Optimizing Power Generation Maintenance Strategies Using RCM Analysis

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Background

Before starting its current Reliability Centered Maintenance & Operations (RCMO) initiative, Sugar Creek Generating Station (SCGS) was focused on time-based, non-quantifiable PMs (e.g., check motor, check pump), and its maintenance strategy on much of the equipment was very reactive. Typically assets were run-to-failure then replaced (e.g., cooling tower gearboxes, reverse osmosis (RO) pumps). Prior to 2009, the capacity factor of the plant was never greater than 10 percent. There was adequate time to perform maintenance, but the process was loosely defined, and there was not enough failure history for root-cause analysis. The equipment was still relatively new, and the turnover package after construction had come with a large number of OEM recommended PMs.

The original challenge was that, like many combined cycle plants, SCGS is staffed lean (15 operators, 4 managers), and there were so many recommended OEM PMs that SCGS was simply picking and choosing the ones to perform without analytical rigor. Fortunately, because the equipment was still relatively new, this process seemed to be working fairly well. SCGS had the fourth best Equivalent Forced Outage Rate (.5) in the country in 2010.

In addition to the high number of PMs, a secondary challenge developed due to a decrease in the price of natural gas. The capacity factor of the plant had continued to rise over the past couple of years. Before 2009, it was less than 10 percent. By 2010, it was 31 percent; in 2011 it was 46 percent, and it is projected to grow to 80 percent for 2012. In the first quarter of 2012, the plant started up on January 19 and ran the entire month of February. This sustained running period meant the equipment had to maintain performance, and there was less time available to perform PMs.

Despite its success to date, SCGS realized that the current maintenance approach was not sustainable long term because there was little structured reasoning to back up the current maintenance approach. In addition, the plant was being measured on PM compliance against the other plants in the NIPSCO generation portfolio. These included coal plants with about the same number of PMs as SCGS but with approximately four times the resources to execute them. With almost 1,200 PMs, there was no way to complete every task, but its approach to selecting which PMs to perform was not defensible; if the plant was not doing all the PM’s, what was the basis for not doing them? SCGS needed to change its approach to PM compliance and create a supportable maintenance practice to ensure that it was focusing on the correct PMs to prevent forced outages and maintain or lower the existing EFOR.

The organization began looking at areas to optimize the maintenance strategy. The typical approach is to replace PMs with classic PdM technologies while ensuring the remaining PMs are quantitative in nature. However, SCGS decided to strive for even greater results by partnering with MRG to revitalize its approach to combined cycle maintenance.

Approach

SCGS used MRG’s Reliability Centered Maintenance (RCM) analysis template as a starting point and tailored the analysis to meet its specific needs. The project, which began in February 2011, commenced with SCGS working with MRG to align MRG’s standard 2 x 1 combined cycle RCM template with the SCGS equipment configuration. The template covers the balance of plant (BOP) assets (all assets except the gas turbines, the heat recovery steam generator, and the steam turbines). The next step was to look at the actual performance data available from the facility and integrate that information into the analysis. The result was the identification of all the potential failure modes associated with the BOP equipment along with the possible mitigation strategies for each identified failure. MRG’s partner, GE-Bentley Nevada, also supported the effort by helping to generate an overall sensor plan that monitors identified potential failure modes on critical equipment while complementing or replacing current PMs or route-based PdM activities. Overall, this approach ensures optimal coverage and supports a facility that is already staffed lean. The strategy is backed by a verifiable, defensible RCM analysis and supplies the data necessary to back up the improvements on both a practical and financial basis.
The underlying principles that drove the approach were as follows:

- **Leveraged existing knowledge of combined cycle systems and equipment base to accelerate results:** The approach enabled SCGS to jumpstart the initiative and achieve more in a shorter period of time than if the company had started with a blank slate.

- **Employee Involvement:** As mentioned previously, one of the challenges was that combined cycle plants are staffed lean and often with people from outside of power generation. This process embraced the small staff and actively involved everyone in the analysis and the review of the failure modes. The operators and staff gained valuable learning and insight about the systems being reviewed. In addition, from a change management perspective, it helped create ownership and buy-in to the entire approach.

