



Memorandum from the Office of the Inspector General

July 13, 2020

Jamie E. Choate
Preston P. Pratt
Timothy S. Rausch

REQUEST FOR FINAL ACTION – EVALUATION 2019-15644 – NUCLEAR ARC FLASH PROTECTION

Attached is the subject final report for your review and final action. Your written comments, which addressed your management decision and actions planned or taken, have been included in the report. Please notify us when final action is complete. In accordance with the Inspector General Act of 1978, as amended, the Office of the Inspector General is required to report to Congress semiannually regarding evaluations that remain unresolved after 6 months from the date of report issuance.

If you have any questions or wish to discuss our findings, please contact Meghan H. Petty, Senior Auditor, at (423) 785-4812 or E. David Willis, Director, Evaluations, at (865) 633-7376. We appreciate the courtesy and cooperation received from your staff during the evaluation.

David P. Wheeler
Assistant Inspector General
(Audits and Evaluations)

MHP:FAJ

Attachment

cc (Attachment):

TVA Board of Directors
Anthony D. Camilleri
James R. Dalrymple
Megan T. Flynn
Lucia W. Harvey
Jeffrey J. Lyash
Justin C. Maierhofer
Jill M. Matthews
Sherry A. Quirk
OIG File No. 2019-15644



Office of the Inspector General

Evaluation Report

To the Director of Technical Training;
Director of Safety and Enterprise
Improvement; and Senior Vice
President and Chief Nuclear Officer

NUCLEAR ARC FLASH PROTECTION

Evaluation Team
Meghan H. Petty
Lucas W. Cotter

Evaluation 2019-15644
July 13, 2020

ABBREVIATIONS

Cal/cm ²	Calories per Centimeter Squared
JSA	Job Safety Analysis
NPG	Nuclear Power Group
OSHA	Occupational Safety and Health Administration
PJB	Pre-Job Briefing
PPE	Personal Protective Equipment
SPP	Standard Programs and Processes
SVP&CNO	Senior Vice President and Chief Nuclear Officer
TSP	TVA Safety Procedure
TVA	Tennessee Valley Authority
V	Volts
WO	Work Order

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- A. OBJECTIVE, SCOPE, AND METHODOLOGY
- B. MEMORANDUM DATED JULY 4, 2020, FROM TIMOTHY S. RAUSCH TO DAVID P. WHEELER
- C. MEMORANDUM DATED JUNE 26, 2020, FROM PRESTON P. PRATT TO DAVID P. WHEELER



Evaluation 2019-15644 – Nuclear Arc Flash Protection

EXECUTIVE SUMMARY

Why the OIG Did This Evaluation

According to the Occupational Safety and Health Administration, workers in the electric power industry are potentially exposed to a variety of serious hazards that can cause injury and death such as electric shock, thermal burn, and arc flash. Arc flash is a dangerous release of energy caused by an electric arc. The Tennessee Valley Authority's (TVA) medical records system indicated there were seven arc flash injuries between 2015 and 2019.

Due to the risk of personnel injury from arc flash hazards, we initiated evaluations of arc flash programs in TVA Nuclear and Power Operations. This report summarizes our evaluation of the arc flash program at nuclear plants.ⁱ The objectives of our evaluation were to determine if (1) TVA's arc flash proceduresⁱⁱ were being performed as required, (2) required personal protective equipment (PPE) was available and properly maintained, and (3) required training was completed.

What the OIG Found

We found some requirements of TVA's arc flash procedures were not being performed. Specifically, (1) arc flash hazard analyses were incomplete, not reflective of current plant operating conditions, and not reviewed timely; (2) identified hazards were not communicated accurately to workers; (3) plants had not adequately evaluated and implemented controls to reduce exposure to high hazard incident energies;ⁱⁱⁱ and (4) hazards and mitigations were not routinely documented.

In addition, we determined arc flash training needs improvement. TVA's identified population of individuals required to have arc flash training had completed initial training; however, the trainee population was incomplete and not a reliable indicator as to who is required by the Occupational Safety and Health Administration to receive the training. TVA has also not implemented retraining at the frequency required by its procedures. Also, while PPE was generally available and in good condition, its management could be improved with an inventory listing and preventive maintenance.

ⁱ Our evaluation, *Power Operations Arc Flash Protection*, was reported under Evaluation 2019-15642.

ⁱⁱ TVA Safety Procedure 18.1022, *Arc Flash Protection*, establishes requirements for minimizing risk when working around equipment that poses an arc flash hazard. Nuclear Power Group Standard Programs and Processes 18.4.9, *Electrical Safe Work Practices and Protective Boundary Matrices*, provides expectations for a safe work environment when working in or near arc flash boundaries.

ⁱⁱⁱ The amount of energy impressed on a surface generated during an electrical arc event. Incident energy is measured in calories per centimeter squared.



Evaluation 2019-15644 – Nuclear Arc Flash Protection

EXECUTIVE SUMMARY

What the OIG Recommends

We made recommendations regarding (1) arc flash procedures, (2) training requirements, and (3) management practices around PPE. Our detailed recommendations are listed in the body of this report.

TVA Management's Comments

TVA management generally agreed with the recommendations in this report and provided planned actions to address the recommendations. See Appendices B and C for TVA's complete responses.

Auditor's Response

We concur with TVA management's planned actions.

BACKGROUND

According to the Occupational Safety and Health Administration (OSHA), workers in the electric power industry are potentially exposed to a variety of serious hazards that can cause injury and death such as electric shock, thermal burn, and arc flash. Arc flash is a dangerous release of energy caused by an electric arc. Electrical arc flashes can expel large amounts of deadly energy and reach temperatures high enough to set fire to clothing and severely burn human skin. When workers can be exposed to electrical arcs, OSHA indicates the first effort should be to eliminate the exposure through engineering design. If elimination is not possible, exposures should be limited through other means, including work practices.

