

Water Chemistry

Program Overview

Program Description

The Water Chemistry Program develops and updates water chemistry guidelines for nuclear reactors based on industry research and plant experience. The program also develops water chemistry optimization tools to mitigate corrosion, achieve and maintain design fuel performance standards, and minimize plant radiation fields.

Industry Needs and Issues Addressed

- Improved understanding of water chemistry impacts on nuclear plant performance and related impacts on equipment and systems
- Scientifically and technically based water chemistry guidelines to minimize operational risks to plant materials, maintain design fuel performance standards, and mitigate plant radiation fields
- First-of-a-kind technology demonstrations targeting improved water chemistry control
- Software tools that can accurately and cost-effectively monitor and assess water chemistry

Impact

- Improved plant availability and safety through cost-efficient chemistry optimization
- Validation of new chemistry applications through first-of-a-kind technology demonstrations
- Software-enabled improvements in chemistry control, diagnostic capabilities, and staff productivity
- Enhanced technology transfer through plant-specific collaborations

Key Accomplishments

- Regular revisions to water chemistry guidelines: *Pressurized Water Reactor Primary Water Chemistry Guidelines*, *Pressurized Water Reactor Secondary Water Chemistry Guidelines*, *Boiling Water Reactor Water Chemistry Guidelines*
- First-of-a-kind plant demonstrations of dispersant application to mitigate steam generator fouling and of zinc injection to mitigate stress corrosion cracking and reduce radiation fields
- Regular updates to scope, functionality, and technical content of ChemWorks and SMART ChemWorks software tools to optimize water chemistry
- Close collaboration with nuclear plant personnel through users groups to drive continuous water chemistry improvements

Current Year Objectives

- Review of pressurized water reactor primary water chemistry guidelines to evaluate gaps related to industry initiatives (Nuclear Energy Institute 97-06 and 03-08)
- Evaluation of dispersant application during startup to reduce corrosion product transport to the steam generator
- Evaluation of septa and precoat media for iron transport control in boiling water reactors
- Boiling water and pressurized water reactor monitoring and assessment tools to benchmark the industry and to evaluate chemistry improvement opportunities
- Continued software updates to ChemWorks and SMART ChemWorks

Industry Involvement

- Estimated 2009 funding: \$3.2

Program Technical Lead

Keith Fruzzetti650-855-2211, kfruzzet@epri.com

Summary of Projects

Project Number	Project Title	Value
	Chemistry Guidelines	<i>The Water Chemistry Guidelines</i> are the program's key products, produced in collaboration with the Electric Power Research Institute (EPRI) issue programs, considering research together with plant and industry experience. Much of the work in this base-funded project involves technology developments needed to improve guidelines, including corrosion mitigation, water chemistry control methods, and improved monitoring techniques.
	First-of-a-kind Technology Demonstrations	This base-funded project develops and tests new chemistry additives, analysis methods, and new instrumentation and develops application guidance on how to efficiently utilize chemistry technologies.
	Software Development	This based-funded project enhances and develops the ChemWorks software, providing codes that the plant chemist and engineer can use to optimize water chemistry. These codes have been incorporated into the day-to-day duties of many plant chemists and also support industry initiatives.
	SMART chemWORKS Development	SMART ChemWorks is a real-time chemistry monitoring and advisory system that integrate ChemWorks with a plant's chemistry data management system (CDMS) and a real-time intelligence engine. This supplemental project encompasses the improvement of SMART ChemWorks functionality.
	Technology Demonstrations	This supplemental project evaluates the performance of advanced chemistry techniques through plant demonstrations by evaluating the most effective use of the technology. Members can draw on lessons learned for further, improved application.
	Chemistry User Groups and Specific Applications	This supplemental project covers chemistry user groups, including the ChemWorks User Group and the BWR Condensate Filter User Group. Assistance on specific applications of EPRI technology, funded by members, also is included in this project.
	Water Chemistry Guide	This supplemental project covers plant-specific application of chemistry tools and strategies, including chemistry evaluations and strategic chemistry planning.

