



Memorandum from the Office of the Inspector General

July 11, 2017

James R. Dalrymple, MR 3H-C

**REQUEST FOR FINAL ACTION – EVALUATION 2016-15431 – TRANSMISSION AND
POWER SUPPLY PREVENTIVE MAINTENANCE**

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 Lucas W. Cotter, Auditor, at (423) 785-4826 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
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cc (Attachment):

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OIG File No. 2016-15431



Office of the Inspector General

Evaluation Report

To the Senior Vice
President, Transmission
and Power Supply

TRANSMISSION AND POWER SUPPLY PREVENTIVE MAINTENANCE

Evaluation Team
Lucas W. Cotter

Evaluation 2016-15431
July 11, 2017

ABBREVIATIONS

| | |
|------|---|
| CR | Condition Report |
| FY | Fiscal Year |
| LNS | Load Not Served |
| NERC | North American Electric Reliability Corporation |
| PM | Preventive Maintenance |
| PRC | Reliability Standard Protection and Control |
| SIR | System Interruption Report |
| SPP | Standard Programs and Processes |
| TCM | Transmission Construction and Maintenance |
| TPRC | Transmission Programs and Regulatory Compliance |
| TPS | Transmission and Power Supply |
| TSC | Transmission Service Center |
| TVA | Tennessee Valley Authority |

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MEMORANDUM DATED JUNE 30, 2017, FROM JAMES R. DALRYMPLE
TO DAVID P. WHEELER



Evaluation 2016-15431 – Transmission and Power Supply Preventive Maintenance

EXECUTIVE SUMMARY

Why the OIG Did This Evaluation

Preventive maintenance (PM) includes tasks carried out on a predetermined interval to reduce the likelihood of a failure. Due to the importance of PM on the reliable operation of assets and as a result of findings identified related to nuclear and coal PM in previous evaluations,ⁱ we initiated an evaluation of the Tennessee Valley Authority's (TVA) transmission PM. The objective of our evaluation was to determine if transmission PM was performed in accordance with established schedules and, if not, what effects the deviations had.

What the OIG Found

We could not determine if transmission PM had been performed in accordance with established schedules because:

1. Work completion dates in Maximoⁱⁱ did not consistently match the date the PM was completed.
2. TVA did not require supporting documentation evidencing work completion dates to be maintained.

Additionally, we reviewed documentation related to equipment failures and did not identify any failures or Load Not Servedⁱⁱⁱ attributed to Transmission and Power Supply (TPS) PM practices.

What the OIG Recommends

We recommend the Senior Vice President, TPS:

- Evaluate the process for recording PM work order completion dates in Maximo to accurately represent when the work was completed.
- Consider whether requiring all PM work order documentation to be entered into Maximo would be beneficial.

ⁱ Evaluation 2014-15053, Coal Plant Preventive Maintenance, September 29, 2014; and Evaluation 2012-14845, Review of TVA's Nuclear Power Group Preventive Maintenance, September 24, 2013.

ⁱⁱ Maximo is TVA's work management system.

ⁱⁱⁱ TVA defines Load Not Served as a measure of the magnitude and duration of transmission system outages that affect TVA customers, expressed in system minutes.



Evaluation 2016-15431 – Transmission and Power Supply Preventive Maintenance

EXECUTIVE SUMMARY

TVA Management's Comments

TVA management stated TPS is moving to implement use of the “Actual Finish” date to record the actual completion of the field work portion of all work order closures as they pertain to PM activities. However, management stated the present requirement for documentation to be added to Maximo only when there is a regulatory requirement was adequate for maintenance needs. See the Appendix for TVA management's complete response.

Auditor's Comments

We concur with TVA management's planned actions.

BACKGROUND

The Tennessee Valley Authority (TVA) transmission system is one of the largest in North America, with over 100,000 transmission structures across an 80,000 square mile region that has delivered 99.999 percent reliability since the year 2000. However, TVA acknowledges aging assets are putting reliability at risk and are a top contributor to frequency of customer interruptions.¹ Aging assets, with an increasing exposure to failure, can adversely impact system reliability, cause customer outages, and adversely affect generator availability.

Transmission Construction and Maintenance (TCM), Standard Programs and Processes (SPP) TCM-SPP-06.000, Transmission Construction and Maintenance Conduct of Maintenance, states the purpose of the Preventive Maintenance (PM) program is to maintain a balance of maintenance activities to ensure the safe, reliable and long-term operation of transmission system assets. PM is conducted on a predetermined interval to reduce the likelihood of a failure.

