2015

VOLUME 39

Structural Integrity Associates, Inc.®

NEWS & VIEWS

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PRESIDENT'S CORNER

By: LANEY BISBEE
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This is my 10th year as Structural Integrity's CEO/ President and I have written 20 President's Corner articles in those years. Time goes by so fast, so I find it fun to stop and look back at what has happened in my "SI life" over those years and then look ahead again to see what the future may bring.

In the last 10 years, the electric power generation market has had a dramatically shifting and changing landscape:

- Coal plants have come under increasing pressure from EPA emission regulations with many plant closures, in fact many of the plants I cut my consulting teeth on are now closed.
- The Nuclear renaissance came and went and now several plants are under economic pressure from cheap natural gas while entering their 40-60 year operating lives. Fortunately, some are considering extension to 80 years.
- Wind generation ramped up dramatically from subsidies and Solar is starting to gain in generation; however, there are still storage technology challenges for large scale renewables.
- Natural gas plants are again a favorite generating source as fuel costs have plummeted.
- There is less enthusiasm about Small Modular Reactors (SMRs); however, they are being considered on a limited basis.
- While discussed in the past, a distributed power generation model (e.g., each home being a generating source) is now gaining traction.
- There's a massive knowledge drain in the industry from retirements and lagging hiring and training (hence our new training offering).
- Hazardous Liquids and Gas Pipelines (our second market) are faced with increasing regulations as they age and experience accelerating risks and potential catastrophic failures.
- While Europe has seen challenges similar to those in the US, other countries/regions have had tremendous growth, most notably in Asia and particularly China.

Like everywhere in daily life, technology has produced incredible change:

- NDE development is again accelerating with technology from spray-on transducers to guided wave UT to microwave technologies.
- The combination of sensor technology and data analytics has led to a range of diagnostic and prognostic technologies for components. This is proving to be a real technology integrator: on-line sensors, databases and engineering know-how embedded in software to provide insight that was not previously possible without an outage.
- Data storage capacity and sharing is almost unlimited and unencumbered through the cloud, combined with computing power that allows for high-fidelity modeling of operating and fault scenarios that couldn't have been conceived of a few years ago.
- Advanced alloys (including the now infamous Grade 91 steel) have allowed coal and gas plants to achieve steam temperatures in excess of 1100F (600C), allowing combined cycle plants to exceed 60% efficiency while, astonishingly, achieving startup times that no coal plant ever dreamed of.
- Communication technologies are changing how we interact with our clients and with each other; everything is now in the palm of our hand and available anywhere (including our reports!).

Along with the industry and technological changes, Structural Integrity has changed over the last decade as well.

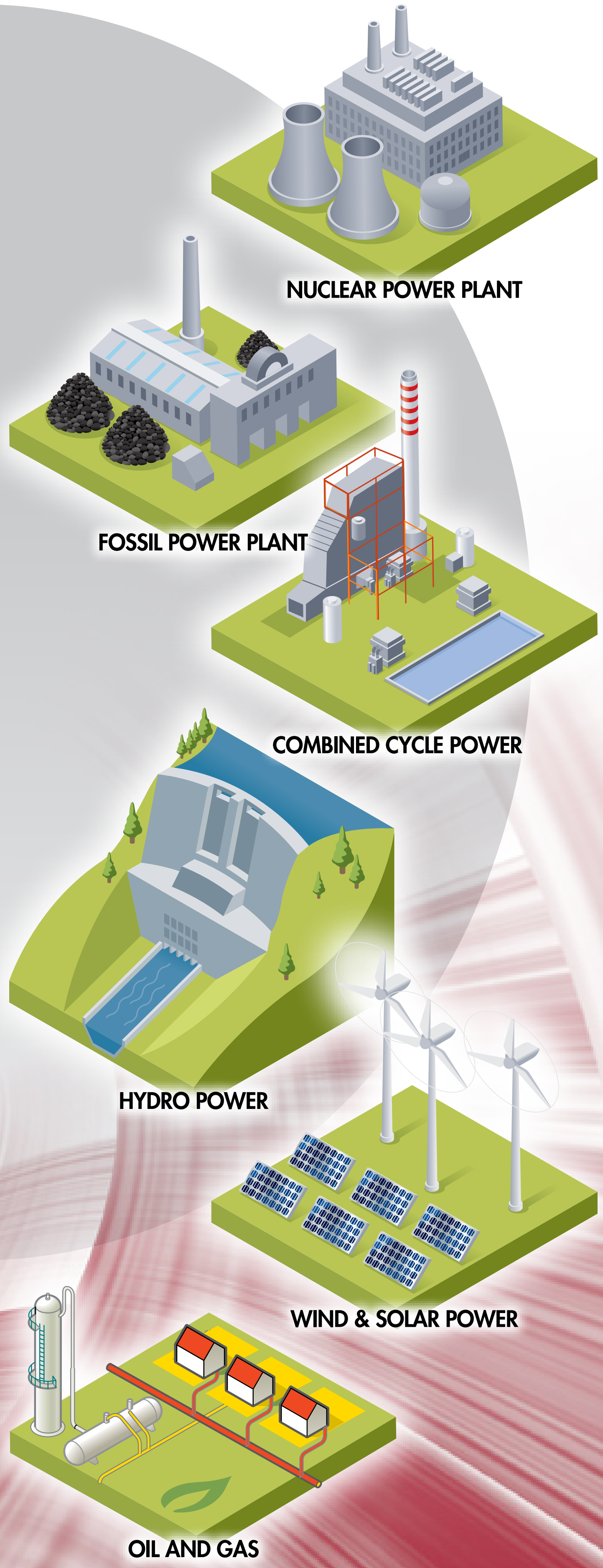
- We've significantly increased the amount of work we do.
- We've continued to attract industry-leading consultants, more than doubling the size of our staff.
- We've made several acquisitions to expand our capabilities and created partnerships to increase the breadth of services we offer our clients.
- We've opened offices in new locations and closed some older office locations.
- We've expanded into more international work on almost all continents (not Antarctica, yet) as a result of economic globalization.

- We have a new generation of leaders and employee owners (our third generation) implementing their vision for Structural Integrity.

While I'm not normally one to make predictions, I do have a hunch or two about what we might see in the future:

- Technology will be a major driver of continued change.
  - Significant growth in remote sensors to assess plant health driven by lower costs and increased speed of information gathering.
  - Additional growth in distributed generation, currently driven by the low cost of solar panels but new technologies for businesses, neighborhoods and individual homes will emerge.
  - Improved storage/battery technology, but I think we're a ways off from any industry-shattering developments.
- Government regulations will continue to start and stop but always continue creeping towards cleaner generation and more efficient consumption of electricity.
- Electric utilities will continue to be pushed by technology, with new companies moving into the power generation market just as we've already seen a transition from pure utilities to financial players owning generation.
- Many US nuclear plants will pursue life extension to 80 years.
- The continuing growth of new generating facilities (fossil and nuclear) in emergent and developing countries will be smoother as they learn from our decades of operational experience and lessons-learned to avoid mistakes and challenges.
- Structural Integrity will continue to innovate, adapt, and deliver valued solutions to industry's toughest technical challenges.

And despite all of the change I've seen over the last decade, there is still stability and consistency in our Mission and Core Values and for our industry – I wake up each work day looking forward to being a part of Structural Integrity and when I hit that switch on the wall the lights come on.



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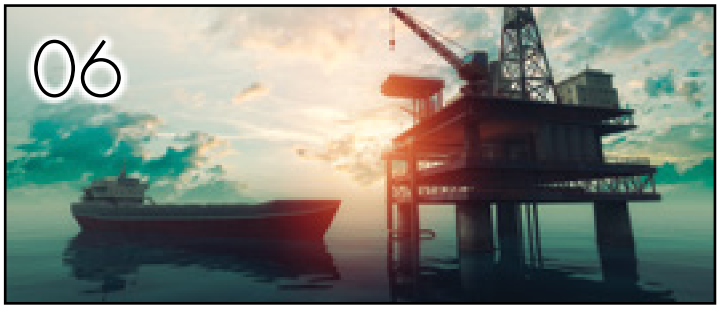

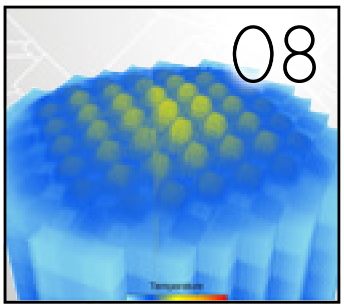

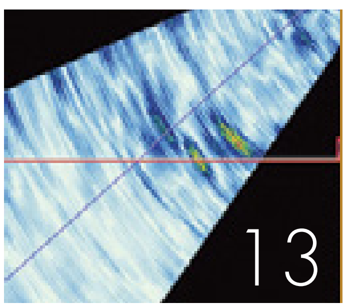

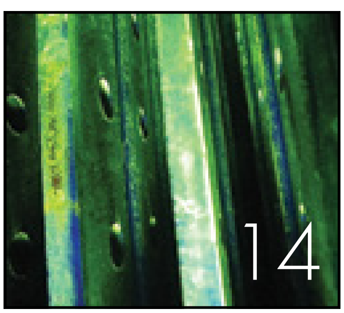

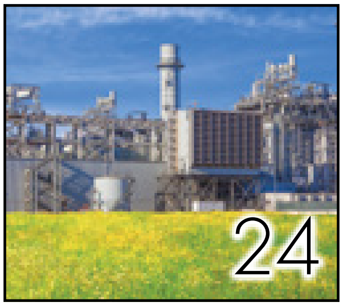
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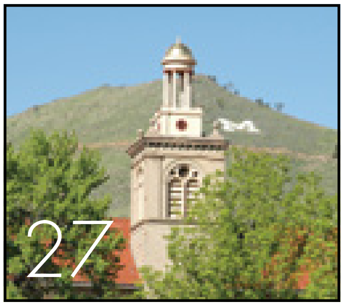
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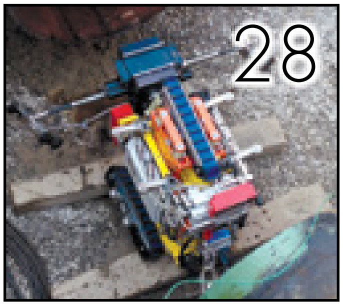
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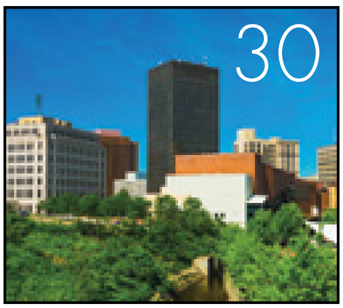
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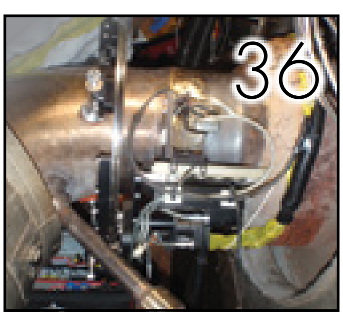
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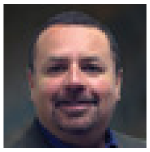
BRINGING BEST-IN-CLASS FATIGUE MONITORING TO OFFSHORE HPHT APPLICATIONS



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Many engineers in the nuclear and fossil electric power industry are well aware of the viability and benefits of our ***SI:FatiguePro 4.0*** software and methodology. For more than 25 years, Structural Integrity has been using FatiguePro to help utilities monitor and manage fatigue damage of critical, safety-related equipment. In nuclear power plants, the components inside these heavily reinforced containment structures are inaccessible for direct monitoring to directly measure the complex and multiaxial strains at the locations of interest. So, the well-known Transfer Function and Green's Function methodologies are utilized to conservatively determine the current and projected fatigue damage, based on already existing measurements of temperature, pressure, etc.

