Structural Integrity Associates, Inc.®

NUCLEAR CHEMISTRY AND MATERIALS

DEVOTED TO NUCLEAR | FUELED BY SCIENCE

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ABOUT STRUCTURAL INTEGRITY

Structural Integrity Associates, Inc. (SI) is a leading engineering and consulting firm dedicated to the analysis, control, and prevention of structural and mechanical failures. The company was founded in 1983 in San Jose, CA, and has since opened offices throughout the United States and Canada, as well as established overseas affiliates.

Over the past 5 years, we've expanded our mechanical-based expertise to include nuclear fuel and advanced structures analysis capabilities. We also added chemical engineering to our cadre of nuclear plant offerings when SI acquired Finetech in 2015. SI Chemistry and Materials was formed providing unmatched experience and expertise. Our ability to integrate a full scope of services, from inspection and condition assessment, to monitoring and remaining life analysis, repair or remediation, and ultimately, total risk management of critical equipment and structures continues to grow.

Our history is one of innovation marked by a creative multi-disciplined approach to component evaluation and repairs, as well as development of increasingly sophisticated tools reflecting a unique blend of technical expertise with the latest computer and expert system technologies.

Over the years, Structural Integrity has established itself as an innovative and responsive resource for answering virtually any challenge in the analysis, control, and prevention of failures in critical equipment and structures. Our experience ranges from R&D to engineering, metallurgy, fabrication, and NDE; from petrochemical to nuclear and fossil-fueled power plant support.

We welcome new challenges and urge you to contact us whenever the need arises **24/7/365**.

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PRODUCTS & SERVICES

Engineering Services

4 EPRI Support
5 Chemistry Assessments and Evaluations
Conceptual Design
6 Hydraulic Analysis & Modeling
7 Shell & Tube Heat Exchanger Performance Evaluation
Liquid Radwaste Process Optimization
8 Makeup Water Treatment
CAD Modeling
9 Ion Exchange Modeling
10 BWRVIA Modeling
11 Fracture Mechanics Analysis and Risk Assessment
Heat Exchangers and Condensers
12 License Renewal / Subsequent License Renewal
13 Management of Aging Buried Piping
14 Pressure-Temperature Curves and RPV Material Surveillance
Corrosion Cracking
15 Materials/Metallurgical/Corrosion Evaluations
Metal Fatigue Evaluations
16 NEI 03-08 and Degradation Management Programs
New Plant Consulting
17 Root Cause Evaluation
Service Water
18 Wall Thinning Evaluations
Water Chemistry and Corrosion Mitigation
Weld Residual Stress Analysis
19 Welding Engineering
20 Training

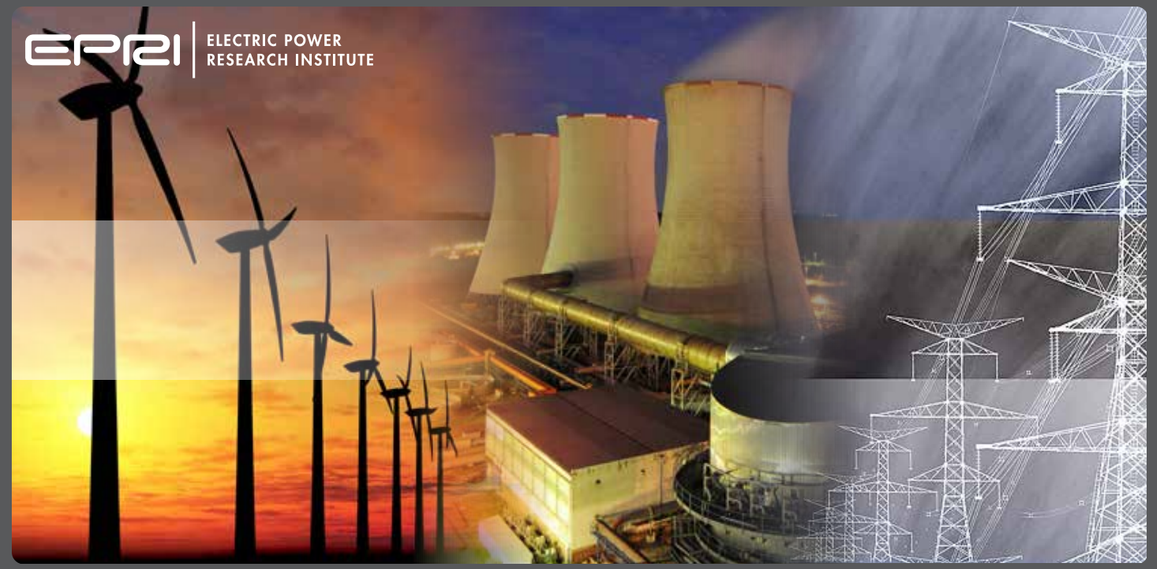
Products

Hardware

21 Process Controls & Automation
23 Measurement & Instrumentation Control
24 Integrated Flow Distributor (IFD)
25 BloGEORGE

Software

26 Condensate Demineralizer Ionic Loading Program (CDIL)
27 Ion Conductivity Program (ICON)



EPRI SUPPORT

BWR Chemistry Control
- BWR Chemistry Monitoring & Assessment
- BWR Condensate Filter/RWCU Chemistry Control Users Group
- PWR Primary and Secondary Resins and Filters Users Group
- EPRI PWR and BWR Condensate Polishing Guidelines
- BWR Chemistry Technical Strategy Group
- PWR Chemistry Technical Strategy Group
- BWR Cycle Chemistry Evaluations

BWR Vessel and Internals Project (BWRVIP)
- BWR Water Chemistry Guidelines
- BWRVIP Mitigation Committee Support
- BWRVIP HWC/NMCA Experience Report and NMCA Applications Guidelines
- BWRVIP Mitigation Monitoring Focus Group
- BWR Shutdown and Startup Chemistry Sourcebook
- BWR Startup ECP Reduction
- BWR EHWC (Early Hydrogen Water Chemistry) Demonstration
- BWRVIA Radiolysis Model Users Group and Model Development Support
- Radiolysis Modeling for the Advanced BWR
- BWRVIP-62 Revisions and Implementation Guidelines (Inspection Relief for Reactor Internals)
- BWR Platinum Deposition Modeling and Benchmarking

BWR Fuel Reliability Program
- Fuel Reliability Program Support (B-TAC)
- BWR Fuel Crud Database
- Fuel Reliability Guidelines: BWR Fuel Cladding Corrosion and Crud
- BWR Fuel Crud Deposition Model
- Comparison of Effects of BWR Filter Demineralizer and Deep Bed Demineralizer Condensate Polishing on Water Quality
- BWR Channel Distortion Database and Model Development
- Boiling Water Reactor (BWR) Zinc Injection Strategy Evaluation

BWR Radiation Management
- Revised BWR Primary System Radiation Survey Program (BRAC Program)
- BWR Radiation Management and Source Term Reduction
- Cobalt Reduction Sourcebook
- Assessments of BWR Operational and Shutdown Chemistry Control on Cobalt Transport and Radiation Fields

Advanced Nuclear Technology
- Assessment of BWR Water Chemistry Control in Advanced Plants: Advanced Boiling Water Reactor (ABWR)
- Assessment of BWR Water Chemistry Control in Advanced Plants: Economic Simplified Boiling Water Reactor (ESBWR)

