



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 21, 2018

Mr. Joseph W. Shea, Vice President
Nuclear Regulatory Affairs
and Support Services
Tennessee Valley Authority
1101 Market Street, LP 4A
Chattanooga, TN 37402-2801

SUBJECT: BROWNS FERRY NUCLEAR PLANT, UNITS 1, 2, AND 3; SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2; AND WATTS BAR NUCLEAR PLANT, UNITS 1 AND 2 – REQUEST FOR ADDITIONAL INFORMATION RELATED TO LICENSE AMENDMENT REQUEST TO INCORPORATE NEW TECHNICAL SPECIFICATION FOR UNBALANCED VOLTAGE RELAYS (EPID L-2017-LLA-0030)

Dear Mr. Shea:

By letter dated November 17, 2017, Tennessee Valley Authority (TVA, the licensee) submitted a request for an amendment to Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68 for Browns Ferry Nuclear Plant, Units 1, 2, and 3; Renewed Facility Operating License Nos. DPR-77 and DPR-79 for Sequoyah Nuclear Plant, Units 1 and 2; and Facility Operating License Nos. NPF-90 and NPF-96 for the Watts Bar Nuclear Plant, Units 1 and 2. This license amendment request (LAR) proposed addition of a new level of protection, "Unbalanced Voltage" to the Technical Specifications for the loss of power instrumentation. TVA stated that the proposed change provides protection against potentially adverse unbalanced voltage conditions in offsite power sources. In addition, this LAR addresses potential concerns with open phase conditions in U.S. Nuclear Regulatory Commission (NRC) Bulletin 2012-01, "Design Vulnerability in Electric Power System," dated July 27, 2012.

The NRC staff reviewed the licensee's submittal and determined that additional information is needed. The NRC staff forwarded draft requests for additional information (RAIs) from Instrumentation and Control Branch and Electrical Engineering Operating Reactor Branch, Division of Engineering, to TVA by electronic mails dated February 27 and March 27, 2018, respectively. On March 8 and 27, 2018, the NRC staff held two conference calls to provide the licensee with the opportunity to clarify any portion of the draft RAIs and discuss the timeframe for which TVA would provide the requested information. Subsequently, the NRC staff forwarded its revised draft RAIs to TVA on April 23, 2018, and discussed them during a regulatory audit on the 1st and 2nd of May at the TVA Corporate Office in Chattanooga, TN. The NRC staff's RAIs, as discussed with the TVA staff, are provided in Enclosures 1 and 2.

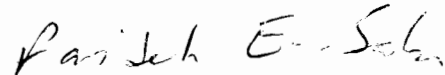
J. Shea

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By an email dated May 10, 2018, Mr. Gordon Williams of your staff proposed to submit TVA's responses to the NRC staff RAIs by June 18, 2018, and the NRC staff agreed.

If you have any questions, please contact me at 301-415-1447 or Farideh.Saba@nrc.gov.

Sincerely,



Farideh E. Saba, Senior Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-259, 50-260, 50-296,
50-327, 50-328,
50-390, and 50-391.

Enclosure:

1. RAI from Instrumentation and Control Branch
2. RAI from Electrical Engineering Operating Reactor Branch

cc: Listserv

REQUEST FOR ADDITIONAL INFORMATION
BY THE OFFICE OF NUCLEAR REACTOR REGULATION
REGARDING TENNESSEE VALLEY AUTHORITY
PROPOSED APPLICATION TO
MODIFY TECHNICAL SPECIFICATIONS FOR
BROWNS FERRY NUCLEAR PLANT, UNITS 1, 2, AND 3
SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2
AND WATTS BAR NUCLEAR PLANT UNITS 1 AND 2
DOCKET NOS. 50-259, 50-260, 50-296; 50-327, 50-328; 50-390 AND 50-391
EPID L-2017-LLA-0391

BACKGROUND

By application dated November 17, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17324A349), Tennessee Valley Authority (TVA, the licensee) submitted a request for an amendment to Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68 for the Browns Ferry Nuclear Plant, Units 1, 2, and 3; Renewed Facility Operating License Nos. DPR-77 and DPR-79 for the Sequoyah Nuclear Plant, Units 1 and 2; and Facility Operating License Nos. NPF-90 and NPF-96 for the Watts Bar Nuclear Plant, Units 1 and 2. This license amendment request (LAR) proposed addition of a new level of protection, "Unbalanced Voltage" to the Technical Specifications (TSs) for the loss of power instrumentation. TVA stated that the proposed change provides protection against potentially adverse unbalanced voltage conditions in offsite power sources. In addition, this LAR addresses potential concerns with open phase conditions in U.S. Nuclear Regulatory Commission (NRC) Bulletin 2012-01, "Design Vulnerability in Electric Power System," dated July 27, 2012 (ADAMS Accession No. ML12074A115).

