

65 Steam Turbines, Generators, and Balance-of-Plant

Program Overview

Program Description

This program develops technology applications and guidelines that help plant operators optimize steam turbine, generator, and balance-of-plant (BOP) equipment life cycles to increase availability, shorten scheduled maintenance outages, and improve steam turbine performance. Using an integrated approach that incorporates work from related EPRI programs, this program focuses on reducing operations and maintenance (O&M) costs, managing risk, maximizing plant performance, providing technical support for plant staff, and producing information to support upgrade studies and asset management strategies. Products and information delivered by this program are developed collaboratively and shared with EPRI's Nuclear Steam Turbine-Generator Initiative.

Industry Needs and Issues Addressed

- Plant operators need to cost-effectively manage unit operation and performance using independent analysis and testing methods
- Program develops technology, applications, and guidelines that meet those needs.

Impact

- By participating in this program, plant operators can
 - reduce maintenance costs
 - lower operating and regulatory risks
 - implement cost-effective thermal performance improvements
 - extend component life
 - increase staff technical expertise
- Involvement in the program will
 - educate participants about worldwide turbine-generator (T-G) issues and solutions
 - provide opportunities to share information with industry experts, utility engineers, major T-G original equipment manufacturers (OEMs) and vendor/service providers worldwide

Key Accomplishments

- Solutions to low-pressure (LP) turbine phase transition zone (PTZ) corrosion/stress corrosion cracking (SCC) evaluation, prevention and mitigation
- Staff education and training through turbine and generator workshops and seminars
- Turbine auxiliary systems maintenance guides for turbines and generators
- T-G outage reduction guidance
- T-G equipment and component repair and purchase specifications
- Torsional vibration primer and plant vulnerability guidance for turbines and generators
- Nondestructive evaluation (NDE) testing and application guidance
- Regular interaction with all major turbine and generator OEMs worldwide

Current Year Objectives

- Participants receive information on
 - T-G outage management
 - Unit maintenance intervals
 - T-G outage scope
 - T-G alternative repair/replacement options
 - Industry best practices for maintenance of turbines and generators
 - Approaches and solutions to controlling corrosion in the LP PTZ

- Participants also receive information and technologies on turbine and generator
 - nondestructive examination
 - remaining life assessment
 - condition monitoring that supports risk management
- Participants are eligible to attend the Turbine Generator User Group meetings/workshops, the 2009 11th EPRI Steam Turbine Generator Workshop and Vendor Exhibition, and other workshops offered by the program.

Industry Involvement

- Estimated 2009 funding: \$4.1M

Program Technical Lead

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Summary of Projects

Project Number	Project Title	Value
P65.001	Operations and Maintenance Cost Reduction	Activities include developing guideline documents for outage planning; disposition of damaged components; repair techniques; corrective actions; specific maintenance practices; preventive maintenance; optimized generator rotor maintenance; exciter maintenance; and retrofit/replacement. For more details about specific projects in this area of the T-G program, refer to the P65.001 project description.
P65.002	Risk Management	This project provides emerging technologies, such as advanced inspection techniques, new NDE technology that reduces inspection time and increases accuracy, analytical tools to address component cracking, and corrosion degradation modeling, for turbine-generator condition assessment and component failure risk assessment on components such as turbine blading/rotors and generator capability and monitoring (NERC standards). For more details about specific projects in this area of the T-G program, refer to the P65.002 project description.
P65.003	Steam Turbine Performance	This project has developed steam path performance assessment tools such as the Flowpath Analysis for Steam Turbine (FAST) software program, which allows users to validate unit performance on a stage-by-stage basis or better quantify proposed steam path modifications or replacements. These tools are used to identify recoverable steam path or cycle losses such as steam path deposits, while decision-analysis guidelines assess potential upgrade options that can enhance the effectiveness of plant performance. For more details about specific projects in this area of the T-G program, refer to the P65.003 project description.

Project Number	Project Title	Value
P65.004	Information Exchange for Plant Staff	Lessons learned in addressing common reliability and maintenance issues are shared as program participants provide up-to-date information, including industry experiences, data, and turbine-generator problems for common equipment in the Turbine Generator User Group, the T-G Technology Transfer workshops, the Steam Turbine Generator Workshop and Vendor Expositions and other workshops. For more details about specific projects in this area of the T-G program, refer to the P65.004 project description.