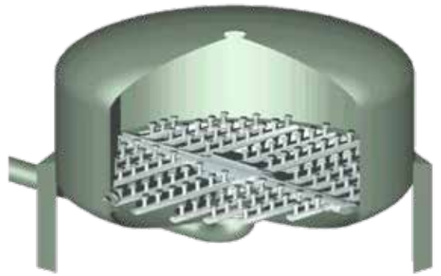
CHEMISTRY ASSESSMENTS AND EVALUATIONS

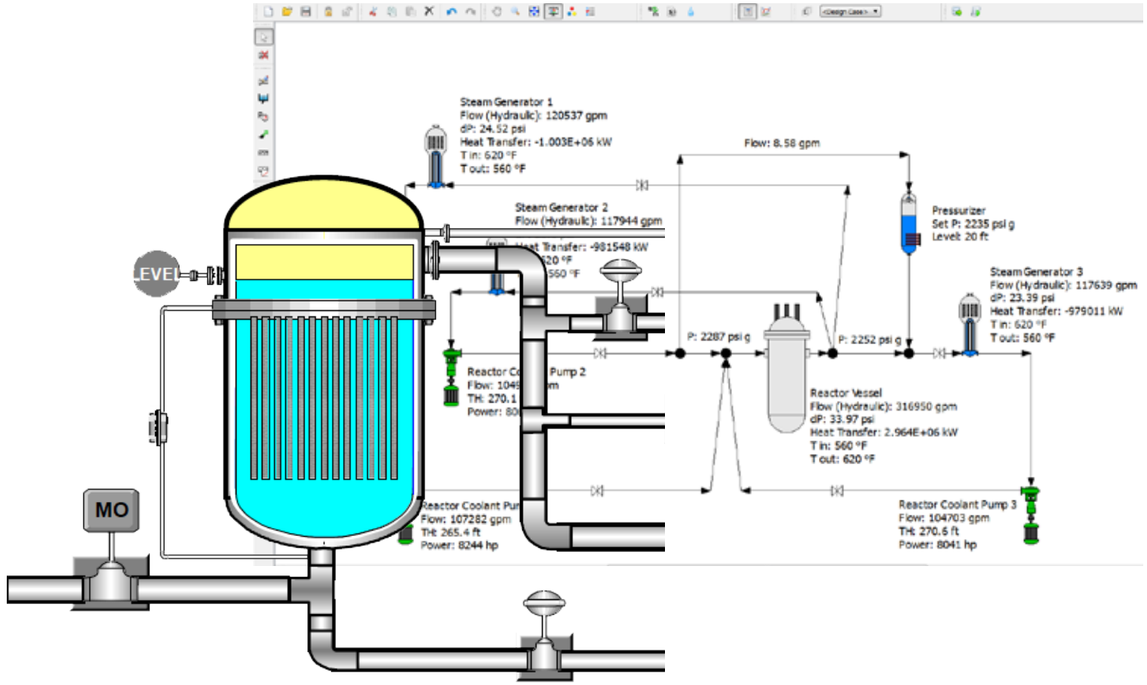
Areas of Assessments Performed
- Chemistry Program & Control Assessments
  - General (pre-INPO), BWRVIP, Fuel Reliability, Radiation Dose, Targeted, Program Enhancement
- GAP Assessments (Plant Practice vs. Industry Best or Standard)
- Reactor Coolant Cleanup Systems
- Source Term Assessments
- BWR Zinc Injection System
- Raw Water Chemical Treatment Systems
- System Assessments
  - Condensate Polishing
  - Closed Cooling Water Systems
  - Stator Liquid Cooling
  - Torus/Suppression Pool
  - Radwaste Processing
  - Makeup Water Treatment
  - Reactor Water Cleanup

Other Types of Plant Assistance
- Root Cause Investigations
- Laboratory Jar Testing
- Laboratory Test Method Development
- Operational Chemistry Control
- Chemistry Data/Anomaly Evaluations
- Plant Decommissioning Water Processing Plans
- Chemistry Projects – Examples:
  - Strategic Water Chemistry Plan
  - Chemical Decontaminations
  - Chemistry Procedure Upgrades
  - HWC/NMCA Program Support
  - Chemistry Process Performance Teams
  - Chemistry Limits & Frequencies Matrix

CONCEPTUAL DESIGNS

Conceptual Designs and Equipment/ Process Specifications
- Early Hydrogen Water Chemistry (EHWC)
- Extended Power Uprate Design Upgrades for Chemistry Control
- Service Water Chemical Treatment System Improvements
- Closed Cooling Water Systems
- Condensate Polisher System Upgrades
- Radwaste Processing Improvements
- Condensate Filter Backwash Optimization
- Condensate Filter Backwash Waste Processing
- Reactor Water Cleanup Upgrades
- Makeup Water Treatment Designs
- Fuel Pool Cleanup System Upgrades
- Sampling System Upgrades





QUICK OPEN DRAIN VALVE

HYDRAULIC ANALYSIS & MODELING

SI chemistry has developed computer hydraulic models to analyze a variety of systems important to nuclear power plant performance. These models have been used to evaluate the causes of system performance issues, to assess changes for performance improvement, and to assess the impacts of flow and temperature increases that occur from plant changes, such as extended power uprates. Examples of steady state and non-steady state models are:

Piping Network Analysis
Hydraulic models are often based on a 3-D CAD model of the piping system. Examples include: condensate deep bed demineralizer systems, condensate filtration systems, condensate filter demineralizer systems, and reactor water cleanup systems.

Top Tubesheet Filter Backwash
Unsteady-state model to evaluate the effectiveness of current configurations and settings, and effects of design and operating changes.

Bottom Tubesheet Filter Backwash
Steady-state and unsteady-state (i.e., air surge) backwash models.

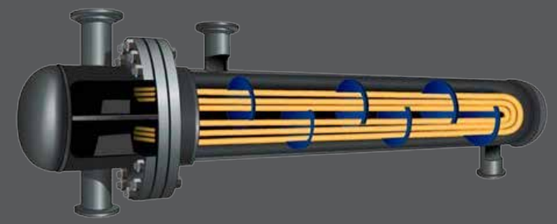
Flow Distribution
In collaboration with Organo Corporation, flow distribution within a bottom tubesheet filter vessel is modeled by CFD (computational fluid dynamics) for the purpose of designing components for internal flow distribution improvements. This allows the IFD (integrated flow distributor) design to be customized to the geometry and flow range of each vessel.

The radial flux distribution along the length of filter elements is modeled using a finite element approach.

The combination of CAD and hydraulic modeling is used to improve the flow distribution within deep bed demineralizer vessels.

SHELL & TUBE HEAT EXCHANGER PERFORMANCE EVALUATION

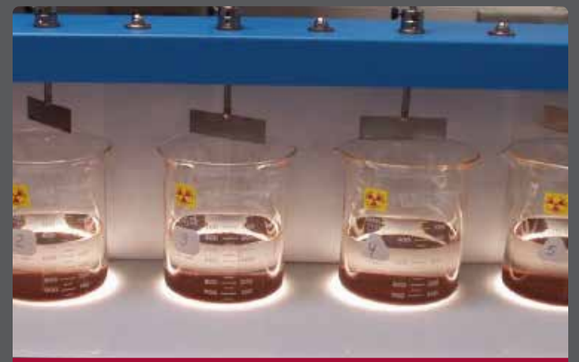
Plant systems evaluated for performance improvement often include shell and tube heat exchangers. As part of the overall system evaluation, operational impacts are evaluated on heat exchanger performance (hydraulic, thermal, etc.). Using both proprietary and commercial software, we have the capability to perform the necessary evaluations.



Thermal Analysis
Utilizing the heat exchanger's specification sheet, the exchanger system is modeled until the available/required thermal capacity is determined via correlation with current operating conditions. One of the following solution methods may be used to converge on results:

- LMTD (Log Mean Temperature Difference)
- Effectiveness – NTU (Number Transfer Units)

Flow Induced Vibration
TEMA (Tubular Exchanger Manufacturers Association) software is employed to determine if potential flow induced vibration issues may be present at specific operating conditions. A positive result may require further analysis.



LIQUID RADWASTE PROCESS OPTIMIZATION

We have performed numerous evaluations of existing liquid radioactive waste processing systems for BWRs and PWRs. Services involve the following processes:

- Filtration: Filter demineralizers, non-precoat filters
- Filter Media Selection and Optimization
- Body Feed Optimization
- Deep Bed Demineralization: Resin/media selection
- Evaporation
- Liquid Processing for Recycle or Discharge
- Membrane Systems

With the advent of high efficiency iron removal processes in BWRs, we developed a comprehensive program for the application of polyelectrolytes to improve processing of backwash and cleaning liquids in the radwaste plant. This successful process has resulted in significant cost, labor and dose savings.