Tennessee Valley Authority (TVA) Safety Procedure (TSP) 18.1022, *Arc Flash Protection*, establishes requirements for minimizing risk when working around equipment that poses an arc flash hazard. Plants are required to identify and analyze electrical circuits and equipment with arc flash exposure potential operating at 480 volts (V) through 500 kilo-volts. For analyzed equipment, arc flash hazard analyses provide calculated values for worst-case potential exposures for the following:

- **Incident Energy** – The amount of energy impressed on a surface generated during an electrical arc event. Incident energy is measured in calories per centimeter squared (cal/cm^2).
- **Flash Protection Boundary** – An approach limit established at the distance from an exposed energized part within which a person without proper personal protective equipment (PPE) could receive a second-degree burn if an electrical arc flash were to occur (second-degree burns can occur at $1.2 \text{ cal}/\text{cm}^2$).

When analyses are complete, TVA-TSP-18.1022 requires posting of signs or labels on equipment that can develop an incident energy greater than $1.2 \text{ cal}/\text{cm}^2$. Labels are required to be updated if calculations change. See Illustration 1 for an example warning label on nuclear equipment. Such labels must include the incident energy potential, flash protection boundary needed for work at that location, and level of PPE required. The PPE level required to conduct work at a location is determined by the calculated incident energy.

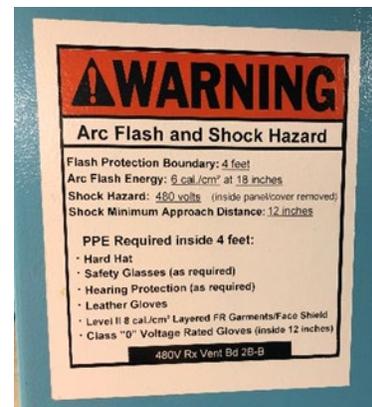


Illustration 1: Arc Flash Warning Label at Watts Bar

TVA-TSP-18.1022 requirements for plants also include (1) adherence to requirements in TVA-TSP-18.006, *Plan Jobs Safely*, regarding pre-job briefings (PJB) and job safety analyses (JSA) under certain conditions, (2) training for personnel who enter a defined and marked arc flash protection boundary;

(3) evaluation of controls¹ to reduce high hazard incident energies; and (4) use of controls, when available.

Nuclear Power Group (NPG) Standard Programs and Processes (SPP) 18.4.9, *Electrical Safe Work Practices and Protective Boundary Matrices*, provides expectations for a safe work environment when working in or near arc flash boundaries. NPG-SPP-18.4.9 incorporates practices from TVA-TSP-18.1022 and provides attachments detailing arc flash incident energies and boundaries for electrical components at each nuclear plant.

TVA's medical records system indicated there were seven arc flash injuries between 2015 and 2019. Of the seven, two injuries occurred at nuclear plants. Two contract workers were seriously injured in March 2018 by an arc flash incident while completing a maintenance activity at Sequoyah Nuclear Plant.² Due to the risk of personnel injury from arc flash hazards, we initiated evaluations of arc flash programs in TVA Nuclear and Power Operations. This report summarizes our evaluation of the arc flash program at nuclear plants.³

OBJECTIVE, SCOPE, AND METHODOLOGY

The objectives of our evaluation were to determine if (1) TVA's arc flash procedures were being performed as required, (2) required PPE was available and properly maintained, and (3) required training was completed. The scope of our evaluation included the arc flash programs at Browns Ferry, Sequoyah, and Watts Bar nuclear plants. A complete discussion of our audit objective, scope, and methodology is included in Appendix A.

FINDINGS AND RECOMMENDATIONS

We found (1) some requirements of the arc flash procedures were not being performed, and (2) arc flash training needs improvement. Also, while PPE was generally available and maintained in good condition, management of PPE could be improved with inventory listings and preventive maintenance.

SOME REQUIREMENTS OF THE ARC FLASH PROCEDURES WERE NOT PERFORMED

We found some requirements of the arc flash procedure were not being performed. Specifically, (1) arc flash hazard analyses were incomplete, not

¹ Controls are intended to reduce risk of possible injury and limit effects of human error. Engineering controls include changing relay settings; addition, or replacement of relays and breakers; and installation of arc-rated switchgear. Administrative controls are means such as remote racking, remote switching, and/or upstream switching.

² TVA determined contributing causes included inadequate (1) oversight of contract personnel, (2) execution of PJBs to ensure hazard recognition and mitigation of work-site hazards, and (3) adherence to procedure requirements.

³ Our evaluation, *Power Operations Arc Flash Protection*, was reported under Evaluation 2019-15642.

reflective of current plant operating conditions, and not reviewed timely; (2) identified hazards were not communicated accurately to workers; (3) plants had not adequately evaluated and implemented controls to reduce exposure to high hazard incident energies; and (4) hazards and mitigations were not routinely documented.

Hazard Analyses Were Not Complete, Updated, or Reviewed Timely

We determined procedural requirements for arc flash hazard analyses were not met, resulting in hazard analyses that were (1) incomplete, (2) unreflective of current plant operating conditions, and (3) not reviewed timely. TVA-TSP-18.1022 requires plants to identify and analyze all electrical circuits and equipment with arc flash exposure potential greater than 480V and perform an arc flash hazard analysis. The arc flash hazard analysis shall be updated when a major modification or renovation takes place. It shall also be reviewed periodically, not to exceed 5 years, to account for changes in the electrical distribution system that could affect the results of the arc flash hazard analysis. If the results of the analysis yield higher or lower values, TVA-TSP-18.1022 requires labels be adjusted accordingly.