The NRC staff from the Office of Nuclear Reactor Regulation, Division of Engineering, Instrumentation and Controls Branch (EICB) reviewed the information provided by TVA and determined that additional information as discussed below is needed to complete its review.

EICB RAI-1

In the LAR, the licensee proposed to add Function 3, "4.16kV Shutdown Board Undervoltage (Unbalance Voltage Relay)," into Browns Ferry TS Table 3.3.8.1-1, "Loss of Power Instrumentation." Provide the Nominal Trip Setpoints (Permissive Alarm, Low, and High Unbalanced Voltage Relay) for the Function 3. The NRC staff needs this information to verify that the requirements of Section 50.36(c)(2) of Title 10 of *Code of Federal Regulations* are being met regarding the selection of the setpoints and allowable values for "Unbalanced Voltage."

REQUEST FOR ADDITIONAL INFORMATION
BY THE OFFICE OF NUCLEAR REACTOR REGULATION
REGARDING TENNESSEE VALLEY AUTHORITY
PROPOSED APPLICATION TO
MODIFY TECHNICAL SPECIFICATIONS FOR
BROWNS FERRY NUCLEAR PLANT, UNITS 1, 2, AND 3
SEQUOYAH NUCLEAR PLANT, UNITS 1 AND 2
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The NRC staff from the Office of Nuclear Reactor Regulation, Division of Engineering, Electrical Engineering Operating Reactor Branch (EEOB) reviewed the information provided by TVA and determined that additional information, as discussed below, is needed to complete its review.

Applicable Regulatory Requirements

NRC Information Notice 2012-03, "Design Vulnerability in Electric Power System," and NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," described industry operating experience that identified a vulnerability related to General Design Criterion (GDC) 17, "Electric power systems," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10

of the *Code of Federal Regulations* (10 CFR) Part 50. The identified vulnerability concerned open phase conditions (OPCs) in offsite power sources. GDC 17 states, in part:

An onsite electric power system and an offsite electric power system shall be provided to permit functioning of structures, systems, and components important to safety. The safety function for each system (assuming the other system is not functioning) shall be to provide sufficient capacity and capability to assure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

The BFN Units 1, 2, and 3 were not licensed to the 10 CFR Part 50, Appendix A, GDC. The Updated Final Safety Analysis Report (UFSAR), Appendix A, "Conformance to AEC [Atomic Energy Commission] Proposed General Design Criteria," provides an assessment against the draft GDC published in November 1965 (Units 1 and 2) and July 1967 (Unit 3). For BFN, the licensee performed a review of plant-specific requirements and concluded that AEC criterion is sufficiently similar to the Appendix A, GDC 17. UFSAR Section 8.4.6 - "Safety Evaluation" discusses conformance to 10 CFR Part 50, Appendix A, GDC 17, and concludes that the BFN units are in conformance with the requirements of GDC 17.

For the BFN units, AEC Criterion 39, "Emergency Power for Engineered Safety Features," states "Alternate power systems shall be provided and designed with adequate independency, redundancy, capacity, and testability to permit the functioning required of the engineered safety features. As a minimum, the onsite power system and the offsite power system shall each, independently, provide this capacity assuming a failure of a single active component in each power system." In view of the similarity between AEC Criterion 39 and BFN conformance to GDC 17, the discussion below references GDC 17 only for TVA plants in general.

Section 50.36 of 10 CFR, "Technical specifications," provides requirements for proposed technical specifications to be included in license applications.

Section 50.36(c)(1)(ii)(A) of 10 CFR states, in part:

Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded. If, during operation, it is determined that the automatic safety system does not function as required, the licensee shall take appropriate action, which may include shutting down the reactor.

10 CFR 50.36(c)(2)(ii) states, in part:

A technical specification limiting condition for operation of a nuclear reactor must be established for each item meeting one or more of the following criteria:

(C) *Criterion 3.* A structure, system, or component that is part of the primary success path and which functions or actuates to mitigate a design basis accident

or transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier.

Section 50.36(c)(3), "Surveillance requirements," of 10 CFR states:

Surveillance requirements are requirements relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met.

The regulation at 10 CFR 50.55a(h), "Protection and safety systems" requires all portions of the protection and safety systems to be designed in accordance with the Institute of Electrical and Electronic Engineers (IEEE) Standard 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," or IEEE Standard 603-1991, "Criteria for Safety Systems for Nuclear Power Generating Stations."