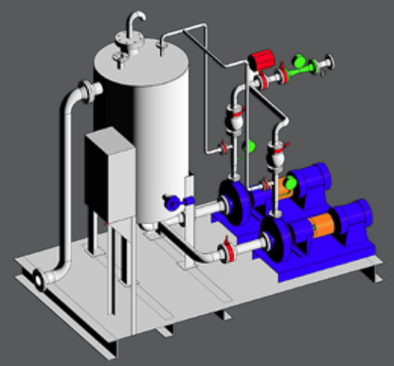
MAKEUP WATER TREATMENT

We have also been engaged in makeup water treatment for nuclear power and industrial applications. Our engineers have strong backgrounds in the research and development, design, startup, troubleshooting and evaluation of a wide variety of systems and materials used in the purification of water and other aqueous solutions. Applicable makeup water technologies in which our engineers have direct experience and detailed knowledge include:

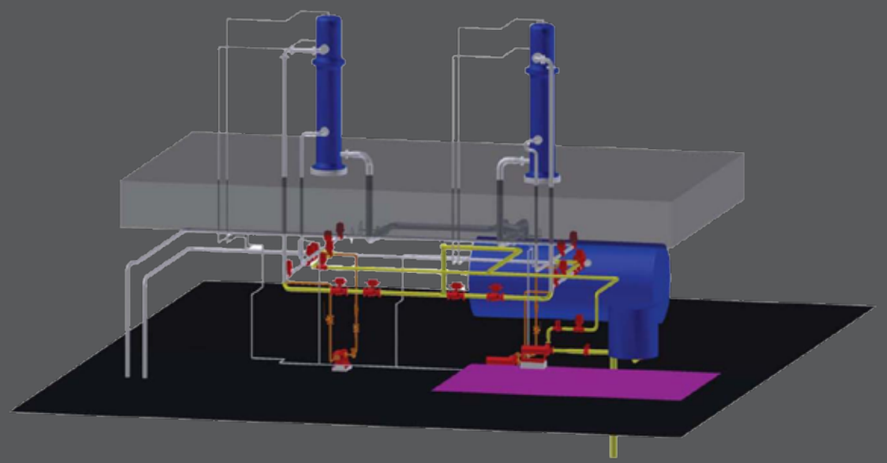
- Water Chemistry
- Ion Exchange
- Filtration
- Coagulation
- Adsorption
- Membranes Processes
- Chemical Cleaning & Sterilization
- Chemical Treatment

CAD MODELING

We create CAD drawings to support conceptual and detailed design projects using a MicroStation™ platform, which is compatible with AutoCAD™ and other popular programs. Typical drawings to support such projects include Piping and Instumentation Diagrams (P&IDs), layouts (plan and elevation), instrumentation and controls, electrical and civil/structural as needed.



3-D CAD models are often created to support evaluations for nuclear power plant equipment and piping systems to which access by personnel may be limited. This approach has been used to provide a clear visual depiction of high points in piping networks and pipe routings that may traverse multiple plant elevations. In addition, 3-D CAD models are often created in the design of systems to allow clients to visualize sizing and ensure that interferences are avoided. 3-D CAD models are also developed to support hydraulic modeling of systems.

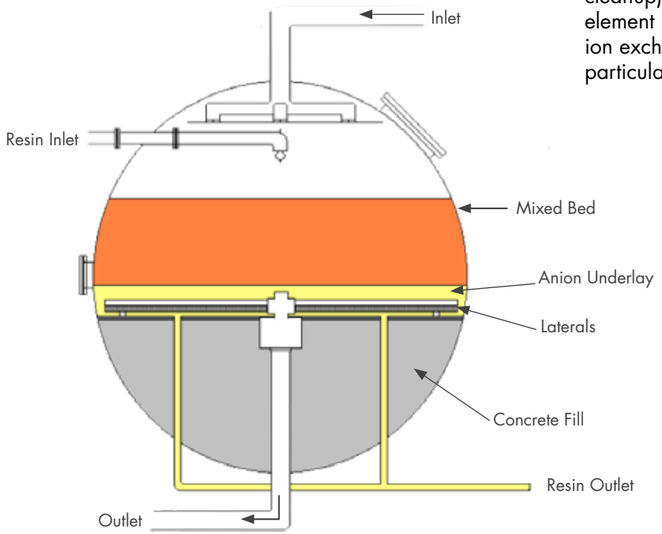


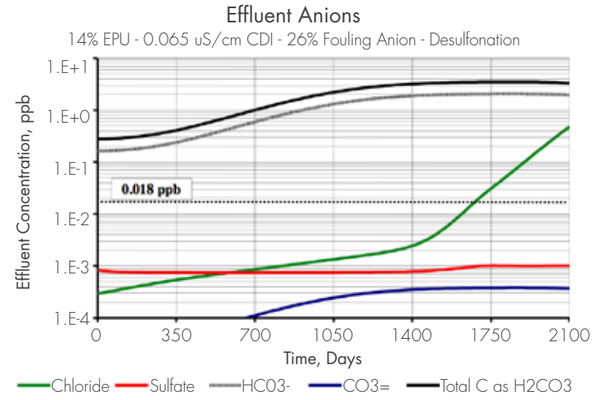
ION EXCHANGE MODELING

Ion exchange is a widely used water purification process to control power plant water quality. Models are developed and applied for new demineralizer system designs and to evaluate performance of existing systems. Two basic demineralizer designs are modeled:

Deep Bed Demineralizers
Deep bed demineralizer systems employing bead ion exchange resins have been evaluated using the Oklahoma State University MBIE (Mixed Bed Ion Exchange) model. This model has adjustable parameters that can be varied to simulate performance under a range of conditions. For instance, condensate polishing with condenser leaks of different magnitudes can be modeled for a given system. An example of extensive use of the model is in projecting the effects of operation with condenser leaks at EPU (extended power uprate) conditions on effluent quality of condensate polisher operations.

Flow distribution within the demineralizer vessel can be affected by the designs of the inlet flow distribution system and the underdrain system. CAD and hydraulic models are used to evaluate changes to optimize the flow distribution.

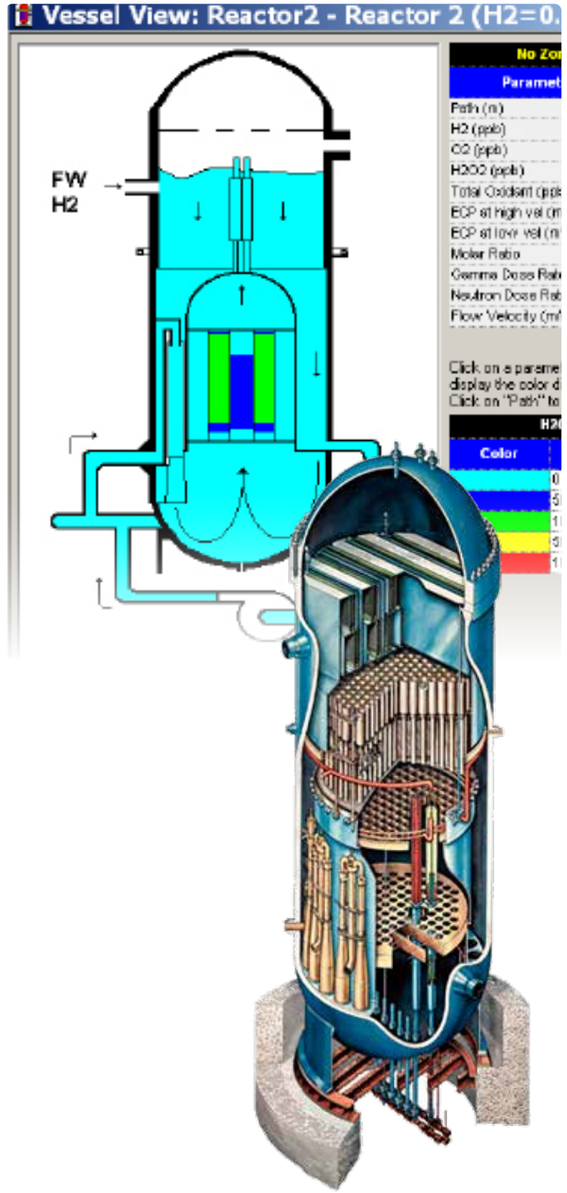




Filter Demineralizers
Filter demineralizers precoated with powdered ion exchange resin are used in many power plant water treatment applications. The ion exchange performance is particularly important in high purity water applications, such as condensate polishing and RWCU (reactor water cleanup). The radial flux profile along the length of the filter element must be taken into account to accurately project ion exchange performance. Silica removal efficiency is particularly sensitive to velocity.

EPRI BWR VESSEL AND INTERNALS APPLICATION (BWRVIA) MODELING

EPRI's BWRVIA modeling is a Windows® based PC code that performs radiolysis and ECP calculations for specified regions in a BWR reactor vessel. Because sampling and ECP measurements in all regions would be difficult and costly, analytical modeling is the best approach. Once benchmarked, it can guide engineering and chemistry personnel with hydrogen injection operational strategies for IGSCC mitigation in regions of concern.



SI Chemistry's Involvement with BWRVIA

- Assisted with beta testing for both Versions 2 & 3.1
- Delivered EPRI-sponsored, utility, and station training for model operations
- Performed analyses, developed reports, and provided recommendations for applying BWRVIA model results for multiple clients and utilities

Product Solutions

Proficiency with BWRVIA software is maintained by consistent hands-on use by our staff by serving multiple utilities and sites.

