



**Memorandum from the Office of the Inspector General**

July 16, 2015

Jacinda B. Woodward, MR 3H-C

**REQUEST FOR FINAL ACTION – EVALUATION 2015-15269 – TRANSMISSION FIRE 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.

Information contained in this report may be subject to public disclosure. Please advise us of any sensitive information in this report that you recommend be withheld.

If you have any questions or wish to discuss our findings, please contact Heather R. Kulisek, Manager, Evaluations, at (423) 785-4815 or Gregory R. Stinson, Director, Evaluations, at (865) 633-7367. We appreciate the courtesy and cooperation received from your staff during the evaluation.

*Robert E. Martin*

Robert E. Martin  
Assistant Inspector General  
(Audits and Evaluations)  
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Attachment

cc (Attachment):

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TVA Board of Directors  
OIG File No. 2015-15269



Office of the Inspector General

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# *Evaluation Report*

To the Senior Vice  
President, Transmission  
and Power Supply

# **TRANSMISSION FIRE PROTECTION**

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Audit Team  
Heather Kulisek

Evaluation 2015-15269  
July 16, 2015

## **ABBREVIATIONS**

FY	Fiscal Year
kV	Kilovolt
NERC	North American Electric Reliability Corporation
NFPA	National Fire Protection Association
SPP	Standard Process and Procedure
TVA	Tennessee Valley Authority

**TABLE OF CONTENTS**

EXECUTIVE SUMMARY ..... i

BACKGROUND..... 1

OBJECTIVE, SCOPE, AND METHODOLOGY ..... 1

FINDINGS ..... 2

    SOME ESTABLISHED SYSTEMS ARE ANTIQUATED AND  
    UPGRADED SYSTEMS DO NOT MEET TVA REQUIREMENTS OR  
    NATIONAL CODE ..... 3

    MAINTENANCE IS PERFORMED BUT SYSTEM CONDITION IS  
    NOT CONSISTENTLY MONITORED OR DOCUMENTED..... 4

RECOMMENDATIONS ..... 6

**APPENDIX**

MEMORANDUM DATED JULY 1, 2015, FROM JACINDA B. WOODWARD TO  
ROBERT E. MARTIN



## Evaluation 2015-15269 – Transmission

### Fire Protection

## EXECUTIVE SUMMARY

### Why the OIG Did This Evaluation

Fires in substations can severely impact the supply of power to customers and the utility company's revenue and assets. These fires can also create a fire hazard to utility personnel, emergency personnel, and the general public. There are 14 sites managed by Transmission that have fire protection systems to protect their 500-kilovolt transformers. This review was initiated based on findings from a previous review conducted by the Office of the Inspector General related to fire protection in coal plants.<sup>i</sup> The objective of this review is to determine if fire protection systems are established and maintained to effectively manage fires within the Tennessee Valley Authority's (TVA) Transmission system.

### What the OIG Found

According to TVA management, fire protection systems have been established where needed; however, the risk fire protection systems will not function effectively is increased by the condition of systems and systems not meeting national code or TVA requirements. The current systems have antiquated equipment that is being replaced as funding allows. The upgrades do not include modifying the current system's water supply, which does not meet National Fire Protection Association code or TVA Standard Process and Procedure requirements. While TVA management indicated that TVA is not required to meet national code, not doing so in the case of the water supply could limit the effectiveness of the fire protection system if it were engaged during a fire. According to TVA management, maintenance on fire protection equipment is performed or requested by personnel at the Transmission Service Center; however, the maintenance is not always documented. We found there are no requirements to track the fire protection systems or their condition. In addition, the inspections of fire protection equipment that are part of the preventive maintenance program are not conducted consistently. There is an increased risk an issue could go unrecognized if systems are not being consistently inspected and the condition tracked.

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<sup>i</sup> 2014-15216 – Follow-Up Review of TVA's Coal Plant Fire Protection Systems



# Evaluation 2015-15269 – Transmission Fire Protection

## EXECUTIVE SUMMARY

### What the OIG Recommends

We recommend the Senior Vice President, Transmission:

- Upgrade water tanks or incorporate feed lines at the sites needed to bring systems up to National Fire Protection Association code.
- Evaluate system-tracking procedures to ensure all fire protection systems and the condition of those systems are tracked.
- Evaluate standard procedures and time frames for inspections and, where needed, establish site-specific work programs to provide steps on how each inspection should be completed.