A similar challenge exists for offshore, subsea applications, which will inevitably approach ever greater depths over the coming years. These subsea depths found in the Gulf of Mexico (up to 10,000 feet of water) expose the pressure-containing components to high temperature and high pressure (HPHT) conditions. Due to the inhospitable and remote environmental conditions, in-service NDE and direct measurements of strains are all but impossible at some critical locations. In order to perform safely under these harsh conditions, we must rely on sound engineering principles to manage the fatigue life.

Metal fatigue from cyclic stresses (e.g., pressure, thermal and live loads) can shorten the life of critical HPHT components, but ***SI:FatiguePro 4.0*** can automatically determine environmentally-assisted fatigue usage and count events, using existing and strategically placed instrumentation. ***SI:FatiguePro 4.0*** facilitates the periodic safety assessment related to fatigue life concerns by providing an immediate, up-to-date and continual assessment of fatigue usage (either S-N based or fracture mechanics based analyses) for any critical HPHT component.

The offshore oil & gas industry is moving into new frontiers in the Gulf of Mexico. Proposed new fields will rely on equipment that will be required to operate at increased HPHT conditions, for which the American Petroleum Institute (API) and The American Society of Mechanical Engineers (ASME) standard class are not yet adopted. The next generation of equipment designs will need to perform at temperatures up to 350°F, pressures up to 20,000 psi and in extreme sour service environments (NACE SSC Region 3). As such, this industry is breaking new ground and will benefit from transitioning the lessons and technology, proven in the electric power industry, to their emerging fatigue threats offshore.

When companies submit for a conceptual Deep Water Operations Permit (DWOP) for HPHT operations, operators will need to comply with 30CFR250.807(a). The federal regulator for such matters, the Bureau of Safety and Environmental Enforcement (BSEE), expects the operator to describe their plans to monitor all loads that affect the service life of HPHT equipment after installation. To achieve the design requirements in these harsh environments, manufacturers have considered increasing the wall thicknesses in proportion to the increased pressure. A consequence of increased thickness may be increased susceptibility to fatigue damage, primarily associated with the thermal gradients experienced during the life of the well. In

addition, the increased costs and technical difficulties associated with manufacturing, inspecting and deploying components with extreme thicknesses and weight further complicate the design. Based on our experience and leadership with design and analysis of high pressure equipment, we think there is a better way.

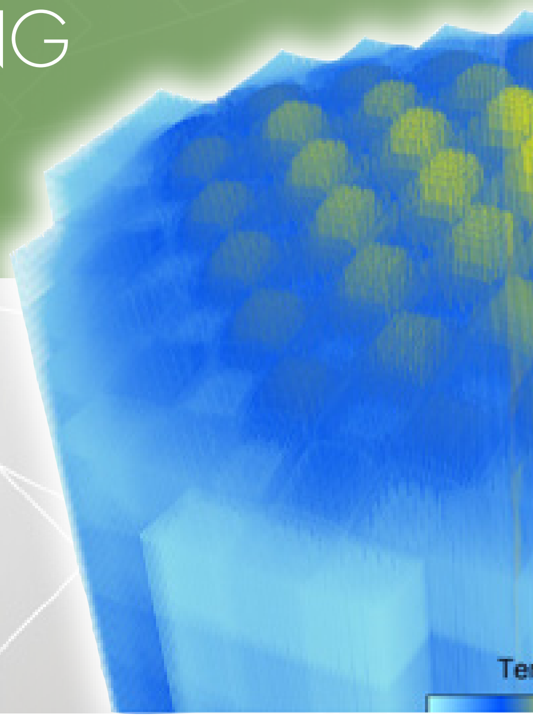
Structural Integrity has begun sharing our experience with fatigue monitoring, specifically through our participation on the API 17TR8 committee – *High-Pressure High-Temperature (HPHT) Design Guidelines*. We have also

increased our participation in the offshore Oil & Gas sector by publishing more at industry events on such topics as **Fatigue Management Alternative for HPHT Deep Water Applications** and **Integrating Fatigue Monitoring of HPHT Systems into a Conceptual DWOP**, and serving as the principal investigators on a new research project under the offshore consortium DeepStar (www.deepstar.org). Simulated case histories are being used to understand and address specific concerns with a given subsea design, reviewing modeling principles needed to monitor the fatigue life using existing sensors and data available from standard subsea completions. These efforts focus on demonstrating how fatigue damage of components using actual operating data can be evaluated over time, in order to satisfy BSEE's expectation for comparing the actual load cycles experienced by the HPHT component to the load cycles used in the design verification analyses at 25 percent of the design service life and beyond. The approach leverages proven principles employed for several decades in the nuclear and fossil power industry, which have successfully met similar technical and regulatory challenges involving fatigue monitoring of remote locations using limited instrumentation.

This is an exciting time for us, and we are looking forward to providing the offshore oil & gas industry with our technical leadership and expertise, that many of you know us for, to this new application.

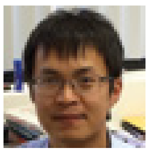
For additional information on SI:FatiguePro 4.0 or Structural Integrity's subsea capabilities, see www.structint.com/subseaHPHT

ADVANCED FUEL MODELING AND SIMULATION



ANATECH CORP.

A Structural Integrity Associates, Inc.® COMPANY



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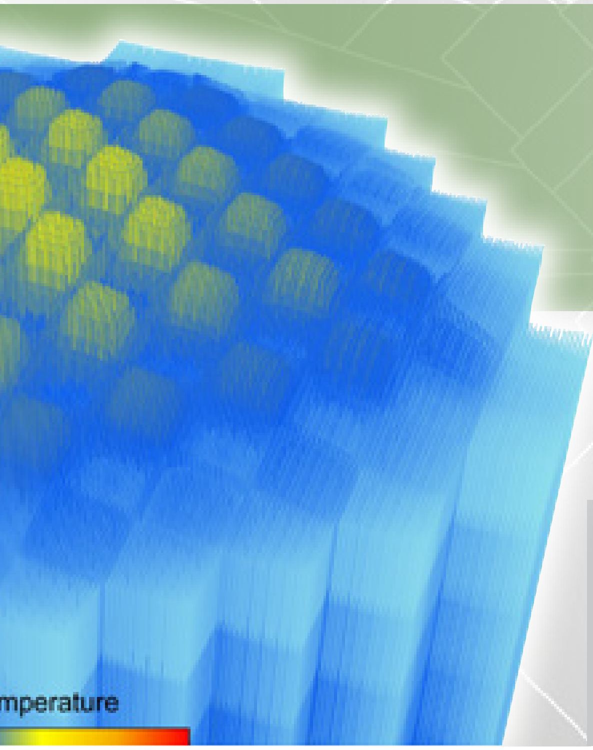
Nuclear fuel is operated in aggressive environments; the combination of material degradation and operating conditions can cause fuel failures and have safety implications in accident conditions. This is particularly true when the industry was pursuing high fuel utilization. However it is difficult to monitor fuel behavior in the reactor environment. In-core experiments are costly to perform, and measurement data are scarce and often limited in applicable ranges. Using a computer code to model a fuel rod and predict its behavior is an important approach to help understand and address fuel performance issues. This necessitates the development of fuel performance code (a computer program that computes the thermal and mechanical response providing output information such as fuel temperature, cladding stress and strains, and other performance parameters). The use of fuel performance codes for modeling fuel behavior can be dated to as early as the 1970s. However, in general, fuel performance codes did not gain broad application. Many of the traditional fuel performance codes are proprietary and restricted to certain users. Also, there is a strong inertia code modifications implemented for licensing purposes which has limited applications to fuel code improvements.

With the advancement of computational technology, there is a renewed interest in the fuel modeling and simulation. The expectation is that one can improve the fidelity of modeling and simulation by using the computing powers we have today. This has been the motivation for the recent U.S. DOE's research programs, Consortium for the Advanced Simulation of Light Water Reactors (CASL) and Nuclear Energy Advanced Modeling and Simulation (NEAMS), which develop the advanced computational technology for the modeling and simulation of reactor operations. As these efforts had been geared towards high-fidelity simulation, multi-physics, and multi-scale modeling, development of fuel modeling capability emerges as one of the most important areas in these programs.

The new modeling and simulation technology leverages the computational capabilities in many existing numerical software and well-validated material models in the traditional fuel codes. Multiple organizations closely collaborated in the DOE's development process. Progress had been made in the development of modeling and simulation capability which culminated in the release of advanced fuel performance codes. With a goal of high fidelity computation, advanced capabilities are being developed aiming to capture the three-dimensional behavior which includes but is not limited to, the eccentricity of the pellet, ovalization of the cladding tube, and clad ridging, manufacture defects in pellets or cladding tubes, and non-axisymmetric power distributions. Such capabilities could provide new insights from a modeling and simulation perspective. The development also scientific community to benefits from scientific research results, particularly, knowledge and models at lower length of scale to inform the engineering calculations.

Consortium for the Advanced Simulation of Light Water Reactors (CASL) is one of the Energy Innovation Hub sponsored by United States Department of Energy (DOE). It was created in May 2010, and is based at Oak Ridge National Laboratory (ORNL). CASL combines fundamental research and technology development through a partnership of national labs, universities, and other industry participants. The goal is to develop advanced computational models for light water reactors (LWRs) that can be used by utilities, fuel vendors, universities, and national laboratories to improve the performance of the existing fleet and future nuclear reactors in the U.S.