- Reduces errors in application
- Efficient use of time to gather required inputs, perform analyses and evaluate model outputs
- Eliminates training needs and costs for site personnel
- Tailored to meet utility/station needs and budget

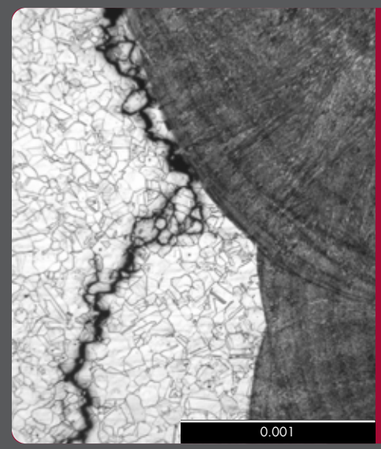
HWC Ramp Tests

To effectively implement hydrogen injection strategies, a hydrogen ramp test shall be conducted [BWRVIP-62 Rev. 1].

- Determine feedwater hydrogen concentration required to reduce ECP less than -230 mV(SHE) in lower vessel head.
- ECP measurements correlated to secondary parameters (i.e. FW H2 injection rate, FW H2 concentration, RW DH, RW DO, MSLRM).
- Ramp test results are benchmarked to BWRVIA Version 3.1.
- Performed once per ten years unless a significant plant change occurs (i.e., EPU, regime change)

HWC Ramp Tests support:

- Providing on-site support with technical staff experienced with multiple tests at multiple sites
- Developing test plans
- Benchmarking plant data during ramp test to BWRVIA Version 3.1.
- Providing recommendations on station specific goals and limits for IGSCC mitigation



FRACTURE MECHANICS ANALYSIS AND RISK ASSESSMENT

When a flaw is found in a reactor pressure vessel, piping, or other nuclear plant component, fracture mechanics calculations are used to analyze and predict flaw behavior, including crack growth rates and critical crack sizes. Structural Integrity uses deterministic and probabilistic fracture mechanics techniques, including finite element analysis, to disposition flaws in a variety of materials, geometries, and applied stress fields. Specialized fracture mechanics software developed and used by Structural Integrity includes pc-CRACK, employed for ASME Code Section XI flaw evaluations and weld overlay design; ANSC, used for net section collapse analysis for arbitrarily flawed sections in ductile materials; and EPRI's Viper/Viper-Noz, used to determine probability of failure for reactor pressure vessel welds and nozzles.

HEAT EXCHANGERS AND CONDENSERS

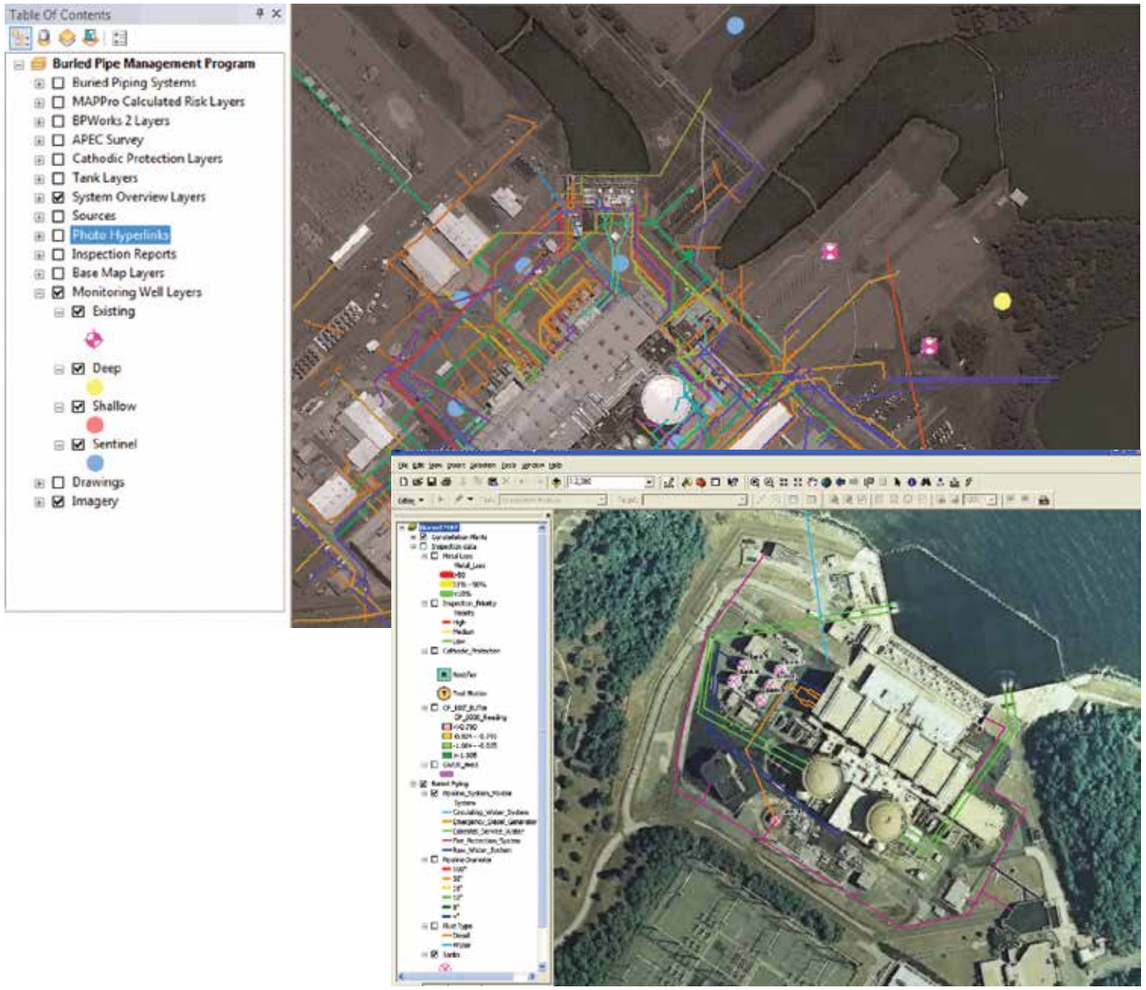
Nuclear plants contain numerous heat exchangers, ranging from very large condensers to small coolers; high energy steam generators; safety and non-safety related essential service water coolers; and regenerative MSRs. Heat exchangers are degraded by fouling resulting in a loss of heat transfer, cracking resulting in a loss of structural integrity, localized thinning and pinhole leaks, and wear resulting in the need to plug those tubes. Structural Integrity's expertise in the disposition, mitigation, and control of all known degradation mechanisms, as well as in NDE, provides the high-level assistance that the heat exchanger owner needs to maintain the system and plant reliability and safety.

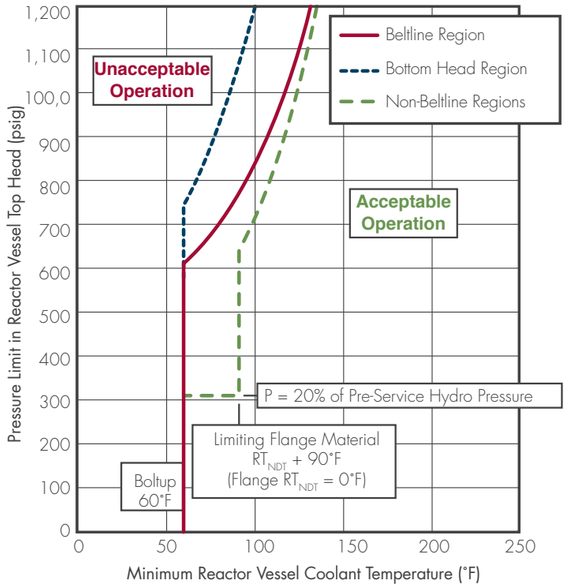
LICENSE RENEWAL / SUBSEQUENT LICENSE RENEWAL