Project Descriptions

P65.001 Operations and Maintenance Cost Reduction (052070)

Issue

Power producers continually seek ways to optimize operation and maintenance activities on aging turbine-generator fleets. Reduced staffing levels and the retirement of experienced personnel have added challenges to meeting industry goals for equipment availability in the current competitive environment.

Description

This project addresses a core issue facing engineering staff today — reducing O&M costs — by:

- Generating guidelines for T-G outage planning, disposition of damaged components, repair techniques, corrective actions, and specific maintenance practices
- Analyzing the effects of flexible operation and unit upgrades and uprates
- Producing preventive maintenance (PM) guides to include development of modules for the EPRI PM Basis Database
- Optimizing generator rotor maintenance, exciter maintenance, and retrofit and replacement guidance

Value

- Decrease outage duration
- Increase outage intervals
- Improve repair of components
- Improve turbine-generator PM/Predictive Maintenance (PdM) process and practices

How to Apply Results

The content within the guideline documents can be used when a utility is faced with equipment repair. Members can integrate the content within the guidelines into their own procedures and training materials. The guidelines can be placed on member utilities' intranet and provide an excellent resource for continuous improvement training as well as new-hire orientation for system owners and maintenance staff. Utilities facing new equipment purchases can take advantage of the guidelines' content in preparing their own site-specific procurement specifications.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
<p>Foam Cleaning of Valve Internals to Remove Oxide Buildup: This report will document trial application of a method for chemically removing oxide growth from the valve internals without disassembly. Process effectiveness and issues surrounding the practical implementation of this cleaning procedure in situ will be identified and addressed.</p>	12/31/2009	Technical Report
<p>Guidelines for Reducing the Time and Cost of Turbine Generator Maintenance and Overhauls: This deliverable will add material to the seven-volume set of guidelines first generated in 1999 and updated every year since. New material will continue to focus on turbine-generator centerline components, with an emphasis on maintenance, repair, and procurement processes before, during, and after an outage. The objective is to educate plant staff on how to reduce time and cost of turbine-generator outages through better pre-planning and contingency planning during the outage.</p>	3/31/2010	Assembled Package
<p>Turbine Generator Auxiliary System Maintenance Guide- Volume 5: T-G Auxiliary Systems Maintenance Guide development will continue an effort initiated in 2005 and focus on non-centerline components that support turbine and generator operation. The <i>Lubrication System Maintenance Guide</i> was completed in 2005, followed by the <i>Steam Seal System Maintenance Guide</i> in 2006, the <i>Generator Hydrogen Gas System Guide</i> in 2007, and the <i>Generator Stator Cooling System Guide</i> in 2008. Based on members' feedback, this next guide will focus on the turbine emergency trip systems.</p>	12/31/2009	Technical Report
<p>EHC Fluid On-line Monitoring Demonstration Study: The EPRI <i>Guidelines and Procedures for Turbine Valve Condition Assessments</i> (1008352) was produced in 2004 and included the General Electric and Siemens Westinghouse manufactured valves. This project will produce a maintenance guide providing detailed instruction on valve component inspection and assessment criteria during disassembly and specifications for proper valve reassembly clearances for internationally manufactured valves including those produced by Alstom, Hitachi, Mitsubishi, and Toshiba.</p>	12/31/2009	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<p>Turbine Valve Actuator Condition Assessment for International Steam Valves: A guide on the international manufactured steam turbine valves will be completed in 2009. This follow-up guide to cover actuators of internationally manufactured valves is planned for 2010. The valves include those produced by Alstom, Hitachi, Mitsubishi, and Toshiba.</p>	2010	Technical Report

P65.002 Risk Management (052072)

Issue

Risk assessment is an increasingly important aspect of both short- and long-term planning. Managing risk requires a combination of advanced inspection techniques, new nondestructive evaluation (NDE) technologies that reduce inspection time and increase accuracy, analytical tools to address component cracking, and corrosion degradation modeling.

