



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

September 29, 2014

James R. Dalrymple, LP 3K-C

**REQUEST FOR MANAGEMENT DECISION – EVALUATION 2014-15053 – COAL  
PLANT PREVENTIVE MAINTENANCE**

Attached is the subject final report for your review and management decision. You are responsible for determining the necessary actions to take in response to our findings. Please advise us of your management decision within 60 days from the date of this report.

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 Janell B. Cunio, Senior Auditor, at (423) 785-4811 or Gregory R. Stinson, Director, Evaluations, at (865) 633-7367. We appreciate the courtesy and cooperation received from your staff during the review.

*Robert E. Martin*

Robert E. Martin  
Assistant Inspector General  
(Audits and Evaluations)  
ET 3C-K

JC:FAJ

Attachment

cc (Attachment):

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TVA Board of Directors  
OIG File No. 2014-15053



Office of the Inspector General

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# *Evaluation Report*

To the Senior Vice President,  
Power Operations

## **COAL PLANT PREVENTIVE MAINTENANCE**

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Audit Team  
Janell B. Cunio  
Lucas W. Cotter

Evaluation 2014-15053  
September 29, 2014

## **ABBREVIATIONS**

EPRI	Electric Power Research Institute
MBO	Maintenance Basis Optimization
PaSTA	Planning and Scheduling Tool Assistant
PdM	Predictive Maintenance
PER	Problem Evaluation Report
PM	Preventive Maintenance
RTF	Run-To-Failure
TVA	Tennessee Valley Authority

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MEMORANDUM DATED SEPTEMBER 26, 2014, FROM JAMES R. DALRYMPLE TO ROBERT E. MARTIN



## Evaluation 2014-15053 – Coal Plant Preventive Maintenance

### EXECUTIVE SUMMARY

#### Why the OIG Did This Evaluation

Preventive Maintenance (PM) is maintenance tasks carried out at a predetermined interval to reduce the likelihood of a failure. PM is important to the reliable operation of assets. As a result of findings identified with nuclear PM in a recent evaluation,<sup>i</sup> we conducted a review of coal PM. The objective of our review was to determine if coal plant PM has been performed in accordance with established schedules and, if not, what effect the deviations are having.

#### What the OIG Found

We found compliance with PM schedules varies by plant and the PM compliance metric captured may not fully represent all PM activities not completed. The monthly PM compliance percentage varied from 10.5 to 100 percent. The most common reasons cited for not completing PMs or adjusting the PM schedule was resource driven and/or due to emergent/sponsored work.<sup>ii</sup> We also found if a work order does not have the correct reconciliation code, a canceled PM would be counted as complete, which would skew the data. Reconciliation codes are essential for accurate reporting, but they are not a required field in Maximo.

We found that both uncompleted PMs and unestablished PMs contributed to equipment failures. In a review of 65 Problem Evaluation Reports (PERs), we identified 6 PERs linking failures to PM issues. Four of those PERs relate to equipment for which no PM schedule or requirement had been established, and 2 PERs relate to uncompleted PMs. We also found plants are making progress implementing the new Maintenance Basis Optimization (MBO), but have seen some delays in achieving target dates. Support of outages has impacted some sites abilities to complete its MBO phases. Additionally, we found the absence of PM requirements could make it harder to manage equipment reliability risk.

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<sup>i</sup> Evaluation 2012-14845 – Review of TVA's Nuclear Power Group Preventive Maintenance.

<sup>ii</sup> Emergent work is defined by Standard Programs and Processes 06.037, Work Management (work management process) as any emergent activity where immediate attention is required to protect the health and safety of the general public, correct a significant hazard, or prevent the deterioration of system conditions to a possible unsafe and unstable level. The terms emergent work and sponsored work are very often used interchangeably, and in regard to impacting scheduled work, they are the same. Sponsored work is not defined in the work management process; however Tennessee Valley Authority management explained that it is an activity where immediate attention is requested, and it is chosen to break the schedule to accommodate the work.



## Evaluation 2014-15053 – Coal Plant Preventive Maintenance

### EXECUTIVE SUMMARY

#### What the OIG Recommends

We recommend the Senior Vice President, Power Operations, take steps to:

- Increase PM completion/reduce deviations from PM schedules and reinforce importance of PM activities.
- Develop a way to more accurately capture and report PM compliance and other appropriate PM tracking metrics.
- Expedite MBO efforts.
- Consider the potential impact of having PM governed only by guidelines and not requirements.