Incomplete Analyses

Each plant's hazard analysis was incomplete because they did not include all electrical circuits and equipment with arc flash exposure potential greater than 480V as required. We reviewed a sample of 87 work orders (WO) involving arc flash potential and identified 107 work locations where work was performed. For each location, we compared warning labels to the hazard analysis or other engineering documents and found 7 of the 107 locations did not have available calculations.

In addition, hazard analyses at Browns Ferry and Watts Bar did not include normal, alternate, and emergency feed calculations, which typically have higher incident energies. According to TVA, an external review in 2018 observed Browns Ferry did not include feeder transformers or breakers in its arc flash calculations as required by industry standards. We found as of January 2020, Browns Ferry had still not updated the arc flash calculations to include feeder breakers and transformers. While many feeder breakers were included in Sequoyah's hazard analysis, one feeder breaker included in the identified work locations did not have an available calculation in the analysis.

Unincorporated Modifications

Hazard analyses were unreflective of current plant operating conditions because they were not always updated after a major modification or renovation. We determined 15 of the 107 work locations had arc flash calculations in engineering documents that were not incorporated in the arc flash hazard analysis. We also identified instances where modifications were made to plant design that resulted in higher arc flash incident energies and were not properly incorporated in the hazard analyses.

We communicated concerns to TVA management regarding certain locations where we found calculated values were significantly higher than values on equipment labels and in NPG-SPP-18.4.9. As discussed below, these issues were not remediated in a timely manner.

- **Browns Ferry** – Two electrical boards were affected by plant modifications in November 2018 and January 2019. In July 2019, we observed warning labels and notified plant management and engineering that the hazard analysis updated in May 2019 did not properly reflect worst-case scenario at these locations. In December 2019, we revisited the plant and noted a warning tag had been placed on one of the boards but not the other. We communicated this to plant management and they placed a warning tag on the board. Browns Ferry engineering subsequently determined five additional boards had increased arc flash values as a result of the modifications. A stop-WO was issued by the maintenance group until engineering recalculated the values and NPG-SPP-18.4.9 was updated. The procedure was revised in January 2020 to incorporate the new values.
- **Sequoyah** – An electrical board and feeder breaker were affected by a plant modification in June 2018, significantly increasing the incident energies at these locations. In early December 2019, we notified plant management and engineering that the site's hazard analysis was not updated to properly reflect worst-case scenarios at these locations. We visited the plant in January 2020 and found the plant had not revised warning labels or added signage at the affected locations. We notified plant management and they placed warning tags; however, as of April 2020, the procedural values had not been updated to reflect higher incident energies.

Untimely Reviews

Hazard analyses were not reviewed timely as required by TVA-TSP-18.1022. No plant's hazard analysis had been reviewed within the 5-year period required by procedure. The most recent reviews were completed at Browns Ferry in 2008, Sequoyah in 2011, and Watts Bar in 2012. During the course of our evaluation, Watts Bar issued a review of its plant analysis in March 2020.

If the basis of arc flash protection values provided to workers is unreliable, TVA has little assurance its processes will adequately protect workers exposed to arc flash potential.

Identified Hazards Were Not Communicated Accurately

TVA-TSP-18.1022 and NPG-SPP-18.4.9 require warning labels to (1) include incident energy, boundaries, and PPE levels and (2) be updated when calculations change; however, we identified missing and/or outdated warning labels at each plant.⁴ In addition, we were informed by management at each site that personnel are expected to use incident energies and boundaries provided in

⁴ We did not draw conclusions on the accuracy of the values on the warning labels because we determined the arc flash hazard analyses were incomplete and unreflective of current plant operating conditions.

NPG-SPP-18.4.9 to determine appropriate PPE for work locations rather than warning labels present on electrical equipment. However, we compared incident energies and boundaries in the procedure to arc flash hazard analyses and found several discrepancies.

Missing/Outdated Warning Labels

We observed 107 work locations where arc flash potential existed; however,

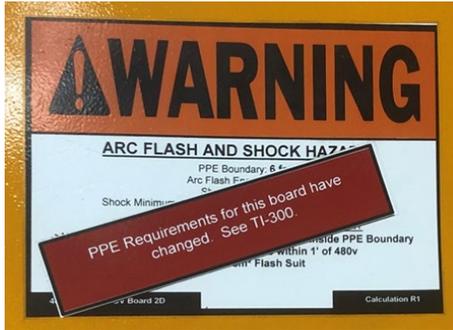


Illustration 2: Example of Label with Outdated Information at Browns Ferry

24 (22 percent) were unlabeled—16 at Browns Ferry, 4 at Sequoyah and 4 at Watts Bar. We also observed work locations at Browns Ferry that had arc flash labels marked out with a notice to consult a calculation that we determined to be obsolete (see Illustration 2). We were provided evidence dating back to 2018 that Browns Ferry was aware of over 130 missing arc flash labels. When we visited the plant in December 2019, plant management indicated there was no plan to post and/or update the labels.

Discrepancies Between SPP and Hazard Analyses

As stated previously, plant management's expectation was for workers to use incident energies and boundaries provided in the NPG-SPP-18.4.9 to determine appropriate PPE for work locations rather than the posted warnings labels. However, we compared the hazard analyses to NPG-SPP-18.4.9 and found what appeared to be numerous discrepancies. We found instances where discrepancies would result in a higher PPE hazard level being necessary to protect workers than what was listed in the procedure.

We communicated the discrepancies to plant engineering and Nuclear Engineering personnel. As a result, plant engineering at Sequoyah compared its hazard analysis to procedural values in NPG-SPP-18.4.9. Preliminary findings indicated roughly a quarter of the components listed in the procedure would increase in incident energy with a procedural revision. While the apparent discrepancies we observed were not limited to Sequoyah, plant engineers at Browns Ferry and Watts Bar did not perform similar comparisons during our evaluation.