TVA's TRANS-SPP-06.001, Transmission System Preventive Maintenance Program provides instructions for managing the documentation, control, and administration of the PM program for all transmission system equipment. According to Transmission Program Management, Transmission Service Centers (TSC) are responsible for PM program oversight and execution, including the maintenance of all transmission assets within their region. There are 18 TSCs located geographically throughout the TVA transmission service region. TSCs are responsible for reviewing and closing their PM work orders after they are completed. The 18 TSCs track their performance locally, and overall Transmission and Power Supply (TPS) results are consolidated.

TPS uses PM due date adherence percentages to track the percentage of all PM work orders completed within established windows. The adherence window includes time prior to and after the established due date to gauge that PM work orders are not being performed too early or too late. According to TPS PM due date adherence metrics, an average of 78.6 percent of PM work orders across the fleet were completed within their adherence window for the 12-month period ending September 8, 2016. Monthly adherence values vary and site averages ranged from a low of 55.4 percent to a high of 96.3 percent.

North American Electric Reliability Corporation (NERC)² Reliability Standard Protection and Control (PRC) 005-2(i), provides guidance for the maintenance of

¹ Customer interruption refers to Connection Point Interruption Frequency, which is a measure of the interruption frequency at connection points where the TVA transmission system interfaces with customers, generators, and interties.

² NERC is a not-for-profit international regulatory authority whose mission is to assure the reliability and security of the bulk power system in North America.

all Protection Systems³ affecting the reliability of the Bulk Electric System.⁴ NERC's regional entity, SERC Reliability Corporation, performs compliance audits of maintenance testing for compliance with the standard. TVA uses Transmission Programs and Regulatory Compliance (TPRC), TPRC-SPP-03.001, TVA Transmission Programs and Regulatory Compliance Maintenance and Test Program, as a means of complying with the NERC standard.

Previous Office of the Inspector General evaluations of other operating areas⁵ found TVA's PM compliance metrics may not be accurate. Due to the importance of PM on the reliable operation of assets, we performed an evaluation of TVA's transmission system PM.

OBJECTIVE, SCOPE, AND METHODOLOGY

The objective of this evaluation was to determine if transmission PM was performed in accordance with established schedules and, if not, what effects the deviations had. The scope of our evaluation was fiscal years (FY) 2015 and 2016 TPS (1) PM and (2) transmission equipment failures.

To achieve our objective, we:

- Conducted interviews with pertinent TSC and TPS personnel to obtain information about work management processes.
- Reviewed the following procedures to obtain and understand PM processes and requirements:
 - TCM-SPP-06.000, Transmission Construction and Maintenance Conduct of Maintenance
 - TRANS-SPP-06.001, Transmission System Preventive Maintenance Program
 - TPRC-SPP-03.001, TVA Transmission Programs and Regulatory Compliance Maintenance and Test Program
 - TRANS-SPP-03.003, Administration of Transmission Maintenance Program
 - NERC Standard PRC-005-2(i), Protection System Maintenance
- Reviewed PM compliance metrics to assess TPS' historical PM due date adherence percentage.

³ Protection Systems is a subset of transmission system assets that includes protective relays that respond to electrical quantities; communications systems necessary for correct operation of protective functions; voltage and current sensing devices providing inputs to protective relays; station direct current supply associated with protective functions; and control circuitry associated with protective functions through the trip coil(s) of the circuit breakers or other interrupting devices.

⁴ The Bulk Electric System is comprised of electrical generation resources, transmission lines, interconnections with neighboring systems, and associated equipment generally operated at voltages of 100 kilovolts or higher.

⁵ Evaluation 2014-15053, Coal Plant Preventive Maintenance, September 29, 2014; and Evaluation 2012-14845, Review of TVA's Nuclear Power Group Preventive Maintenance, September 24, 2013.

- Judgmentally selected 6 of 18 (33 percent) TSCs to review work order documentation. The TSCs were comprised of the 3 with the highest PM due date adherence percentages and 3 with the lowest PM due date adherence percentages for the 12 months prior to September 8, 2016. From those 6 TSCs, we randomly selected a nonstatistical sample of 20 percent (228 of 1,131) of PM work orders closed within 90 days of September 30, 2016,⁶ to determine if documentation of the work order completion date matched the work order completion date in Maximo.
- Compared available supporting documentation in Maximo to the “Actual Finish” dates listed in Maximo for our work order sample to determine if the dates matched and if any differences impacted PM due date adherence percentages.
- Reviewed the seven System Interruption Reports (SIR) generated in FYs 2015 and 2016 for equipment failures resulting in Load Not Served (LNS) at the TSCs in our scope to determine if those failures were a result of not performing PMs in accordance with schedule.
- Performed a Condition Report (CR) Word Search and Advanced Search in Maximo for Power System Operations CRs between October 1, 2014, and October 11, 2016, to determine if PM was identified as a cause of transmission equipment failure. This resulted in a population of 71 and 954 CRs, respectively. We reviewed all 71 CRs and found no PMs identified as a cause of failure. We selected a statistical sample of 138 CRs from the 954 found by way of Advanced Search. Because we found no errors in the 71 CRs identified by way of CR Word Search, we performed stop-and-go sampling on the sample of 138 resulting in a review of 34 CRs. We found no PMs identified as a cause of failure in this sample and terminated testing.