For more information on Fuel Rod Training click here

Both research programs are related to fuel modeling and simulations, but the focus is different. The BISON code development in NEAMS program is focused more on the generic capabilities which can be extended to fuel types not limited in LWRs. The CASL activity is more focused on the industry challenging problems such as fuel performance issues in operating transients and in design basis accident conditions.

The Nuclear Energy Advanced Modeling and Simulation (NEAMS) is a research program within the U.S. DOE which develops a simulation tool kit using advanced computational methods that aims to accelerate the development and deployment of nuclear power technologies efficiently. NEAMS is organized along Fuels Product Line (FPL) and Reactors Product Line (RPL). The approach of the FPL is simulations with the BISON code at the engineering (continuum) scale informed by mesoscale (grain-scale) simulations. Multiphysics integration connects separate phenomena, while multiscale integration connects different scales of each phenomenon. High-performance computing methods and modular code design ensures the modeling and simulation run efficiently.

ANATECH Corp. a Structural Integrity Associates, Inc. company, as internationally recognized experts in modeling the nuclear fuel rod behavior, has participated in the fuel performance code development efforts for NEAMS since 2011 and for CASL since 2012, respectively, through collaboration with national laboratories. We contributed to the fuel code development and assessment activities both as code developers and as advisors to provide technical guidance and support to both research programs.

We have a unique position in the industry in the computational technology and fuel technology areas. We are experts of developing computation methods and material models, and have accumulated a deep experience in providing practical engineering solutions to our clients in fuel performance issues. Such a unique combination enabled us to play a critical role in CASL and NEAMS to advance of fuel modeling and simulation technology.

We had been responsible for leading a number of areas for CASL and NEAMS, and have a track record of accomplishment including the first release of CASL's fuel performance code Peregrine (BISON-CASL). This code pairs the computation and modeling capability of the existing industry code Falcon (A 2-D finite element model fuel code we developed for EPRI), extending the code's capability to modeling transient conditions, and demonstration of linking the polycrystal plasticity model to the engineering fuel code.

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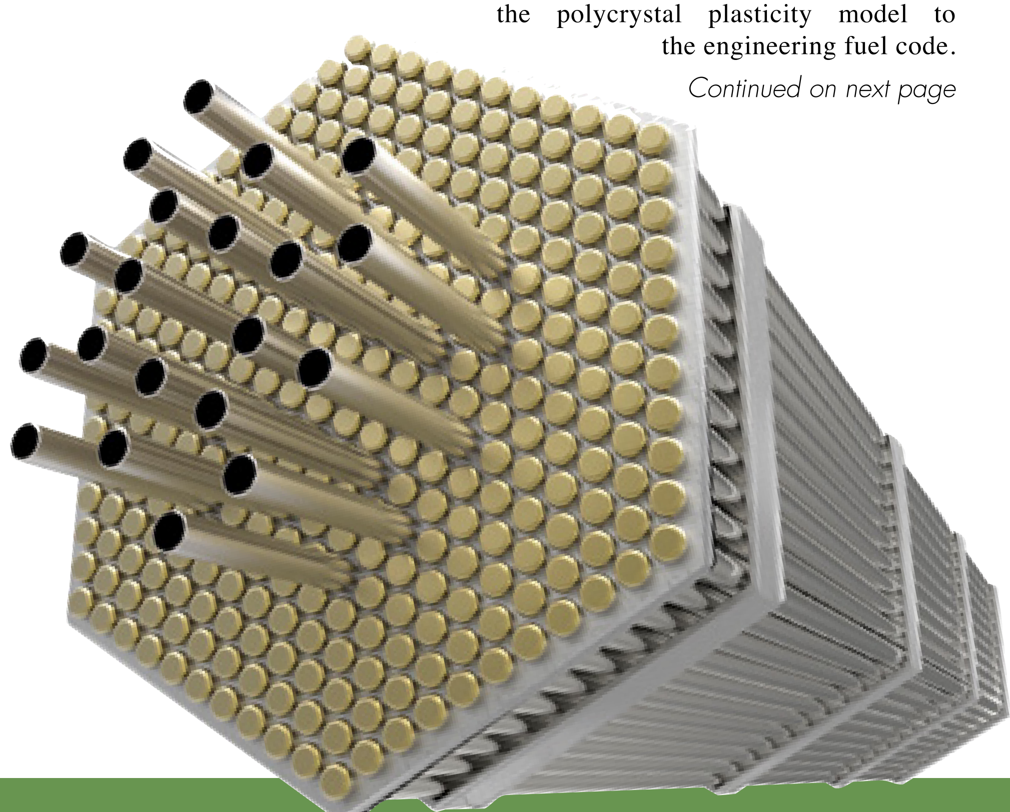

ADVANCED FUEL MODELING AND SIMULATION

CONTINUED

A LIST OF PUBLICATIONS AND REPORTS ANATECH HAD CONTRIBUTED TO NEAMS AND CASL:

R.O. Montgomery, D.J. Sunderland, W. Liu, C. Kirby, N. Capps, B.D. Wirth, C.R. Stanek, M. Zikry, and J.D. Hales, "Assess Peregrine as a 3D Fuel Performance Model for the PCI Challenge Problem," L1.CASL.09.01, July (2014).

W. Liu, R.O. Montgomery, C. Tome, "Demonstration of Atomistically-informed Multiscale Zr Alloy Deformation Models in Peregrine for Normal Operation and Accident Scenarios", L2.MPO.P9.02, September (2014).

Wenfeng Liu, Joe Rashid, et. al., "Numerical Method of Modeling Creep of Zirconium Alloy Cladding in a Multiphysics Fuel Performance Code," 2013 International Meeting on LWR Fuel Performance, Charlotte, NC, U.S., September, (2013).

Robert Montgomery, C. Stanek, W. Liu, and B. Kendrick, "US DOE CASL Program Fuel Performance Modeling for Steady State and Transient Analysis of LWR Fuel," IAEA Technical Meeting "Modelling of Water-Cooled Fuel Including Design-Basis and Severe Accidents," Chengdu, China, (2013).

Robert. Montgomery, Wenfeng Liu, Dion Sunderland, Nathan Capps, Brian D. Wirth, Chris Stanek, and Jason Hales, "Peregrine: Validation and Benchmark Evaluation of Integrated Fuel Performance Modeling Using Test Reactor Data and Falcon," CASL Milestone: L1:CASL.P7.02, June (2013).

Nathan Capps, Dion Sunderland, Wenfeng Liu, Robert Montgomery, Jason Hales, Chris Stanek, and Brian D. Wirth, "Benchmarking of Peregrine against Experimental Data and Falcon Code," 2013 International Meeting on LWR Fuel Performance, Charlotte, NC, U.S., September, (2013).

Wenfeng Liu, Robert Montgomery, Carlos Tomé, Chris Stanek, and Jason Hales, "VPSC Implementation in BISON-CASL Code for Modeling Large Deformation Problems," ANS MC2015 - Joint International Conference on Mathematics and Computation (M&C), Supercomputing in Nuclear Applications (SNA) and the Monte Carlo (MC) Method • Nashville, TN • April 19-23, 2015, on CD-ROM, American Nuclear Society, LaGrange Park, IL, U.S.A., April, (2015).

W. Liu, C.N. Tomé, R.O. Montgomery, and C. Stanek, "A Study on Effects of Crystallographic Texture on the Irradiation Growth of Zirconium Alloy Using Visco-Plastic Self Consistent Modeling Approach," TOPFUEL September, (2015).

R. J. Gardner, S. R. Novascone, D. M. Perez, G. Pastore, R. L. Williamson, J. D. Hales, and W. Liu, "Improving the Accuracy of PCMI Simulations with more Realistic Geometry and Material Models," TOPFUEL September, (2015).

J.D. Hales et. al., "BISON Theory Manual," Idaho National Laboratory, (2015).

We are expecting the advanced fuel modeling and simulation to benefit the nuclear industry in the long run:

- It establishes the foundation that can potentially remove the limitation in the traditional empirically based modeling approach.
- It could assist the innovative fuel designs to improve its resistance to damage in the accident conditions. The modeling of fuel could be performed in an integrated environment that could couple the neutronics and thermal hydraulics codes.

With the advanced computational capability, performing analysis on a large number of fuel pins with high fidelity could be also feasible. The plant operator could benefit from the modeling and simulations of detailed behavior to improve the safety margin of operation.

In addition to being an active participant, we are also a licensee of the BISON code, which means that we will develop and maintain our own version of code for commercial application purposes. This enables us to provide state-of-the-art services to our clients should the need arise.

In the past, we had witnessed and participated in the birth of advanced fuel performance codes, joined the code development, and overcome many technical challenges. We appreciate the opportunities that showcase our technical capabilities. In the future, we will continue to provide our best solutions to advance the fuel modeling and simulation capabilities by ***linking theory and practice***.

STEMMING THE KNOWLEDGE BRAIN DRAIN

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The statistics associated with the US energy market and its aging workforce are well documented. As one example, nearly 40% of the current workforce supporting electric power generation will be eligible to retire in the next three to five years.(1) As with all statistics, they are subject to interpretation and that means they can be misinterpreted or taken out of context and sometimes exaggerated. However, workforce aging is an issue many of our clients have experienced first-hand, are concerned with, and are taking proactive action to address.

At the same time, economic pressures within the energy market in recent years have required our clients to continually reduce headcount and increase workload. This reduced headcount/increased workload situation has stretched client resources insofar as coverage and increased reliance on suppliers for the most challenging component and system issues; thus further complicating knowledge transfer to those being hired to replace resources lost or eventually lost to retirement and attrition.

Over its 30+ year history, Structural Integrity (SI) has often been a resource to our clients for training on material degradation issues, related engineering analyses and programs (including software), and NDE and monitoring technologies needed to quantify and maximize component/asset life. This training has been deployed for brand new resources, as well as for enhancing the skills and knowledge of our more experienced clients.

In late 2014 and early 2015, we stepped up our game around training with several objectives and the response has been positive:

- Identify target areas for training based upon historical demand
- Obtain client input on current needs, interests, and perceived gaps
- Match the result from above with our internal competencies and resources, and then plan and schedule out our improved training offer
- Upgrade and standardize training materials to maximize our clients' ability to credit the training (e.g., PDHs for Professional Engineers)
- Ensure that rich examples of real-life applications are provided in our training that link the underlying theory with practice
- Improve the marketing and promotion of our training through our website, printed collateral materials and our client interface

As a result of this 2014 initiative, we have seen a significant uptick in interest from our clients in training. The format for the training is flexible: (1) centralized training at our offices in accordance with a set schedule on a variety of topics; and (2) custom scheduled training delivered at the client site. Examples of high demand topics thus far include flaw evaluation methodologies, corrosion/corrosion control, and NDE for Engineers. A complete listing of the currently planned training topics is provided in our training catalog found at www.structint.com/competencies/training.

