EPRI ELECTRIC POWER RESEARCH INSTITUTE

2017 Research Portfolio

P65 - Steam Turbines-Generators and Auxiliary Systems

Program Description

The power generation industry today requires strategies for maintaining turbine-generator system availability. This requires a focus not only on maintenance outage planning and execution, but on mitigating risk of unplanned outages as well. EPRI's research program addresses the changing needs as the coal and gas fleet adapts to an evolving mission profile.

The EPRI's Steam Turbines-Generators and Auxiliary Systems program (Program 65) supports continuous improvement in the safety and availability of steam turbines, generators, and auxiliary systems. It supports all aspects of turbine-generator component life-cycle management. This support is accomplished through applied research in component life management, preventive maintenance, condition assessment, advanced monitoring, and control systems.

The program fosters collaboration among all industry stakeholders to support proactive strategies and best-practice sharing to solve industry reliability issues. The ongoing research and technology transfer activities fully support the needs of member organizations seeking to improve knowledge and effectiveness of turbine-generator system engineers.

Research Value

Using an integrated approach that incorporates work from related EPRI programs and industry input from user groups, this program focuses on reducing operations and maintenance (O&M) costs, managing risk, providing technical support for plant staff, and producing information to support upgrade studies and asset management strategies. Research results inform run/repair/replace decisions and provide detailed guidance for planning and performing critical overhaul and maintenance activities.

By participating in this program, plant operators obtain information that they can use to:

- Reduce maintenance costs
- Maintain high asset availability
- Take proactive measures to lower operating risks
- Extend component life
- Increase staff technical expertise and awareness of industry issues

Involvement in the program can help:

- Educate participants about turbine-generator (T-G) issues and solutions
- Provide opportunities to share information with industry experts, engineers, major T-G original equipment manufacturers (OEMs), and vendor/service providers worldwide

This program improves the reliability and availability of steam turbines and generators, key drivers of overall plant performance for all asset types. It is essential for plant viability, and therefore bulk power availability, to cost-effectively maintain and operate large steam turbine generators. Safety of the power plant environment is also dependent of effective management of component failure risk, which is an element of this program.

Approach

This program produces a range of deliverables including published guidelines, software, web applications, specialized sensors, and technical meetings/webcasts. Specific project selection is based on periodic advisor input and issue prioritization. The portfolio addresses current areas of need such as flexible operations, risk

management, component upgrades, nondestructive examination, condition monitoring technologies, preventive maintenance (PM) guides, and repair strategies. Project advisory groups are involved in project scope creation, draft report reviews, and sharing of research implementation best-practices. The Turbine-Generator Users Group (TGUG), included with Program 65 membership, provides an effective forum for sharing emerging issues and research implementation experiences, as well as guiding further EPRI research in key areas. In addition, program members have access to recorded technical webcasts, an annual newsletter, and a catalog of past research abstracts. These documents allow members to easily disseminate the latest knowledge to key staff at the main office and plants.

Many members begin their participation in Program 65 research through regular participation in the TGUG biannual meetings. These meetings are member-run forums for sharing technical knowledge, awareness of emerging reliability issues, and O&M best-practices among turbine-generator system engineers. The group also provides a structured forum for engaging the major turbine-generator equipment manufacturers worldwide. Program members also are eligible to attend the workshops associated with the biannual group meetings.

Potential projects for the following year's R&D portfolio are discussed and prioritized with the program member advisors during the program advisory meetings held twice yearly. Roundtable discussions held at the advisory meetings, as well as the TGUG, provide opportunities for EPRI's collaborative R&D to immediately address emerging issues that broadly affect the industry.

Accomplishments

EPRI’s Steam Turbines-Generators and Auxiliary Systems program is recognized in the power industry as an authoritative source for up-to-date information on turbine-generator issues and solutions. Several documents, many updated periodically, have become guiding resources for the industry. These resources are increasingly important in training and educating new staff. EPRI has created a successful process for continual dialogue among all industry stakeholders, including commercial suppliers, that focuses on key technical issues and resolutions. Some key specific accomplishments of the program include:

