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Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

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February 3, 2014

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ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Sequoyah Nuclear Plant, Units 1 and 2
Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327 and 50-328

Watts Bar Nuclear Plant, Unit 1
Facility Operating License No. NPF-90
NRC Docket No. 50-390

Watts Bar Nuclear Plant, Unit 2
Construction Permit No. CPPR-92
NRC Docket No. 50-391

Subject: **Response to Request for Additional Information Regarding Response to Bulletin 2012-01, "Design Vulnerability in Electrical Power System"**

References:

1. NRC Bulletin 2012-01, "Design Vulnerability in Electrical Power System," dated July 27, 2012
2. TVA Letter to NRC, "90-Day Response to NRC Bulletin 2012-01,'Design Vulnerability in Electrical Power System,'" dated October 25, 2012
3. NRC Letter to Those on the Enclosed List, "Request for Additional Information Regarding Response to Bulletin 2012-01, 'Design Vulnerability in Electrical Power System,'" dated December 20, 2013

In Reference 1, NRC requested that information be provided describing how the protection scheme for Engineered Safety Feature (ESF) buses is designed to detect and automatically respond to single-phase open circuit conditions or high impedance ground fault conditions, including a description of the operating configuration of the ESF buses.

In Reference 2, the Tennessee Valley Authority (TVA) provided the information requested in Reference 1 for the Browns Ferry, Sequoyah, and Watts Bar Nuclear Plants.

In Reference 3, NRC requested that additional information be provided regarding the completion of interim actions and compensatory measures and the status of long-term corrective actions.

This letter provides the requested information for the Browns Ferry, Sequoyah, and Watts Bar Nuclear Plants in Enclosures 1, 2, and 3, respectively.

There are no new regulatory commitments contained in this letter. If you have questions regarding this matter, please contact Beth Wetzel at (423) 751-2403.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 3rd day of February 2014.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosures:

1. Browns Ferry Nuclear Plant, Units 1, 2, and 3 Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," Request for Additional Information
2. Sequoyah Nuclear Plant, Units 1 and 2 Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," Request for Additional Information
3. Watts Bar Nuclear Plant, Units 1 and 2 Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," Request for Additional Information

cc: See page 3

cc: (Enclosures):
NRC Regional Administrator - Region II
NRR Director - NRC Headquarters
NRR Project Manager - Browns Ferry Nuclear Plant
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
NRR Project Manager - Sequoyah Nuclear Plant
NRC Senior Resident Inspector - Sequoyah Nuclear Plant
NRR Project Manager - Watts Bar Nuclear Plant, Unit 1
NRR Project Manager - Watts Bar Nuclear Plant, Unit 2
NRC Senior Resident Inspector - Watts Bar Nuclear Plant

ENCLOSURE 1
Browns Ferry Nuclear Plant, Units 1, 2, and 3
Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System" Request for Additional Information

NRC Request for Additional Information

NRC letter dated December 20, 2013 requested the following:

> *"In order for the NRC staff to complete its review of responses to the bulletin, the following additional information is requested:*
>
> 1. *Provide a summary of all interim corrective actions that have been taken since the January 30, 2012, event at Byron Station, Unit 2, to ensure that plant operators can promptly diagnose and respond to open phase conditions on the offsite power circuits for Class-1E vital buses until permanent corrective actions are completed.*
>
> 2. *Provide a status and schedule for completion of plant design changes and modifications to resolve issues with an open phase of electric power."*

Response 1 - Summary of All Interim Corrective Actions

Lessons learned from the events at Byron station were reviewed and various interim corrective actions evaluated for safety and efficiency at Browns Ferry Nuclear Plant (BFN). Based on the plant's offsite power configuration, electrical design details, and industry lessons learned shared through the Institute of Nuclear Power Operations (INPO) and Nuclear Energy Institute (NEI), the following actions were taken to ensure plant operators can promptly diagnose and respond to open phase conditions (OPCs):

- A walk-down of the BFN switchyards was performed to identify OPC vulnerabilities. The walk-down determined if an open phase condition were to occur, it would be most likely at the overhead line connection to the offsite power transformers. This would most likely be a grounded open phase condition since the distance between most poles/structures was greater than the height of the lines and a breakpoint in these spans would allow the transmission line to fall to the ground. The walkdown also determined a potential vulnerability of an ungrounded open phase condition in the overhead transmission line connection points (i.e. stingers). While stinger failure provided a conceivable ungrounded open phase condition, it was determined unlikely since most stingers have a multi-bolt connection and are inspected by thermography during routine PM inspections of the switchyard.

- Procedures for daily transformer yard inspections were reviewed to ensure the thoroughness and completeness relative to the identification of off-normal conditions by Operations personnel. The procedures for periodic thermography of switchyard components (performed to assist in the early identification of degraded components) were also reviewed.

- Bus transfer procedures were verified to ensure three phase voltages are checked prior to bus transfers and the bus voltage is checked on the bus voltmeter after the bus transfers.