EEOB-Request for Additional Information (RAI)-1

The LAR states, "The main issue with an open phase event degrading an offsite power circuit is that loss of a phase can cause a voltage unbalance in the connected distribution system." For the TVA plants, the licensee has installed Unbalanced Voltage Relays (UVRs) to detect and protect against consequential unbalanced voltages, including those caused by an OPC in the offsite power sources and offsite power circuit. In order for staff to understand the limits at which the UVRs will perform their automatic protective action and how these limits were developed to correct an abnormal situation, the staff is requesting the following additional information:

- a) A discussion that summarizes the magnitude of the unbalance voltage considered on the associated bus for each UVR setpoint.
- b) A discussion of how percentage voltage unbalance is calculated based on negative sequence voltage and whether other sequence components such as zero and positive sequence components were considered in determining the power system unbalance.
- c) A discussion explaining the setpoints for the UVR alarm and operator actions taken in accordance with plant procedures.

EEOB-RAI-2

The NRC staff notes the discussion in the LAR related to offsite power operability as determined by several factors including but not limited to: breaker alignment, communication from transmission system operator, voltage indications in the nuclear power station, voltage correcting device availability/operation, and transformer cooling fans operational. The LAR further states that "Any additional actions to provide reasonable assurance of offsite power capacity and capability (i.e., operability due to an open phase) will be consistent with existing practices of providing reasonable assurance of offsite power capacity and capability (i.e., operability due to degraded voltage) and are not part of this LAR." The LAR further states "Non-automatic methods of detection are not included in this LAR. The operators' determination of offsite power source operability would satisfy the required non-automatic

detection criteria for an open phase on a standby source within a reasonable time as stated in the Voluntary Industry Initiative.”

Operating experience discussed in Attachment 1.4 of the LAR Enclosure 1 provides examples of plant events where degraded power sources could not be detected for extended durations and continued to supply plant safety-related loads. In some cases where a single pole of breaker or disconnect switch did not fully close or conductor strands in overhead transmission lines have broken, resulting in a high impedance connection and reducing conductor capacity, the OPC cannot be detected by visual methods.

At the TVA plants, for offsite power sources that are lightly loaded, the magnetization effects in transformer windings may mask an unbalanced voltage caused by an open phase that is not visually observable.

Please provide a discussion of how the UVR relays would detect (and protect safety-related equipment) for this condition. Please include in your discussion how the unbalanced voltage protection circuitry ensures that the offsite power system is capable of performing its design function during any period that this condition is not detected at TVA Plant(s). Additionally, considering the UVR is on the medium voltage shutdown board, include a discussion for light to no-load on the safety bus.

EEOB-RAI-3

Section 4.0, "Regulatory Evaluation" in Enclosure 1 of the LAR discusses applicable regulatory requirements/criteria and provides the justification for including UVR setpoints in TS according to 10 CFR 50.36 Criteria. Section 4 states:

The need to include the proposed negative sequence voltage protection function operability and surveillance requirements into the BFN, SQN, and WBN TS was evaluated against the 10 CFR 50.36(c) criteria, and it was determined to meet Criterion 3 of 10 CFR 50.36(c)(2)(ii) as discussed below.

Criterion 3 states:

“A structure, system, or component that is part of the primary success path and which functions or actuates to mitigate a design basis accident or transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier.”

The operability of the station electric power sources is part of the primary success path for mitigating an accident assuming a loss of all onsite AC power sources (e.g., loss of all EDGs [Emergency Diesel Generators]). An operable offsite power circuit must be capable of maintaining rated voltage while connected to the Class 1E buses and accepting required loads during an accident. Similar to the loss of voltage and degraded voltage protective circuitry, **the unbalanced voltage protection circuitry is integral to ensuring that the offsite power system is capable of performing its design function** [emphasis added] of powering the medium voltage Class 1E buses. Therefore, the BFN, SQN, and WBN unbalanced voltage scheme satisfies Criterion 3 for inclusion in the TS.

The LAR states, "The Class 1E UVR protection scheme exceeds the requirements of both the VII and BTP 8-9 by including **all events in any location** [emphasis added] outside the Class 1E boundary that can negatively affect voltage balance to Class 1E equipment." The LAR also states, "The main issue with an open phase event degrading an offsite power circuit is that loss of a phase can cause a voltage unbalance in the connected distribution system."

GDC 17 states that at least one of the offsite power circuits, with adequate capacity and capability, shall be designed to be available within a few seconds following a loss-of-coolant accident to assure that core cooling, containment integrity, and other vital safety functions are maintained.

Please provide a discussion of the sequence of events for BFN, SQN, and WBN, including associated equipment response times when emergency loads need to start (e.g., postulated accident conditions, anticipated operational occurrences, etc.) during the period of operation when an unbalanced voltage may not be detected for an extended duration.

EEOB-RAI-4

This RAI is related to the highest magnitude of consequential unbalanced voltage conditions resulting from an OPC in the offsite power source.