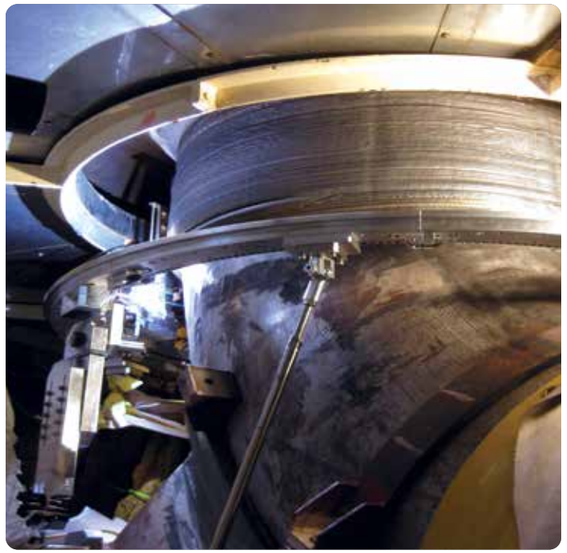
In the United States and some international countries, after a nuclear reactor has been in operation for 40 years, operating licenses may be renewed for another 20 years provided it can be demonstrated that the unit will maintain adequate safety levels over the extended period of operation. Most U.S. plant owners have sought or will seek extended operating licenses, and most find the need for technical support to see them through the NRC license renewal process. In addition, plants are now actively considering a subsequent or second renewal for an additional 20 years to operate these valuable non-carbon emitting assets for 80 years. Structural Integrity provides comprehensive license renewal support, and has provided consultation and support to the majority of the utilities that have sought license extensions to date. Support services include preparation and review of License Renewal Applications (LRAs) including Time Limited Aging Analyses (TLAAs), Aging Management Reviews (AMRs), Aging Management Programs (AMPs), responses to NRC questions on LRA submittals, and support for implementation of LRA commitments. We have significant technical experience with a wide range of age-related degradation mechanisms, including fatigue, neutron embrittlement, CASS thermal aging, concrete degradation and metal corrosion, amongst others. Our experience can benefit plants seeking license renewal and subsequent license renewal by helping to identify the most cost-beneficial approaches to aging management.

MANAGEMENT OF AGING BURIED PIPING

Many nuclear units have operated for more than 30 years, with buried piping systems that may be experiencing degradation. Using guidance from the Nuclear Energy Institute (NEI) and the Electric Power Research Institute (EPRI) for buried piping programs, Structural Integrity has developed a systematic buried piping management program (MAPPro) that includes a baseline assessment plan; data collection; risk assessment; indirect and direct examinations utilizing our long-range and short-range guided-wave ultrasonic G-Scan technology and in-line inspection using electro-magnetic acoustic transducers (EMAT); and SI developed pulsed eddy current (PEC) technology. Results from this management program include remediation or mitigation as needed, including improved cathodic-protection anode beds and rectifiers; monitoring; and prioritized maintenance.







PRESSURE-TEMPERATURE CURVES AND RPV MATERIAL SURVEILLANCE

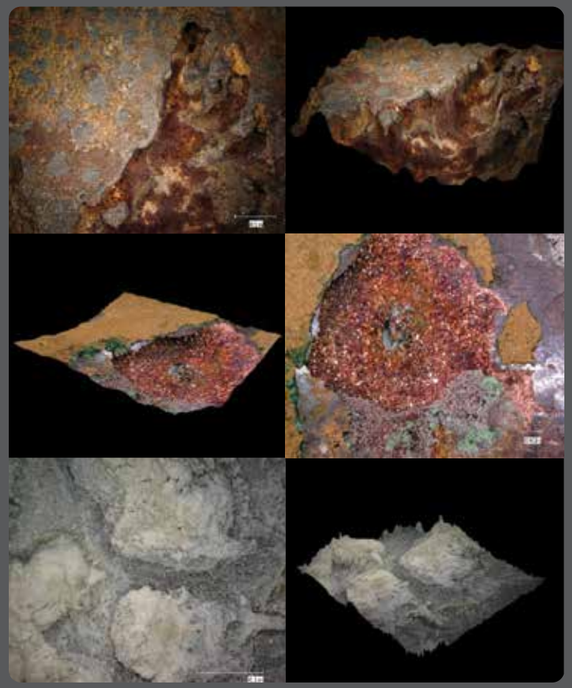
Reactor pressure vessel (RPV) material surveillance programs are required for all U.S. PWRs and BWRs. The results of these surveillance programs are used to develop pressure-temperature (P-T) limit curves that incorporate appropriate safety margins to protect against brittle fracture of RPVs, particularly in the irradiated beltline region. These P-T limit curves must be re-evaluated using new surveillance data in situations such as license renewal, power uprates, or when revised fluence calculations affect adjusted reference temperature values. Structural Integrity, well-experienced in P-T curves and vessel integrity for both PWRs and BWRs, can provide utilities with technical support including materials reviews, P-T curve development, P-T limits reports (PTLRs), reactor vessel integrity/P-T limit curve.

PRIMARY WATER STRESS CORROSION CRACKING

Primary water stress corrosion cracking (PWSCC) can occur in PWR primary systems where Alloy 600 components and associated Alloy 82 (GTAW) and Alloy 182 (SMAW) welds were used. Such components and welds were widely applied in PWRs. Prompted by industry experience with PWSCC in PWR Alloy 82/182 butt welds and small-bore penetrations, as well as by related examination and mitigation requirements many PWRs are conducting ongoing PWSCC examinations and related repairs for unmitigated locations. Structural Integrity and its field repair partner, AZZ Nuclear, are leaders in these weld overlay butt weld repairs, as well as in nozzle repairs for small-bore primary system penetrations. Our team, has completed weld overlay projects encompassing more than 150 weld overlays since 2006 – and not a single welded repair was required for any of these overlays.

MATERIALS/METALLURGICAL/ CORROSION EVALUATIONS

Accurate materials, metallurgical, and corrosion evaluations are essential to the appropriate disposition of degraded plant components. Such evaluations also help identify improved materials and fabrication processes to prevent future degradation. Structural Integrity offers a complete range of materials engineering services, supported by our full-service metallurgical laboratory in Austin, Texas. Our materials engineering specialties include welding engineering; corrosion and stress corrosion cracking evaluations; materials selection; and corrosion-fatigue. Low-temperature and high-temperature corrosion phenomena, including microbiologically influenced corrosion, are a particular area of our expertise.



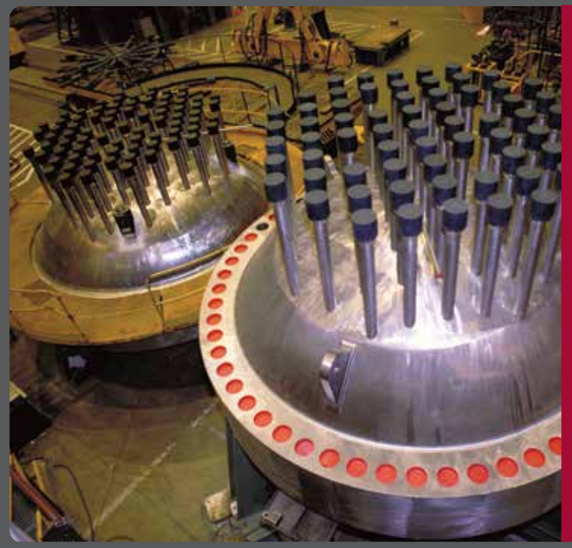
METAL FATIGUE EVALUATIONS

Metal fatigue from nuclear plant cyclic stresses and strains is a major contributor to degradation of aging components – and a specialty at Structural Integrity. In fact, EPRI relied on our metal fatigue expertise to develop the EPRI Fatigue Management Handbook as well as FatiguePro, a widely used, real-time thermal fatigue monitoring system that automatically tracks fatigue transients and usage for critical nuclear components. Our metal fatigue services and products include FatiguePro evaluations; fatigue management handbooks that help identify potential damage locations; fatigue repair support; design of modifications to extend component fatigue life; analysis of reactor vessels and piping to determine effects of reactor water environment on fatigue life; determination of fatigue impact of cyclic thermal stratification in reactor piping; and vibration fatigue.

NEI 03-08 AND MATERIALS DEGRADATION MANAGEMENT PROGRAMS

The nuclear industry's Materials Initiative, NEI 03-08, developed in response to events involving materials degradation in nuclear plants, requires a Materials Degradation Management Program at all U.S. PWR and BWR units. Audits of these programs are often conducted by INPO and the NRC. At a minimum, the programs must address BWR vessels/internals, Alloy 600 issues, reactor vessel integrity, PWR vessels/internals, boric acid corrosion control, steam generator management, primary and secondary system water chemistry, and fuel reliability. Any deviations from mandatory/needed program requirements require supporting documentation. Structural Integrity can support nuclear plants in Materials Degradation Management Program development, implementation, deviation requests, third-party reviews, utility training, preparation for INPO/NRC audits, and other related services.

