard Analyses of HLW, PT, and LBL will be updated to reflect the results of the study and to obtain consistency between the plant areas. Safety Class UPS must demonstrate meeting single failure criteria established in the SRD. In addition, SS UPS must "consider single failure criteria" and will document the technical bases for addressing this in the hazard analyses, accident analyses, and control decision process for HLW, PT and LBL, as appropriate.

Follow-up Action: BNI will perform a documented study of the 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.

6. Valve-Regulated Lead-Acid Battery Installation Location

<u>DNFSB Concern:</u>

During a walk-down of the WTP facilities, the DNFSB'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

As discussed under item 5, this issue will be included as part of the documented study and hazards analyses, accident analyses, and control decisions on the VRLA battery installations at WTP.

WTP's interpretation of IEEE C2-2012 is that it requires that batteries be located within a protective enclosure or be in areas accessible only to qualified persons. WTP complies with the second option since the areas with VRLA batteries are accessible only to persons who have received specific training to work at the WTP site. Only qualified workers, performing work under an approved work package that includes a work hazards analysis, are permitted to work on the batteries. The commitment to develop a study and associated hazards analyses, accident analyses, and control decisions for VRLA battery installations will address if additional controls are required to protect other Safety Equipment or workers.

In summary, the DNFSB makes a key point, which is addressed by:

a) DNFSB Key Point: 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.

The project complies with IEEE C2-2012 that permits batteries to be located in areas accessible only to qualified persons, in lieu of providing protective enclosures. The project does not agree with the DNFSB's interpretation that the purpose of the protective enclosure is to protect workers from battery fires or explosion. The context of the requirement is that the protective enclosure is to protect the contained equipment (battery), and to prevent inadvertent contact with energized parts by unqualified workers (see IEEE C2-2012).

> *"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."*

The live parts of batteries are guarded to prevent inadvertent contact, and the building areas containing batteries are locked when not occupied and accessible only to qualified workers.

Follow-up Action: Potential hazards associated with the UPS system will be addressed in the issue commitment for item 5.

7. Unprotected Electrical Equipment

DNFSB Concern:

During a walk-down of the WTP facilities, the staff identified numerous pieces of installed safety and non-safety 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 DNFSB's letter to DOE dated August 26, 2004. The staff believes that if DOE had adopted the 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 DNFSB's staff could readily determine the extent to which procured electrical equipment is affected by this problem. The DNFSB'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:

BNI will perform a documented study as to the need to protect the SS and 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.

NEC Article 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.* WTP complies with these requirements.

The NEC recognizes that the sprinklers need to spray the source of the fire, and the source of the fire could be the electrical equipment. By the time the area around a sprinkler head reaches its melting point (286 °F), the electrical equipment in the zone of the spray will be damaged due to smoke and high temperature, and the area in the zone of the spray will be uninhabitable.

WTP Types of Sprinkler Systems:

- For BOF Main Switchgear Buildings 87 and 91 and electrical rooms with safety class electrical distribution equipment - The firewater pipes are normally dry; these are referred to as interlocked pre-action firewater sprinkler systems. The pipes have supervisory air, and fire water will not enter the pipes unless the pre-action sprinkler valve is activated by a smoke detection signal from the fire alarm panel. Water then only sprays from the sprinkler head with the melted fuse.

- Sprinkler systems in non-safety electrical rooms, other than the BOF switchgear buildings, are wet pipe type, and only spray from the sprinkler head that melts.

- The standard response sprinkler heads used are listed up to a 15 foot spacing, depending on available delivered pressure to the head.

- Non-fire water piping is normally not permitted above electrical distribution equipment, unless evaluated (on a case-by-case basis) and accepted by the Authority Having Jurisdiction (AHJ), and only if leak protection is provided for the equipment.

Subsequent to an earlier DNFSB WTP review, WTP installed splash shields above ventilation openings on the tops of Medium Voltage Switchgear, in recognition of the high voltage of this equipment and the relatively long lead time required for their replacement.

In summary, the DNFSB makes two key points, which are addressed by:

a) DNFSB Key Point: 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.