- The Byron OPC event was reviewed in Operations training during BFN Licensed Operator Requalification training during the Cycle 13-1 sessions which incorporated industry lessons learned and BFN system specifics.

Response 2 - Status and Schedule for Completion of Plant Design Changes

Holders of operating licenses and combined licenses for nuclear power reactors are investigating options being researched by several vendors (PSC2000, EPRI, Schweitzer, etc.) to detect OPC faults. TVA has sent representatives to evaluate the PSC2000 solution, is working with EPRI to provide a possible testing facility for their proposed solution, and is in the process of contracting relay experts to evaluate various proposed protective relay solutions. There is currently no generic, off-the-shelf technology that has been proven to detect all the required open phase fault conditions for all plant and transformer designs.

TVA is fully engaged in the development of the NEI OPC Guidance Document, as well as development of enhancements to software tools being used to analyze OPC faults. TVA has provided technical expertise to participate in the NEI steering committee and are providing technical experts in a leadership capacity to aid in the development of the only nuclear QA software, ETAP.

With the goal of ensuring accurate detection without compromising nuclear safety or increasing plant risk, this new OPC technology is being thoroughly evaluated, will be tested, and will be fully analyzed before installation.

Vulnerability studies of the OPC faults are in progress for BFN and additional operator meetings are being scheduled to communicate the results.

The TVA nuclear fleet has endorsed the generic schedule provided in the Industry OPC Initiative.

It is BFN's intention to meet the milestones of this schedule; however, deviations may be required to accommodate outage schedules, software and hardware availability, manufacturer's delivery capabilities, licensing delays, etc.

Any deviation from the Industry OPC Initiative schedule will be documented through the deviation/exemption process addressed in the NEI OPC Guidance Document.

ENCLOSURE 2
Sequoyah Nuclear Plant, Units 1 and 2
Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System" Request for Additional Information

NRC letter dated December 20, 2013 requested the following:

> *"In order for the NRC staff to complete its review of responses to the bulletin, the following additional information is requested:*
>
> 1. *Provide a summary of all interim corrective actions that have been taken since the January 30, 2012, event at Byron Station, Unit 2, to ensure that plant operators can promptly diagnose and respond to open phase conditions on the offsite power circuits for Class-1E vital buses until permanent corrective actions are completed.*
>
> 2. *Provide a status and schedule for completion of plant design changes and modifications to resolve issues with an open phase of electric power."*

Response 1 - Summary of All Interim Corrective Actions

Lessons learned from the events at Byron station were reviewed and various interim corrective actions evaluated for safety and efficiency at Sequoyah Nuclear Plant (SQN). Based upon the plant's offsite power configuration, electrical design details, and industry lessons learned shared through the Institute of Nuclear Power Operations (INPO) and Nuclear Energy Institute (NEI), the following actions were taken to ensure plant operators can promptly diagnose and respond to open phase conditions (OPCs):

- A walk-down of the SQN switchyards was performed to identify OPC vulnerabilities. The walk-down determined if an open phase condition were to occur, it would be most likely at the overhead line connection to the offsite power transformers. This would most likely be a grounded open phase condition since the distance between most poles/structures was greater than the height of the lines and a breakpoint in these spans would allow the transmission line to fall to the ground. The walkdown also determined a potential vulnerability of an ungrounded open phase condition in the overhead transmission line connection points (i.e. stingers). While stinger failure provided a conceivable ungrounded open phase condition, it was determined unlikely since most stingers have a multi-bolt connection and are inspected by thermography during routine PM inspections of the switchyard.

- Procedures for daily transformer yard inspections were reviewed to ensure the thoroughness and completeness relative to the identification of off-normal conditions by Operations personnel. The procedures for periodic thermography of switchyard components (performed to assist in the early identification of degraded components) were also reviewed.

- Bus transfer procedures were verified to ensure three phase voltages are checked prior to bus transfers and the bus voltage is checked on the bus voltmeter after the bus transfers.

- A Training Needs Analysis was performed relative to Operations procedures and training curriculum associated with OPC. This led to the inclusion of additional Operations training during SQN Licensed Operator Requalification training during the Cycle 13-2 sessions which incorporated industry lessons learned and SQN system specifics.

Response 2 - Status and Schedule for Completion of Plant Design Changes

Holders of operating licenses and combined licenses for nuclear power reactors are investigating options being researched by several vendors (PSC2000, EPRI, Schweitzer, etc.) to detect OPC faults. TVA has sent representatives to evaluate the PSC2000 solution, is working with EPRI to provide a possible testing facility for their proposed solution, and is in the process of contracting relay experts to evaluate various proposed protective relay solutions. There is currently no generic, off-the-shelf technology that has been proven to detect all the required open phase fault conditions for all plant and transformer designs.

TVA is fully engaged in the development of the NEI OPC Guidance Document, as well as development of enhancements to software tools being used to analyze OPC faults. TVA has provided technical expertise to participate in the NEI steering committee and are providing technical experts in a leadership capacity to aid in the development of the only nuclear QA software, ETAP.