Scope of NEI 03-08 Initiative
Covers RCS Materials Aging Management

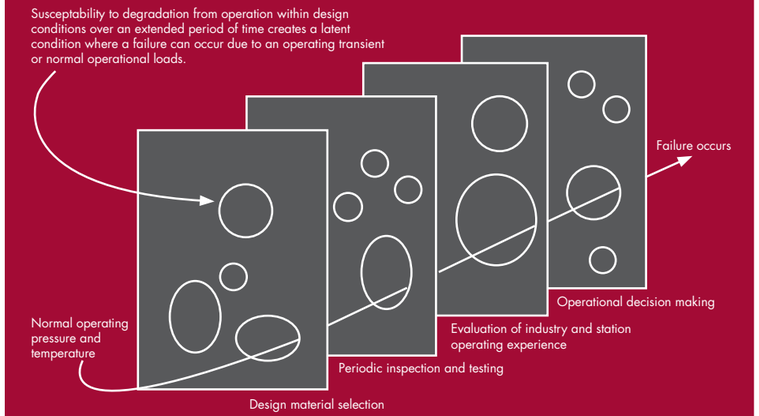


NEW PLANT CONSULTING

In spite of Fukushima, over 60 plants worldwide are currently under construction and or in the licensing process. Engineering and licensing a new nuclear unit can be daunting, but Structural Integrity's extensive experience with the multiple generations of nuclear units places us in a unique position to provide new plant support. Available services for new plants include design analysis/third-party design review, design specification preparation and review, stress and fatigue analyses, welding/material engineering, fabrication review, fracture toughness/pressure-temperature curves, probabilistic risk assessment reviews, and licensing support. We can also provide ASME Code consultation, startup vibration testing, buried piping program support, fatigue and condition monitoring programs, inspection programs, training programs, and many other related services.

ROOT-CAUSE EVALUATION

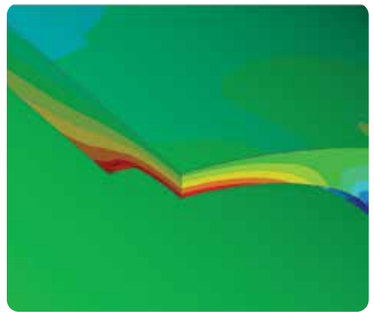
At the bottom of every plant component failure is a root-cause, and root-cause failure analyses are a proven way to avoid repeat or related failures. Structural Integrity offers a complete range of root-cause failure analyses, varying in complexity from one or two specialists focused on material fractography to a multi-discipline team performing a full-scope investigation. To support its investigations, we maintain both a metallurgical laboratory and an advanced nondestructive testing capability. Additionally, we perform human-error analyses and organizational/programmatic evaluations to uncover possible contributing factors. Structural Integrity is also available to perform third-party reviews of root-cause failure analyses, and evaluations of related corrective actions.



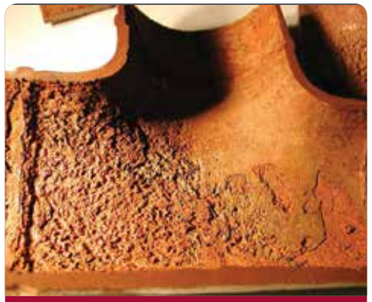
SERVICE WATER

Nuclear plant service water systems are affected by a multitude of situations and operate under a wide variety of operating conditions. The differences in design, materials, water chemistry, and operation necessitate plant-specific approaches for the examination of piping, management of degradation issues, corrosion mitigation, and repairs and replacements. Many times, management approaches may be reactive (e.g., leaks present themselves, thinning is detected by inspections, run vs. repair decisions made on critical path) or preventive (proactive examinations on selected locations, heat transfer testing, water treatment, cleaning, monitoring, planned/staged repairs, and replacements). Structural Integrity's expertise in corrosion and corrosion control, materials engineering, vibration, fracture mechanics, stress analysis, statistical methods, root-cause and failure analysis, and NDE provide the multidisciplinary approach required for proactive, cost-beneficial management of service water system degradation.

WALL THINNING EVALUATIONS



Even when local wall thinning in nuclear pressure vessels, piping, valves, or other components is well below the general minimum wall thickness required by ASME Code, continued operation may be justified by ASME-approved evaluations methodologies. Structural Integrity is a leader in wall-thinning evaluations for nuclear plants, including evaluation of mechanisms and rate of thinning, as well as familiarity with applicable ASME Code criteria. In fact, the evaluation methods in ASME Section XI Code Cases N-480, N-513, and N-597 were based on a Structural Integrity report generated for EPRI or developed by the Code committees with our significant contributions. We use either the simplified analytical methods found in the ASME Code Cases, or more-complex finite element models that determine local stress distributions in thinned components. In situations where there is local through-wall leakage, we conduct fracture mechanics analyses to demonstrate sufficient margin against fracture. With our unique industry expertise, and our catalog of evaluated flawed configurations, we can complete wall thinning evaluations quickly, enabling rapid run/repair/replace decisions.

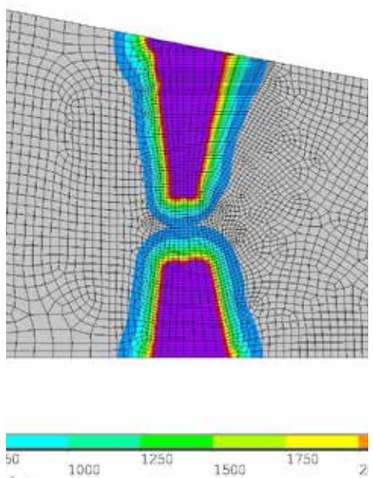


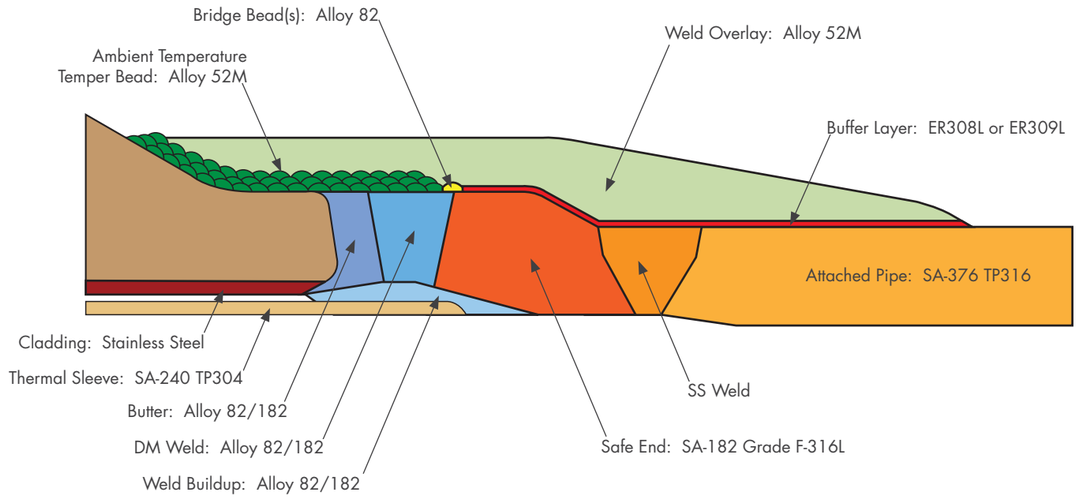
WATER CHEMISTRY AND CORROSION MITIGATION

Intergranular stress corrosion cracking (IGSCC) in BWRs and primary water stress corrosion cracking (PWSCC) in PWRs, as well as microbiologically influenced corrosion (MIC), are perennial industry concerns. These corrosion mechanisms, as well as many others, are influenced by water chemistry and especially water chemistry transients. Structural Integrity's long-time water chemistry experience can help utilities mitigate these problems in vessels and piping. We provide corrosion mitigation and remediation consulting, optimizing programs such as hydrogen water chemistry (HWC) zinc injection, and noble metal injection for BWRs, and elevated hydrogen and zinc injection for PWRs. We also offer corrosion-related weld overlays and repairs, crack growth rate modeling, alloy selection, failure analysis, MIC mitigation, and support for license renewal and NRC inspection issues involving corrosion.