In addition to the courses listed in the training catalog, we welcome inquiries regarding other training topics not currently listed in the training catalog. Please email us with any requests at info@structint.com.

REFERENCES:
1 - http://www.power-eng.com/articles/npi/print/volume-8/issue-1/nucleus/who-will-replace-nuclear-power-s-aging-work-force.html

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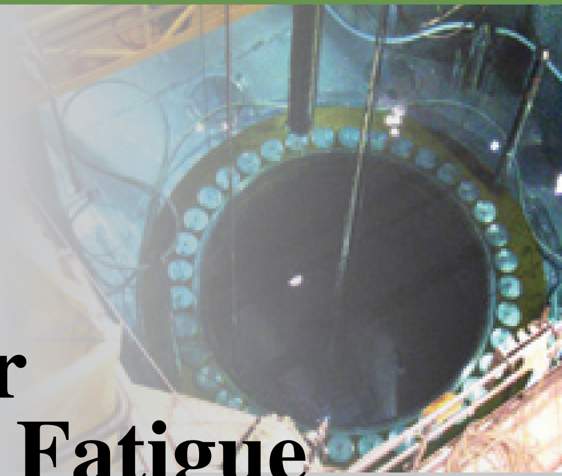


Interim Requirements for Management of Thermal Fatigue

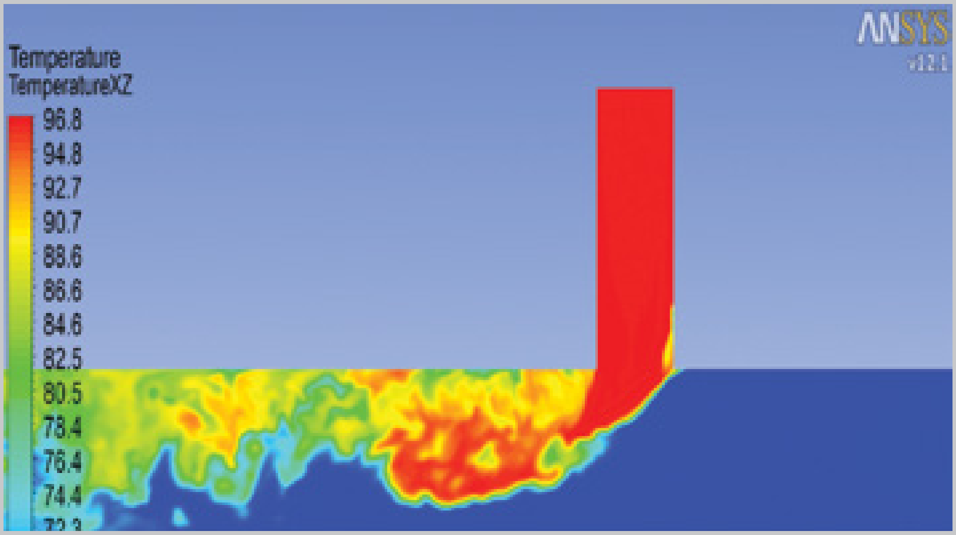
Interim guidance has recently been issued by the EPRI Materials Reliability Program (MRP) related to the MRP-146 and MRP-192 thermal fatigue management programs. MRP-146 provides guidance for the management of cyclic stratification thermal fatigue induced by swirl penetration in reactor coolant system stagnant branch piping in nuclear power plants. MRP-192 provides guidance for the management of thermal mixing in residual heat removal, shutdown cooling and decay heat removal system branch tees.

Earlier this year, EPRI formed the Thermal Fatigue Focus Group (TFFG) in response to several thermal fatigue cracking events. The operating experience identified weaknesses in the current thermal fatigue management guidance provided in MRP-146 and MRP-192 resulting in interim guidance being developed by the TFFG. Two (2) "Good Practice" and eight (8) "Needed" NEI 03-08 requirements are introduced with implementation deadlines of either 10/1/2015 or 6/1/2016 depending on the specific requirement.

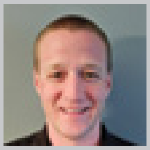
The first NEI Good Practice requirement relates to the review of key assumptions made during the analyses and examination plans used to support MRP-146 and MRP-192 actions. Justifications used for these key assumptions may have changed since initial completion and may not remain valid. The second NEI Good Practice requirement increases the scope of MRP-192 examinations to all branch mixing tee welds.

The first of three NEI Needed requirements possibly increase the population of down horizontal (DH) piping requiring examination. The next two NEI Needed requirements are related to up horizontal (UH) piping where additional lines previously determined not to require examination may indeed need to be inspected as well as the examination scope being increased in some instances. The last of the three NE I Needed requirements apply to all screened in piping and are related to examination volume specification, documentation of limitations and coverage during inspections, and examination volume coverage requirements.

Structural Integrity has worked closely with the nuclear industry on thermal fatigue issues for many years. Thus, we are well-positioned to assist utilities in understanding the new requirements and providing engineering and non-destructive examination support for related actions.



MRP-146 THERMAL FATIGUE EXAMINATIONS



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HISTORY

In the late 1980's, there was thermal fatigue cracking and leakage in several PWR plants. This led to the issuance of NRC Bulletin 88-08. The cracking was attributed to thermal cycling mechanisms and was found in normally stagnant lines attached to RCS piping. In the late 1990's to early 2000's, there were several other instances of thermal fatigue cracking in other components such as drain lines and a high pressure injection/makeup line. In January 2001, MRP-24 was made available as an interim guideline. After the issuance of MRP-24, additional testing and evaluations were done to better characterize thermal fatigue damage. In 2009, supplemental guidance to MRP-146 was issued providing revised evaluation guidance for screened in branch piping.

EXAMS

Structural Integrity (SI) recently completed three exams looking for thermal fatigue and craze cracking at a client's site in April 2015. The exams were successfully performed on reactor coolant pump drain lines with an elbow to pipe configuration. The exams were completed using the guidelines of MRP 146 and supplemental guidance report MRP-146S. We used the OmniScan MX ultrasonic instrument with the OMNI-MPA32 (128 PR) phased array module running a 20°-70° shear wave azimuthal scan with an angle resolution of 1°. This allowed for a thorough inspection of the exam area. Figure 1 shows an example of coverage for an exam. Figure 2 shows craze cracking in a mockup. Figure 3 shows an example of a thermal fatigue crack in a mockup.

Our involvement in the development and implementation of the governing documents, along with the ability to develop customized examination solutions, positions us to provide our clients with fully integrated, best in value solutions.

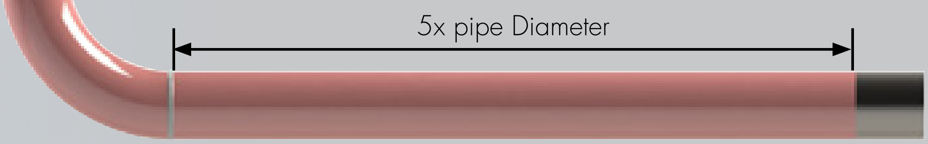

Figure 1. Example Coverage

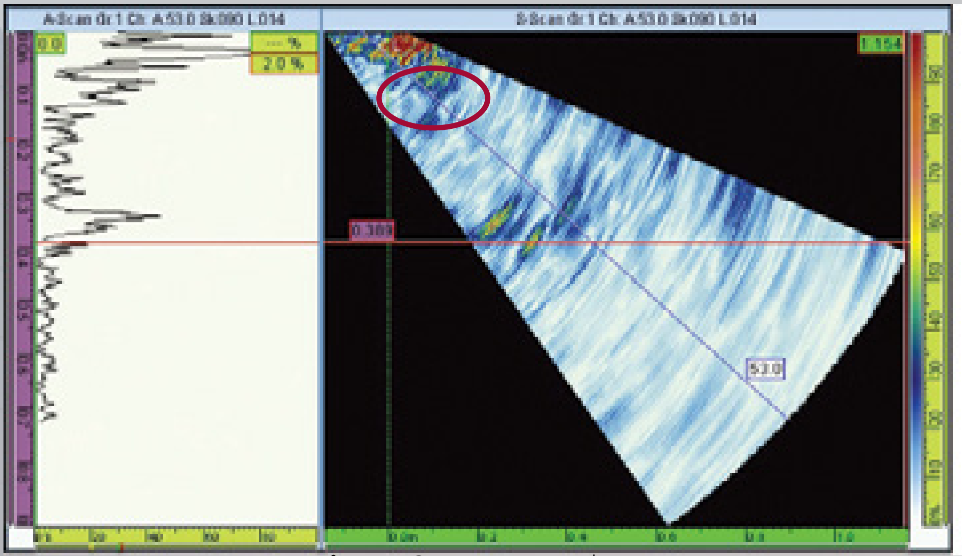

Figure 2. Craze Cracking

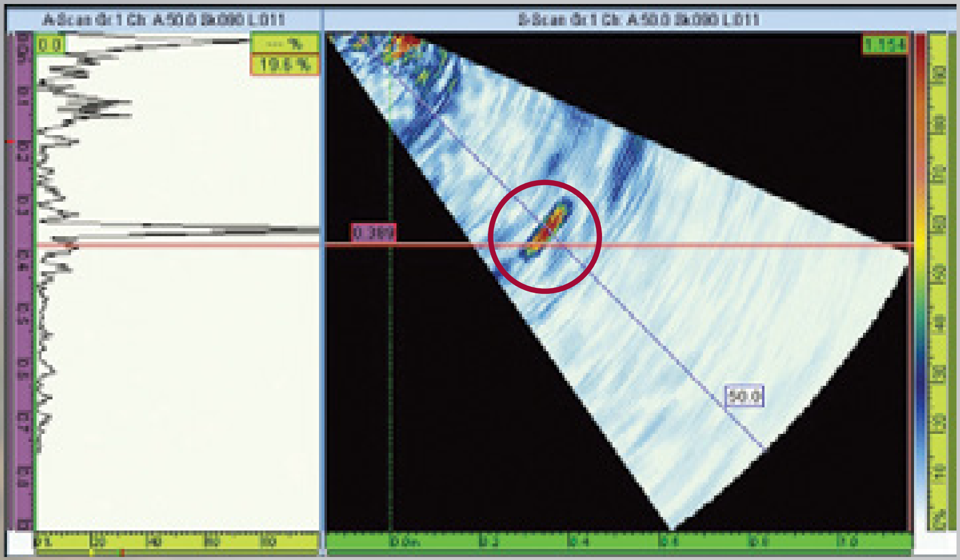

Figure 3. Thermal Fatigue Crack

CRACKED PINNED FINGER TURBINE BLADE ATTACHMENT ASSESSMENT FOR CONTINUED OPERATION

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OEMs recommend periodic inspection of pinned finger turbine blade attachments for detection of service-induced damage. Some designs require removal of the pinned finger blades for inspection of the blade fingers and the mating disk finger attachment. This article provides an example where Structural Integrity detected cracking on one of the disk finger attachments and provided an engineering assessment to support continued operation and to identify a re-inspection interval for the LP rotor. Pinned finger attachments are commonly used to secure last-stage (L-0) or next-to-last stage (L-1) blades in low-pressure (LP) turbines. This approach could be applied to other pinned finger blade attachments to determine suitability for service.