With the goal of ensuring accurate detection without compromising nuclear safety or increasing plant risk, this new OPC technology is being thoroughly evaluated, will be tested, and will be fully analyzed before installation.

Vulnerability studies of the OPC faults have been completed for SQN and additional operator meetings are being scheduled to communicate the results. For the analyzed configurations, the vulnerability studies showed existing protection automatically actuates and provides protection to the Class-1E system for grounded open phase conditions. Vulnerability to an ungrounded open phase condition has been identified for some analyzed configurations.

The TVA nuclear fleet has endorsed the generic schedule provided in the Industry OPC Initiative.

It is SQN's intention to meet the milestones of this schedule; however, deviations may be required to accommodate outage schedules, software and hardware availability, manufacturer's delivery capabilities, licensing delays, etc.

Any deviation from the Industry OPC Initiative schedule will be documented through the deviation/exemption process addressed in the NEI OPC Guidance Document.

ENCLOSURE 3
Watts Bar Nuclear Plant, Units 1 and 2
Response to NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System" Request for Additional Information

NRC letter dated December 20, 2013 requested the following:

> *"In order for the NRC staff to complete its review of responses to the bulletin, the following additional information is requested:*
>
> 1. *Provide a summary of all interim corrective actions that have been taken since the January 30, 2012, event at Byron Station, Unit 2, to ensure that plant operators can promptly diagnose and respond to open phase conditions on the offsite power circuits for Class-1E vital buses until permanent corrective actions are completed.*
>
> 2. *Provide a status and schedule for completion of plant design changes and modifications to resolve issues with an open phase of electric power."*

Response 1 - Summary of All Interim Corrective Actions

Lessons learned from the events at Byron station were reviewed and various interim corrective actions evaluated for safety and efficiency at Watts Bar Nuclear Plant (WBN). Based upon the plant's offsite power configuration, electrical design details, and industry lessons learned shared through the Institute of Nuclear Power Operations (INPO) and Nuclear Energy Institute (NEI), the following actions were taken to ensure plant operators can promptly diagnose and respond to open phase conditions (OPCs):

- A walk-down of the WBN switchyards was performed to identify OPC vulnerabilities. The walk-down determined if an open phase condition were to occur, it would be most likely at the overhead line connection to the offsite power transformers. This would most likely be a grounded open phase condition since the distance between most poles was greater than the height of the lines and a breakpoint in these spans would allow the transmission line to fall to the ground. The walkdown also determined a potential vulnerability of an ungrounded open phase condition in the overhead transmission line connection points (i.e., stingers). While stinger failure provided a conceivable ungrounded open phase condition, it was determined unlikely since most stingers have a multi-bolt connection, are not in tension, and are inspected by thermography during routine PM inspections of the switchyard.

- Procedures for daily transformer yard inspections were reviewed to ensure the thoroughness and completeness relative to the identification of off-normal conditions by Operations personnel. The procedures for periodic thermography of switchyard components (performed to assist in the early identification of degraded components) were also reviewed.

- Bus transfer procedures were verified to ensure three phase voltages are checked prior to bus transfers and the bus voltage is checked on the bus voltmeter after the bus transfers.

- NRC Bulletin 2012-01 was presented to all licensed operators during Cycle 2013-02 Licensed Operator Requalification (LOR) training.

Response 2 - Status and Schedule for Completion of Plant Design Changes

Holders of operating licenses and combined licenses for nuclear power reactors are investigating options being researched by several vendors (PSC2000, EPRI, Schweitzer, etc.) to detect OPC faults. TVA has sent representatives to evaluate the PSC2000 solution, is working with EPRI to provide a possible testing facility for their proposed solution, and is in the process of contracting relay experts to evaluate various proposed protective relay solutions. There is currently no generic, off-the-shelf technology that has been proven to detect all the required open phase fault conditions for all plant and transformer designs.

TVA is fully engaged in the development of the NEI OPC Guidance Document, as well as development of enhancements to software tools being used to analyze OPC faults. TVA has provided technical expertise to participate in the NEI steering committee and are providing technical experts in a leadership capacity to aid in the development of the only nuclear QA software, ETAP.

With the goal of ensuring accurate detection without compromising nuclear safety or increasing plant risk, this new OPC technology is being thoroughly evaluated, will be tested, and will be fully analyzed before installation.

Vulnerability studies of the OPC faults have been completed for WBN and additional operator meetings are being scheduled to communicate the results. For the analyzed configurations, the vulnerability studies showed existing protection automatically actuates and provides protection to the Class-1E system for grounded open phase conditions. Vulnerability to an ungrounded open phase condition has been identified for some analyzed configurations.

The TVA nuclear fleet has endorsed the generic schedule provided in the Industry OPC Initiative.

It is WBN's intention to meet the milestones of this schedule; however, deviations may be required to accommodate outage schedules, software and hardware availability, manufacturer's delivery capabilities, licensing delays, etc.

Any deviation from the Industry OPC Initiative schedule will be documented through the deviation/exemption process addressed in the NEI OPC Guidance Document.