- Guidelines for reducing the time and cost of turbine-generator maintenance overhauls and inspections
- Maintenance to address damage mechanisms specific to combined-cycle generators
- Comprehensive guidelines for maintenance of electrohydraulic control (EHC) system fluid
- Maintenance guides covering seven key turbine-generator auxiliary systems
- Series of reports covering emerging technologies and procedures for assessing the health of generator insulation through monitoring
- Guidelines for maintaining generator stator water cooling systems
- Technical information to guide management of lubrication oil, lubrication systems, and journal bearings
- Over 50 recorded webcast tutorials covering all aspects of turbine generator reliability
- Comprehensive guidelines for troubleshooting turbine steam path damage, published in detailed reports as well as handbook formats
- Turbine-generator equipment and component repair and purchase specifications
- Web application for support of fluid film bearing run-replace decisions, Turbine-generator component nondestructive evaluation (NDE) testing and application guidance
- Shaft torsional vibration measurement system demonstrated in commercial plants
- Searchable compilation of over 1000 past TGUG meeting technical presentations as a resource for solving current turbine-generator issues.

Key Activities

The program R&D for 2017 will focus on component risk management, condition monitoring, plant operation changes due to flexible operation, and the education of utility plant staff through workshops, seminars, and webcasts. Specific efforts will include:

- Assisting in flexible operation of coal assets through research on alternative layup protection strategies
- Outage intervals of generators under flexible operation Lab demonstration of turbine valve and actuator online condition monitoring technology
- Web-based resource to support members' turbine-generator risk management programs
- Shaft voltage/current monitoring to assess generator stator core condition
- Electrohydraulic control system preventive maintenance
- NDE of stress corrosion cracking in pinned-finger blade dovetails
- Turbine-Generator User Group meetings and technical webcast series

Estimated 2017 Program Funding

$5.75M

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Summary of Projects

Operation & Maintenance

Electrohydraulic Control System Owner's Guide

The electrohydraulic control system (EHC) supplies high pressure fluid to control operation of the steam turbine valves. These valves are critical to protecting the steam turbine against overspeed events as well a regulating steam flow to match unit output demands. The EHC system function is to maintain proper fluid purity and regulate pressure. There is a need for a comprehensive guide for plant engineers responsible for the EHC system. The guide should describe system operation, a preventive maintenance regime, troubleshooting tips, and advances in technology.

Guidelines for Reducing the Time and Cost of Turbine-Generator Maintenance Overhauls and Inspections: 2017

Steam turbine generator outages are often critical path and therefore a major factor in asset availability. Outage performance is achieved with proper planning, procurement, execution, and close-out. There is a need for a comprehensive industry resource that can educate and guide system owners through the entire outage process with best practices, work templates, and sample specifications. Common tasks such as balancing and alignment can consume time during the outage. There is a need for information and tools that ensure these tasks take the minimum time required at the end of the overhaul.

Operator Training Modules for Decisions Following Unusual Generator Events

Unusual events such as stator core over fluxing, synchronization out of phase, loss of cooling water to hydrogen coolers, loss of excitation etc., can inflict significant damage and accelerate the aging process.

Anecdotal evidence shows the industry experiences inadvertent energizing of the generator at standstill with significant rotor damage about every 24 month. Similarly, generator core over fluxing that may require partial core lamination replacement occurs about every 3 years. These incidents are caused by equipment failure but often made worse by human error.

Since these events occur infrequently, the operator may not have prior experience to recognize the event and act to limit the consequential damage.

Outage Intervals for Generators used in Flexible Operations

Most generators that are in service today were not specifically designed for weekly or daily shut downs. In addition, wide-spread use of renewable generation requires fast loading of conventional assets.

The generator rotor and stator will experience frequent copper winding expansion, mechanical and thermal stresses, accelerated aging and low cycle fatigue for rotor components such as the “J strap”. The effect of this on condition of each generator depends on design, vintage, past operating duty and maintenance.

Equivalent Operating Hours (EOH) calculations are often used to determine inspection intervals. An example is the VGB Guideline R 167 “Overhaul recommendations for turbo-generators”. The weighting factors used to multiply the operating hours, number of starts/stops, hours on turning gear, active and reactive power, and operating duty have been agreed upon by various original equipment manufacturers, however, the guideline does not provide technical basis for these weighing factors.

There is a need to develop a process for determining inspection intervals that are plant-and machine-specific.

Shaft Voltage/Current Monitoring for Generator Condition Assessment

U.S. power plans experience a generator core meltdown about every five years. This catastrophic failure occurs without warning and the root-cause investigation is hampered by destruction of the evidence.