- **Foundational awareness of living RCM.**
  - Applied the seven questions of SAE JA1011.
    - What are the functions and associated desired standards of performance of the asset in its present operating context (functions)?
    - In what ways can it fail to fulfill its functions (functional failures)?
    - What causes each functional failure (failure modes)?
    - What happens when each failure occurs (failure effects)?
    - In what way does each failure matter (failure consequences)?
    - What should be done to predict or prevent each failure (proactive tasks and tasks intervals)?
    - What should be done if no suitable proactive task can be found (default actions)?
  - Managed all maintenance at the failure mode. Identification of the failure modes is a key component in maintenance strategy development.
  - Considered equipment class/sub-class best practices.
  - Considered use of all controls. Focused on making sure they were applicable, effective, repeatable, and feasible.
  - Assumed the preferred deployment of controls was training, condition-based analytics, PdM, quantifiable PM, Run-to-Failure (RTF), and Redesign.

- **Validate analysis, expand analysis, and select controls.**

- **Reality check with field verification (maintenance and operations):** Used field verification to spot check and validate the revised RCM. This ensured that the plant was physically constructed the way it was modeled.

- **Commit to strategy:** Once a mitigation strategy was chosen, the plant committed to the change and discontinued its former strategy.
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Results

SCGS personnel and MRG reviewed more than two dozen balance of plant (BOP) systems using the RCM analysis template. The outcomes of that analysis were:

- Validated current and future state Predictive Maintenance (PdM) deployment in order to understand exactly what was available to be applied to failure mitigation.

- Examined the majority of the defensible failure controls, which included sensing/conditioned-based analytics. The team took the following actions to leverage this control type.
  - Identified requisite control schemes and trending analytics
  - Updated sensing to provide necessary inputs and outputs (I/O)
  - Implemented necessary programmatic solutions

These steps allowed SCGS to leverage systems already in place and expand their value while helping reduce the number of time-based PMs required. This greater reliance on existing monitoring capabilities for use in failure mitigation will lead to better utilization of plant resources (Labor, Materials, Contractors, and MRO inventory).

- Identified training needs for critical systems. Operators of critical systems play an important part in maintaining overall asset health. Through the analysis of the failure modes, it was determined that additional operator training would result in the mitigation of some possible failures. One example of this was simply ensuring cooling tower fans were started in slow speed instead of high.

- Determined necessary redesign or upgrade of several high-profile assets/systems. Examples of a redesign identified through the process include the redesign of High Pressure (HP) feedwater valves and the installation of Hi-Temperature shutoffs on RO pumps to protect them in case of a discharge valve failing to open.

- Documented need for reliability, equipment, inventory, and preventive maintenance strategies. This documentation provides the defensible support for ongoing maintenance strategy development.

- Rewrote necessary PMs to collect value-added data. Part of the pilot involved identifying which PMs should be eliminated, which PMs should be replaced with condition monitoring or PdM, which PMs needed to be rewritten, and which were acceptable as written. The previous tasks were completed in early 2012. With coaching and mentoring by MRG, the team learned the proper way to write a quantifiable PM and set up a roadmap to manage the ongoing rewrite process. The goal is to ensure that all PMs are feasible, applicable, repeatable, and effective.
  - All 1,158 have been reviewed
  - 544 were ok as written
  - 469 were made “inactive” immediately
  - 102 needed revision
  - Expected a 30% - 40% reduction of manual PMs (actual was 40.5%)

- Leveraged run-to-failure decisions to drive materials management strategies and develop appropriate proactive corrective repair job plan packages. This helped establish a link with MRO inventory and highlighted the impact that supply chain has on reliability.
Next Steps

SCGS has made significant progress on its journey, but there are more opportunities for improvement. The organization understands that reliability is a culture not a project. Given this mindset, there are several key areas moving forward that will be addressed:

- Increase use of predictive analytics by the planned implementation of SmartSignal to continuously monitor the equipment and help detect faults even earlier along the P-F curve. (In progress)
- Hire a full-time reliability engineer to continue to drive the reliability culture and improve operations.
- Implement a Machinery Health Database to bring together all known condition information about an asset.
- Develop more structured work processes with an emphasis on the use of Maximo to execute those processes.

Conclusion

SCGS has accelerated its progress and jumpstarted the RCMO process by leveraging an existing market solution instead of developing it themselves. By engaging in a partner approach, SCGS has retained ownership of the process and tailored a known RCM-analysis based approach to its specific needs while receiving expert, overarching direction and support as needed.

As a result, SCGS expects to maintain and improve its standing as a dependable, reliable, and environmentally friendly source of power generation.