In Section 3.4 of Enclosure 1, "Analytical Limits and UVR Nominal Setpoints," the LAR states that the analytical limits for the unbalanced voltage relays were established based on a "bottom-up" manner that considers load requirements, and are independent of characteristics of the incoming power source. The NRC staff notes that there is a 3.5-second time delay proposed for high unbalanced voltage conditions. The magnitude of unbalanced voltage conditions experienced at the point of detection will vary according to configuration of electrical systems. In order for staff to understand the basis and adequacy of the proposed UVR setpoints to protect safety-related equipment for postulated events and accidents:

- a) Please provide a summary of the limiting case analyses, key assumptions used, and the results obtained for all the loading conditions and operating configurations including plant trip(s) followed by bus transfers (if required) for the unbalanced voltages considered at the three plants.
- b) Please include a discussion on the maximum unbalanced voltage condition that can occur at the safety busses in the three plants.

EEOB-RAI-5

Section 3.4 of Enclosure 1, "Analytical Limits and UVR Nominal Setpoints," provides an overview of the criteria used for establishing the lower and upper analytical limits related to alarm, low trip and high trip setpoints for the UVRs. The LAR states, "The main issue with an open phase event degrading an offsite power circuit is that loss of a phase can cause a voltage unbalance in the connected distribution system." The LAR does not provide plant-specific parameters that were established to protect safety-related equipment from unbalanced voltage conditions. In order to understand the margin between allowable range(s) of unbalance conditions that can exist and the limiting values established for protection of equipment please provide:

- a) A discussion on the magnitude of unbalance observed during the monitoring phase of the unbalanced voltage relays at each of the safety buses for the three plants where the UVR relays are installed.
- b) A discussion on the applicable plant-specific industry standards used for establishing these analytical limits.

EEOB-RAI-6

In Section 3.5 of Enclosure 1, "Failure Modes and Effects Considerations," the LAR states, "If one of the Class 1E PTs [potential transformers] fail, all levels of undervoltage protection would be actuated and begin timing. Due to the longer time delay of the UVR with respect to the Loss of Voltage (LOV) protection scheme, the LOV scheme would actuate the transfer due to the substantially low voltage measurements." This design feature has the potential for a single spurious failure in the sensing element to disable both offsite and onsite power systems if the UVR and LOV outputs are factored in the logic associated with the breakers for onsite power systems.

Section 7 of the UFSAR for WBN discusses instrumentation and controls and states, in part, "The information provided in this chapter emphasizes those instruments and associated equipment which constitute the protection system as defined in IEEE Std. 279-1971 'IEEE Standard: Criteria for Protection Systems for Nuclear Power Generating Stations.'" Similarly, IEEE 279-1971 requirements are stated for conformance in Section 7.1.2.1.2, "Engineered Safety Features Actuation System (ESFAS)." UFSAR Section 7.1.2.1.4 identifies standby power as part of protection systems. UFSAR Section 7.1.2.2.2, "Specific Systems," states that "Channel independence is carried throughout the system, extending from the sensor through to the devices actuating the protective function." The regulation at 10 CFR 50.55a(h), "Protection and Safety Systems," requires that all portions of the protection and safety systems should be designed in accordance with IEEE Standard 279-1971 or IEEE Standard 603-1991.

- a) Please provide a discussion on how the UVR design is in conformance with the licensing basis of the TVA plants.
- b) The LAR states that the UVR logic scheme is set up in a permissive 1-out-of-2 logic to ensure reliability and security. Please provide a discussion on how the 1-out-of-2 logic is satisfied if there is a common sensing point for multiple channels.

EEOB-RAI-7

The LAR states, "The need to include the proposed negative sequence voltage protection function operability and surveillance requirements into the BFN, SQN, and WBN TS was evaluated against the 10 CFR 50.36(c) criteria, and it was determined to meet Criterion 3 of 10 CFR 50.36(c)(2)(ii) as discussed below."

The LAR also states Surveillance of the UVRs is required as defined in 10 CFR 50.36(c)(3) to "assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met."

The UVR Setpoints are proposed for inclusion in Section 3.3, "Instrumentation," of the TSs, specifically in the "Loss of Power (LOP) Diesel Generator (DG) Start Instrumentation." The requirements for LOP DG start instrumentation are delineated in 10 CFR 50.36(c)(1)(ii)(A),

which states, "Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded." Please provide a detailed discussion on how the proposed TS amendment is in conformance with 10 CFR 50.36(c)(1)(ii)(A).

EEOB-RAI-8

Excerpts from UFSAR sections for BFN, SQN, and WBN pertinent to the electrical system design and operation are provided in Attachments to Enclosure 1 of the LAR. These excerpts include information about current design of offsite power systems and degraded voltage protection that is referenced as part of the unbalanced voltage protection scheme. The staff did not notice any changes to the UFSAR sections with regard to proposed installation of UVRs. In order for NRC staff to develop an understanding of the changes to the UFSAR, please provide a mark-up of the proposed UFSAR section(s).

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