We found there was no procedurally defined process or group responsible for ensuring arc flash values in NPG-SPP-18.4.9 remain accurate. Discrepancies between hazard analyses and the procedure were due to (1) a gap in the engineering process to update the procedure, (2) procedure writers not always being notified when hazard analyses were issued, and (3) components listed in the procedure were not easily traced to the hazard analyses due to terminology used by plant engineering.

Providing a single, up-to-date reference source for arc flash values may decrease the possibility inaccurate information is used to protect workers at these locations.

High Hazard Exposures Were Not Adequately Evaluated and Reduced

Plants have not adequately evaluated and implemented controls to reduce exposure to high hazard incident energies. OSHA indicates the first effort should be to eliminate the exposure through engineering design. If elimination is not possible, exposures should be limited through work practices. TVA-TSP-18.1022 indicates “Incident energy exposures greater than or equal to 40 cal/cm² [i.e., high hazard exposures] shall be evaluated to determine if incident energy can be reduced by instituting engineering and/or administrative controls.” It also requires plants to implement controls such as remote racking devices,⁵ remote switching, and maintenance mode switches to reduce exposure and use controls when available.

NPG-SPP-18.4.9 lists over 130 components with high hazard incident energies, as of January 2020; however no plant in the TVA nuclear fleet had a plan in place to reduce incident energies. While there are limitations to the applicability of certain controls due to nuclear safety and cybersecurity concerns in the nuclear environment, we found the efforts to evaluate and implement controls were lacking. For example, according to TVA, an external review in 2018 observed Browns Ferry did not have an arc flash mitigation strategy plan to reduce incident energies to below 40 cal/cm² and recommended the plant create a plan. At that time, Browns Ferry engineering indicated they would review settings to lower the incident energies, but have not done so. In contrast, Power Operations has developed plans to reduce its highest energy boards in addition to implementing numerous projects in recent years to reduce the hazards at its plants.

Although TVA-TSP-18.1022 requires the use of controls such as remote racking devices when available, we identified controls available that were underused. We were informed the plants purchased approximately \$600,000 of remote racking devices in 2016 and 2017. During our site visits, we observed the remote racking devices stored at training facilities or work control centers rather than in the plant for use. Personnel at all three plants confirmed the remote racking devices were infrequently, if ever, used due to lack of training on the devices, being cumbersome to use, and the limited number of locations where they can be used. Sequoyah has an initiative to incorporate use of remote racking devices and purchased an additional \$166,000 of devices in 2019.

Without adequate evaluation and implementation of controls, NPG’s program to protect workers may be overly reliant on PPE, which is the least effective means according to OSHA.

⁵ Remote racking devices allow circuit breakers to be racked in and out remotely at a distance that reduces the incident energy exposure to personnel.

Arc Flash Hazards and Mitigations Were Not Routinely Documented

Nuclear plants were not routinely identifying arc flash hazards in documented PJBs and documenting related JSAs as required. PJBs and JSAs are intended to identify hazards to those performing work and ensure hazards are eliminated or controlled prior to beginning work. TSP-TVA-18.1022 requires JSAs to be reviewed in the PJB and completed in accordance with TVA-TSP-18.006, *Plan Jobs Safely*. TVA-TSP-18.006 requires a documented JSA and PJB to be retained in the work package for any work involving (1) work on or near exposed energized equipment or (2) work involving fire/explosion burn hazards.

Since we confirmed arc flash hazard potential for each of our sampled WOs, we anticipated each work package would have identified PPE as a required element unless an alternate method of mitigation was identified. While we found 72 of 87 work packages included a documented PJB, 44 of those PJBs did not indicate arc flash clothing or alternative mitigation method was required. In addition, our review found JSAs were not documented for 86 of the 87 work packages.

In contrast to TVA-TSP-18.006, TVA-TSP-18.1022 only requires a JSA for work on any equipment with *high hazard* incident energies (greater than or equal to 40 cal/cm²) or exposed energized parts. Of the 87 work packages reviewed, 20 involved electrical components with high hazard incident energies and only 1 included a documented JSA in the work package. While neither procedure's documentation requirement was met, establishing consistency between the two procedures may enhance compliance.

Hazards and mitigation strategies were not documented, so we were unable to determine whether work was performed in accordance with the procedure. For example, we were unable to determine whether the appropriate level of PPE was worn or other controls were used to reduce risk to workers during the performance of the sampled work.

Recommendations

We recommend the Senior Vice President and Chief Nuclear Officer (SVP&CNO):

- Update Browns Ferry and Sequoyah arc flash hazard analyses to ensure the analyses are reflective of current plant operating conditions and comply with requirements for a 5-year review.

TVA Management's Comments – TVA management partially agreed with our recommendation. Although TSP-18.1022 specifically references a 5-year walkdown, NPG's engineering procedure does not explicitly require a plant walkdown when verifying plant configuration. Hazard analyses have been completed at Browns Ferry (December 22, 2019) and Sequoyah (February 6, 2020). TVA will revise its engineering procedure and state that a walkdown will be used as a method to verify plant configuration. NPG will also coordinate with Safety to ensure that TVA-TSP-18.1022 references NPG's arc flash hazard analysis process. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

- Update plant hazard analyses to provide calculated values for normal, alternate, and emergency feeds.

TVA Management's Comments – TVA management partially agreed with our recommendation. TVA Engineering has reviewed the arc flash hazard analysis calculations and determined that normal, alternate, and emergency feeds are included in the existing analysis for both Sequoyah and Watts Bar, but not for Browns Ferry. TVA indicated it will update Browns Ferry's hazard analysis to provide calculated values for normal and alternate (emergency) feeds. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

- Develop and implement controls to ensure all relevant arc flash values are traceable in plant arc flash hazard analyses.