Description

This project provides emerging technologies for:

- Guidance in decisions such as run/repair/replace, plant life extension, life-cycle management, and overall optimal use of capital resources
- Turbine-generator condition assessment and component failure risk assessment
- Risk-assessment technology, producing failure probability data that can be combined with maintenance and replacement power costs to assess financial risk using tools such as EPRI's Turbo-X program
- Emphasis on NDE of turbine-generator components, condition assessment, and remaining-life assessment
- Completion of advanced modeling of corrosion-assisted cracking including delivery of a corrosion cracking computer program

Value

- Accurately assess risk with plant turbine-generator upgrades and maintenance
- Investigate emerging technologies for assessing turbine-generator condition and component failure risk

How to Apply Results

The EPRI technology produced by this program will enhance the ability to analyze and quantify the risks associated with component failure, replacement, upgrades, and uprates. Members will be able to customize their turbine operations windows, in order to assess the economic impact of applying the methodologies presented in the Turbine Blade Vibration Monitoring report. Access to improved inspection mockups allows members to more confidently evaluate nondestructive inspection systems and personnel.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Mitigating Actions During Major Turbine-Generator Events: Several recent major failures of T-G equipment have included catastrophic fires due to failed buckets and the ensuing damage, generator rotor cracks, generator explosions due to hydrogen gassing issues, transformer fires/failures, and the largely misunderstood phenomenon of torsional vibration causing significant unit damage. The project will identify actions needed after an unscheduled major and/or catastrophic T-G failure occurs, including mitigating environmental concerns or impacts, required regulatory actions/notifications, Occupational Safety and Health Administration (OSHA) reporting, limiting damaging effects on supporting plant equipment and the first responder-type activities by station and other utility personnel. Past events will be reviewed as examples of how utilities have responded to the events, and the lessons learned will be documented. EPRI also will seek input from insurers.	12/31/2009	Technical Report

Product Title & Description	Planned Completion Date	Product Type
<p>Implantation of Cracks in Blade Attachment Mockups: This project will provide improved tangential entry disk blade attachment mockups for evaluation of nondestructive inspection systems and personnel. EPRI maintains a variety of mockups for evaluation of nondestructive inspection systems and personnel. The tangential entry disk blade attachment mockups currently are made up of electro-discharge machined (EDM) notch targets and undocumented in-service cracks. Implantation of 25-30 cracks among three attachment hooks of the mockups would expand the flaw target count and type. The additional cracks would more effectively represent typical in-service flaws found in the attachment area.</p>	12/31/2009	Technical Report
<p>Turbine Blade Vibration Monitoring: Blade Vibration Monitoring (BVM) on LP rotors provides continuous monitoring and early indication of blade cracking or conditions contributing to cracking (high cycle fatigue, low cycle fatigue, stress corrosion cracking). BVM can be used for feedback to operators considering expansion of operational range based on unit-specific real-time data as opposed to using generic limits. This project would require measurement of a candidate unit during outage in preparation for hardware installation on the pilot unit. After a computer model of the unit is completed and the needed instrumentation installed, "off-design" runs of the unit will be needed to identify safe limits for blade vibration.</p>	12/31/2009	Technical Report
<p>Non-Intrusive Methods to Validate NERC Standards: Steam Turbine Frequency Response: In 2007, three utilities funded a Power Delivery and Utilization supplemental project to derive generator, excitation system, and governor parameters from off-line and on-line tests. The Power Plant Parameter Derivation (PPPD) software allows engineers to derive parameters for standard (IEEE) generator and exciter models, as well as for combustion turbine governor models. The objective of this project is to extend the PPPD software to calculate steam turbines parameters from system disturbances (e.g., loss of a major generator that results in system frequency deviations) that are automatically captured during ambient monitoring.</p>	12/31/2009	Technical Report
<p>Inspection of Generator Rotor following a Motoring/Negative Sequence Incident: When a generator experiences unusual operation, such as single phasing or motoring, large negative sequence currents flow in the pole face of the rotor body and can severely damage the rotor. This software will allow the plant to assess the risk of damage following an incident and decide whether a rotor inspection is warranted.</p>	12/31/2009	Software

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<p>Integrating Generator On-Line Monitors: Many large generators have been retrofitted with partial discharge, flux probe, core, and shaft voltage monitors to detect symptoms of developing problems. Correct identification of the problem in time to act can be increased by integrating the output of the monitors. This report will provide logic rules to combine the output of continuously monitored flux probes, shaft voltage monitors, rotor ground detectors, and generator vibration monitors.</p>	2010	Technical Report

P65.003 Steam Turbine Performance (052074)

Issue

Maintaining or enhancing thermal performance of plant equipment is a cost-effective means to improve a power producer's financial operation and meet the increasing demand for power without new construction. But accurate assessment of the actual improvement and measurement of thermal performance gains is difficult.