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

FINDINGS

We could not determine if transmission PM had been performed in accordance with established schedules. Specifically, we found (1) work completion dates in Maximo did not consistently match the date the PM was completed, and (2) TVA did not require supporting documentation evidencing work completion dates to be maintained. Additionally, we reviewed documentation related to equipment failures and did not identify any failures or LNS attributed to TPS PM practices.

⁶ To analyze recently closed work orders, we filtered our sample to only include those with a status of Closeout Review Completed (“REVWCMP”). A PM work order that was reviewed for completeness would have a status of REVWCMP for 90 days before automatically changing to “CLOSE” status in the work management system.

TVA'S ADHERENCE TO ESTABLISHED PM SCHEDULES COULD NOT BE CONFIRMED

We could not determine if transmission PM had been performed in accordance with established schedules. Our review found work completion dates in Maximo did not consistently match the date the PM was completed. Using inaccurate dates to record work order completion could misrepresent PM due date adherence percentages and lessen the value of this information to TPS. We also found TVA did not require all supporting documentation be maintained. Without supporting documentation, the work order completion dates could not be verified.

Work Completion Dates in Maximo Were Not Accurate

Actual Finish dates in Maximo differed from work completion dates listed on the documentation attachments for a majority of the PMs with attachments. To determine if Actual Finish dates in Maximo matched the date work was completed, we reviewed the attachments for the work orders, and found 51⁷ of the 79⁸ had Actual Finish dates that did not match the date work was completed. Figure 1 below shows the difference between the Actual Finish date recorded in Maximo and work order completion dates according to attachments for each of the 79 work orders.

| Difference in Days Between Actual Finish Recorded in Maximo and Work Order Completion According to Attached Documentation | |
|---|-----------|
| Difference in Days | Count |
| Actual Finish Date Before Documentation Date | 3 |
| Actual Finish Date Matched Documentation Date | 28 |
| Actual Finish Date 1-7 Days After Documentation Date | 37 |
| Actual Finish Date 8-14 Days After Documentation Date | 7 |
| Actual Finish Date 15-21 Days After Documentation Date | 3 |
| Actual Finish Date 22-28 Days After Documentation Date | 0 |
| Actual Finish Date More Than 29 Days After Documentation Date | 1 |
| Total | 79 |

Figure 1

We found 20⁹ of the 51 work orders with a difference between Actual Finish date and the supporting documentation date were designated as NERC-regulated in Maximo; however, none of those 20 resulted in any impact to schedule adherence.

⁷ In addition to the work orders we reviewed as part of our sample, we also found one instance where physical documentation contradicted a Maximo Actual Finish date because a reviewer had prematurely closed the work orders prior to work completion.

⁸ Of the 228 work orders selected in our sample, only 79 had supporting documentation attached in Maximo.

⁹ TVA personnel indicated 10 of the 20 work orders were misclassified as NERC-regulated status. TPS is currently in the process of revising its list of assets covered by the NERC Reliability Standard, though at the time of this evaluation, these changes have not been recognized in Maximo.

TVA personnel informed us if no Actual Finish date is input in Maximo, the field will automatically match the Status Date. In this circumstance, the Actual Finish date may not represent the date work was completed, but rather the date of work order closure.

As discussed above, the intent of the PM due date adherence metric is to track the percentage of all PM work orders completed within established windows. Calculation of the PM due date adherence metric is performed using the Actual Finish date found in Maximo. According to TPS PM due date adherence metrics, an average of 78.6 percent of PM work orders across the fleet was completed within their adherence window for the 12-month period ending September 8, 2016. However, as noted above, Actual Finish dates used to calculate PM due date adherence do not necessarily match the date work was completed.

We recalculated the PM due date adherence metric using the documentation date rather than the Actual Finish date for PM work orders closed within 90 days of September 30, 2016, and found no change in due date adherence compliance. However, calculating PM due date adherence using the Actual Finish date field, which generally did not represent the date of work completion, puts TPS at risk of misrepresenting its PM due date adherence percentage, thereby not providing itself the most reliable information to gauge performance.