TVA Management's Comments – TVA management agreed with the recommendation and will add the requirement in each hazard analysis calculation to inform the procedure owner of any changed values for Browns Ferry and Watts Bar. This action has already been completed at Sequoyah. All three NPG locations will add the requirements to reference other site arc flash calculations from the main calculation. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

- Implement a standard method for providing workers arc flash values and remove outdated information posted on equipment.

TVA Management's Comments – TVA management agreed with the recommendation and will update postings on electrical boards as needed following the arc flash value revisions to NPG-SPP-18.4.9. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

- Clarify the process and responsibilities for ensuring arc flash values remain accurate in NPG-SPP-18.4.9.

TVA Management's Comments – TVA management agreed with the recommendation and provided information on responsibilities to be incorporated in NPG-SPP-18.4.9. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

- Implement a control to review all arc flash values for each plant included in the procedure when a plant modification with implications for arc flash is implemented or a hazard analysis is issued.

TVA Management's Comments – TVA management agreed with the recommendation and indicated a statement will be added to NPG-SPP-09.3, *Plant Modifications and Engineering Change Control*, to evaluate changes to hazard analyses and inform procedure owners of NPG-SPP-18.4.9 of any changed values. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

- Evaluate available engineering and administrative controls to reduce high hazard exposures and formalize reduction strategies in a site-specific plan.

TVA Management's Comments – TVA management agreed with the recommendation and indicated a study will be performed to look at available engineered and administrative controls, discuss options with appropriate peer teams, and create implementation plans of chosen options specific to each site. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

- Reinforce use of remote racking devices, where available.

TVA Management's Comments – TVA management agreed with the recommendation and will revise NPG-SPP-18.4.9 to reinforce the use of remote racking devices, where available. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

- In conjunction with the Director of Safety and Enterprise Improvement, implement a control to monitor documented PJB and JSA requirements and verify proper documentation is maintained.

TVA Management's Comments – TVA management agreed with the recommendation and will perform an effectiveness review 6 months following Safety's planned revisions to TVA-TSP-18.1022. The review will verify that JSA and PJB documents are completed and retained in accordance with TVA-TSP-18.1022 for jobs involving arc flash potential. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

We recommend the Director of Safety and Enterprise Improvement:

- Align its procedures to clarify when a JSA is required for electrical work involving potential for arc flash.

TVA Management's Comments – TVA management agreed with the recommendation and stated TVA-TSP-18.006 has been revised to require work with an arc flash potential greater than 40 cal/cm² to have a JSA. The revision is currently going through the review and approval process. See Appendix C for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

ARC FLASH TRAINING NEEDS IMPROVEMENT

We determined TVA's identified population of individuals required to have arc flash training had completed initial training; however, the trainee population was incomplete and not a reliable indicator as to who is required by OSHA to receive the training. In addition, TVA has not implemented retraining at the frequency required by its procedures.

TVA's Identified Required Trainee Population Was Incomplete and Unreliable

OSHA requires employees who face a risk of electric shock or other electrical hazards to be trained in and familiar with certain safety-related work practices. Our review of 1,155 personnel identified by TVA as requiring arc flash training⁶ found 3 had not completed the curriculum as of March 31, 2019. These individuals had completed the required trainings as of February 1, 2020. However, we determined TVA's identified required trainee population was incomplete and not a reliable indicator as to personnel who would be required by OSHA to take the courses. Our conclusion was based on the following factors:

- Training was not assessed for all job codes. Technical Training⁷ assigns training to personnel within job codes assessed as requiring the arc flash curriculum. In September 2019, we were informed Technical Training had a backlog of less than 100 unassessed job codes, down from about 1,200 a year prior. Between March 31, 2019, and January 13, 2020, 57 job codes added arc flash curriculum as a requirement. As of February 1, 2020, 114 nuclear personnel were active in those job codes.
- Nuclear training program descriptions for employees within certain disciplines typically at risk of arc flash exposure (operators and electrical maintenance) required arc flash training but did not identify the affected job codes. This creates the potential for jobs required to have the courses not being identified in TVA's population of required trainees. For example, we determined 1 job code for electrical contractors was identified in the TVA Central In-Processing Center's training program description, and the individuals were not assigned the course by Technical Training. As a result, we identified 53 of the 250 electrical contract workers had not received the required courses as of March 31, 2019.⁸

⁶ TVA-TSP-18.1022 Revision 14, Section 5.0, required the following two courses (or an equivalent training block) during initial training: 00059115, *Electrical Safety per OSHA* and 00059242, *Arc Flash Hazard*. The TSP's current revision, effective May 2019, removed language identifying specific courses required. We followed up with personnel in Safety and Technical Training who indicated these courses continue to constitute TVA's arc flash training curriculum.

⁷ During the course of the evaluation, TVA revised the name of the group responsible for assigning training from Enterprise Improvement to Technical Training.

⁸ TVA training personnel indicated 1 contractor did not require the training because the individual does not conduct work involving arc flash risk. In addition, numerous contractors terminated employment prior to receiving the courses. However, we found 7 contractors actively employed as of November 2019 had not received the initial arc flash course. As of May 15, 2020, 4 of the 7 had completed the course and 3 had terminated employment with TVA.

- Nuclear training personnel indicated 46 personnel listed as required in TVA's trainee population should not be included in the population because the individuals did not conduct work involving arc flash potential.

According to Nuclear and Technical Training, there is no formal process for NPG to routinely review the list of positions assigned the training for completeness and accuracy.