### TVA Management's Comments

TVA management generally agreed with the findings and recommendations in this report. TVA management will perform, on a case-by-case basis, fire risk assessments that include water supply during major replacements of transformer units. See the Appendix for TVA's complete response.

### Auditor's Response

The OIG concurs with TVA management's response.

## **BACKGROUND**

The risk of fire in substations has been historically low, but the possible impacts of a fire can be catastrophic. Fires in substations can severely impact the supply of power to customers and the utility company's revenue and assets. These fires can also create a fire hazard to utility personnel, emergency personnel, and the general public.

According to Tennessee Valley Authority (TVA) management, the most recent procedure that applied to management of the Transmission fire protection is TVA-TSP-1201, Corporate Fire Protection Program. The corporate fire protection program was eliminated within the last year at which time Transmission became responsible for its own program. There is also a TVA Standard Process and Procedure (SPP), ESP-SP-DES-09-200.4.7, Substation and Switchyard Design Standards Fire Protection for Major Equipment, which establishes design standards for the fire protection system and includes TVA's minimum requirements for water supply for the fire protection systems. TOM-SMM-FP-06.019, Substation Maintenance Manual – 500-kV [kilovolt] Transformer Fire Protection, provides instructions and recommendations for the fire protection systems on 500-kV transformers.

Fire prevention and fire protection codes and standards are established by the National Fire Protection Association (NFPA).<sup>1</sup> NFPA codes provide recommendations, not requirements, for fire prevention and fire protection for electric generating plants. Other fire protection codes and standards exist, but their contents are usually based on NFPA documents.

## **OBJECTIVE, SCOPE, AND METHODOLOGY**

This review was initiated based on findings from a previous review conducted by TVA's Office of Inspector General related to fire protection in coal plants.<sup>2</sup> The objective of this review is to determine if fire protection systems are established and maintained to effectively manage fires within TVA's Transmission system. The scope of this review included Transmission fire protection systems monthly inspection reports in calendar year 2014 and annual and biennial inspections reports for fiscal years (FY) 2013 and 2014. There were no annual or biennial inspection reports provided to the team to review so this review included only the Transmission fire protection monthly inspection reports for calendar year 2014.

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<sup>1</sup> NFPA is an international, non-profit organization whose mission is to reduce the burden of fire and other hazards on the worldwide quality of life by providing and advocating consensus codes and standards, research, training, and education. NFPA has designed 300 codes and standards to minimize the risk and effects of fire. NFPA also provides public safety education, advocacy campaigns, professional development training, a premier source for fire data research, and multiple publications on fire and fire safety.

<sup>2</sup> 2014-15216 – Follow-Up Review of TVA's Coal Plant Fire Protection Systems

To achieve our objective, we:

- Reviewed related SPPs and guidance to determine the fire protection systems that should be in place and the requirements for inspection.
- For the 14 sites managed by Transmission that have fire protection systems, we:
  - Reviewed related inspection reports to determine if they were completed.
  - Conducted interviews with the sites to determine the condition of the fire protection system assets and plans to address issues.
- Reviewed documentation of recent fire events to determine if the systems worked as expected.
- Performed a walk-down of the inspection process at one site to gain a better understanding of the process.

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

## **FINDINGS**

According to TVA management, the fire protection systems have been established where needed; however, the risk fire protection systems will not function effectively is increased by the condition of systems and systems not meeting national code or TVA requirements. The current systems have antiquated equipment that is being replaced as funding allows. The upgrades do not include modifying the current systems' water supply, which do not meet NFPA code or TVA SPP requirements. While TVA management indicated that TVA is not required to meet national code, not doing so in the case of water supply could limit the effectiveness of the fire protection system if it were engaged during a fire. According to TVA management, maintenance on fire protection equipment is performed or requested by personnel at the Transmission Service Center; however, the maintenance is not always documented. We found there are no requirements to track the fire protection systems or their condition. In addition, the inspections of fire protection equipment that are part of the preventive maintenance program are not conducted consistently. There is an increased risk an issue could go unrecognized if systems are not being consistently inspected and the condition tracked.

## **SOME ESTABLISHED SYSTEMS ARE ANTIQUATED AND UPGRADED SYSTEMS DO NOT MEET TVA REQUIREMENTS OR NATIONAL CODE**

According to TVA management, the fire protection systems have been established where needed; however, the current systems have antiquated equipment being replaced as funding allows. The upgrades do not include modifying the water supply. The current system's water supply does not meet NFPA code or TVA SPP requirements. However, TVA management indicated that TVA is not required to meet national code. The risk fire protection systems will not function effectively is increased because of the condition of systems and the systems not meeting national code or TVA requirements.