#### TVA Management's Comments

TVA management generally agreed with the recommendations in this report. See the Appendix for TVA's complete response.

#### Auditor's Response

The Office of the Inspector General concurs with TVA management's response.

## **BACKGROUND**

According to the Tennessee Valley Authority (TVA), a maintenance strategy is essential in today's utility industry, which is looking for maximum reliability at the lowest cost. Preventive Maintenance (PM) is maintenance tasks carried out at a predetermined interval, including Predictive Maintenance (PdM)<sup>1</sup> routes, and intended to reduce the likelihood of a failure, according to Engineering Guidance Document 09.022, Maintenance Basis (maintenance basis process). Standard Programs and Processes 06.037, Work Management (work management process), elaborates that PM is system generated repetitive work orders in support of operation, maintenance, calibration, inspection, testing and periodic non-destructive examination of station system equipment and components. PMs are generated on a predetermined frequency. Once generated, PM work orders are loaded into the Planning and Scheduling Tool Assistant (PaSTA), planned, executed and closed-out as any other work order.

The maintenance basis process states its purpose is to document the maintenance basis/PM basis used to generate an optimized strategy focused on condition and PM. TVA is currently on their third iteration of maintenance optimization. The first maintenance optimization took place in the 1990s and focused on Reliability Centered Maintenance.<sup>2</sup> The second iteration, the Maintenance Optimization Program, deployed in 2001, was an improvement over the original program. Currently, TVA Coal, Gas, and Hydro are implementing Maintenance Based Optimization (MBO), which is the third iteration of optimization. MBO is a maintenance strategy to utilize PMs, PdM, and other condition monitoring to avoid equipment failures. It is an aspect of Electric Power Research Institute's (EPRI) Plant Reliability Optimization.<sup>3</sup> The MBO involves evaluating and prioritizing equipment (components) based on criticality to plant operation; as critical, non-critical, or run-to-failure (RTF). According to TVA management, this iteration of optimization is more rigorous and has more guidance from EPRI, which allows for an improved, risk-based PM program.

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<sup>1</sup> PdM is an advanced PM technique that focuses on using technology to determine the condition of equipment of assets. PdM involves periodic equipment condition monitoring and diagnostics to increase the availability of plant equipment, reduce maintenance costs, and increase personnel safety by detecting equipment deterioration and taking preventative action prior to failure.

<sup>2</sup> Reliability Centered Maintenance was used widely in the aircraft industry. It reviews the design of each system and postulates a set of failure modes based upon an assumed failure of each component in the system. Based on the assumption, all possible outcomes are postulated and a maintenance program formulated.

<sup>3</sup> According to EPRI, EPRI's Plant Reliability Optimization processes, such as MBO, Condition Based Maintenance, PdM, and Work Week Management, will result in the improvement of key power plant functional areas.

Also, the importance of an optimized PM strategy includes:

- Higher reliability at a lower cost.
- Minor repairs before failure in lieu of broken/catastrophic failures.
- Efficient use of resources.
- Just-in-time maintenance.
- Scheduled maintenance is more efficient than emergency maintenance.
- Provides focus for reducing causes of premature failure, and opportunities for life extension.

The MBO is broken down into four phases. Figure 1 below details the four phases and their benefit.

**Figure 1: MBO Phases**

Phase	Benefit
1 – Component Criticality Review	Utilize component ranking to make risk based decisions when prioritizing work and allocating resources.
2 – RTF Component Review	Begin reduction of existing PM and Corrective Maintenance backlog on critical components by re-allocation of resources that were previously assigned to RTF tasks.
3 – Critical and Non-Critical PM Review	Optimized PM tasks based on risk based analysis of component criticality and equipment failure modes. Focus available resources to PM and Corrective Maintenance activities critical to reliable equipment/plant operation.
4 – Implementation/Optimization of MBO	Sustainable optimized PM strategy with component criticality, risk based work process with resource loading, accurate metrics for driving progress toward proactive maintenance; higher reliability at lower cost.