Description

This project develops performance assessment tools used for identifying recoverable steam path or cycle losses, and decision-analysis guidelines to assess upgrade options that can enhance the effectiveness of plant performance engineering staff.

Value

- Improve heat rate
- Gather objective information to help procure replacement components

How to Apply Results

The performance assessment tools developed in this program can be used to identify recoverable steam path or cycle losses, and develop decision-analysis guidelines for assessing potential upgrade options to enhance the effectiveness of plant performance engineering staff. Members can directly apply the improved heat rate information to procure replacement components and to assess changes to steam path to evaluate actual efficiency increases.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
<p>Steam Deposit Effect on Thermal Performance: Steam-path deposits adversely affect turbine efficiency. Often several species are involved, with different actions required to reduce the rate of deposition or actually remove deposits. This report will review deposition processes, sources, and methods for species identification from turbine scraping; conduct a parametric study of the effects of specific deposit types and thicknesses; and develop a cost-benefit approach to assess the value of remedial action.</p>	12/31/2009	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Steam Deposit Effect on Thermal Performance: This task will explore several aspects of low-pressure turbine steam deposits to provide plant engineers with the means to quickly assess options for cost-effective remedial action, focusing on deposits having the greatest effect on performance.	2010	Technical Report

P65.004 Information Exchange for Plant Staff (052076)

Issue

Use of EPRI material and products in members' plants is made more difficult by decreasing staff and loss of expertise. For example, an estimated 30% of the U.S. nuclear workforce will be eligible to retire in the next five years. New employees need a much faster, more efficient method to gain knowledge of plant equipment and the problems and issues associated with operating and maintaining their equipment.

Description

One of the most effective ways for plants to reduce operating cost is to apply lessons others have learned in addressing common reliability and maintenance issues. This program will help members share up-to-date information, including industry experiences, data, and turbine-generator (T-G) problems for common equipment. Participation in the Turbine Generator User Group (TGUG), the T-G Technology Transfer workshops, and the Steam Turbine Generator Workshop and Vendor Expositions educate plant engineering staff about resources available through EPRI and the industry that can help solve their operating and maintenance problems.

Value

- Increase turbine-generator staff expertise
- Apply other utilities' lessons learned
- Be aware of emerging issues
- Establish and maintain direct contact with industry peers and T-G OEMs and vendors

How to Apply Results

Active participation in the Turbine Generator User Group (TGUG) and attendance at the workshops and conferences will aid members in applying the results from the Turbine Generator research program. Two opportunities to attend EPRI-sponsored events to share lessons learned with other utilities and stay abreast of technologies include:

- The sixth EPRI T-G Technology Transfer Workshop and 11th Steam Turbine Generator Workshop and Vendor Exposition
- Winter/Summer Turbine-Generator User Group (TGUG) meetings and January workshop

2009 Products

Product Title & Description	Planned Completion Date	Product Type
11th Steam Turbine Generator Workshop and Vendor Expositions: EPRI will continue its successful series of biennial Turbine-Generator Workshop and Vendor Expositions with the 11th workshop in 2009. The workshop will feature parallel technical tracks on current industry issues, with presentations by utility representatives, vendors, and OEMs. The popular vendor exposition also will be included in this three-day event.	12/31/2009	Workshop, Training, or Conference
Turbine Generator User Group (TGUG): The TGUG meets twice yearly and assists participating companies in sharing up-to-date information, including industry experiences, data, and issues associated with all types of turbine-generators manufactured worldwide. Each January meeting includes a workshop with T-G topics determined by the TGUG members.	12/31/2009	Technical Resource

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Sixth EPRI T-G Technology Transfer Workshop: In 2010, the turbine-generator program will conduct the Sixth EPRI T-G Technology Transfer Workshop. The workshop will feature current EPRI deliverables related to turbines and generators, with a focus on implementation and demonstration of how various T-G deliverables can be used.	2010	Workshop, Training, or Conference
