Steam Turbines-Generators and Auxiliary Systems - Program 65

Program Overview

Program Description

Because up to 70% of outages planned for steam power plants involve work on the turbine, power producers continually seek ways to optimize operation and maintenance activities on aging turbine-generator fleets. Such activities can reduce maintenance costs, improve component reliability, and increase generator output. Maintaining a detailed awareness of effective maintenance techniques, however, is challenged by evolving operating experience, advanced materials and upgrade options, reduced staffing levels, and the retirement of experienced personnel.

The Electric Power Research Institute's (EPRI's) Steam Turbines-Generators and Auxiliary Systems program (Program 65) develops technologies and guidelines that help plant operators optimize steam turbine and generator equipment life cycles to increase availability, shorten scheduled maintenance outages, and improve steam turbine performance. Research and technical support activities enable power plants to reduce operation and maintenance costs, maximize plant performance, and more effectively implement plant upgrades and asset management strategies.

Program 65 has been fully integrated with the EPRI Nuclear Steam Turbine Initiative (NSTI) since 2000. This leveraging has increased the value of each program to its respective members, as well as provided the benefit of increased information exchange between Fossil and Nuclear sectors in areas of common interest. In 2010, the combined R&D from both fossil and nuclear units will continue, but now it will be made available to members of both sectors under Program 65. Past NSTI members can continue their involvement in EPRI's T-G R&D through membership in Program 65.

Research Value

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. Research results inform utility decisions regarding run/repair/replace and provide detailed guidance for planning and performing critical overhaul and maintenance activities.

- 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

Approach

The program portfolio includes generating guidelines; analyses of the effects of flexible operation and unit upgrades and uprates; preventive maintenance (PM) guides; guidance on maintenance and repair optimization; risk assessment and advanced modeling technologies; performance assessment tools; and information exchanges, including reports, workshops and users groups.

- 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 EPRI Steam Turbine Generator Workshop and Vendor Exhibition, and other workshops offered by the program.

Many utilities begin their participation in Program 65's R&D by joining the Turbine Generator Users Group (TGUG), a forum for sharing technical expertise among utilities and the six major T-G OEMs worldwide. TGUG is offered as a supplemental project in Program 65.

Accomplishments

EPRI's Turbine-Generator program is recognized in the electric utility industry as the authoritative source for up-to-date information on T-G issues and solutions in today's competitive environment. When utilities have uprated/upgraded existing units, performed unit scheduled or forced outages, evaluated component conditions and associated operational risks, or educated current T-G staff, these products have provided invaluable information and assistance:

- 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 torsional vibration detection and mitigation
- T-G equipment and component repair and purchase specifications
- NERC regulation education and TG capability validation assistance
- T-G nondestructive evaluation (NDE) testing and application guidance
- Regular interaction with all major turbine and generator OEMs worldwide

A free, downloadable comprehensive list of more than 200+ past project deliverables from this TG program is available on EPRI web under product ID 1016900.

Current Year Activities

The program R&D for 2010 will focus on operation and maintenance costs reduction, unit and component risk management, turbine thermal performance, and the education of utility plant staff through workshops, seminars, and webcasts. Specific efforts will include:

- Continued additions to the *Guidelines for Reducing Time/Cost of TG Maintenance and Overhauls* CD set
- Completing the *Turbine Generator Auxiliary System Maintenance Guide: Vol. 6* Guide
- PM Database Module Additions
- Completing *International Turbine Valve Condition Assessment Guide*
- Completing *International Turbine Valve Actuator Condition Assessment Guide*
- Completing a SAFER-PC CBT Module
- Continuing further development of the Fatigue Reference Specimen testing and evaluation
- Completing the *Stator Winding Insulation Condition Assessment using DC Hipot Ramp Test* Guide

- Completing *Validity of 0.1 Hz Stator Winding Hipot Test Guide*
- Completing a LP Rimlife CBT Module
- Completing a *Turbine Performance Engineer Guideline*
- Conducting two Turbine Generator User Group (TGUG) meetings with the associated winter workshop
- Conducting the Sixth Technology Transfer Workshop
- Conducting NERC Interest Group meetings as needed

Estimated 2010 Program Funding

$5.0M

Program Manager

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Summary of Projects

Project Number	Project Title	Description
P65.001	Operations and Maintenance Cost Reduction	This project develops guideline documents for condition assessments, outage planning, replacements, disposition of damaged components, repair techniques, corrective actions, and specific maintenance practices for turbine generators and their auxiliary systems.
P65.002	Risk Management	This project provides emerging technologies for turbine-generator condition and component failure risk assessments. Risk assessment technology produces failure probability data that can be combined with maintenance and replacement power costs to assess financial risk.
P65.003	Steam Turbine Performance	This project continues to produce software for analyzing internal flow and efficiency in steam turbine sections, and to develop guideline documents for effective use of online condition monitoring to improve turbine cycle heat rate.
P65.004	Information Exchange for Plant Staff	Participation in this project's workshops and meetings allows utility personnel to quickly determine the most appropriate repair techniques, identify current industry experience and best practices in improving the reliability and availability of the unit, and transfer the technology developed by the overall TG program into their TG maintenance practices systemwide.