Structural Integrity Associates (SI) performed inspections of an LP rotor from a 380MW unit. Inspections included fluorescent magnetic particle inspection of the exposed L-1 and L-0 finger attachments on the turbine-end and generator-end rows, as well as phased array ultrasonic inspections of L-2 and L-3 tangential entry dovetail attachments. Those inspections identified numerous shallow indications on the L-1 attachments, with engineering condition assessment requested for one notable indication on the generator end.

The one indication of note was identified on the L-1 generator end, circumferentially oriented at the base of the step below the outermost pinhole for two adjacent buckets. The indication is 1 inch long and is apparent on both the admission and discharge side of finger #4, therefore the indication is assumed to have propagated through the finger (approximately 0.2 inch thick). A photo of the indication is shown in Figure 1.

A proposed modification to the pin in the vicinity of the crack is a reduction in the pin diameter only at the location of disk finger #4. The nominal pin diameter would be maintained at the adjacent blade-side fingers and all other disk-side fingers. The pins for the affected adjacent buckets, bound the current circumferential extent of the crack, and the objective of the modified or recessed pin geometry is to reduce radial loading adjacent to the crack location. We evaluated effects of the modified pin on applied stresses in the vicinity of the crack.

We created a finite element model and performed stress evaluations to determine operating stresses in the L-1 stage finger pin attachments. Stress evaluations were also performed to determine the impact on operating stresses of cracking detected on disk finger and proposed pin modifications. Stress analyses were performed to evaluate the effect of the crack in the finger on redistribution of stresses to pin holes at adjacent blades. We considered two crack sizes for analysis. The as-found crack length (1 inch) was explicitly included

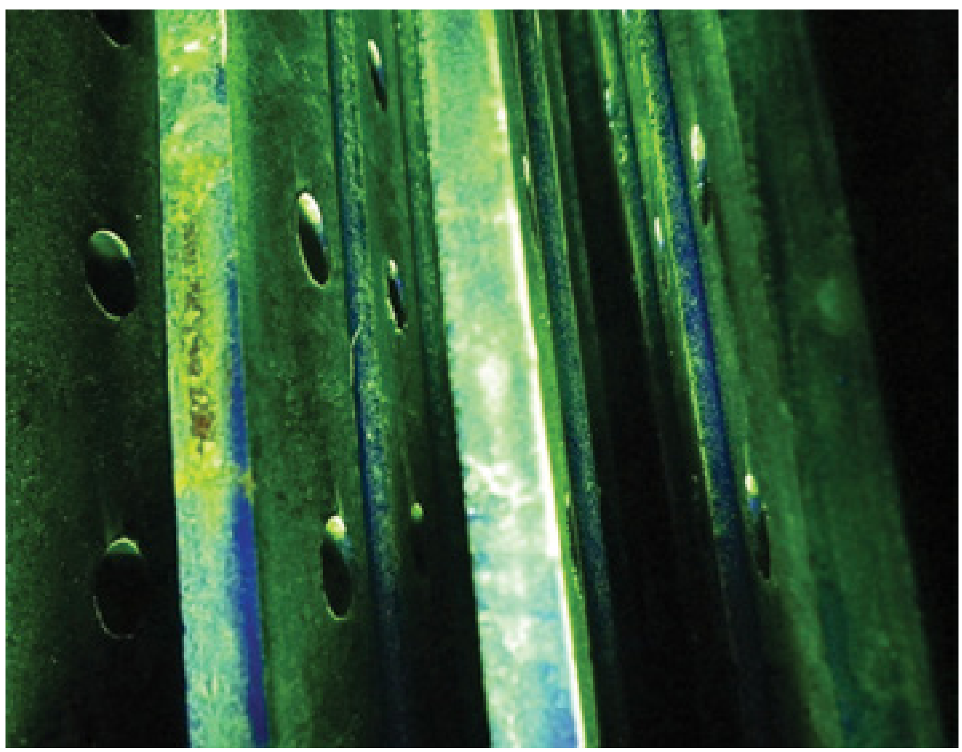
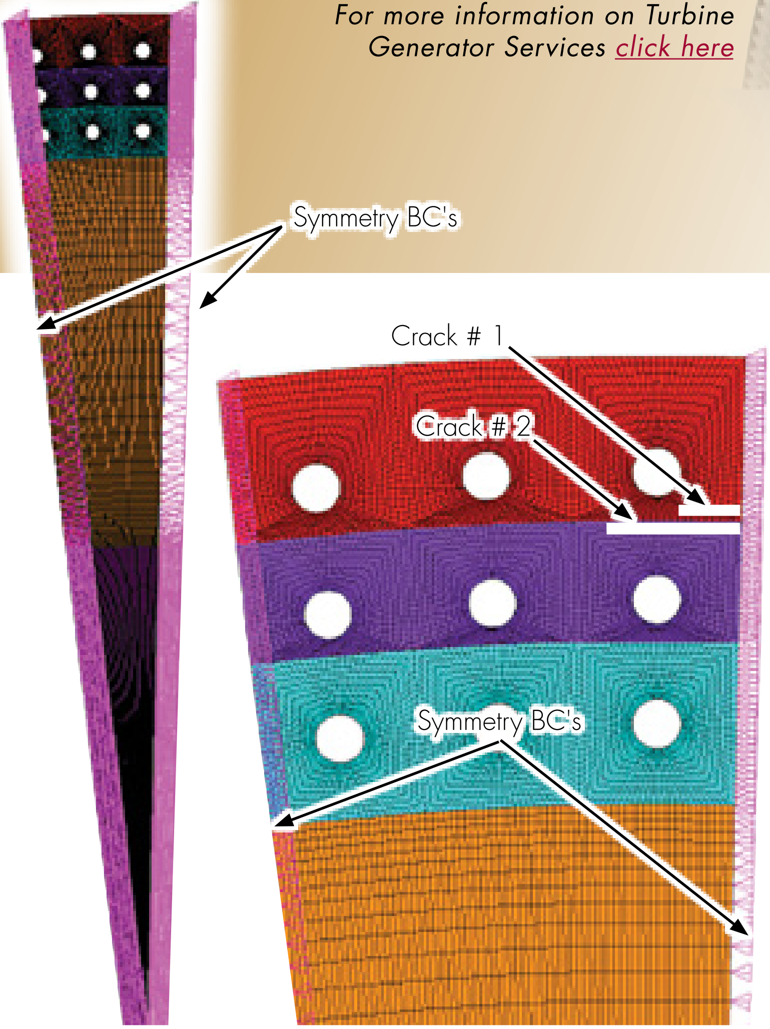


Figure 1. Photo of indication on disk finger #4, admission side of generator-end L-1 stage.

For more information on Turbine Generator Services [click here]



in an FE model comprising 6 blade widths. A second flaw was modeled having a conservative projected flaw length after 8 years operation. Separate models were created to evaluate the effects on finger ligament stresses for the nominal top pin case and the proposed pin modification, i.e. reduced diameter top pin for the two blades adjacent to the as-found crack and nominal top pins for the other blades. Stresses due to disk RPM and blade loading were evaluated separately, with the respective FE models illustrated in Figure 2 and Figure 3. *Continued on next page*

Figure 2. (Left) Finite element model for cracked L-1 disk finger showing boundary conditions and applied loads due to rotational velocity.

- Plane stress solution independent of element thickness
- E = 27,000 ksi
- ν = 0.29
- Load =3600 RPM
- No blade load included
- Crack # 1 is the current crack size
- Crack # 2 is the projected size at 8 years

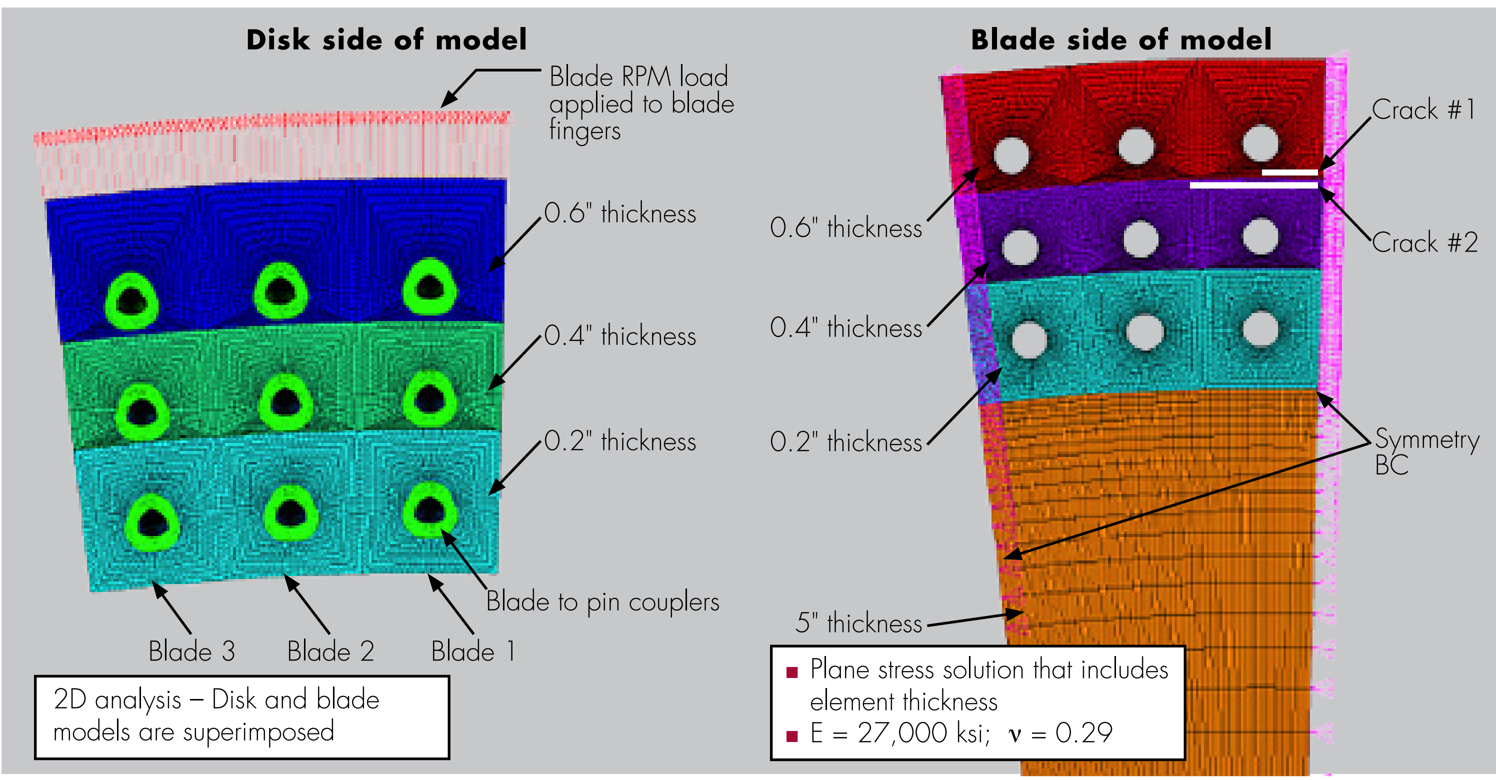


Figure 3. Finite element model for cracked L-1 disk finger showing boundary conditions and applied loads due to blade loading.