Project Descriptions

Chemistry Guidelines (052415)

Issue

Improving water chemistry has contributed to a reduction in the frequency of transient fault conditions and an overall reduction in impurity concentrations. However, continued improvements are sought to optimize water chemistry and balance the resulting impacts and improvements on system materials corrosion, fuel performance, and radiation fields. In addition, advanced technology is needed to improve water chemistry control.

Description

The *Water Chemistry Guidelines* are the program's key products. They are produced in collaboration with the EPRI issue programs, based on ongoing research and plant and industry experience. Each guideline is a technical consensus document developed by industry experts to optimize water chemistry programs and control methods, thereby maximizing the long-term availability and safe operation of nuclear power plants. Guidelines are formally reviewed on a two-year cycle and revised on a four-year cycle. Much of the work involves technology developments needed to improve guidelines, including water chemistry control methods, improved monitoring techniques, and chemical additives to control corrosion.

Value

- Improved water chemistry technology to support corrosion mitigation, fuel performance, radiation management, water chemistry control methods, and improved monitoring techniques
- Optimization methods that nuclear plants can use to create strategic water chemistry plans customized for maximizing plant availability and cost-efficiency in a manner consistent with safety and regulatory requirements

How to Apply Results

Technology development and Water Chemistry Guidelines can be applied by members to implement improved monitoring techniques, as well as optimize strategic water chemistry plans. These products must be read, understood, and implemented by the chemistry community.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
PWR Primary Water Chemistry Guidelines, interim review for NEI 97-06 and NEI 03-08: This product is a biennial review of the <i>Primary Water Chemistry Guidelines</i>	12/31/2009	Technical Update
Dispersant use during Recirculation Loop Cleanup to Reduce Corrosion Product Transport to the Steam Generators during Startup: A comprehensive evaluation to assess the feasibility of cleanup application of dispersant during recirculation loop cleanup during startup. Evaluations will include review of three "typical" feedwater cleanup systems, laboratory testing, development of an application procedure, and generic qualification for a lead plant.	9/30/2009	Technical Report
BWR Startup and Shutdown Guidelines: This product provides guidance on startup and shutdown chemistry.	12/31/2009	Technical Update
Evaluation of Septa and Precoat Media for BWR Iron Transport Control: This program evaluates industry experience to provide recommendations for optimized condensate filter demineralizer performance for bottom and top tubesheet systems. As appropriate, alternate precoat media, iron injection, and non-precoated septa also are explored.	3/31/2009	Technical Report

Product Title & Description	Planned Completion Date	Product Type
PWR Activity Transport Characterization: This product evaluates existing and project-funded gamma scan data to improve understanding of plant effects (for example, steam generator replacement, zinc injection, and core duty changes) on nuclide generation and deposition.	12/31/2009	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
PWR Secondary Water Chemistry Guidelines, interim review for NEI 97-06 and NEI 03-08: Biennial review of the <i>PWR Secondary Water Chemistry Guidelines</i>	2010	Technical Update
BWR Water Chemistry Guidelines, interim review: Biennial review of the <i>BWR Water Chemistry Guidelines</i>	2010	Technical Update
PWR Dispersant Application for Steam Generator Wet Layup: Dispersant application during steam generator wet layup.	2010	Technical Report

First-of-a-kind Technology Demonstrations (052418)

Issue

Implementing new chemistry technology typically requires demonstration at a plant site under very controlled and monitored conditions, informed by EPRI expertise and management.

Description

The project develops and tests new chemistry additives, new analysis methods, new instrumentation, and application guidelines on how to efficiently utilize new chemistry technology. Field testing is an essential part of the development process, as many new developments would not be implemented without an initial plant demonstration.