### **Equipment Is Antiquated but Updates Are Being Made as Budgeting Allows**

According to TVA's SPP, to protect its 500-kV transformers from fire recently constructed switchyards are built with adequate spacing between transformers so that a fire at one transformer would not affect the others, and transformers not built with adequate spacing between them use a high-pressure water fog type system as a fire protection system. TVA management indicated that 14 out of 33 substation sites managed by Transmission have 500-kV transformers with a fire protection system. The average age of the fire protection equipment at the 14 substations was 37 years old in 2011. At the time of our review, TVA management stated 4 sites' fire protection systems had been updated and 3 sites have received partial updates, and there are plans to update other equipment as funding allows. According to TVA personnel, the condition of the current equipment is in poor condition at 3 of the sites. The risk of the fire protection systems not operating as intended in the event of a fire could increase when the condition of the equipment is in poor condition.

During the course of our review, we found 3 sites where pumps were not being tested monthly during the inspections due to the age of the equipment, condition of the equipment, and a site that did not test monthly at all due to fears of spraying water. There was an additional site that stated the system was inspected monthly, but that sometimes the pumps would fail to start. In addition, when we witnessed an inspection at a site that does not consistently inspect the fire protection system, one of the pumps was not tested because it was low on oil and the other did not start right away when tested.

According to TVA personnel, the current fire system upgrades can costs upwards of \$1 million and upgrades everything in the pump house and detection equipment. The budget for FY2015 has been extended from \$500,000 to \$1 million. The future budget is \$800,000 in FY2016 and 2017 and \$1 million in future years.

**Additional Improvements Could Be Made to the Fire Protection Systems**

The upgrades to the systems do not include modifications to the water supply. According to a Transformer Fire Protection System Condition Report from 2011, the current system allows for approximately 25 minutes of water to spray. The NFPA code requires an hour of available water and TVA SPP requires 30 minutes. TVA management indicated that TVA is not required to adhere to the National Code; however, even with the other upgrades to the system, the limitation on water supply could limit the effectiveness of the fire protection system if it were engaged during a fire.

TVA ESP-SP-DES-09-200.4.7, Substation and Switchyard Design Standards Fire Protection for Major Equipment, requires the fire protection systems have a minimum of 30 minutes of water available through the water tanks onsite. According to a Transformer Fire Protection System Condition Report from 2011, the water storage tanks in place deliver 25 minutes of spray protection in a worse-case scenario. According to TVA personnel, the water tank then requires a day or more to refill. In one of the interviews conducted with a Transmission Service Center, TVA personnel believed the current system would be out of water in 15 to 20 minutes.

The NFPA 15 Standard for Water Spray Fixed Systems for Fire Protection states that “the water supply shall be capable of supplying both the design flow rate and 250 gpm [gallons per minute] . . . for hose streams for a minimum duration of one hour.” While TVA management indicated that TVA is not specifically required to meet the NFPA code, it would seem to be good practice when upgrading systems to try to make the necessary adjustments to the system to meet national code and increase the effectiveness of the system in the case of a fire.

According to TVA personnel, discussions were held between the site personnel and project management on two potential upgrades to tie feed lines to nearby fire hydrants or wells to provide adequate supply. Both requests were declined due to budget constraints. As of March 2015, TVA personnel have included upgrades to water supply and storage in specifications for the project at Cordova. The costs for those upgrades have not been determined and funding will be requested once bids are obtained.

**MAINTENANCE IS PERFORMED BUT SYSTEM CONDITION IS NOT CONSISTENTLY MONITORED OR DOCUMENTED**

According to TVA management, maintenance is performed or requested by personnel at the Transmission Service Center; however, maintenance is not always documented. We found there are no requirements to track the fire protection systems or their condition. In addition, the inspections that are part of the preventive maintenance program are not conducted consistently. There is an increased risk that an issue could go unrecognized if systems are not being consistently inspected and the condition tracked.