P65.001 Operations and Maintenance Cost Reduction (052070)

Key Research Question

Power producers continually seek ways to optimize operation and maintenance activities in 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.

Approach

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

- Developing 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

Impact

- 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 documents produced and PM modules added to the PM database can be used when a utility is faced with equipment repair or testing or component condition assessment. Members can integrate the content in these guidelines in 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.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Non-Contact LVDT: This report will highlight the demonstration of magnetostrictive sensors for measuring turbine valve position.	12/31/10	Technical Update
Turbine Valve Condition Assessment for International Steam Valves: This report will cover the condition assessment criteria for the international members' steam turbine valves.	12/31/10	Technical Report
Lessons Learned from TG Upgrades/Uprates using non-OEM Components: This research will highlight industry findings from retrofits and uprates of turbine generator major equipment components, including root cause analysis findings from failures, along with interviews from plant management personnel and utility corporate systems managers / engineers. All of the major equipment manufacturers and aftermarket equipment retrofit suppliers will be contacted for input.	12/31/10	Technical Report
Validity of 0.1 Hz Stator Winding Hipot Test : New generator and motor stator windings are Hipot-tested in the factory with AC. Maintenance testing at the plant usually is performed with equivalent DC voltage because of significantly smaller test equipment size/expense. Very-low-frequency (VLF) 0.1 Hz testing is being used routinely on installed cables. VLF test sets are small, inexpensive, and readily available. This project will document VLF testing user experiences and provide scientific data to define the ratio between 60 and 0.1 Hz test levels for generator winding.	12/31/10	Technical Report
Guidelines for Reducing Time/Cost of TG Maintenance and Overhauls: This project 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 repair/ replacement strategies and techniques during the outage.	12/31/10	Assembled Package

Product Title & Description	Planned Completion Date	Product Type
Turbine Generator Auxiliary System Maintenance Guide- Vol. 6: The existing five volumes of the Auxiliary System Maintenance Guides include Lube Oil System, Steam Seal System, Generator Hydrogen Gas System, Generator Stator Cooling System, and Assuming Emergency Trip System. Volume 6 will address the turbine generator turning gears and the systems around them, such as the oil system. This addition to the ASM Guides will expand the reference information available to EPRI members.	12/31/10	Technical Report
PM Database Module Additions: The Preventive Maintenance Basis Database (PMBD) serves the utility maintenance community as an essential reference for maintenance strategy task selection on common major components. The PM Basis Database software, Version 2.0 [Product ID: 1014971], is the most comprehensive effort undertaken to date to establish credible preventive maintenance (PM) recommendations and their supporting basis for the utility industry. To date, over 145 modules exist in the database with several T-G modules to be added in 2010. PM modules will continue to be added, as appropriate, to the PM Basis database from completed TG projects.	12/31/10	Software
Turbine Valve Actuator Condition Assessment for International Steam Valves: A guide to the international manufactured steam turbine valves will be completed in 2009. This follow-up volume to cover actuators of internationally manufactured valves is planned for 2010. The valves include those produced by Alstom, Hitachi, Mitsubishi, and Toshiba.	12/31/10	Technical Report

P65.002 Risk Management (052072)

Key Research Question

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.

Approach

This project provides emerging technologies for:

- Guidance in run/repair/replace decisions, 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
- 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 prevention guide

Impact

- 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 such as those contained in the Turbine Blade Vibration Monitoring report. Access to improved inspection mockups allows members to more confidently evaluate nondestructive inspection systems and personnel.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Risk assessment of generator rotor damage following operation under electrically unbalanced condition: With increasing demand on the electrical grid, plant operators need to be aware of interaction of the grid with the turbine generator. Unsymmetrical electrical faults in the transmission system, a stuck circuit breaker pole, accidentally connecting the generator to the grid when at standstill, or losing excitation at speed can cause the generator rotor surface to overheat. EPRI developed a program in 2009 to quickly assess the risk of allowing the unit to operate after such incidents. The objectives of the project are to validate the software and implement any changes needed based on field experience.	12/31/10	Software
SAFER-PC CBT Module: A computer-based training (CBT) course may be delivered via a software product installed on a single computer or through a corporate intranet. CBT can be used to teach almost any conceivable subject, but it is especially popular for computer-related studies. Utility users will be able to take advantage of CBT to learn how to run SAFER-PC, a software analysis program for determination of rotor remaining life that supports operations and asset management. SAFER-PC training sessions offered by EPRI are effective in providing detailed instruction for new users and for familiarizing licensees and utility users with new features of program upgrades. Development of SAFER-PC CBT will allow greater access to SAFER-PC training.	12/31/10	Software
Quantification of Fatigue Sensor Technology for 12 CR Steam Turbine Blades: Steam turbine blade failures are a common reason for unplanned outages. The damage associated with failure of large, low-pressure blades can be extensive and costly. Many nondestructive inspection methods and technologies exist to detect cracking that already has occurred. However, standard nondestructive inspection technologies are not able to predict cracking before it occurs. Fatigue sensor technology has been qualitatively proven as a technology for identification of fatigue damage accumulation and life consumption. This project will conduct quantitative benchmarking of this technology using 12 CR fatigue test specimens to provide a detailed quantification of the fatigue damage measurements and its uncertainty using existing technology. Results of this project will be applied to development of field inspection procedures using fatigue sensor technology.	12/31/10	Technical Report
Generator On-Line Monitoring Using Enhanced EMI (Electromagnetic Interference): Condition assessment based on information from continuous online monitoring can prevent forced outages and reduce the amount of emergent work during scheduled outage. Foreign objects, loose current-carrying parts, compromised electrical insulations or connections in or around motors and electrical generators cause sparking that can be detected online and in a noninvasive manner by devices designed to measure/detect electromagnetic interference. Currently, the interpretation of EMI signature to detect the source of sparking requires great amount of experience, but Rensselaer Polytechnic Institute has developed an electromagnetic propagation model that can be used to separate the signal caused be	12/31/10	Technical Report

