

Nuclear Steam Turbine Initiative

Program Overview

Program Description

The Nuclear Steam Turbine Initiative develops technologies 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. Research and technical support activities enable nuclear power plants to reduce operation and maintenance costs, maximize plant performance, and more effectively implement plant upgrades and asset management strategies.

Industry Needs and Issues Addressed

- Independent analytical and testing methods to cost-effectively manage unit operation and performance
- Best practice guidelines and technical advances to improve steam turbine-generator performance
- Technical guidance for making life-cycle decisions related to the operation and maintenance of the steam turbine, generator, and associated auxiliary systems
- Advanced inspection techniques and analytical tools that enhance component risk assessments

Impact

- Reduced maintenance costs through application of comprehensive guidelines for turbine-generator outages and overhauls
- Lower operating and regulatory risks through refined evaluation of component conditions and failure mechanisms
- Thermal performance improvements through implementation of steam path assessment tools
- Extended component life through life-cycle analyses and guidance related to outage planning, repair techniques, and corrective actions
- Increased staff technical expertise through participation in user groups and access to lessons learned at nuclear and fossil power plants
- Interface with industry experts, utility engineers, major turbine-generator manufacturers, and vendor/service providers worldwide

Key Accomplishments

- Solutions to improve evaluation, prevention, and mitigation of low-pressure turbine phase transition zone corrosion and stress corrosion cracking
- Staff education and training through turbine and generator workshops/seminars
- Turbine auxiliary systems maintenance guides
- Turbine-generator outage reduction guidance
- Turbine-generator equipment/component repair and purchase specifications
- Torsional vibration primer and plant vulnerability guidance relative to turbines and generators
- Nondestructive evaluation testing and application guidance

Current Year Objectives

- Evaluate industry best practices and technology advances to drive improvements in turbine-generator outage management, maintenance intervals, outage scope, and alternative repair/replacement options
- Develop techniques and guidance for nondestructive examination, remaining-life assessment, and condition monitoring of turbine-generators that support risk management and equipment maintenance

- Develop approaches and solutions to controlling corrosion in the low-pressure phase transition zone
- Provide technology transfer and lessons learned forums, including the Turbine Generator User Group meetings/workshops and the 11th Electric Power Research Institute (EPRI) Steam Turbine Generator Workshop and Vendor Exhibition

Industry Involvement

- Estimated 2009 funding: \$0.7

Program Technical Lead

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Summary of Projects

Project Number	Project Title	Value
	NSTI O&M Cost Reduction (supplemental)	These project activities include generation of guideline documents to address outage planning, disposition of damaged components, repair techniques, corrective actions, and specific maintenance practices. Other issues addressed under this area include preventive maintenance guides, optimized generator rotor maintenance, exciter maintenance, and retrofit/replacement. For additional details on specific projects produced in this area of the Turbine Generator (T-G) program, refer to P41.06.30.01 project description.
	NSTI Information & Training (supplemental)	One of the most effective ways for plants to reduce operating cost is by applying the lessons others have learned in addressing common reliability and maintenance issues. This is be accomplished by helping program participants share up-to-date information, including industry experiences, data, and turbine-generator problems for common equipment. Participation in the Turbine-Generator User Group, the T-G Technology Transfer workshops, and the Steam Turbine-Generator Workshop, and Vendor Expositions are direct benefits of this project. For additional details on specific projects produced in this area of the T-G program, refer to P41.06.30.04 project description.
	NSTI Risk Management (supplemental)	Risk assessment is an increasingly important aspect of both short- and long-term planning. This project provides emerging technology to assist program participants with turbine-generator condition assessment and component failure risk assessment on components such as turbine blading/rotors and generator capability and monitoring (North American Electric Reliability Council [NERC] standards). Managing risk requires a combination of advanced inspection techniques, new nondestructive evaluation (NDE) technology that reduces inspection time and increases accuracy, analytical tools to address component cracking, and corrosion degradation modeling, particularly in the phase transition zone (PTZ). For additional details on specific projects produced in this area of the T-G program, refer to the P41.06.30.02 project description.

Project Number	Project Title	Value
	NSTI Turbine Performance (supplemental)	Power uprates have been completed on several nuclear plants and are now being performed on key baseload fossil plants, as well. This project assists power producers by developing steam path performance assessment tools (such as the Flowpath Analysis for Steam Turbine [FAST] software program that allows users to validate current unit performance on a stage-by-stage basis or better quantify proposed steam path modifications or replacements). These tools are used for identification of recoverable steam path or cycle losses and decision-analysis guidelines for assessing potential upgrade options that can enhance the effectiveness of plant performance engineering staff. For additional details on specific projects produced in this area of the T-G program, refer to P41.06.30.03 project description.