Value

- Provides experience and plant data from the first demonstration of new technologies
- Industry application guidelines developed based on lessons learned for optimized application

How to Apply Results

Implementation of application guidance

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Capillary Electrophoresis for BWR Cation Analysis: Analytical methodologies will be established for cation analysis using laboratory instrumentation as follows: 1) document synthesis procedures for probes and capillary pre-treatment, 2) define operational and performance limits for cation analysis, and (3) define parameters as per anion work performed in 2008.	3/31/2009	Technical Update

Product Title & Description	Planned Completion Date	Product Type
Capillary Electrophoresis for BWRs: On-line Installation and Application: Installation and plant use of an in-line capillary electrophoresis system at a boiling water reactor plant. Materials, procedures, and methodology will be tailored for plant-specific use.	12/31/2009	Technical Report

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Assessment of Capillary Electrophoresis for PWRs – Analysis Report: Investigation of application of capillary electrophoresis to pressurized water reactors	2010	Technical Update
Field Evaluation of alternate precoat media for BWR iron reduction: Document field experience of an alternate precoat media for boiling water reactor iron reduction	2010	Technical Report

Software Development (052419)

Issue

Nuclear power plants must meet strict system performance guidelines as specified by EPRI Chemistry Guidelines, the Institute for Nuclear Power Operations (INPO), and the Nuclear Regulatory Commission (NRC) to ensure pressure boundary integrity, fuel performance, and minimize radiation fields. Members require calculation tools that are robust and consistent with industry practice to manage their programs within the specified guidance.

Description

Chemistry managers, engineers, and technicians rely on EPRI ChemWorks tools for developing and optimizing their chemistry programs. The results of EPRI ChemWorks software programs are used in a variety of chemistry system evaluations, including high-temperature pH calculations for reactivity control in pressurized water reactors, hideout return evaluations for the secondary side of the steam generators, and estimating corrosion product inventory during shutdown. From these predictions, chemistry personnel can assess corrosion control, guide life-cycle strategies, and optimize the overall cost of the chemistry program.

Value

- ChemWorks codes provide members with the opportunity to evaluate, optimize, and train plant personnel on various chemistry programs and strategies.
- Continued optimization of ChemWorks can provide members with direct cost reductions.
- ChemWorks codes allow assessments of chemistries that impact component/asset management strategies.

How to Apply Results

Chemistry personnel can implement the ChemWorks codes to evaluate the effects of chemistry on a variety of situations, including corrosion mitigation, amine optimization, and resin life management.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Continued ChemWorks Development: Continued development of ChemWorks based on an ongoing development strategy and in collaboration with the ChemWorks User Group	12/31/2009	Software

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
ChemWorks Tools version 3.0 ChemWorks Tools version 3.0, which will include MULTEQ high-temperature chemistry calculator, hideout return calculator with integrated MULTEQ crevice chemistry calculation, primary chemistry pH calculator, low-temperature primary chemistry pH calculator, and shutdown chemistry calculator for boiling water and pressurized water reactors	2010	Software

SMART chemWORKS Development (052420)

Issue

Increasing demands on chemistry staff, coupled with reductions in the number of staff, has heightened efforts to optimize staff productivity. SMART ChemWorks is a real-time, online chemistry monitoring and advisory system that provides station chemists with improved monitoring, diagnostic, and alerting capabilities. However, continued development of the tool is needed to be responsive to the continuing needs of the station chemist.

Description

This project encompasses specialized improvement and development of SMART ChemWorks functionality. Development may include a range of issues, including web page upgrades, email/pager alerts with increased functionality, addition of new technical analysis methods, and increasing robustness of the SMART ChemWorks application to allow for faster run-times and capability to handle even greater volumes of data.

Value

- Improves chemistry application related to control and diagnostic capabilities while optimizing staff productivity

How to Apply Results

Improvements are made directly to the SMART ChemWorks software by EPRI. Added functionality is automatically implemented for all SMART ChemWorks users.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Continued SMART ChemWorks Development: Added functionality to SMART ChemWorks as agreed to by the supplemental funders	12/31/2009	Technical Resource

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Continued SMART ChemWorks Development: Continued development of SMART ChemWorks as agreed to with project funders	2010	Technical Resource

Technology Demonstrations (052421)

Issue

New technologies may not be readily implemented in the field, requiring additional support or guidance.