Retraining Requirements Were Not Implemented for NPG

NPG-SPP-18.4.9 requires retraining on a 2-year interval for certain operations and maintenance employees. We reviewed training program descriptions for operations and maintenance personnel and determined the frequency of arc flash retraining and course required was not formalized in NPG's training program descriptions. As a result, we were unable to determine with certainty which employees would be required to take a refresher course or which course was required.

A computer-based arc flash refresher course is available in TVA's training catalog, though it was not assigned as part of the required arc flash curriculum. As an indication of the prevalence of retraining, we tested records for employees previously identified as receiving initial arc flash training 2 or more years prior to March 31, 2019.⁹ Of the 825 employees potentially due for retraining, only 136 employees (16 percent) had completed the available refresher course. Plant training personnel provided evidence that alternate courses for certain groups may be used to provide arc flash training content annual and biennial trainings such as clearance process or electrical safety courses. Those courses do not show in TVA's training software as equivalences for the arc flash refresher course, currently making tracking of refresher completion difficult.

Recommendations

We recommend the SVP&CNO:

- Provide employees with required refresher training.

TVA Management's Comments – TVA management agreed with the recommendation and indicated Corporate Training will ensure all affected work groups (1) have been properly assigned and (2) complete training after job codes and/or task qualification requirements have been revised to include the required retraining frequency for arc flash. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

We recommend the SVP&CNO, in coordination with the Director of Technical Training:

⁹ We were informed by TVA training personnel that a refresher course would not be required for managed task contractors; therefore, we removed 63 contractors from the analysis.

- Identify all job codes and personnel potentially exposed to arc flash risk at its facilities to ensure TVA's trainee population is in accordance with OSHA.

TVA Management's Comments – TVA management agreed with the recommendation and indicated Corporate Training will coordinate completion with the Director of Technical Training. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

- Establish a monitoring protocol for ensuring the training population is periodically reviewed and approved by plant management.

TVA Management's Comments – In addition to completion of the other training actions referenced in this report, Corporate Nuclear Training will conduct an assessment upon completion of all training to verify it has been completed for all affected work groups and no further gaps exist. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

- Clearly define which operations and maintenance roles are required to attend a refresher course and specify the course required as well as any acceptable equivalences.

TVA Management's Comments – TVA management agreed with the recommendation and indicated (1) analysis and design worksheets have been completed for disciplines in nuclear and (2) retraining periodicities have been determined with input from Corporate Functional Area Managers. NPG Corporate Training will also coordinate with the Director of Technical Training to define retraining frequencies for all affected personnel and a specific training course will be developed to meet this requirement. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

REQUIRED PPE WAS AVAILABLE AND MAINTAINED; HOWEVER, PPE MANAGEMENT PRACTICES COULD BE IMPROVED

According to TVA-TSP-18.1022, arc flash PPE shall “. . . be stored in a manner that prevents physical damage; damage from moisture, dust, or other deteriorating agents; or contamination from flammable or combustible materials.” The PPE shall also be inspected before each use as well as cared for and maintained in accordance with the garment manufacturer's instructions to avoid loss of protection. There is no centralized storage or point of contact for arc flash PPE at nuclear plants; each work group maintains its PPE or borrows from another work group onsite as needed. Based on our observation of PPE storage areas, we concluded that PPE appeared to be generally stored in a manner to avoid loss of protection and was in good condition. We received positive feedback from plant personnel regarding availability of PPE at the plants.

However, we were informed during site visits that plants did not maintain a current inventory listing of PPE and did not have a PPE preventive maintenance program to care for and maintain its PPE in accordance with manufacturer's instructions.¹⁰ While not required by procedure, we noted PPE management practices could be improved to ensure continued availability and good material condition.

Recommendation

We recommend the SVP&CNO:

- Consider maintaining plant-level inventory listings of arc flash PPE and implementing a preventive maintenance program to routinely inspect PPE.

TVA Management's Comments – TVA management indicated the TVA Maintenance Peer Team will determine ownership of plant inventory listings and a preventive maintenance program for arc flash PPE. See Appendix B for TVA's complete response.

Auditor's Response – We concur with management's planned actions.

¹⁰ A 2016 assessment by TVA's Operational Assurance group also found that routine inspections of arc-rated equipment had not been consistently performed.

OBJECTIVE, SCOPE, AND METHODOLOGY

The objectives of our evaluation were to determine if (1) TVA's arc flash procedures were being performed as required, (2) required personal protective equipment was available and properly maintained, and (3) required training was completed. The scope of our evaluation included the arc flash programs at Browns Ferry, Sequoyah, and Watts Bar nuclear plants and the time frames noted below. To achieve our objectives, we:

- Interviewed the following pertinent personnel to gain an understanding of the arc flash protection process, requirements, and potential areas for improvement:
 - Corporate Functional Area Manager for Maintenance
 - Corporate and plant safety personnel
 - Corporate and plant engineers
 - Plant operations and maintenance managers
- Reviewed relevant documentation to gain an understanding of the arc flash protection process and identify potential areas for improvement:
 - *TVA Safe Work Requirements Manual*
 - *TVA-TSP-18.1022, Arc Flash Protection*
 - *TVA-TSP-18.006, Plan Jobs Safely*
 - *NPG-SPP-18.4.9, Electrical Safe Work Practices and Protective Boundary Matrices*
 - *OSHA 1910 Subpart S - Electrical Standard*
 - *OSHA Electric Power Generation, Transmission, and Distribution Standard (29 CFR §1910.269)*
 - *National Fire Prevention Association Standard for Electrical Safety in the Workplace (70E)*
- Obtained and reviewed arc flash hazard analyses and additional engineering calculations for each of the plants for identification and analysis of arc flash potential.
- Compared NPG-SPP-18.4.9 to arc flash hazard analyses to determine whether procedural values were supported by hazard analyses.
- Selected a random, nonstatistical sample of 90 work orders (WO) at nuclear plants from the 46,682 WOs completed in TVA's work management system between April 1 and June 30, 2019. We stratified our sample of WOs by energized, de-energized by grounding, and de-energized by other means. We confirmed with plant electrical maintenance personnel that WOs selected would have arc flash potential. We then obtained WOs to determine whether hazards and mitigation strategies were documented. Of the 90 sampled work packages, we reviewed 87 work packages for this evaluation.¹

¹ Three of the 90 WOs were later determined to have no arc flash risk. We did not replace these 3 items in our sample.