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

PM is important to the reliable operation of assets. As a result of recent findings identified in Evaluation 2012-14845 – Review of TVA's Nuclear Power Group Preventive Maintenance, we conducted a review of coal PM. The objective of our review was to determine if coal plant PM has been performed in accordance with established schedules and, if not, what effect the deviations are having. The scope of our review included August 2012 through June 2014 and coal plants that are currently running and do not currently have plans to close or are closing fiscal year 2017 or later. Coal plants included were: Allen, Bull Run, Cumberland, Gallatin, Kingston, Paradise, and Shawnee.



To achieve our objective, we:

- Reviewed processes and guidance documents and conducted interviews to determine PM requirements.
- Reviewed PM compliance metrics from August 2012 through April 2014 to determine historical status of PMs.
- Selected a sample of sites including Bull Run, Kingston, Cumberland, and Gallatin to:
  - Conduct interviews of plant personnel to determine the status of PMs for the sites.
  - Review 65<sup>4</sup> Problem Evaluation Reports (PERs) with reported dates between January 1, 2012, and June 30, 2014, to determine if lack of PMs resulted in failures.

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**

We found compliance with PM schedules varies by plant and the PM compliance metric captured may not fully represent all PM activities not completed. The monthly PM compliance percentage varied from 10.5 to 100 percent. The most common reasons cited for not completing PMs or adjusting the PM schedule was resource driven and/or due to emergent/sponsored work.<sup>5</sup> We also found, if a work order does not have the correct reconciliation code, a canceled PM would be counted as complete, which would skew the data. Reconciliation codes are essential for accurate reporting, but they are not a required field in Maximo. We found that both uncompleted PMs and unestablished<sup>6</sup> PMs contributed to equipment failures. In a limited review of PERs, we identified 6 PERs linking failures to PM issues. Four of the PERs relate to unestablished PMs and 2 of the PERs relate to uncompleted PMs. We also found that plants are making progress implementing the new MBO, but have seen some delays in achieving target dates. Support of outages has impacted some sites' abilities to complete

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<sup>4</sup> In order to select a population of PERs to review, we performed a summary word search in Maximo for "failure." The search resulted in 14 PERs at Bull Run, 12 PERs at Kingston, 13 PERs at Gallatin, and 26 PERs at Cumberland. This search may not have included all PERs related to failures as the word search function does not search the whole PER and the site could have entered a PER for a failure with different wording.

<sup>5</sup> Emergent work is defined by the work management process as any emergent activity where immediate attention is required to protect the health and safety of the general public, correct a significant hazard, or prevent the deterioration of system conditions to a possible unsafe and unstable level. The terms emergent work and sponsored work are very often used interchangeably, and in regard to impacting scheduled work they are the same. Sponsored work is not defined in the work management process; however TVA management explained that it is an activity where immediate attention is requested, and it is chosen to break the schedule to accommodate the work.

<sup>6</sup> Equipment for which no PM schedule or requirement has been established.

its MBO phases. Additionally, we found the absence of PM requirements could make it harder to manage equipment reliability risk.

## **COMPLIANCE WITH PM SCHEDULES VARIES BY PLANT AND PM METRICS CAPTURED MAY NOT FULLY REPRESENT ALL PM ACTIVITIES NOT COMPLETED**

We found compliance with PM schedules varies by plant. Also, we found the PM compliance metric captured may not fully represent all PM activities not completed. The PM compliance metric is created by dividing the number of PMs completed by the number of PMs scheduled for that reporting period.

The average PM compliance percentage for the plants in our scope from August 2012 through April 2014 varied significantly, ranging from a low of 45 percent at Bull Run to a high of 95 percent at Cumberland. The averages by plant can be seen in Figure 2 below.