Description

This project supports application and performance evaluation of advanced chemistry technology through plant demonstration. This project generally follows a first-of-a-kind demonstration of newly developed technology that is viewed as the culmination of the development process. For example, dispersant application for steam generator fouling mitigation was initially demonstrated at ANO-2 (short-term trial) and then McGuire (long-term trial) as part of the first-of-a-kind demonstration. Application of dispersant at other sites is supported via this project.

Value

- Supports application of chemistry technology through plant demonstrations
- Members can draw on lessons learned for further, improved application

How to Apply Results

Results are delivered through a combination of application guidance and plant chemists' workshops, providing improved implementation as a result of lessons learned.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Plant-specific Evaluation for Dispersant Application: Continued evaluation of dispersant application, in consultation with project funders	12/31/2009	Technical Resource
BWR ECP Reduction during Startup: Continued support for electrochemical potential reduction during boiling water reactor startup, in consultation with project funders	12/31/2009	Technical Resource
BWR Feedwater Iron Optimization: Continued support for boiling water reactor feedwater iron optimization, in consultation with project funders	12/31/2009	Technical Resource

Chemistry User Groups and Specific Applications (052422)

Issue

Chemistry staffs in the nuclear power industry continue to shrink as a result of economic pressures and the aging work force. Highly skilled personnel spend too much time completing mundane but necessary tasks, while the backlog of important, but less time-sensitive obligations continue to grow.

Description

At User Group meetings, members learn about chemistry code improvements with the goal of optimizing work force usage, learn how other utilities utilize the software, and give input on future development. This supplementary-funded project covers user groups and support for application of EPRI technology.

Value

- Direct support from EPRI in application of EPRI technology
- Coordination by EPRI in making application of chemistry technology most effective
- Increased efficiency and better utilization of plant personnel
- Applying technology to adjust instrument calibration and verifications by using EPRI technology

How to Apply Results

User group members receive direct support via meetings coordinated by EPRI and development of products as determined by members within available funding. SMART ChemWorks User Group members gain access to a real-time plant water chemistry monitoring and advisory system that aids chemistry staff by completing routine chemistry analysis, identifying early indications of adverse plant chemistry, and alerting personnel to emerging issues. In addition, SMART ChemWorks User Group members can directly access EPRI engineers for specific support. ChemWorks User Group members receive direct support on application of ChemWorks codes. The EPRI-sponsored Zinc User Group provides a common forum of plant personnel, EPRI, and vendors to share plant experiences related to zinc injection and challenges.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
BWR Filter Users Group Meeting: Disseminate information on the performance, operation, and modifications of condensate filters in a timely fashion, quantitatively compare group members' condensate filter performance data, monitor and report performance trends, and organize forums for face-to-face exchange and discussion of operating experiences	12/31/2009	Technical Resource
ChemWorks Users Group Meeting: Hold an annual meeting to discuss uses of the ChemWorks codes, receive advanced chemistry training, and give recommendations for future code modules or enhancements. Newsletter informing members of ChemWorks codes improvements and applications. Webcast training sessions given periodically throughout the year.	12/31/2009	Technical Resource
PWR Primary Zinc Addition Users Group Meeting: Disseminate information related to the performance, operation, and implementation of zinc addition in a timely fashion, quantitatively compare zinc performance data, monitor and report performance trends, and organize a forum for exchange and discussion of operating experiences.	12/31/2009	Technical Resource
SMART ChemWorks Users Group Meeting: SMART ChemWorks monitors chemistry, online, 7 days per week/24 hours per day with minimal utility resources. The system provides accurate, prompt plant chemistry monitoring, including diagnosis of abnormal chemistry, and alerts utility personnel through a combination of an email/paging system.	12/31/2009	Technical Resource
PWR Filter and Resin Users Group Meeting: Facilitate and improve the use of high-efficiency filter technology and ion exchange resins in PWRs by assisting in the evaluation of filter septa and ion exchange performance and in the communication of information on filter septa design, novel resin use, and other general operating experience.	12/31/2009	Technical Resource