WELD RESIDUAL STRESS ANALYSIS

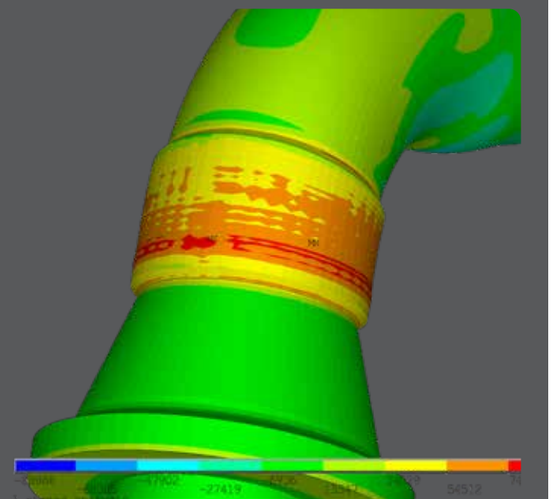
Certain welding processes – pipe-to-pipe butt welds, small-bore penetration J-groove welds, and weld overlay repairs, for example – leave residual stresses that can affect the stresses within welded nuclear plant components. Structural Integrity offers a full range of temperature-controlled, non-linear, path-dependent weld residual stress analyses, using ANSYS finite element analysis software to simulate various welding processes. These analyses simulate a thermal pass, complete with appropriate weld heat input, heat efficiency, and appropriate cooling time, to determine temperature distributions due to the welding process. A simulated stress pass in turn calculates residual stresses due to non-linear, elastic-plastic load/unload stress-reversal cycles from the heating and cooling of the weld elements throughout the thermal transients. For especially complicated weld geometries, we can perform three-dimensional moving heat source residual stress analyses.





WELDING ENGINEERING

Appropriate weld design, procedures, and qualification are vitally important at nuclear plants. Structural Integrity offers comprehensive welding engineering services, including development and review of welding programs; selection and development of welding processes for critical applications; review and evaluation of procedure qualification records and weld procedure specifications; review of welder qualification; review and evaluation of weld failures; development of corrective actions; and welding code review and reconciliation. We're also available to develop innovative welded repair techniques for specific situations. In fact, we pioneered development and application of weld overlay and temperbead welding for nuclear plant repairs with our field repair partner, AZZ Nuclear.



TRAINING

Structural Integrity's training courses focus on Linking Theory and Practice. With this focus, you'll get more in-depth education on specific topics in the industry. We know people learn in different ways and may have differing needs, so we're *Linking Theory and Practice* to provide the following advantages to our clients:

- **Build Knowledge** – We build our training courses with one goal – to equip you with the knowledge to solve more of your complex problems. All of our courses are designed to improve your understanding of a highly technical topic and are taught in a way that lets you start turning theory into practice.
- **Reduce Risk** – Challenging problems occur regularly at any facility. With the right expertise, you can solve them faster, before small issues become significant threats. You'll also be able to take the uncertainty out of your ability to analyze and review externally-generated, specialized reports, thereby ensuring you can provide the proper oversight required by regulators and other stakeholders.
- **Save Money** – Our courses help you identify issues and resolve them faster. We provide a framework you can put into practice to reduce outage critical path time and limit any reduction in capacity factors. The end result? More time generating and transmitting energy, and less lost revenue.

www.structint.com/training

WEBINARS

Structural Integrity provides webinars on numerous industry topics to our clients.

Visit our website at *www.structint.com/webinars* for a current schedule of upcoming webinars, related registration information, and archived versions of previously conducted webinars that are available for viewing.

PROCESS CONTROLS & AUTOMATION

SI Chemistry is a full service integrator of automation and process control systems with extensive experience in both the nuclear and fossil-fuel power generation industry. Automation service includes the following:

- Preliminary design and specification development
- Control philosophy/ system description
- Detailed design packages (drawings, calculations, etc)
- Control panel design and fabrication
- PLC & HMI programming & validation
- Installation instructions
- Installation, operation and maintenance manuals
- Plant engineering change package (technical support)
- Plant operating procedure development/ markup
- Training
- Installation & post modification test procedures
- Field support services (installation, testing and startup)
- Maintenance support

Our experience using various automation hardware and software products affords us the flexibility to meet and exceed the customer's requirements regardless of the specified hardware, software or communication platforms including GE-IP, AB/Rockwell, Modicon or Siemens.

Whether the process control system is needed for a new plant process or as an upgrade to an existing plant system, and no matter the size, we will tailor each to the plant's specific needs and design. Our expertise in power plant process design and operation provides for an exceptional design which results in exceptional system performance and client satisfaction.

We employ a multi-step process to ensure the specified process control system is delivered on-time and within budget.

Preliminary Design/Specification
Our multi-disciplined engineering staff is experienced in providing conceptual/preliminary system designs which are of enough detail for the development of the customer's bid specification. In instances where the customer may also need support in the development of the bid specification, again, we have the resources to meet those needs.

Control Philosophy/System Description
In order to convey the basic operating principles and functions of the proposed control system, a Control Philosophy is developed prior to a detailed design package. This document typically includes a description of the process along with applicable system equipment. More importantly, an overview of operational functionality, commands and and settings are outlined. Process control loops are identified along with their respective operating ranges and alarm setpoints. Automation sequence and/ or logical flow charts are also incorporated along with associated operational permissives, failure modes and process alarms.

Detailed Design Package
The detailed design package incorporates all required software code, calculations, drawings and documentation associated with the control system design necessary for final approval of the customer's overall modification design package (Engineering Change Package, etc.). SI Chemistry can provide the necessary calculations for the electrical, mechanical and structural components of the control system. All drawings are provided in CAD format (Microstation/ AutoCAD).

Fabrication
We maintain a 20+ year, collaborative relationship with a local fabrication shop. All fabrication work is completed within specification using quality workmanship.

Simulation Testing/Inspection
SI Chemistry incorporates intense testing of the completed control system using a hard-wired simulation system. This device is used to validate all component wiring as well as the developed software code. It provides the ability to simulate operation of the control system therefore providing the customer with the ability to perform operational test runs during final inspection of the system. This level of testing minimizes post-installation design changes and/ or "fixes". After final approval and delivery, the simulation unit is typically setup on-site with the control system where the customer can continue with operational procedural development training.

Training
We can provide knowledgeable staff and the necessary documentation for on-site training of the customer's plant personnel (Operations, Maintenance, etc.). Using the simulation system provided, hands-on training is typically the most effective as personnel are comfortable with the system components and functionality prior to field installation.

PRODUCTS

Installation
On-site installation support is available to ensure all post-installation equipment is in working order. This includes working with installation crews during both point-to-point continuity checks, system power-up and process signal loop calibration.

Start-Up
On-site support is available during system start-up. Typically, start-up support covers final system configuration and/ or calibration during both dry and wet-run testing. Wet-run testing with the plant process during this phase may require final software code "tweaks".

Additional Services
- Installation & Start-Up Testing Procedure Development
- System Operating Procedure Development
- Independent Third-Party Review
- 24/7 Post-Installation Service & Support Contracts

MEASUREMENT & INSTRUMENTATION CONTROL

Structural Integrity designs and builds computer-based measurement and instrumentation control systems. Utilizing National Instrument's LabVIEW® system design software, we have the capability to deliver a customized product that will meet each plant's specific needs.

We develop solutions to meet a wide range of applications from direct measurement for data visualization and/or acquisition, to remote instrument automation and control. The LabVIEW software, with a full array of third-party hardware and software communication bus driver libraries, allows for seamless integration of the application, thus eliminating the need to replace existing system components. We can also design, build and develop a state of the art system using the latest equipment and technologies.

Applications
- Chemistry Laboratory Equipment
- Remote Field Instrument Monitoring & Data Acquisition
- Automating Measurements and Processing Signal Data
- Instrument Control

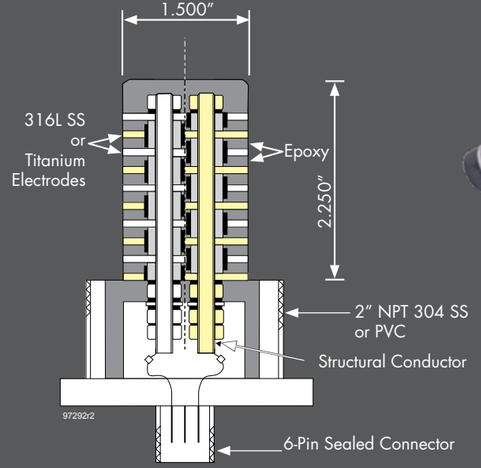
INTEGRATED FLOW DISTRIBUTOR (IFD)

In order to improve the performance of bottom tubesheet Condensate Filter Demineralizers (CF/Ds) in Japan, Organo Corporation studied the optimum vessel internal configuration for precoat application and retention. The studies were performed in the laboratory, pilot plant and at actual BWR plants. Organo was successful in achieving significant performance improvements by adding what is the IFD (Integrated Flow Distributor) technology. The performance improvement with yarn-wound cylindrical septa was measured in terms of operating run length to a differential pressure endpoint, which was increased by a factor of about two. As a result, all bottom tubesheet BWR CF/D vessels in Japan were retrofitted with the Organo IFD and new vessels were designed with this technology incorporated. When RWCU (Reactor Water Cleanup) system flow rates were increased in Japan from 1% to 2% of feedwater flow, IFDs were added to existing RWCU F/D vessels. Despite doubling of the area flow rates, DFs for cobalt were actually improved.