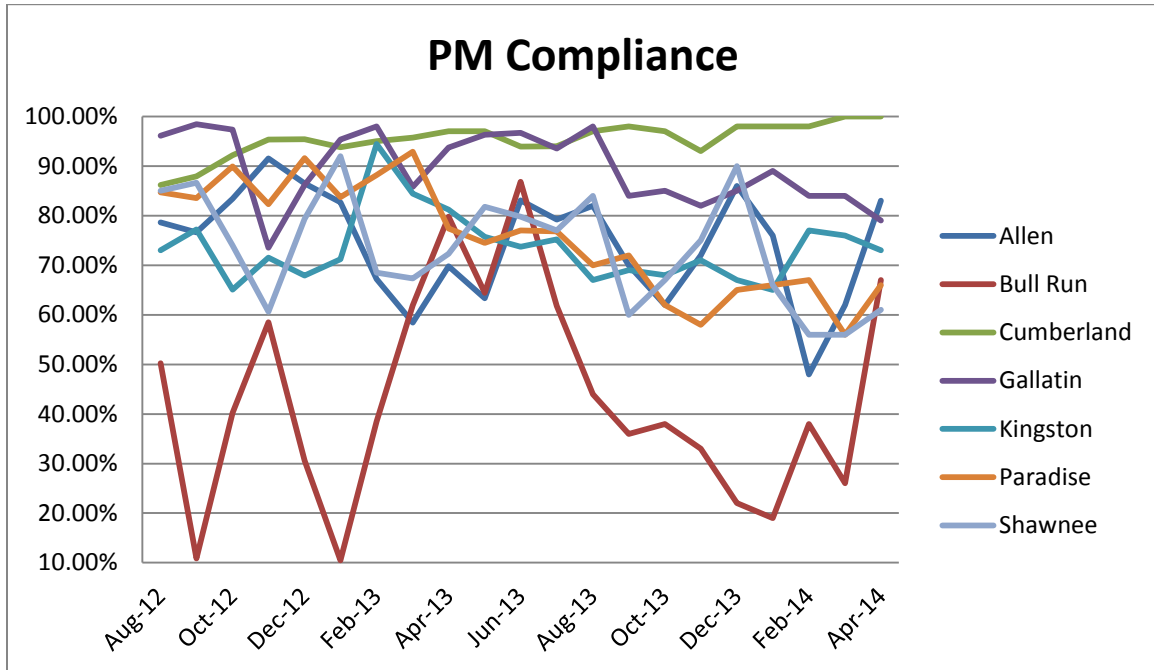
**Figure 2: Average of PM Compliance for August 2012-2014**

<b>Plant</b>	<b>Average Percentage</b>
Allen	74%
Bull Run	45%
Cumberland	95%
Gallatin	90%
Kingston	74%
Paradise	75%
Shawnee	73%

The month-by-month PM compliance percentage for the plants in our scope also varied widely from August 2012 through April 2014. The lowest monthly PM compliance percentage reported was 10.5, at Bull Run in January of 2013, while the highest monthly PM compliance percentage reported was 100, at Cumberland in March and April of 2014.

Figure 3 below shows the month-by-month PM compliance percentages.

**Figure 3: PM Compliance by Plant for August 2012-April 2014<sup>7</sup>**



We found the focus on PM priority varied by plant. At some plants, personnel stated that PMs are the number 1 focus and management makes PMs a priority. In contrast, at other sites we were told PM was the first activity to be pushed from the schedule. For the sites we visited, the PM compliance percentages were higher where the sites stated PM was given a priority.

In discussions with plant personnel, the most common reasons cited for not completing PMs or adjusting the PM schedule was resource driven (lack of manpower) and/or due to emergent/sponsored work. More than 50 percent of personnel interviewed indicated that a lack of resources impacted their ability to complete PMs. Additionally, 47 percent of personnel interviewed indicated emergent/sponsored work impacted their ability to complete PMs. One plant employee indicated the work getting sponsored in could wait, but the plant operates very “operations-centric,” and corrective maintenance is done before PM.

While TVA management and many plant personnel felt the metrics were representational of the actual PM completion to the best of their knowledge, we

<sup>7</sup> The PM compliance metric percentages for August 2013 and after were pulled through Cognos (a function of Maximo) from PaSTA. The data previous to August 2013 was pulled directly from PaSTA because prior to that date, the data did not exist in a database that Cognos could read, because there was a period of time where PaSTA was not being used. According to TVA, the data should be accurate prior to that time even though it is from a different source, except for a few variables. There is potential for small discrepancies in the data because the data could only be pulled based on the crews that are current now, not based on the crews that were current at the time the data was representing.

found the metric may not fully capture all PMs not completed. According to TVA management, if a work order does not have the correct reconciliation code or does not have a reconciliation code applied at the time of work order closure, a canceled PM would be counted as complete, which would skew the metric. The most likely scenario provided for skewed data would be that work orders are being closed without reconciliation codes. Under this scenario, Cognos would not have the information necessary to differentiate between closed (completed as planned) and closed (canceled). According to TVA management, the real issue then is that within Maximo, reconciliation codes are essential for accurate reporting, but they are not a required field. This happens because Maximo allows users to close a work order without applying a reconciliation code. The reason cited for the reconciliation code not being a required field is because all non-nuclear users of Maximo do not agree it should be a required field.