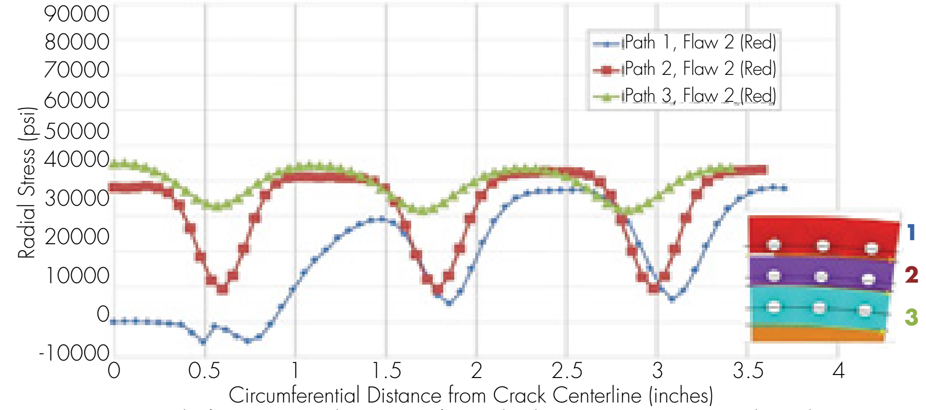


Figure 4. Radial stress vs. distance along thickness transitions, reduced top pin, as-found crack (flaw 1).

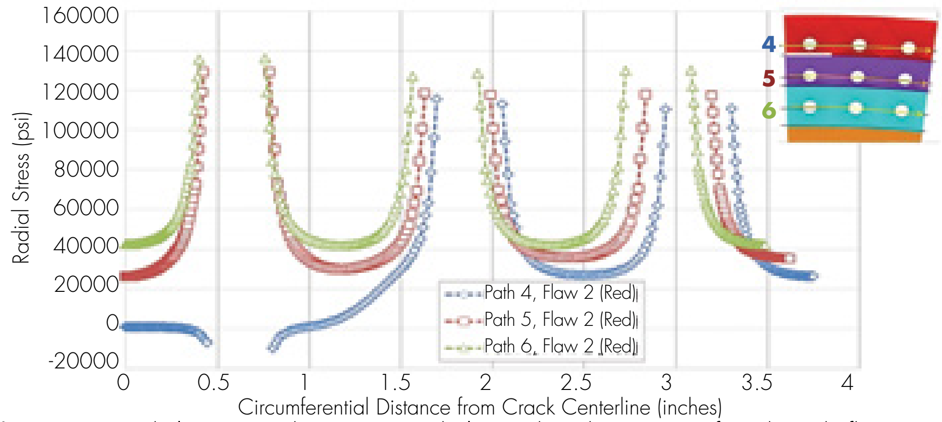


Figure 5. Radial stress vs. distance at pin holes, reduced top pin, as-found crack (flaw 1).

Stress results for the nominal pin geometry showed excessively high radial stresses on path 1 in the crack tip region for both crack models (not shown here). For the reduced top pin case, radial stresses versus distance along thickness transitions (paths 1-3) and at pin holes (paths 4-6) for the as-found flaw (flaw 1) are shown in Figure 4 for paths 1-3 and Figure 5 for paths 4-6. The corresponding stress distributions for the 8-year projected flaw (flaw 2) are shown in Figure 6 and Figure 7.

Finite element stress analyses show that stresses in the disk remain within acceptable levels with the use of the recessed pin. Analysis of the detected crack on the generator-end L-1 disk finger at its current size (1 inch long) and conservative 8-year projected crack demonstrate that stresses remain within acceptable limits. Critical crack lengths were also calculated with consideration for overspeed operation. The results of these analyses show that the use of a modified pin geometry could be used to alleviate stresses in the vicinity of the crack tips without raising stresses to unacceptable levels elsewhere in the disk, demonstrating that the detected crack produces little risk of attachment failure for an 8-year operating period from the unit's return to service following the inspections.

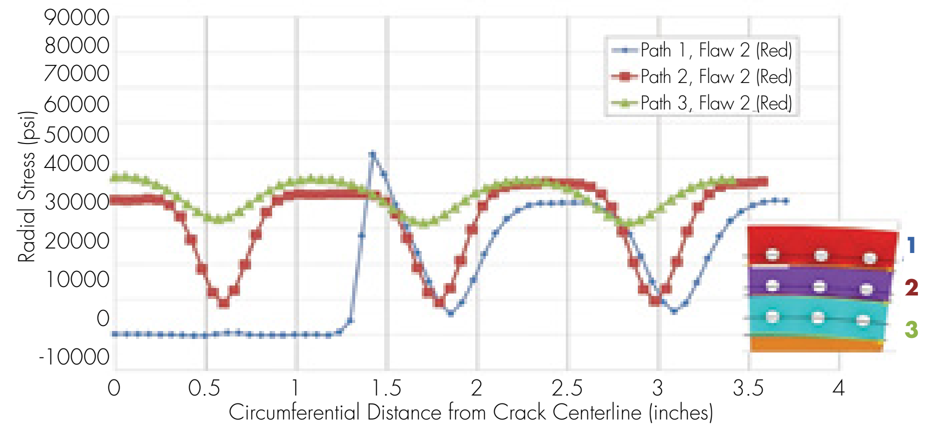


Figure 6. Radial stress vs. distance along thickness transitions, reduced top pin, 8-year projected crack (flaw 2).

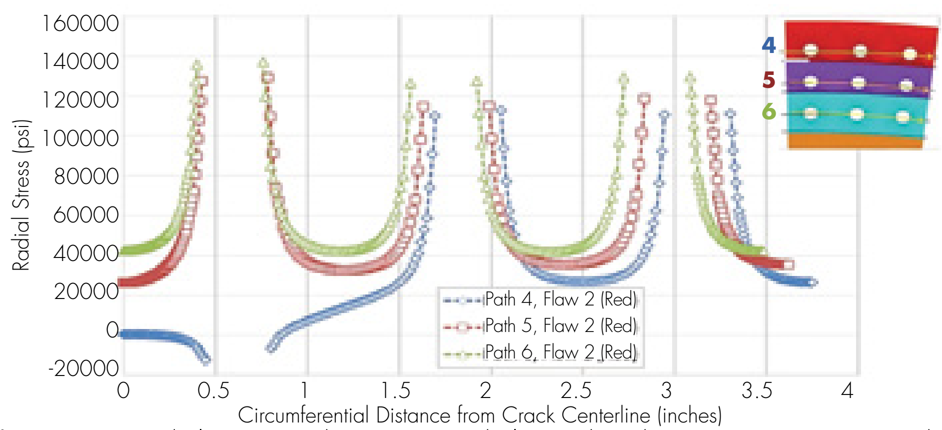


Figure 7. Radial stress vs. distance at pin holes, reduced top pin, 8-year projected crack (flaw 2).

Graphitization in Steam-Cooled Boiler Tubes

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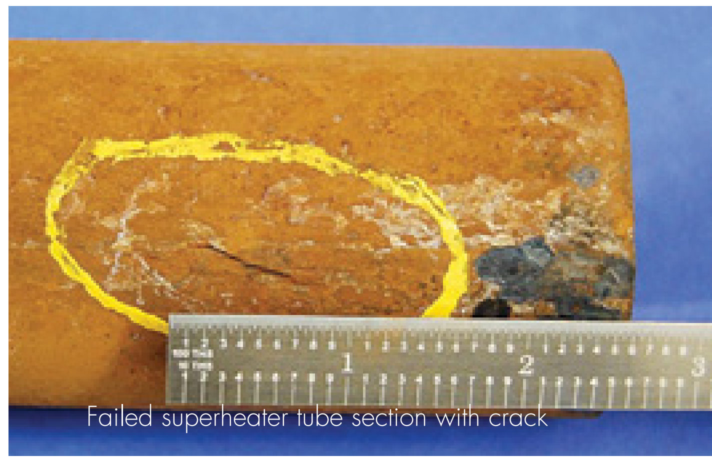
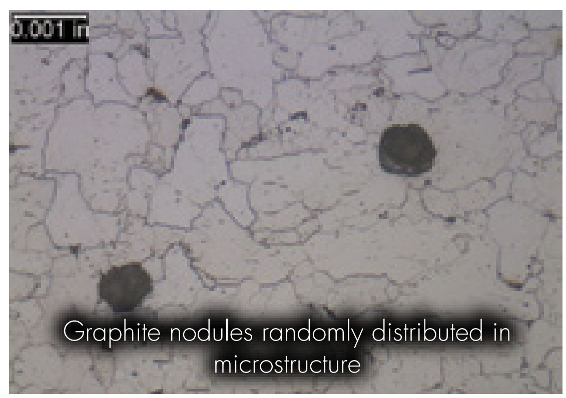
Graphitization occurs when carbon or chromium-free low alloy steels operate above a critical level of temperature for a long period of time. The mechanism and root cause are well understood, although the ability to predict when a tube may fail by graphitization remains limited.