BNI will perform a documented study as to the need to protect the SS and SC electrical equipment from water intrusion consistent with IEEE 833. For all non-Safety plant electrical equipment the study would 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.

b) DNFSB Key Point: The DNFSB'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.

A study will determine implementing certain criteria in IEEE 833 for Safety Equipment, and spray shields will be evaluated for application to non-Safety equipment, based on their importance to plant operation, and their replacement time.

Follow-up Action: BNI will perform a documented study as to the need to protect the SS and 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.

8. High Voltage Cables in Manholes

DNFSB Concern:

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 modification 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:

WTP will implement a manhole inspection program and will require supporting of power conductors so they are protected from submergence in temporary water accumulation in the bottom of the manhole. WTP will also investigate the effectiveness of providing protection to help prevent water from entering the manholes during the construction phase of the project. All cables will be tested prior to turnover.

Manholes are not designed to be watertight and are expected to have occasional water in them. A french drain is provided at the bottom of the manhole to permit accumulations of water to drain out. The permanent plant medium voltage cables are approved for direct burial in the soil as well as operation in wet locations, but these cables are not approved for total submergence in water.

Permanently installed cables will be tested (Hi-potted) for insulation integrity prior to energization. Manholes will be inspected, cleaned, and french drains checked for functionality prior to their turnover to operations.

WTP is in the process of initiating a Manhole Inspection program. The program will periodically inspect manholes, document the condition of the manholes and cables, pump-out any accumulations of water, and clean the French Drains. The project is committed to have this Manhole Inspection program formally in place before the coming wet season.

As a result of this issue, WTP conducted a field inspection (24590-BOF-FIR-CON-12-00109) of manholes that are to contain Medium Voltage (MV) cables. There was only one case (MH-49) where there was evidence that water had contacted permanently installed cable. That cable will be tested (Hi-Potted) prior to turnover. The field inspection also indicated that those manholes that are currently below unfinished grade are most susceptible to the intrusion of water. The project will investigate and evaluate possible application of temporary protection over manholes that would effectively reduce water entering them during the construction phase of the project, and prior to finished grade becoming flush with manhole covers.

All manholes contain cable supports at various levels above the bottom of the manholes. WTP design/installation documents will require supporting of the MV cables so that the cable jackets are not submerged in water accumulations at the bottom of the manhole.

In summary, the DNFSB makes three key points, which are addressed by:

a) DNFSB Key Point: 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.

WTP installations documents will require supporting of the MV cables so that the cable jackets do not contact water accumulations at the bottom of the manhole. French drains will be inspected and cleared. WTP will investigate applying temporary protection over manholes to help prevent water intrusion during the construction phase of the project. All cables will be tested prior to turnover.

b) DNFSB Key Point: Protecting the cables will require that the WTP project team develop a program to routinely survey manholes containing power cables for water and make modification as necessary to keep electrical cables dry.

A manhole inspection plan will be implemented on WTP to periodically inspect manholes for water, remove the water and ensure the functionality of the French Drains. Cables will be supported to prevent submergence in water accumulations in the manhole.

c) DNFSB Key Point: 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.

WTP installations documents will require supporting of the MV cables so that the cable jackets are not submerged in water accumulations at the bottom of the manhole.

Follow-up Action: 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.

9. Past Due Calibration of Protective Devices

DNFSB Concern:

During a walk-down of the switchgear room in the A6 substation, the DNFSB's staff observed that the posted calibration date for many of the protective devices was more than 10 years ago (August 2001). Department of Energy Richland Operations Office (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 the calibration electrical protective devices at the manufacturer's recommended intervals, or formally remove the equipment from service.