Project Descriptions

NSTI O&M Cost Reduction (supplemental) (065824)

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 introduced another challenge to meeting industry goals for equipment availability in the current competitive environment.

Description

This project reduces operation and maintenance costs through the following research activities:

- Guidelines for turbine-generator outage planning, disposition of damaged components, repair techniques, corrective actions, and specific maintenance practices
- Analysis of the effects of flexible operation and unit upgrades/uprates
- Preventive maintenance guides for inclusion in the EPRI Preventive Maintenance Basis Database
- Techniques for optimizing generator rotor maintenance, exciter maintenance, and retrofit/replacement

Value

- Reduce outage duration
- Increase outage intervals
- Improve component repair practices
- Improve turbine-generator preventive and predictive maintenance practices

How to Apply Results

Members directly apply repair procedures to improve equipment maintenance and use specifications and guidance to improve equipment purchase and procurement.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Foam Cleaning of Valve Internals to Remove Oxide Buildup: This product 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.	12/31/2009	Technical Report
Guidelines for Reducing the Time and Cost of Turbine Generator Maintenance and Overhauls: Continue updating the seven-volume set of guidelines first generated in 1999 and updated each year since. New material will focus on turbine-generator centerline components, with an emphasis on maintenance, repair, and procurement processes that take place before, during, and after an outage. The overall objective of these guidelines 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.	3/31/2010	Assembled Package
Turbine Generator Auxiliary System Maintenance Guide- Volume 5 The <i>Turbine-Generator Auxiliary Systems Maintenance Guide</i> continues the effort initiated in 2005 by focusing on non-centerline components that support turbine and generator operation. EPRI released the <i>Lubrication System Maintenance Guide</i> in 2005, 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 member feedback, this next guide will focus on the turbine emergency trip systems.	12/31/2009	Technical Report
EHC Fluid On-line Monitoring Demonstration Study: This project will evaluate the ability of the existing FS-3 lubrication system on-line analyzer to evaluate the condition of electrohydraulic control (EHC) fluid in an on-line condition. After installation of this monitor on an EHC fluid system and over a period of several months, the FS-3 analyzer will measure important EHC fluid parameters on a host plant's EHC system. These results will be compared to laboratory analysis of the same fluids.	12/31/2009	Technical Report
International Turbine Valve Condition Assessment: The EPRI <i>Guidelines and Procedures for Turbine Valve Condition Assessments</i> released in 2004 provided maintenance guidance for General Electric and Siemens Westinghouse manufactured valves. This project will extend this guidance to additional valve manufacturers including Alstom, Hitachi, Mitsubishi, and Toshiba. The guidelines include detailed instruction on valve component inspection and assessment criteria during disassembly and specifications for proper valve reassembly clearances.	12/31/2009	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Turbine Valve Actuator Condition Assessment for International Steam Valves: The 2009 maintenance guide on steam turbine valves manufactured by Alstom, Hitachi, Mitsubishi, and Toshiba will be extended to cover the actuators.	2010	Technical Report

NSTI Information & Training (supplemental) (065825)

Issue

Implementation of EPRI materials and products in member plants is often challenged by decreasing staff levels and loss of expertise. An estimated 30% of the U.S. nuclear workforce will be eligible to retire in the next five years. With the skilled workforce leaving, new employees need a much faster, efficient method to gain knowledge of plant equipment and the problems and issues associated with operating and maintaining equipment.

Description

This project adapts the lessons learned from addressing common reliability and maintenance issues to reduce plant operating cost. This project enables members to share up-to-date information, including industry experiences, data, and turbine-generator problems for common equipment. Participation in the Turbine Generator User Group (TGUG), the Turbine-Generator Technology Transfer workshops, and the Steam Turbine Generator Workshop and Vendor Expositions educate plant engineering staffs about resources available through EPRI and the industry that can help solve operating and maintenance problems.

Value

- Increase turbine-generator staff expertise
- Apply lessons learned from other plants
- Remain aware of emergent issues
- Establish and maintain direct contact with industry peers, turbine-generator manufacturers, and vendors

How to Apply Results

Members apply results and lessons learned acquired by attending the EPRI Turbine-Generator Technology Transfer Workshop, the Steam Turbine Generator Workshop and Vendor Exposition, and the Winter/Summer Turbine-Generator User Group meetings.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
11th Steam Turbine Generator Workshop and Vendor Expositions: EPRI will continue the 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 manufacturers.	12/31/2009	Technical Resource
Turbine Generator User Group (TGUG): The Turbine-Generator User Group meets twice a year and assists members in gathering up-to-date information, including industry experiences, data, and issues associated with all types of turbine-generators manufactured worldwide.	12/31/2009	Technical Resource

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
6th EPRI T-G Technology Transfer Workshop: In 2010, the 6th EPRI Turbine-Generator Technology Transfer Workshop will focus on how nuclear plants can implement various EPRI turbine-generator products.	2010	Workshop, Training, or Conference

NSTI Risk Management (supplemental) (065826)

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) technology that reduces inspection time and increases accuracy, analytical tools to address component cracking, and corrosion degradation modeling.