TVA Did Not Require All Supporting Documentation to Be Maintained

We also found TVA had no formal requirement to attach documentation to Maximo work orders during the scope of our evaluation. In our sample of 228 work orders, 149 (65 percent) had no documentation attachments in Maximo that could be used to confirm the accuracy of the work order completion dates. As of January 30, 2017, TRANS-SPP-03.003, Administration of Transmission Maintenance Program, requires all testing documentation for NERC Protection Systems PM work orders to be attached in the Work Management System prior to its closure; however, as stated previously, this covers only a subset of TPS PM.

PM PRACTICE DOES NOT APPEAR TO CONTRIBUTE TO FAILURES

Our review of documentation related to equipment failures did not identify any failures or LNS attributed to TPS PM practices. According to TPRC personnel, TPS performs Interruption Event Analyses for all transmission interruptions to lines, banks, and connection points. These analyses are used to generate SIRs that provide the detailed information about the event. SIRs are written for all transmission interruption events, including those that have any LNS. We reviewed each SIR generated for FYs 2015 and 2016; the reports and testimony from the responsible System Engineers showed no equipment failures resulting in LNS attributable to PM practices. In addition, we reviewed 105 CRs dated between October 1, 2014, and October 11, 2016, and did not identify any incident directly attributed to PM not being performed in accordance with established schedules.

RECOMMENDATIONS

We recommend the Senior Vice President, TPS:

- Evaluate the process for recording PM work order completion dates in Maximo to more accurately represent when the work was completed.

TVA Management's Comments – TVA management agreed that the process for recording PM work order completion dates in Maximo could be improved to more accurately represent when the work was completed. Management stated TPS is moving to implement use of the Actual Finish date to record the actual completion of the field work portion of all work order closures as they pertain to preventive maintenance activities. A change management plan is under development to ensure this process is put into place and communicated. See the Appendix for TVA management's complete response.

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

- Consider whether requiring all PM work order documentation to be entered into Maximo would be beneficial.

TVA Management's Comments – TVA management stated the present requirement is for documentation to be added into Maximo when there is a regulatory requirement, which would require documentation as proof of completion. Management stated that although documentation is not required for all activities, any activities that are performed where measurements or information is put into the mobile inspection application can be retrieved as needed. Management determined that this is adequate for maintenance needs. See the Appendix for TVA management's complete response.

Auditor's Response – TVA management determined that their present requirement for documentation was sufficient for maintenance needs; however, we did not review the information that is contained/maintained in the mobile inspection application.

June 30, 2017

David P. Wheeler, ET 3C-K

RESPONSE TO REQUEST FOR COMMENTS – DRAFT EVALUATION 2016-15431 –
TRANSMISSION AND POWER SUPPLY PREVENTATIVE MAINTENANCE

This memo is in response to the June 7, 2017, Memorandum from the Office of the Inspector General, Request for Comments - Draft Evaluation 2016-15431 - Transmission and Power Supply Preventative Maintenance. We thank the OIG for their thorough evaluation of our Preventative Maintenance program.

This memorandum confirmed that neither equipment failures nor Load Not Served attributed to Transmission and Power Supply practices were found in this evaluation.

This memorandum also makes the following recommendations to the Senior Vice President, Transmission and Power Supply:

1. *Evaluate the process for recording PM work order completion dates in Maximo to more accurately represent when the work was completed.*
2. *Consider whether requiring all PM work order documentation to be entered in to Maximo would be beneficial.*

Regarding Recommendation 1, as was stated in the draft evaluation, not all work completion dates in Maximo match the date that the preventative maintenance activity was performed. Transmission and Power Supply agrees that this process could be improved to more accurately represent when the work was completed. In the past, this date represented the completion of the field work plus administrative functions deemed necessary before closure. This was not performed in a consistent manner and Transmission and Power Supply is now moving to implement use of the 'Actual Finish Date' to record the actual completion of the field work portion of all work order closures as they pertain to preventative maintenance activities. A change management plan is under development to ensure this process is put in place and communicated.

Regarding Recommendation 2, as was stated in the draft evaluation, TVA Transmission and Power Supply does not require supporting documentation that provides evidence of work completion dates to be maintained in all cases. The present requirement is for documentation to be added when there is a regulatory requirement, which would require documentation as proof of completion. Although documentation is not required for all

David P. Wheeler, ET 3C-K
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activities, any that are performed where measurements or information is put into the mobile inspection application, can be retrieved as needed. Transmission and Power Supply has determined that this is adequate for maintenance needs.

The actions and determinations stated above will be part of CR1308899. Thank you again for the detailed review by your audit team and the associated recommendations. If you have any questions regarding this response, please contact Brandy Spraker, Senior Manager, Transmission Field Support, at 423-751-6485.



James R. Dalrymple
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