Water Chemistry Guide (061430)

Issue

Nuclear power plants must continuously review and optimize chemistry controls to enable operation with high-duty cores and outage timeline reductions and to meet department, site, and “as low as reasonably achievable” (ALARA) goals. Thorough reviews require experts who understand the chemistry and operational limitations and can optimize chemistry controls to meet ever-shorter outage timelines, increase plant availability, and reduce plant dose. Individual members sometimes need direct one-to-one assistance from EPRI in the areas of water chemistry assessments and program support.

Description

Direct EPRI support to optimize chemistry, materials, and corrosion control at member nuclear power plants utilizing EPRI technology. EPRI experts use a standardized approach—based on EPRI guidelines, site goals, outage schedules, and plant experience—to review and optimize a plant-specific and technically sound chemistry program. EPRI also applies knowledge gained through related projects, such as the Shutdown Chemistry Benchmarking project, the Fuel Crud Reaction Kinetics project, and the Pressurized Water Reactor Chemistry Monitoring and Assessment project.

Value

- Direct EPRI support in applying EPRI technology on a plant-specific basis
- Benchmark plant chemistry controls based on the Pressurized Water Reactor Chemistry Monitoring Database
- Provide recommendations to optimize chemistry controls, outage schedules, and minimize chemistry impacts on outages
- Review the technical basis for the site-specific chemistry evaluation including application of shutdown chemistry concepts in the outage plan, optimization of amine concentrations, and possible improvements within the overall chemistry process with each evaluation

How to Apply Results

Implementation of recommendations based on plant-specific assessments utilizing EPRI technology can lead to improved chemistry controls and enhanced chemistry strategic plans supporting cycle management goals.

2009 Products

Product Title & Description	Planned Completion Date	Product Type
Strategic Water Chemistry Planning: EPRI has developed a process to aid plants in reviewing and enhancing their strategic water chemistry plans. Members can utilize the experience of EPRI staff to streamline the review and improvement of their strategic water chemistry plans and to assure adherence to the Water Chemistry Guidelines.	12/31/2009	Technical Resource
Plant Chemistry and Materials Optimization: Apply various optimization processes to nuclear chemistry and corrosion management systems to reduce unplanned chemistry excursions, inspections, and component replacements and repairs by improving communication and decisionmaking processes involving chemistry and other plant departments	12/31/2009	Technical Resource
PWR Amine Optimization: Evaluation of corrosion product transport and local pHs throughout the secondary cycle, including estimation of polisher run length as a function of feedwater amine concentrations to provide recommendations for an optimum amine selection and operation	12/31/2009	Technical Resource

Product Title & Description	Planned Completion Date	Product Type
Cycle Chemistry Evaluations and Review: Review of plant cycle chemistry, including an overview of the technical basis for the site chemistry trending program using EPRI guidelines and other industry standards, a review of the corrective action program actions related to system issues, and improvement recommendations	12/31/2009	Technical Resource
PWR Hideout Return Evaluation: Review and evaluation of plant hideout return data to predict crevice chemistry and provide recommendations for subsequent cycle operation and chemistry control	12/31/2009	Technical Resource
PWR Primary Shutdown Chemistry Evaluation and Review: Report summarizing on-site review of 1) the technical basis for the site-specific shutdown chemistry program using the EPRI Guidelines, 2) a review of the application of shutdown chemistry practices in the outage plan, 3) an evaluation using the EPRI Shutdown Calculator, and 4) specific improvement recommendations	12/31/2009	Technical Resource
PWR Primary-to-Secondary Leakage Program Assistance: EPRI has developed an assistance package to target essential aspects of the primary-to-secondary leakage program. The assistance focuses on chemistry compliance with <i>EPRI Primary to Secondary Leakage Guidelines</i> , steam generator management strategies, and operations training and procedure review.	12/31/2009	Technical Resource