- Conducted site visits at the three plants to observe electrical equipment associated with the sampled work to document posted arc flash warning labels. For the 87 WOs reviewed, we observed and photographed 107 related work locations with potential arc flash hazards.
- Analyzed data to determine if individuals had received required training. We identified arc flash training courses required. We obtained records as of March 31, 2019, for (1) active personnel from TVA's human resource management system and (2) training completion records from TVA's training management system.
- Conducted site visits at the three plants to observe physical location and condition of personal protective equipment.

This evaluation was performed in accordance with the Council of the Inspectors General on Integrity and Efficiency's *Quality Standards for Inspection and Evaluation*.

July 4, 2020

David P. Wheeler

RESPONSE TO OIG MEMORANDUM, OIG FILE NO. 2019-15644

Thank you for the opportunity to review and respond to the subject draft report, NPG Arc Flash Protection, provided June 4, 2020. TVA has reviewed the report and agrees to take corrective actions at its nuclear generation stations, Browns Ferry Nuclear, Sequoyah Nuclear, and Watts Bar Nuclear, respectively referred to hereafter as BFN, SQN, and WBN. The details of these actions are described below as they pertain to the OIG's recommendations regarding (1) Arc Flash Procedures, (2) Training Requirements, and (3) Management Practices around PPE.

(1) Arc Flash Procedure OIG Recommendations & TVA Response Detail:

- **OIG Recommendation 1:** Update Browns Ferry and Sequoyah arc flash hazard analyses to ensure that the analyses are reflective of current plant operating conditions and comply with requirements for a 5-year review.
 - TVA Response: TVA is in partial agreement with the OIG's recommendation. NPG's engineering procedure, NEDP-2.2, currently requires that TVA complete hazard analyses as described in the OIG's recommendation. Hazard Analyses updates have been completed at BFN, as of 12/22/2019 and SQN, as of 02/06/2020. TVA-TSP-18.1022 specifically references a 5 year walk down. Although this is performed when verifying plant configuration as part of the calculation baseline, it is not explicitly called out in NEDP-2.2. TVA will revise NEDP-2-2 and state that a walk down will be used as a method to verify plant configuration. This revision is scheduled to be completed by 7/31/2020. NPG will also coordinate with corporate safety to ensure that TVA-TSP-18.1022 references NPG's arc flash hazard analysis process. This revision is scheduled to be completed by 8/31/2020.
- **OIG Recommendation 2:** Update plant hazard analyses to provide calculated values for normal, alternate, and emergency feeds.
 - TVA Response: TVA is in partial agreement with the OIG's recommendation. TVA Engineering has reviewed the arc flash hazard analysis calculations and determined that normal, alternate, and emergency feeds are included in the existing analysis for both SQN and WBN, but not for BFN. TVA will update BFN plant hazard analysis to provide calculated values for normal and alternate (emergency) feeds, with a scheduled completion date of 09/30/2020.
- **OIG Recommendation 3:** Develop and implement controls to ensure all relevant arc flash values are traceable in plant arc flash hazard analyses.
 - TVA Response: TVA agrees with the recommendation and will add the requirement in each hazard analysis calculation to inform the procedure owner of any changed values for BFN and WBN. This action has already been completed at SQN during refueling cycle 15, prior to 02/06/2020. All three NPG locations will add the requirements to reference other site arc flash calculations from the main power block calculation by 09/30/2020.

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- **OIG Recommendation 4:** Implement a standard method for providing workers arc flash values and remove outdated information posted on equipment.
 - TVA Response: TVA agrees with the recommendation and will update postings on electrical boards as needed following the arc flash value revisions to NPG-SPP-18.4.9. The scheduled completion date is 10/30/2020.
- **OIG Recommendation 5:** Clarify the process and responsibilities for ensuring arc flash values remain accurate in NPG-SPP-18.4.9.
 - TVA Response: TVA agrees with the recommendation to clarify. Specifically, when changes are made to systems and components that impact arc flash calculations a CR is generated by the implementing organization. The CR will be owned by the Maintenance CFAM and an action will be assigned to the sites engineering department to define the new arc flash calculation. An action will then be assigned to the owning sites procedure group to make the procedure revisions. The Maintenance Peer Team will also accept an action to brief and update any signage associated with the calculation change. This shall be accomplished by 08/10/2020.
- **OIG Recommendation 6:** Implement a control to review all arc flash values for each plant included in the procedure when a plant modification with implications for arc flash is implemented or a hazard analysis is issued.
 - TVA Response: TVA agrees and will add a statement to NPG-SPP-09.3 to evaluate changes to hazard analyses and inform procedure owners of NPG-SPP-18.4.9 of any changed values. This revision is scheduled to be completed by 08/28/2020.
- **OIG Recommendation 7:** Evaluate available engineering and administrative controls to reduce high hazard exposures and formalize reduction strategies in a site-specific plan.
 - TVA Response: TVA agrees and will perform a study to look at available engineered and administrative controls, discuss options with appropriate peer teams, and create implementation plans of chosen options specific to each site. This shall be completed by 10/29/2021.
- **OIG Recommendation 8: Reinforce use of remote racking devices, where available.**
 - TVA Response: TVA agrees and will revise NPG-SPP-18.4.9 to reinforce the use of remote racking devices, where available. This revision shall be completed by 10/30/2020.
- **OIG Recommendation 9:** In conjunction with the Director of Safety, implement a control to monitor documented PJB and JSA requirements and verify proper documentation is maintained
 - TVA Response: TVA NPG concurs with the response submitted by TVA Safety & Enterprise Improvement to the OIG on 6/26/2020, to align its procedures to clarify when a JSA is required for electrical work involving potential for arc flash. The TVA-TSP 18.006 Plan Jobs Safely decision tree has been revised to require work with an arc flash potential <40 cal/cm² to have a JSA and is currently going