Currently, the PM compliance percentage is the only metric being tracked in regard to PM. As part of the MBO efforts, TVA management has proposed to the Management Peer team some additional metrics for tracking, which includes an indicator for number of PMs past due.

## **BOTH UNCOMPLETED AND UNESTABLISHED PM CONTRIBUTED TO EQUIPMENT FAILURES**

We found that both uncompleted and unestablished PMs contributed to equipment failures. In a review of 65 PERs, we identified 6 PERs linking failures to PM issues. Four of the PERs relate to unestablished PMs and 2 of the PERs relate to uncompleted PMs.

Figure 4 below shows the PM issues in the PERs.

**Figure 4: PERs with PM Issues**

<b>Equipment/Problem</b>	<b>PM Issue Identified</b>
<i>Uncompleted PMs</i>	
Constant oil gun fires.	The investigation found that the most common failure of oil guns is water in the compressed air and missed oil gun PMs. This contributed to longer start up times for the unit resulting in the use of more diesel fuel when trying to establish oil fires in the boilers. Corrective actions included completing multiple PMs and assigning ownership to a multi skill crew that will keep PMs current.
Unit tripped on low vacuum due to ignitor failures after Master Fuel Trip.	PMs are in place for ignitors to be tested weekly by Operations and Instrument Mechanics. Ignitor PMs are not being performed.

Equipment/Problem	PM Issue Identified
<i>Unestablished PMs</i>	
Startup Delays due to Air Pre-Heater failures, electric motors not engaging.	A PM was never set up to maintain the fluid coupling per manufacturer recommendation.
Failure on belt shutdown ability to unload coal.	Failure on a drive roll bearing led to failure of the coupling. It was determined that water contamination of the grease is the apparent cause of the failure. Weaknesses have been determined in PM, PdM, and critical spares.
PK block failure due to stud failure.	This failure could result in abnormal operations. Actions taken as a result of this PER included submitting a PM change form to add a new activity for an infrared inspection of all PK blocks in the plant and Electrical Control Building and verification that the PM was generated and scheduled quarterly.
Derates from pulverizer failures.	One of the actions taken included creating an Action Tracking Item to determine if PM on system can prevent trips. The Action Tracking Item found steps that should be included on Pulverizer Schedule Maintenance Procedure.

As part of the MBO effort, PM's on equipment are being evaluated and prioritized based on criticality to plant operation. This will help plants focus on the most important PMs.

## MBO IS PROGRESSING, BUT HAS SEEN DELAYS

Plants are making progress on the phases of the MBO, but have seen some delays in achieving target dates. This process is only being completed at the six long-term coal sites. Figure 5 below shows the targets, progress, and adjusted dates by plant as of July 30, 2014.

**Figure 5: MBO Phase Progress by Plant**

Plant	Phases, Progress, and Adjusted Dates									
	Phase 1			Phase 2			Phase 3		Phase 4	
	Target	Status	New Target	Target	Status	New Target	Target	New Target	Target	New Target
Kingston	1/14	Actual complete date	-	4/14	100% complete as of 6/11/14	-	7/14	8/14 (kickoff set for 8/5/14)	9/14	10/14
Cumberland	5/14	39% complete as of July 21, 2014	-	7/14	0% complete	-	9/14	-	12/14	-
Paradise	2/14	Actual complete date	-	7/14	63% complete	-	9/14	-	12/14	-

Plant	Phases, Progress, and Adjusted Dates									
	Phase 1			Phase 2			Phase 3		Phase 4	
	Target	Status	New Target	Target	Status	New Target	Target	New Target	Target	New Target
Shawnee	6/14	69% complete	8/14	8/14	0% complete	9/14	11/14	-	1/15	-
Bull Run	6/14	93% complete	-	8/14	0% complete	-	11/14	-	1/15	-
Gallatin	6/14	66% complete	8/14	8/14	0% complete	10/14	12/14	12/14	2/15	2/15

As seen in the chart above, some of the target dates have been pushed out. As of May 2014, coal fleet-wide implementation phase completion for the MBO was scheduled for February 2015; however due to delays, management now expects all sites to start the implementation phase by the end of February 2015. A revised completion date has not yet been determined.