### **There Are No Requirements to Document Inspections or the Condition of the Systems**

While the Substation Maintenance Manual – 500-kV Transformer Fire Protection establishes a time frame for completing inspections, there is no mention of documentation that should be maintained of that inspection. Most of the sites we interviewed were able to provide some documentation of the monthly inspections conducted or the inspections were managed through handheld devices; however, two have no documentation nor do they use handheld devices. According to TVA management, maintenance is performed or requested through a maintenance work order by personnel at the Transmission Service Center. When maintenance is required based on an inspection, at some sites it is performed at that time by the inspection personnel without documentation of the issue or the maintenance specialist is contacted and a maintenance work order is generated. In addition, the fire protection systems are not tracked through Maximo nor does management think they are tracked through the monthly system health review. With no documentation requirements, there is an increased risk an issue with the systems could be overlooked or not followed-up on.

In an interview with TVA personnel, we found the condition of the systems is not centrally monitored on a regular basis unless an issue is identified by the site and the maintenance specialist is contacted. We were provided a document at the start of our review that identified the status of the systems. However, we found system statuses were not up-to-date, and the owner of the document was only aware of issues at the sites that contacted him and that he had not visited all of the sites.

When we asked the sites what they do if an issue is found with the system, several site personnel said the work is performed at that time by the inspection personnel without documentation of the issue, or the maintenance specialist is called and a maintenance work order is generated. One site we spoke with stated they performed the work or called the maintenance specialist and that there was no documentation of the issue. In cases where there is no work order, there would be no record of the issue, and a systemic issue could go unidentified.

The fire protection system health and the assets themselves are not specifically tracked. System engineers at the Transmission Service Centers are responsible for tracking system health and are given prescribed questions to answer. A member of management stated these questions mostly pertain to North American Electric Reliability Corporation (NERC) compliance so he doubted there were any questions specifically related to the fire protection systems. According to TVA management, the Substation Program group is responsible for reviewing the system health reports to identify issues. In addition, neither the fire

protection systems nor the system components are currently tracked in Maximo.<sup>3</sup> The inspection preventive maintenance work orders in Maximo are written for the station and not to the system. TVA management agreed that the fire protection systems should be in Maximo. If this system is not a priority because it does not relate to NERC compliance, there may also be other systems outside NERC compliance that are not being tracked. If the system health and assets are not tracked, there are opportunities for issues to be missed.

### **Inspections of the Fire Protection Systems Are Not Conducted Consistently**

According to the Substation Maintenance Manual – 500-kV Transformer Fire Protection, inspections of the fire protection system are required biweekly, yearly, and biennially. Corporate management stated the inspection schedule was altered to be done monthly rather than biweekly; however, documentation of the change could not be located. Not all the sites we interviewed were conducting inspections on the regularly scheduled intervals. Inconsistent inspections increase the risk that an issue could go unrecognized.

In interviews with TVA personnel, we found that of the 14 sites we reviewed: 1 was not conducting monthly inspections, 1 was not conducting yearly inspections, and 9 were not doing the biennial inspections. The biennial inspection requires the transformer to be out of service. This is not easily done on a biennial basis. Management is considering extending the time frame requirements on the biennial inspection.

At one site we visited, the foreman was given no direction from the former foreman when he took over the position. He had no idea when the last biennial inspection was completed and was unaware that the heat sensors that require testing every 2 years should be tested. In addition, this site was not being tested on a monthly basis. He said it was more likely that the monthly inspection was being conducted quarterly.

## **RECOMMENDATIONS**

We recommend the Senior Vice President, Transmission:

- Upgrade water tanks or incorporate feed lines at the sites needed to bring systems up to NFPA code.
- Evaluate system-tracking procedures to ensure all fire protection systems and the condition of those systems are tracked.
- Evaluate standard procedures and time frames for inspections and, where needed, establish site-specific work programs to provide steps on how each inspection should be completed.

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<sup>3</sup> Maximo is an IBM software TVA uses to manage the Enterprise Asset Management, which is a single application for work management, corrective action, and supply chain business functions for the entire TVA fleet.

**TVA Management's Comments** – TVA management generally agreed with the findings and recommendations in this report. In response to our recommendations, management plans to complete the following actions.

- During major replacements of transformer units, they will perform a fire risk assessment of the station and implement appropriate mitigation strategies per the recommendations of the 2012 revision of Institute of Electrical and Electronics Engineers (IEEE) 979 *IEEE Guide for Substation Fire Protection*.
- Create Maximo records for fire protection systems and components, develop and implement standard inspection questions for PMs, evaluate the use of failure and condition codes in tracking fire protection system health, and evaluate the development and use of a fire protection readiness index.
- Evaluate the Substation Maintenance Manual – 500 kV Transformer Fire Protection SPP to ensure it clearly identifies and provides performance instructions for maintenance requirements, perform a risk assessment and implement necessary changes for inspection of fire protection focusing on the inability to perform major inspections due to outage constraints, and develop and store in Maximo site specific work plans for minor and major fire protection system PMs.