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through the review process. Safety & EI has requested an October 31, 2020 due date to complete the review and approval for this recommendation. The NPG HU/IS Peer team will also perform effectiveness review 6 months following effective date of procedure change to verify that JSA and PJB documents are completed and retained IAW TVA-TSP 18.006 for jobs involving arc flash potential. This action is scheduled to be completed by 4/30/2021.

(2) Training OIG Recommendations & TVA Response Detail:

- **OIG Recommendation 10:** Provide employees with required refresher training.
 - Response: TVA concurs with the recommendation. Corporate Training will ensure all affected work groups have been properly assigned and complete training after job codes and/or task qualification requirements have been revised to include the required re-train frequency for arc flash. This action is scheduled to be completed by 12/1/2020.

- **OIG Recommendation 11:** Coordinate with the Director of Technical Training to identify all job codes and personnel potentially exposed to arc flash risk at its facilities to ensure TVA's trainee population is in accordance with OSHA.
 - TVA Response: TVA agrees with recommendation. Corporate Training will coordinate completion with the Director of Technical Training. This action is scheduled to be completed by 8/1/2020.

- **OIG Recommendation 12:** Coordinate with the Director of Technical Training to establish a monitoring protocol for ensuring the training population is periodically reviewed and approved by plant management.
 - Response: This will be achieved through the completion of the other Training actions referenced in this report. However, Corporate Nuclear Training will also conduct an assessment upon completion of all training to verify that it has been completed for all affected work groups and no further gaps exist. The affected training population will include all individuals with potential to be exposed to arc flashes. Job codes and/or task training requirements will be revised to include all affected personnel. Any individual that does not complete refresher training will show in LMS as "not qualified" for applicable task(s). Current TVA governance for any newly created job codes will preclude future gaps. These actions are scheduled to be completed by 2/17/2021.

- **OIG Recommendation 13:** Coordinate with the Director of Technical Training to clearly define which operations and maintenance roles are required to attend a refresher course and specify the course required as well as any acceptable equivalences.
 - TVA Response: Agreed with recommendation. Analysis and Design Worksheets have been completed for disciplines in nuclear and re-train periodicities have been determined with input from the CFAM's. (Complete 5/1/2020). Nuclear Training will coordinate with Director of Technical Training to clarify re-training frequencies for all affected personnel and a specific training course will be determined to meet this requirement for these individuals. This action is scheduled to be completed by 12/17/20.

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(3) PPE OIG Recommendations & TVA Response Detail

- **OIG Recommendation 14:** Consider maintaining plant-level inventory listings of arc flash PPE and implementing a preventive maintenance program to routinely inspect PPE.
 - TVA Response: The TVA Maintenance Peer Team will determine ownership of plant inventory listings and a preventative maintenance program for arc flash personal protective equipment, PPE. This action is scheduled to be completed by 09/07/2020.

We thank the audit team for their professionalism and cooperation.

Respectfully,



Timothy S. Rausch
Sr. Vice President and Chief Nuclear Officer
TVA Nuclear

cc (Attachment):
Anthony D. Camilleri
James R. Dalrymple
Megan T. Flynn
Lucia W. Harvey
Sherry A Quirk
OIG File No. 2019-15644

June 26, 2020

David P. Wheeler, WT 2C-K

**CORPORATE SAFETY RESPONSE TO 30 DAY REQUEST FOR COMMENTS - DRAFT
EVALUATION 2019-15644 - NUCLEAR ARC FLASH PROTECTION**

TVA Corporate Safety has reviewed your draft evaluation and has the following comments:

- We agree with the recommendation for the Director of Safety and Enterprise Improvement to align its procedure to clarify when a JSA is required for electrical work involving potential for arc flash. The TVA-TSP-18.006 Plan Jobs Safety decision tree has been revised to require work with an arc flash potential > 40 cal/cm² to have a JSA and is currently going through the review process. Safety requests an October 31, 2020 due date to complete the review and approval for this recommendation.
- Corporate Safety agrees with the facts and conclusions. Please consider the following comments for the final report:
 - Page 1 – Second paragraph, second sentence. “Plants are required to identify and analyze all electrical circuits and equipment with arc flash potential.” The prior sentence in the report has the footnote stating TVA-TSP-18.1022 Arc Flash Protection applies to 480v to 500kv. For clarification, consider changing “all” to “480v to 500 kV.” Arc flash events can happen at lower voltages, but they are not within the scope of this procedure.
 - Page 1 – Final paragraph. “... (2) Identification and training for all employees who have arc flash potential,...”. For clarification, consider rewording to “... (2) Training for employees who enter a defined and marked arc flash boundary,...” to align with Section 4.0 Training in the TSP.

Thank you to the audit team for the hard work and helpful review of the Nuclear Arc Flash Program. We appreciate your efforts to help keep workers safe.



Preston P. Pratt
Director of Safety and Enterprise Improvement
BR 4 C
PPP:SAH

cc: James R. Dalrymple
Anthony D. Camilleri
Sherry A. Quirk
Ronald R. Sanders, II
Michael D. Skaggs
OIG File No. 2019-15644