According to TVA management, support of outages has impacted some sites' abilities to complete. Other challenges in the MBO process are cited as lack of resources and miscommunication/misunderstanding of process to complete component criticality. Additionally a disconnect between Windows 7 and PlantView<sup>8</sup> has impacted the ability to begin working on Phase 3. Personnel at one site indicated concern that if Phase 3 didn't get started before outage season in late August, the timeline would be pushed back even further. According to TVA management, this issue has now been resolved.

<sup>8</sup> According to the PlantView manual, PlantView is software that serves to track, assess, and communicate equipment/system problems. Information, such as PdM data, visual observations, testing, etc., is entered against specific components. This places information from various sources in a single location, allowing easy assessment of the overall health of that component thereby ensuring the proper actions are chosen for resolution. Because all organizations have access to PlantView, it is considered the "ultimate communication tool" for ensuring well-informed decisions are made.

## **THE ABSENCE OF PM REQUIREMENTS COULD MAKE IT HARDER TO MANAGE EQUIPMENT RELIABILITY RISK**

TVA has identified asset condition of non-nuclear generation as a key risk area, and PM is important to the reliable operation of assets. Currently the maintenance basis process and PdM program are Engineering Guidance Documents, which contain recommendations rather than requirements. The absence of PM requirements could potentially increase the number of PMs or PdMs that are not completed, thereby making it more difficult for TVA to effectively manage equipment reliability risk.

### **RECOMMENDATIONS**

We recommend the Senior Vice President, Power Operations, take steps to:

- Increase PM completion/reduce deviations from PM schedules and reinforce importance of PM activities.
- Develop a way to more accurately capture and report PM compliance and other appropriate PM tracking metrics.
- Expedite MBO efforts.
- Consider the potential impact of having PM governed only by guidelines and not requirements.

**TVA Management's Comments** – TVA management generally agreed with the recommendations in this report. See the Appendix for TVA's complete response.

**Auditor's Response** – The Office of the Inspector General concurs with TVA management's response.



September 26, 2014

Robert E. Martin, ET 3C-K

REQUEST FOR COMMENTS - DRAFT EVALUATION 2014-15053 - COAL PLANT  
PREVENTIVE MAINTENANCE

We appreciate the opportunity to provide further comments and details on the OIG's evaluation report of TVA's coal plant preventive maintenance dated August 29, 2014.

**What the OIG Recommends:**

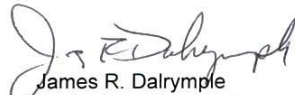
*We recommend the Senior Vice President, Power Operations, take steps to:*

- *Increase PM completion/reduce deviations from PM schedules and reinforce importance of PM activities.*
- *Develop a way to more accurately capture and report PM compliance and other appropriate PM tracking metrics.*
- *Expedite MBO efforts.*
- *Consider the potential impact of having PM governed only by guidelines and not requirements.*

In general, we agree with the recommendations presented in this evaluation which are in line with our ongoing maintenance basis optimization initiative being led and driven by the Asset Management Peer Team and the Coal and Gas Maintenance Peer Teams. The MBO initiative in itself reinforces the importance of PM activities and compliance. These peer teams understand the importance of getting this right and the criticality of its timely completion.

As part of the MBO effort, components are currently being identified by system owners as critical, non-critical, or run-to-failure. This criticality will aid in ensuring Power Operations effectively manages equipment reliability risks. PM metrics will be revised as needed to ensure the timely completion of necessary PMs on critical equipment. Additionally, both the coal and gas work management procedures currently under revision provide guidance to review the PM basis of critical and non-critical component failures to determine if PMs are not defined, not executed, or not executed correctly. This will ensure program effectiveness and provide a basis for continuous improvement and optimization of maintenance tasks on plant equipment.

Please let us know if you have any other questions or need additional information.

  
James R. Dalrymple  
Senior Vice President  
Power Operations  
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