MECHANISM

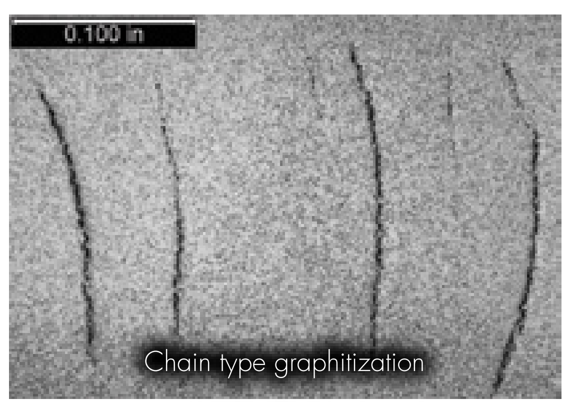
Graphitization is a form of damage that is unique to tubes fabricated from carbon or chromium-free low alloy steels that operate in the superheater or reheater sections of a boiler. The mechanism involves the decomposition of the original iron carbides into ferrite and graphite (the true equilibrium phases at temperatures below the transformation range) following prolonged exposure of the material to temperatures in the range of 425-700°C (800-1290°F). The graphite particles created during this decomposition can be present as individual spheroids (nodules) randomly distributed throughout the material structure, or they can be present as continuous or semi-continuous graphite “chains” (aligned nodules). Because graphite has very limited ductility, when the graphite particles become aligned into “chains,” the mechanical integrity of the tube is compromised and failure can occur. Chain type graphitization is mostly associated with the heat affected zones of welds; however, it can also occur far away from any welds. Note that spheroidization, which is a characteristic of thermal degradation, is a competing mechanism to graphitization at higher temperatures.



Failed superheater tube section with crack



Graphite nodules randomly distributed in microstructure



Chain type graphitization

TYPICAL LOCATIONS

Because graphitization only occurs following prolonged exposure to temperatures in the range of 425-700°C (800-1290°F), failures due to this mechanism normally occur in the superheater and reheater sections of a boiler.

FEATURES

- Brittle fracture appearance
- Graphite nodules observed within microstructure

ROOT CAUSE

The single root cause of graphitization is the prolonged exposure of a susceptible material to temperatures within the graphitizing range for that alloy.

If you would like to learn more about the previously undocumented form of graphitization that SI was the first to report on, please check out this industry notice. This form of graphitization was diagnosed as the root cause of catastrophic failures in boiler external primary superheater (PSH) piping, which is different from the graphitization in steam touched boiler tubes described here. www.structint.com/graphitization.

Misuse of Flex Pipes

By: TONY STUDER
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Flexible metal hoses exist in numerous configurations, lengths, and diameters and have found a wide range of applications. In general flexible metal hoses are used in five types of applications:

- To correct for misalignment
- To provide flexibility for manual handing operations
- To compensate for intermittent or constant movement
- To absorb vibrations
- Dampen or suppress noise

Due to the wide variety of uses and the perceived flexibility, problems can arise when flexible metallic hoses are used in specific applications. Metal hoses are manufactured in three basic styles: corrugated, interlocked, and square locked. In this article, we will consider only corrugated (convoluted) inner pipes with outer braided sheaths.

The flexibility of the pipe is determined by its length, convolute configuration (height and spacing), diameter, and pipe thickness. The existing pipe diameter will normally dictate the size of flex pipe, but flow rate, velocity, and pressure drop can also influence the flex pipe size. The bending behavior and pressure stability of corrugated pipes depends on the convolute configuration.

While flexibility increases with an increase in profile height and a decrease in convolute spacing, pressure resistance decreases. In addition, the pitch of the corrugations can be adjusted to alter the flexibility. Pressure resistance and flexibility can also be altered by varying the wall thickness. A reduction in the wall thickness increases the bending capacity but reduces the pressure resistance of the pipe. Therefore, for a given pressure, the flexibility of the pipe can be obtained by adjusting the thickness and convolute configuration. Another option to deal with flexibility is the length of the flex pipe. The length needs to be great enough to provide flexibility, but short enough to avoid sagging and other design issues with the specific application. Careful pipe selection, design of the assembly, and installation are critical for optimal service life.

One example of a specific application is the use as a flex pipe in association with pumps. In this application, the flex pipe can greatly extend the life of the pump; however, caution needs to be taken to avoid the tendency to use the flex pipe to compensate for piping misalignment. The thought that it is a flex pipe and a little misalignment shouldn't be an issue can lead to premature failures and maintenance issues. The primary function of flex pipe in this application is for vibration absorption and the elimination of piping stress on pumps; not to correct for major piping misalignment. In this application, the flex pipe is not designed for axial movement. Compression of the flex pipe reduces the load carried by the braided mesh and can lead to over pressuring of the inner convoluted pipe and premature failure.

Stainless steel braided pump connectors are constructed of stainless steel annular corrugated metal, surrounded with a woven braid of high tensile strength stainless steel. These assemblies are flexible and can withstand high pressure and temperatures. When the convoluted pipe is subjected to high internal pressure, the pipe has a tendency to elongate and if the convolutes are stretched out of shape, the flexibility of the pipe is impaired. In order to avoid this condition from occurring, the convoluted pipe is covered by a braided wire mesh. In addition to preventing hose lengthening due to internal pressure, the outer braided mesh also absorbs external tensile forces and protects the outside of the hose. The flex pipes must be installed in the proper direction; the vibration direction must be perpendicular to the pipe axis because the braided pipe can only absorb movements in this direction.

CASE STUDY

A system with redundant pumps was experiencing a rash of flex pipe failures. Since there were two redundant pumps, the failure of the flex pipe did not affect operation and was only a maintenance issue. One of the failed flex pipes was eventually submitted for laboratory analysis (Figure 1).

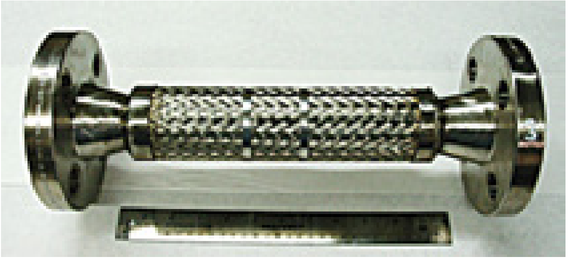

Figure 1. Failed Flex Pipe

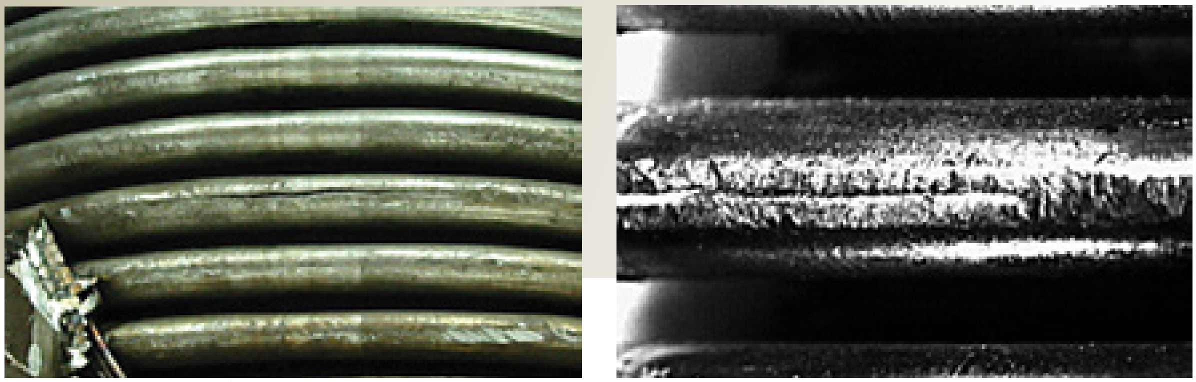

Figure 3. Circumferential crack observed in the inner convoluted pipe. Close-up examination revealed wear on the surface adjacent to the crack.

Due to the construction of the flex pipe with the stainless steel annular convoluted inner pipe covered by the braided mesh, identification of the leak was not straight forward. The flex pipe was immersed in water and pressurized with air to reveal the location of the leak. Once the general location of the leak was identified, the braided wire mesh was removed from the hose and the sample was pressure tested again to pin point the leak. Figure 2 shows the bubbles observed during the leak test before and after the braided mesh was removed.

The leak was due to a circumferential crack located in one of the outer convolutes in the hose (Figure 3). The convolute containing the crack exhibited significant wear.

A cross-sectional sample was removed from the center of the crack and prepared for metallographic examination. Figure 4 shows a cross-sectional view of the crack. The apex of the convolute exhibited significant metal loss. The crack was relatively straight with a transgranular (through grain) morphology and no secondary cracking. No evidence of corrosion was observed on the flex pipe.

Based on the evidence, the failure of the flex pipe was due to fatigue cracking. The straight transgranular cracks are characteristic of fatigue. The wear marks observed on the outer convolutes was due to the braided wire mesh rubbing against the flex pipe. The rubbing indicates that the flex pipe was exposed to significant bending loads. Excessive bending loads were known to be imposed during installation, and they combined with the normal operational cyclic loading (flow-induced vibration) to cause the flex pipe to crack.

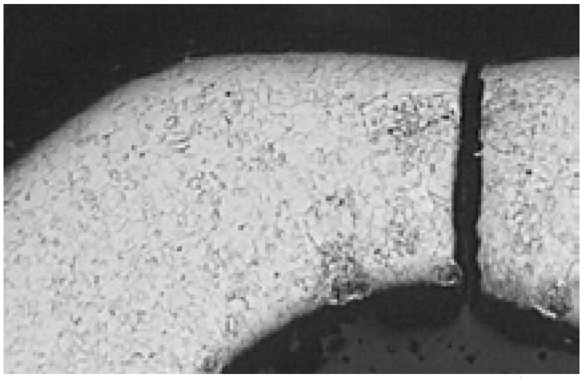

Figure 4. Cross section through the center of the crack.

Reviewing the installation revealed several issues that needed to be corrected. The piping was not properly supported to ensure that the flex pipe was not carrying any pipe loads. The flange holes on the flex pipe and piping were not properly aligned. And the mating flange surfaces were not parallel.

In order to avoid future fatigue failures of the flex pipes, it was recommended that the discharge piping in the unit be realigned. The approach taken to realign the piping and to help ensure better fit-up was to use a rigid flanged pipe section in place of the flex pipe. The rigid pipe section was installed in place of the flex pipe and the piping system was released from its constraints. The line experienced significant movement. After the movement, the piping system was secured in its new position. During this process, the piping was properly supported to minimize piping loads on the flex pipe. By using the rigid flanged pipe section in place of the reinstalled flex pipe for alignment of the piping, proper alignment of the holes was obtained and the flange surfaces were parallel. After the corrections to the piping system were complete, the flex pipe was reinstalled.

Figure 2. Air bubbles escaping from the flex pipe during pressure testing before (left) and after (right) removal of the braided mesh.