Product Title & Description	Planned Completion Date	Product Type
sparking defect from the overall EMI signature of the generator. The objective of the project is to validate the model (in 2010), and to develop a use-friendly software to model any large generator without the need for OEM design data (in 2011+).		
LPRimLife Software Upgrade: LPRimLife is a software analysis program for assessing the remaining life of low-pressure rotor rim attachments with known or suspected cracking. Originally developed in 2000, the LPRimLife software was upgraded to a Microsoft.net technology platform in 2009. This project proposes addition of increased functionality of the software, with upgrades that could include improved accuracy of K-solution for small cracks/threshold effects; elastic-plastic redistribution of elastic stresses to improve accuracy for small cracks; improved load redistribution algorithm to reduce conservatism; FEA overload failure simulations to identify reduce conservatism in failure load vs. crack size; and other user-suggested modifications.	12/31/10	Software
LPRimLife CBT Module: A computer-based training (CBT) course may be delivered via a software product installed on a single computer, or through a corporate intranet. CBT can be used to teach almost any conceivable subject, but it is especially popular for computer-related studies. Utility users will be able to take advantage of CBT to learn how to run LPRimLife, a software analysis program for assessing the remaining life of low-pressure rotor rim attachments with known or suspected cracking and, as such, supports operations and asset management. LPRimLife training sessions offered by EPRI are effective in providing detailed instruction for new users and for familiarizing licensees and utility users with new features of program upgrades. Development of LPRimLife CBT will allow greater access to LPRimLife training independent of formal training class sessions enabled by EPRI. This software project will be initiated in 2010 and scheduled for release 12/31/2011.	12/31/10	Software

P65.003 Steam Turbine Performance (052074)

Key Research Question

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.

Approach

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.

Impact

- 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 to 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.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Turbine Performance Engineer Guideline: Problems involving the maintenance and upgrading of turbines, either from issues such as stress corrosion cracking or life expectancy, create a performance risk assessment and management issue that needs to be met by the plant engineers. Historically the OEMs have created contract language around the turbine generator performance to alleviate the risk from them and sometimes create bonuses at project end. The modern turbine generator performance engineer needs a reference to understand these issues. EPRI's Turbine Performance Engineer Guidelines will compile knowledge from current performance engineers to make performance information available.	12/31/10	Technical Report

P65.004 Information Exchange for Plant Staff (052076)

Key Research Question

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.

Approach

One of the most effective ways for plants to reduce operating cost is to apply the lessons that 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.

Impact

- 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. These results are delivered in the form of services, meeting notes, and web-based information with a focus on current industry information relating to steam turbine generator reliability, failure mechanisms, corrective action, and OEM guidance.

Two opportunities to attend EPRI-sponsored events to share lessons learned with other utilities and stay abreast of technologies include:

- 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

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Conduct two Turbine Generator User Group (TGUG) meetings with the associated winter workshop: The traditional two meetings per year in the United States will continue in 2010. The January 2010 TGUG workshop and meeting will be held in Williamsburg, Virginia (to include a tour of the nearby Alstom repair facility in Richmond, Virginia) the week of January 18, and the summer TGUG meeting (held in conjunction with the Sixth Tech Transfer workshop) will be held August 11-13 in Milwaukee, Wisconsin. The TGUG will also hold its second Australian workshop and meeting in the summer of 2010 (location and date TBD).	12/31/10	Workshop, Training, or Conference
Conduct NERC Interest Group Meetings as Needed	12/31/10	Workshop, Training, or Conference
Sixth EPRI T-G Program 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.	12/31/10	Workshop, Training, or Conference

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Non-Intrusive Methods to Validate NERC Standards: Lessons learned	12/31/11	Technical Report