Adaptation of the IFD to U.S. bottom tubesheet F/D installations offers similar benefits as experienced in Japan with cylindrical surface septa. Organo and SI Chemistry have collaborated in bringing the IFD technology to existing U.S. plants. While IFD experience in Japan was exclusively with cylindrical surface septa, performance benefits have been achieved in the U.S. with both cylindrical and pleated outer surface precoated septa.

BG4 BIoGEORGE™

Microbiologically influenced corrosion is an ever-present threat to nuclear plant service water systems, particularly standby and redundant systems – including safety-related –in wet layup for extended periods of time. Fortunately, the on-line, real-time **BIoGEORGE** monitoring system can provide early warning of biofilms before these rapidly forming films can negatively impact system performance or reliability. **BIoGEORGE** also provides a reliable indication of the effectiveness of biocide treatments, plus feedback on biocide treatment selection, timing, and concentrations. This information on biocide treatment effectiveness enables stations to optimize their treatment selection and approach to lower costs and optimize performance.



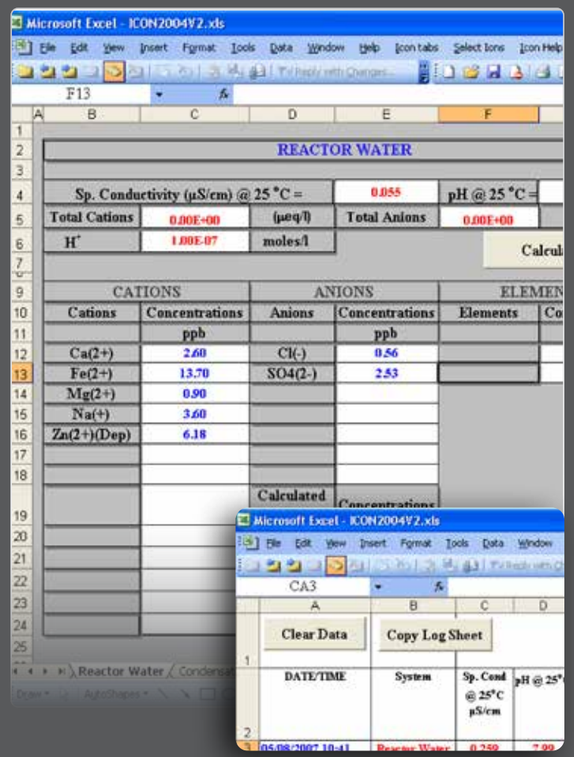
Before

After

CONDENSATE DEMINERALIZER IONIC LOADING PROGRAM (CDIL)

A single-source management and tracking program in Microsoft Excel format for deep bed condensate demineralizers, the program compiles the data and results required by Chemistry, System Engineering and Operations to effectively manage the Condensate Polishers. The plant is provided with a defensible and documented method of conservatively estimating the remaining ion exchange capacity of each bed, without the need for resin sampling and laboratory residual capacity determinations. The program is periodically upgraded based on industry needs or requests by users.

Configuration
Configuration for a specific plant is based on representative analyses of the main condenser circulating cooling water, Condensate Polisher bed volumes and bed/vessel designations.



Features

- All operating and chemistry data are input on a single template. Daily values are input for power, CDI conductivity, condensate temperature, CW conductivity, condensate flow, CDI iron crud, flow through each bed and operating status (In Service, Out of Service, etc.), CDE iron crud, dP (system, bed, post strainer and lateral) and remarks. The program defaults to the previous value if a new value is not input on a given day.
- Templates are included to input the resin analysis for each lot of resin received, both cation and anion, creating a convenient reference to the analyzed physical and chemical properties of each resin lot received.
- The actual new resin capacity data for each bed of resin installed is also input, so differences between resin lots will be accounted for in the ionic loading calculations.
- From a single entry of the capacity of each new bed, the ionic loading calculations are automatically updated for days after the replacement date.
- A template for adding resins to an existing bed is included, which automatically adjusts the remaining capacity after the addition date.
- CDI Conductivity, temperature and power charts.
- Circulating water leak and circulating water conductivity charts
- Auto generation of anion, cation and dP loading or trend chart.
- On-board instructions are included in the program file.
- The program is self-documenting. The bases and algorithms used are documented in the program along with sample calculations and references, facilitating configuration control requirements.
- The history of any revisions and updates is documented in the program.
- Program control is maintained through SI Chemistry's controlled software system.

ION CONDUCTIVITY PROGRAM (ICON)

Calculation Mode
SI Chemistry's ICON software is a menu driven user-friendly program for calculating:

- Conductivity and pH @ 25° C from input concentrations of selected ions.
- Strong ions and weakly dissociated species in an ion-conductivity balance.

Internal Database
ICON has an internal database of Limiting Equivalent Conductances and Equivalent Weights for the significant strong cations and anions, and for weakly ionized substances such as boron, chromium and carbon dioxide. The program can be used to correct conductivity for soluble iron and soluble zinc as allowed by water chemistry guidelines.

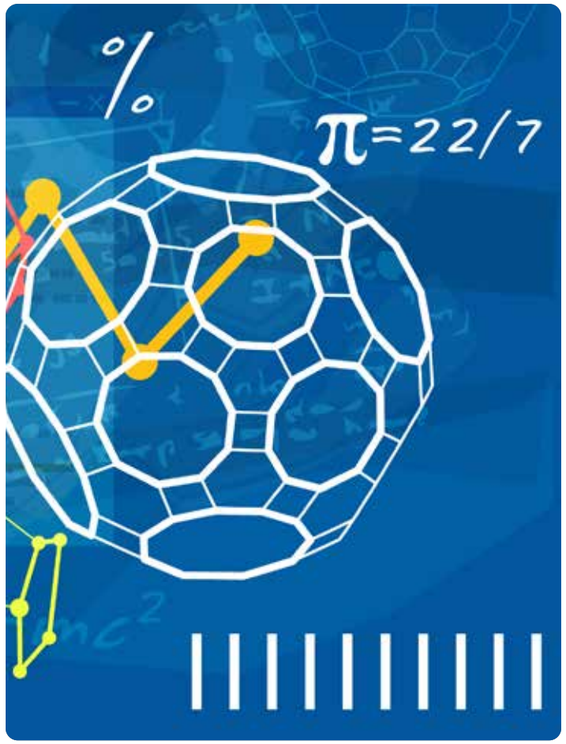
Units of Concentration Options
Units of concentration are selected by the user from a menu of ppb, ppm, µeq/l or meq/l.

Calculating Conductivity and pH from Concentration Inputs
Users select the units for input concentrations and supply the concentration values for each selected ion. Calculations automatically include H^+ and OH^- concentrations consistent with the solution electro-neutrality and dissociation constant for water at 25° C.

In the special case of CO_3^{-2} and HCO_3^-, only one concentration (HCO_3^-) is specified since the other is solved for automatically by the equilibrium relationship between these two ions and the H^+ ion. Species such as boron and chromium are entered as the elemental concentration, and the ionic concentrations of borate, chromate and bichromate are automatically determined by the calculation.

Equivalent weight for natural lithium is used for conductivity calculations. There is <1% difference in the weights of natural lithium and Li-7.

The Program assumes that all soluble iron is Fe^{+2}. This is a reasonable assumption for pH<8.5 since at equilibrium, soluble Fe^{+2} is >90%. However, user should take into account that for pH > 9.5 calculated results will not be representative of actual conductivity since the molar ratio of total Fe to Fe+2 is 2, i.e. half Fe^{+2} and half $Fe(OH)^+$.



Producing Hard Copy Records
Calculated results are shown in the corresponding system worksheet and logged in our ICON Data Log Worksheet in the Program. The Data Log Worksheet may be exported to another workbook with a command button. Calculation results may be printed via the Print button.

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