The stator core can be damaged during an outage. During operation vibration of loose core lamination, foreign object impact cause deterioration of core lamination insulation, which results in electrical currents circulating through the core material, causing it to severely overheat and melt.

Generator condition monitors (GCM) provide strong indicators of severe overheating of the core insulation. The indication of overheating does not prevent the core damage, but it can limit the consequential damage and identify dangerous operating ranges. The industry needs an earlier indication of core health degradation to reduce the risk of a costly catastrophic failure.

Turbine Generator Asset Management Benchmarking Process Development

There is a continual need for a framework for conducting self-assessment of asset management practices relative to critical power plant equipment. This self-assessment would ideally allow companies to benchmark their practices against a broad range of peer organizations, as well as against other standards to manage reliability. This framework will provide justification for increasing spending on O&M, or point out areas where costs could be reasonably reduced without compromising reliability. There needs to be a strong focus on application of new technology to assist in asset management cost reduction.

Turbine-Generator Fluid Forum

Issues with properly maintaining lubrication oil and electrohydraulic control (EHC) fluid properties to minimize forced outage rates continue to challenge the industry. Many of these problems arise from changes made by the fluid supplier that are not fully tested in a real operating environment. Other issues are due to poor O&M practices that lead to fluid degradation. Troubleshooting the resulting real-world fluid problems requires specific knowledge and experience. There is a need for documented case studies of real plant fluid degradation issues to guide the industry in reducing unavailability.

Turbine Generator Preventive Maintenance Database Templates

Preventive Maintenance (PM) program cost reductions are being imposed across the industry. There is a need for these reductions to be made without significantly compromising the risk of future component failures. Preventive maintenance effectiveness can be improved using the process built into the EPRI Preventive Maintenance Database (PMDB). For EPRI members to realize the benefits of PMBD applied to steam turbine generator components, templates must be developed to embed in the PMBD.

Risk Management

Bearing Action Advisor (BAA) Decision Support Tool

There is need for a technical basis to support the run-replace decision that follows discovery of damage to the pad surfaces of fluid-film bearings during inspections. In previous years of activity in this project, Version 1.0 of the Bearing Action Advisor (BAA) web application was developed and made available for use by EPRI members. This web application allows the user to define basic parameters of fluid-film bearings. These bearing types include cylindrical or bumper thrust. With the parameters, the user can also provide input

on observed damage. The BAA tool then calculates the load-carrying capacity and risk associated with a decision to keep the pad in service.

In 2017, Version 1.0 of the BAA will be updated to Version 2.0, which will include tilt-pad bearing types. There will be a need following this release to promote use of the new software and support individual member applications. From this activity, enhancements to the tools can be defined for future releases.

On-line Turbine Valve Health Monitoring

There is an industry need for improved condition-based maintenance of hydraulically-actuated steam valves used for turbine applications. The current time-based approach to scheduling overhaul intervals is, in many cases, conservative and results in increased maintenance costs. It is also possible that increased time-based intervals would fail to observe valve condition degradation, resulting in costly unplanned maintenance.

This multi-year project will examine the technical feasibility of incorporating on-line valve condition monitoring, with a focus on the major component degradation mechanisms inherent to the valve and actuator. The research will focus on the use of existing sensors, or new, commercially-available sensors that can be cost-effectively deployed on stop and control valves. New methods for analyzing the valve control signals as a way to detect emerging degradation will also be researched. The overall result of the EPRI research will be an assessment of the technology needs, costs, and impacts to the plant of widespread deployment of on-line valve condition monitoring. Follow-on work involving prototype system installation at a host plant would be considered based on the findings of this research.

Turbine-Generator Risk Management Resource

Risk is increasingly used as the basis for decisions by plant asset owners who are seeking to lower O&M costs without compromising availability. System owners need easy access to up-to-date information that informs risk evaluation and mitigation. In addition, there is a need to efficiently communicate this risk in a form that is understood by a range of stakeholders.

In 2014-15, EPRI has responded to this need for steam turbines and generators by developing the concept for a Turbine Generator Risk Management Resource (TGRMR). This web application is a structured, searchable repository for technical information as well as operational experience collected by EPRI that relates to turbine generator risk. This work culminated in the Version 1.0 production release of TGRMR during 2016.