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Keep it Spinning:
EPRI Guidelines for Turbine-Generator Maintenance

Updated annually to reflect industry operating experience and new technology advances, the guidelines help steam power plants avoid costly outages and enhance maintenance planning and execution.

In the fall of 2008, AmerenEnergy performed a scheduled maintenance on unit 2 at its E.D. Edwards Plant, a 744-MW coal-fired plant in Bartonville, Illinois. During a low-pressure steam turbine inspection, after the rotor was blast-cleaned, the maintenance crew discovered erosion on the L-1 blades. Ameren quickly had to determine whether the blades could continue in operation or needed to be repaired or replaced.

In the past, like most utilities, Ameren's pre-planning for the inspection would have involved checking to see if a finite element analysis (FEA) for the inspected blades was on hand or available from a third-party vendor, which would allow engineers to calculate blade stresses if damage was discovered.

Without an FEA, however, the decision would be a judgment call. "Given the time constraints, it's pretty hard during an outage to create an FEA and do the actual modeling and analysis to understand the stresses on the blade," says Tom Kordick, Manager, Plant Support Services at Ameren. "You usually end up looking at the history of the blade and the amount of erosion on a previous inspection, and calculating the erosion rate over time. But it's a judgment call on whether the blade's suitable for continued operation."

In this case, though, Ameren had more information. The utility used a tool developed by EPRI called *Guidelines for Reducing the Time and Cost of Turbine-Generator Maintenance Overhauls and Inspections*. The *Guidelines* are a seven-volume set of specifications and procedures necessary for planning and performing a fossil or nuclear steam turbine/generator maintenance outage.

In Volume 7 of the *Guidelines*, Ameren found modeling of the L-1 blade in question. "We were able to take that FEA and compare it to the locations where we had the eroded areas and determine that it was a very low-stress area and the likelihood of failure was pretty low," says Kordick. "It allowed us to document the erosion and put the unit back in service with the recommendation to replace the blade in the next inspection."

Critical Industry Need

The experience at the Edwards plant is not uncommon. Up to 70% of outages planned for steam power plants involve work on the turbine. The challenge for plant engineers is to efficiently utilize the outage to improve equipment performance and extend reliability while limiting downtime costs. A one-day reduction in outage time can save $200,000 to $500,000 for a typical 500-MW fossil unit and more than $1 million for a large nuclear unit.

However, as power producers seek to meet this challenge, they face the loss of expertise through the retirement of senior engineering and craft personnel, and must find ways to transfer the skills and knowledge of departing staff to new employees. In addition, some plant owners are being forced by cost-cutting pressures to discontinue maintenance outage contracts with original equipment manufacturers and to conduct outages in-house.

As a result, many power producers are looking for accurate sources of information on maintenance outages and ways to shorten the learning curve for inexperienced employees, while at the same time properly managing their corporate risk relative to type and frequency of maintenance work on this equipment.

Successful Utility Practices

EPRI's *Guidelines* meet this need by providing a compendium of successful utility practices. Originally published more than seven years ago, the *Guidelines* have been annually updated and expanded to incorporate new information. The complete set now encompasses some 2,000 pages and is used by 45 utilities. The *Guidelines* provide
practical information such as common maintenance outage pre- and post-planning procedures, specific component repair procedures, high-and low-speed rotor-balancing procedures, an alignment and balancing primer, turbine-generator major component purchase specifications, and blade/disc design audit and inspection procedures.

The information in the *Guidelines* was collected under the direction of a Technical Advisory Group made up of utility members. The procedures and practices represent a consensus of what has worked, including simple, practical tools — inspection procedures, engineering models, and guidelines for working with vendors, particularly on work scope definition and inspection of final product received.

Figure 1. Recutting a worn-out helical groove.

Tennessee Valley Authority (TVA) offers an example of this latter application: working with vendors on work scope definition. Over the past five years, TVA has used Volume 3 of the *Guidelines*, "Balancing and Alignment Specifications," to develop specifications for high-speed balancing of rotors at five units at TVA's coal-fired Widows Creek, Bull Run, and Paradise Plants.

"Having those specifications allows us to get a much better product after the testing is done," says TVA's Jerry Best, Manager of Steam Cycle and Generator Systems. "We're able to return the unit to service without having to do trim shots on the unit and without having to do as much online balancing as we would normally have to do. We probably saved at least one start-up on each unit by not having to do the field-balancing on the rotors."

TVA is using Volume 4, "Blade and Rotor Procurement Specifications," to develop specifications for new equipment as part of the utility's future procurements, which is aimed at improving turbine efficiency.

Covering the Bases

The *Guidelines* also provide an expansive reference library to users. "There's a tremendous amount of information in these documents," says Kordick. "As a standard practice, we utilize them to help in pre-planning to make sure we cover all the bases. It's particularly useful for entry-level engineers when they're planning for an outage. They can use them like an auto repair manual that goes step by step on what you need to do when you're taking the components apart, what checks you need to take, how to record the information, and so on."

Another application is as a re-inforcement for in-house maintenance manuals. "When we take components apart in something like a stop valve inspection," says Kordick, "we have our internal guidelines, and we have a two-way checklist to make sure we're looking at everything that needs to be looked at and that we're taking the critical dimensions."

Current Volumes

The current seven-volume set of the *Guidelines* includes:

- **Volume 1: General Practices** for the fundamental maintenance activities typically performed during an outage: Turbine-generator condition assessment (in-service), pre-outage planning and bidding, unit shutdown procedures, disassembly and recording clearances, foreign material exclusion process information, turbine-generator condition assessment (off-line), oil flushing, rotor alignment and balancing, pre-startup checks, and post-outage activities.
- **Volume 2: Repair Procedures** provides details to guide the pre-bid, inspection, disassembly, and repair of critical turbine and generator components.
- **Volume 3: Balancing and Alignment Specifications** includes comprehensive alignment and balancing primers and high- and low-speed balancing procedures for turbines, generators, and exciters.
- **Volume 4: Blade and Rotor Procurement Specifications** provides details for the procurement of turbine buckets, to include blade frequency testing and tuning guidance, high-pressure/intermediate-pressure/low-pressure (HP/IP/LP) fossil rotors, HP/LP nuclear rotors, generator rotor rewind, a new generator rotor, generator stator rewind, new generator stator, generator excitation system, turbine insulation, complete turbine outage services, and turbine bolting.
- **Volume 5: Turbine Directory and Database** of large (>75 MW electric) turbines that operate with last-stage buckets of 23 inches (58 centimeters) or longer.
- **Volume 6: HP/IP Blade/Disk Design and Inspection Specifications** includes blade/ disk design audit and inspection procedures for HP and IP steam turbine blades/disks.
- **Volume 7: LP Blade/Disk Design and Inspection Specifications** presents blade/disk design audit and inspection procedures for LP blades/disks.

The *Guidelines* are available on a four-CD set, which also includes EPRI's TGAlign software program and user manuals. TGAlign determines the optimum coupling alignment for turbine-generator rotor system, enabling users to reduce outage times.

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