Response:

The protective devices in question are Schweitzer Engineering Laboratories (SEL) solid state relays. Unlike an electro-mechanical relay, these relays cannot be calibrated - only programmed - therefore they cannot be subjected to a "calibration check." For this reason there are no "calibration check requirements" to provide to the DNFSB, and thus no "records to support meeting these requirements." Please see attached excerpts from the SEL-351A Instruction Manual. This does not mean, as stated in the report, that DOE-RL is not requiring the contractor to maintain electrical protective devices. In fact, the protective devices are subject to recurring maintenance per HNF-40015, Rev 2. "Bulk Electrical System (BES) Protection System Maintenance and Testing Program" (attached). Note that paragraph 4.2.1.2 of this document specifically addresses Micro-Processor/Digital Relay (Micro) devices.

The existence of "calibration" stickers on these devices is the result of a third-party commissioning process whereby Electro-Test, Inc. (ETI) performed commissioning testing in 2001 when the station was constructed. Given that the relays cannot be calibrated, the use of these stickers indicates that ETI performed commissioning tests. This means ETI verified that the relay was properly connected, verified control signal inputs and outputs, and verified that the current and voltage inputs were of the proper magnitude and phase rotation (see the SEL-351A Instruction Manual, pages 13-1 and 13-2). ETI also was responsible to conduct fault tests and run internal software test routines per the manual. Note that none of these tests per the manufacturer's manual call for calibration. Ordinarily these stickers are removed shortly after commissioning when the station is put in service, at which time the relays are placed into the Preventative Maintenance (PM) program. In this case, the relays have been in the PM program for years and are all current. As part of the process of preparing the station to be placed in service this fall, the commissioning stickers have now been removed.

Based on the above explanation, there are no corrective or follow-up actions required.

10. Emergency Turbine Generator Design Change

DNFSB Concern:

The project team's recent decision to replace the SC reciprocating diesel driven generators with SC 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:

The WTP project is aware that the change from EDGs to ETGs has an impact to the safety basis, and 24590-BOF-JCDPI-M-11-0001 was developed to justify continued design, procurement and installation in advance of completing the hazard analysis and approval of the Authorization Basis (AB) Amendment Request. The JCDPI acknowledges that there will be an evaluation of the delay time between a postulated loss of offsite power and the availability of emergency power, and that hazards and requirements associated with UPS units and their support auxiliaries will be evaluated and documented. ATS's have been initiated to trigger actions to provide information to certain areas of interest on this issue to the DNFSB.

The WTP project is aware that the change from EDGs to ETGs has an impact to the safety basis, and 24590-BOF-JCDPI-M-11-0001 was developed to justify continued design and procurement of the ETG and ETG Building in advance of completing the hazard analysis and approval of the AB amendment request, which is currently under development. The JCDPI does not allow installation of the ETGs nor does it allow excavation or construction for the ETG facility at WTP.

The JCDPI acknowledges that there will be an evaluation of the delay time between a postulated loss of offsite power and the availability of emergency power. It acknowledges that hazards and requirements associated with UPS units and their support auxiliaries will be evaluated and documented. During DNFSB's December 2011 visit, the DNFSB requested that they be sent specific information when available, and to be notified in advance of dates when certain analysis and testing was to be performed so they could elect to attend or review the results.

Therefore, BNI has written ATSs to trigger actions to provide the following information in the identified areas of interest to DNFSB:

- The start date for hazard analysis related to ETG design
- The start date for hazard analysis related to UPS loading, sizing and hazard control strategy
- The seismic test plans for the ETG
- The ETG environmental qualification specification
- Commercial grade dedication plans
- Document numbers for component classification matrix

In summary, the DNFSB makes a key point, which is addressed by:

a) DNFSB Key Point: The project team's recent decision to replace the SC reciprocating diesel driven generators with SC ETGs and large SC UPS systems affects the WTP safety basis.

The WTP project is aware that the change from EDGs to ETGs has an impact to the safety basis, and 24590-BOF-JCDPI-M-11-0001 was developed to justify continued design, procurement and installation in advance of completing the hazard analysis and approval of the AB Amendment Request. The JCDPI acknowledges that there will be an evaluation of the delay time between a postulated loss of offsite power and the availability of emergency power, and that hazards and requirements associated with UPS units and their support auxiliaries will be evaluated and documented.

Based on the above explanation, there are no corrective or follow-up actions required.