Description

This project provides emerging technology to assist members with the following:

- Decisions affecting run/repair/replace, plant life extension, life-cycle management, and optimal use of capital resources
- Turbine-generator condition assessment and component failure risk assessment
- Risk assessment information (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
- Nondestructive evaluation of turbine-generator components, condition assessment, and remaining-life assessment
- Advanced modeling of corrosion-assisted cracking, including delivery of corrosion cracking computer program

Value

- Assess risk with plant turbine-generator upgrades and maintenance
- Investigate emerging technology for assessing turbine-generator condition and component failure risk

How to Apply Results

Members use project results to analyze and quantify the risks associated with component failure, replacement, upgrades, and uprates, as well as quantify other risks from the system to the turbine-generator.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
<p>Mitigating Actions During Major Turbine-Generator Events: Several major failures of turbine-generator equipment have occurred over the last few years, including catastrophic fires due to failed buckets, generator rotor cracks, generator explosions due to hydrogen gassing, transformers fires/failures, and torsional vibration causing significant unit damage. The project will identify the actions needed after an unscheduled major and/or catastrophic turbine-generator failure. Actions include mitigating environmental concerns or impacts, required regulatory actions/notifications, damaging effects on supporting plant equipment, and the first-responder-type actions needed by plant personnel. Past events will be reviewed to examine how utilities have responded to events and the lessons learned. Lastly, EPRI will seek input from insurers on the subject of event response.</p>	12/31/2009	Technical Report

Product Title & Description	Planned Completion Date	Product Type
<p>Implantation of Cracks in Blade Attachment Mockups: EPRI maintains a variety of mockups for evaluation of nondestructive inspection systems and personnel. The tangential entry disk blade attachment mockups currently contain electro-discharge-machined 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 and more effectively represent typical in-service flaws found in the attachment area. The improved mockups would be valuable for evaluating nondestructive inspection systems and personnel.</p>	12/31/2009	Technical Report
<p>Turbine Blade Vibration Monitoring: Blade vibration monitoring (BVM) on low-pressure rotors provides continuous blade monitoring and early indication of blade cracking or conditions contributing to blade cracking (high-cycle fatigue, low-cycle fatigue, stress corrosion cracking). BVM can potentially enable operators to expand operational range based on unit-specific real-time data as opposed to using generic limits. This project would require measurement of candidate units during an outage in preparation for hardware installation on a pilot unit. After completing a computer model of the unit and installing the needed instrumentation, "off-design" runs of the unit will be needed to identify safe limits for blade vibration.</p>	12/31/2009	Technical Report
<p>Non- Invasive Methods to Validate NERC Standards: Steam Turbine Frequency Response: EPRI's Power Plant Parameter Derivation (PPPD) software allows engineers to derive parameters for standard generator and exciter models, as well as for combustion turbine governor models. This project will extend the PPPD software to calculate steam turbine parameters from system disturbances (for example, 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. These currents can severely damage the rotor. The objective of the project is to provide software that will allow the plant to assess the risk of damage following an incident and to decide whether or not 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 with the expectation to detect symptoms of developing problems. The probability of identifying the problem correctly and in time to act can be enhanced by integrating the output of the monitors. This project will provide logic rules to combine the output of continuously monitored flux probes, shaft voltage monitors, rotor ground detectors, and generator vibration.</p>	2010	Technical Report

NSTI Turbine Performance (supplemental)

Issue

Maintaining or enhancing thermal performance of plant equipment is a cost-effective means of improving a power producer's financial operation and meeting increased power demand without new construction. Accurately assessing the actual improvement and measuring thermal performance gains is difficult.

Description

This project assists power producers in developing performance assessment tools. These tools are used for identifying recoverable steam path or cycle losses and developing decision-analysis guidelines for assessing potential 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

Members use improved heat rate and objective information to assist in procurement of replacement components and assessing changes to steam path to evaluate actual increases in efficiency.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Steam Deposit Effect on Thermal Performance: Steam path deposits adversely affect turbine efficiency. Several species are often involved, with different actions required to reduce rate of deposition or removal. This project will review deposition processes and sources, the methods for species identification from turbine scraping, and cost-effective approaches for remedial action.	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 the particular deposit having the greatest effect on performance.	2010	Technical Report