See the Appendix for TVA's complete response.

**Auditor's Response** – The OIG concurs with TVA management's response. If management determines upgrades to the water supply are not warranted, they are accepting the risks associated with that decision.

July 1, 2015

Robert E. Martin, ET 3C-K

REFERENCE DRAFT EVALUATION 2015-15269 - TRANSMISSION FIRE PROTECTION

This memorandum is in response to the May 19, 2015, request for comments from the Office of the Inspection General (OIG), Draft Evaluation 2015-15269 - TRANSMISSION FIRE PROTECTION.

Transmission and Power Supply (TPS) subject matter experts have reviewed the report and developed proposed response plans which are stated below under each recommendation. TPS agrees in principle with Recommendation 1 and agrees with Recommendations 2 and 3 as stated. TPS appreciates the OIG's review and the areas of improvement provided.

**Recommendation 1:**

*Upgrade water tanks or incorporate feed lines at the sites needed to bring systems up to National Fire Protection Association (NFPA) codes.*

TPS agrees in principle with this recommendation. We will continue to aggressively refurbish and replace existing pumps and valves to assure that the existing systems meet their intended design requirements. During major replacements of transformer units, we will perform a fire risk assessment of the station and implement appropriate mitigation strategies per the recommendations of the 2012 revision of Institute of Electrical and Electronics Engineers (IEEE) 979 *IEEE Guide for Substation Fire Protection*. This is in line with our current practice of bringing systems up to current standards during major capital projects. Since the fire protection systems support the transformers, the replacement of the transformer is an appropriate time to address the entire system.

The current systems were designed to meet ESP-SP-DES-09-200.4.7 *Substation and Switchyard Design Standards Fire Protection for Major Equipment*. This TVA technical procedure references the 1984 revision of IEEE 979 for minimum design requirements. This guide required the 30 minutes of water flow that the existing systems were originally designed to meet. These requirements were in the 2004 standard and have been removed with the 2012 revision. The current revision of IEEE 979 has no prescriptive requirements for water flow rate or time. NFPA standards were recommended in the OIG report. However TPS has determined that this IEEE standard is more applicable to transmission substations, as the NFPA standards are specifically for generating plants where employees are stationed on a continual basis, so we will use the IEEE standard instead of the NFPA standard referenced above.

The assessments will be performed on a case-by-case, station-by-station basis and will include the following recommendations from the IEEE guide:

- Review of minimal fire code requirements
- Electrical equipment layout and equipment types
- Criticality of the various pieces of equipment
- Insulating fluids used and their flammability
- Historical frequency of fire for various equipment types
- Availability of a fire department response to the site
- Availability of a firefighting water supply at or adjacent to the site
- Radiant exposure assessment of spacing between transformers and breakers, structures, and property lines
- Fire spread assessment including site grade and oil containment

Robert E. Martin  
Page 2  
July 1, 2015

**Recommendation 2:**

*Evaluate system-tracking procedures to ensure all fire protection systems and the condition of those systems are tracked.*

TPS agrees with this recommendation and will:

- Create Maximo records for fire protection systems and major components
- Develop and implement standard inspection questions for monthly, annual, and biennial PMs
- Evaluate the use of failure and condition codes in tracking fire protection system health
- Evaluate development and use of fire protection system readiness index

**Recommendation 3:**

*Evaluate standard procedures and time frames for inspections and, where needed, establish site-specific work programs to provide steps on how each inspection should be completed.*

TPS agrees with this recommendation and will:

- Evaluate the Substation Maintenance Manual -- 500 kV Transformer Fire Protection SPP to ensure that it clearly identifies maintenance requirements and instructs maintenance personnel in the performance of those requirements
- Perform a risk assessment of current intervals for inspection of fire protection focusing on the inability to perform major inspections due to outage constraints; implement necessary changes
- Develop and store in Maximo site specific work plans for minor and major fire protection system PMs

Again, thank you for the detailed review by your audit team and the associated recommendations that will help us improve the reliability of our fire protection systems and mitigate any catastrophic failure of a power transformer. If you have any questions regarding this response, please contact Paul Barnett, Manager, Substation Program Management, at (423) 751-4662.



Jacinda B. Woodward  
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