HIGH CYCLE FATIGUE FAILURES INCREASING ON SMALL BORE LINES

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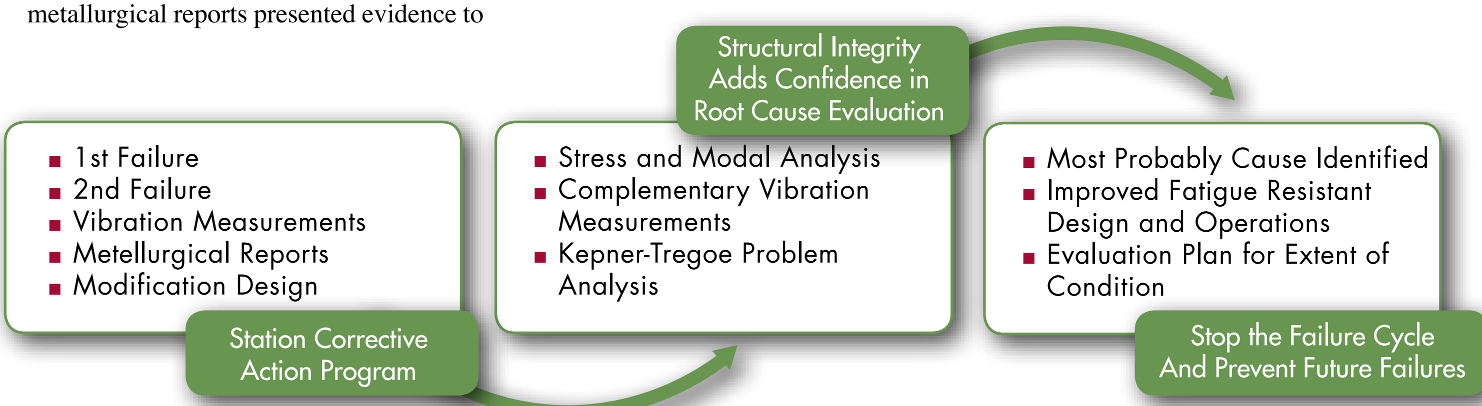
At Structural Integrity, we have noticed an uptick in small bore (2 inch and less) branch connection fatigue failures over the past few years. These branch lines are located throughout the plant and although they appear insignificant when compared to the large pipes responsible for system flow, failures can cause leakage leading to plant shutdowns. The design of these lines inherently incorporates a stress concentration factor at the socket welds making them prone to high cycle fatigue failures. Even with efforts to increase fatigue resistance using 2:1 weld geometry, failures can and still do occur. Stations are equipped with engineering and maintenance support to help evaluate these failures. However, without a true cause identified, well-intentioned modifications such as pipe supports may not address the root cause and could make the situation worse.

At one station, a socket weld began to leak after almost 30 years of operation. The weld was repaired and the weld geometry was modified to a more fatigue resistant 2:1 design. In less than an operating cycle another failure occurred at the same location, despite the modified weld geometry. After each failure, the metallurgical reports presented evidence to support high cycle fatigue as the damage mechanism. In order to reduce vibration movement, a support was added to stiffen the line. The station took vibration data along the line before and after the support was installed in an effort to quantify the effectiveness of the modification. From the vibration data gathered, it was unclear exactly how effective the modification would be in preventing future failures. So the station asked us to provide an independent review of the prior evaluations and corrective actions. Our review determined that additional piping stress analysis was needed to help evaluate the cause of the failure and effectiveness of the support modification.

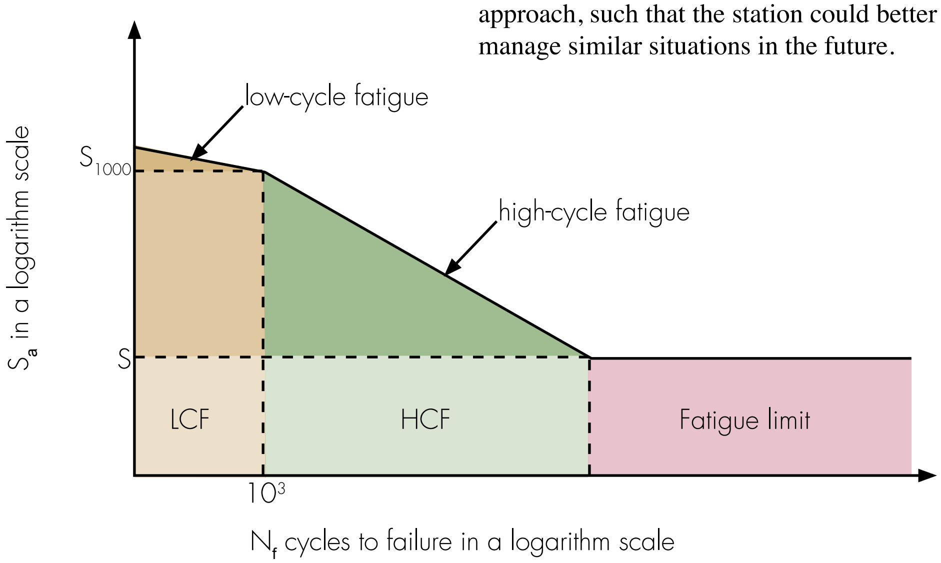
Piping stress analysis for small bore lines serves two important purposes: (1) calculate allowable vibration based upon material fatigue curves; and (2) calculate natural frequencies and mass participation



Did you know the NRC released an Information Notice related to Fatigue Failures in Branch Connections this year – learn more here www.structint.com/fatigue-failures-in-branch-connection-welds.

associated with these frequencies. Unfortunately, these analysis also have greater inaccuracies when compared to larger piping models due to the large influence of stiffness in the connections on the stress and modal results. In this case, vibration data collected by the station was critical in tuning our model's stiffness to calculate accurate allowable vibration levels and the piping's natural frequencies.

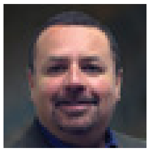
Our comparison of the initial vibration data to the calculated allowable vibration showed that the values recorded by the station were not sufficient to cause a failure. However, the recent failures indicated otherwise, and our team began searching for intermittent sources of vibration. It was clear additional vibration data needed to be gathered. A custom vibration monitoring system was installed to remotely monitor the piping and acquire data when vibration thresholds (developed from the piping model) were exceeded. This allowed for a targeted approach to evaluate various transients and monitor for periods where vibration exceeded calculated allowables. What made this case particularly difficult to diagnose, was the intermittent nature of the high vibration condition. High cycle fatigue can occur in a period of days when the condition is constant. Since the second failure took many months to occur, the system needed to be able to capture these conditions over a longer period of time. Through a Kepner-Tregoe™ Problem Analysis, potential causes were evaluated (service conditions, material quality, welding processes, and other excitation sources) to identify the most probable cause-structurally transmitted vibration from nearby rotating machinery. This was later confirmed through automatic data acquisition and specific test sequences coordinated with operations. Comparisons of the measured displacements to the model's stresses allowed our team to reproduce the timeline (cycles) above the material endurance limit and correlate them to the previous failure timeline. In addition to recommending optimum operating regimes for the rotating machinery, we suggested and then later installed an improved fatigue resistant support, leveraging the model previously developed to prevent a future failure at the same location.



OUR RECOMMENDATION

As a part of our recommendations for preventing future small bore weld failures at other locations, we laid out a plan to evaluate potentially susceptible lines. Due to the large number of small bore lines, a screening process was recommended to focus future efforts on lines with the highest potential for failure. From the initial screening, lines categorized as high risk were recommended for further testing to quantify susceptibility. Then we proposed training station staff to perform many of these activities and develop a tailored approach, such that the station could better manage similar situations in the future.

DEVELOPING YOUR DATA MANAGEMENT AND RISK ALGORITHM SOLUTIONS



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Why Choose Structural Integrity?

In the late 1990's, as part of its Congressional mandate to conduct a Risk Management Demonstration Program, the Office of Pipeline Safety (OPS) began authorizing pipeline operators to conduct demonstration projects to determine how risk management might be used to complement and improve the existing Federal pipeline safety regulatory process. These early risk models initially focused on corrosion and third party damage likelihood concerns, together with consequence concerns that considered business, environmental and safety impacts. Based on these early experiences, combined with the need to act following several serious pipeline incidents, the Pipeline Safety Act of 2002 mandated the use of risk assessment to prioritize the baseline inspections of our nations transmission infrastructure. The predominant risk model algorithms available at the time were based on relative risk indices that leverage subject matter expertise, while a few models tried to elevate that analysis into a probabilistic regime.

The team at Structural Integrity began developing solutions to address the risk assessment of buried piping long before the Pipeline Safety Act of 2000. Our engineers assisted in the development of API 1160, the first standard for pipeline integrity management used by the liquid industry, and then in the creation of the NACE Direct Assessment procedures used today by the gas industry. Over 35 papers have been published in the last 15 years, helping to guide the industry through this challenge.

The industry is now about 15 years into the gathering and analysis of pipeline construction, operation, inspection, and corrosion control information. As part of an effective integrity management program, many operators have used the lessons learned to improve their relative risk models through the adjustment of risk weighting scores or through implementation of targeted conditional queries to identify sets of circumstances at increased risk based on their experience.

Members of our staff have prior experience creating one of the pipeline industry's leading pipeline risk assessment software used by the majority of pipeline operators at the time. And after joining Structural Integrity, this team combined their experience to develop what is today's RiskPro™ and IM-SI™ integrity management suite of data management and software analysis applications – all built on the industry leading PODS™ pipeline data model used by more than 60 major pipeline operators and over 100 leading engineering and service providers (see: www.pods.org/13/current members). We also created the nuclear industry data model standard used in all U.S. nuclear power plants for the integrity management of buried piping, called BPWorks™ (under contract to EPRI) with a companion suite of engineering analytical and GIS data visualization tools called MAPPro and MAPProView™ (see: www.structint.com/MAPPro).

Our approach to pipeline data management and risk analysis begins with obtaining as much information as possible about the installed characteristics of the pipeline. This includes construction, installation and operational details that provide insight into the "susceptibility" of the pipe based on its current environmental exposure threat risks (per ASME B31.8S), as well as the pipe's inherit "resistance" to a multitude of degradation threats. This initial baseline perspective, common to any subject matter expert (SME) indexed approach is then tempered with performance data known about the system. Performance details include corrosion control measures (e.g., CP, pigging, inhibition) as well as other preventative and mitigation measures like patrol frequencies, pipeline depth, hydrotesting and other monitoring techniques.

Lastly, the risk results become dynamic in nature as results from inspections (e.g., ILI, bell hole) are fed back into the model as these provide critical pieces of information as to the "current actual state" of the pipeline. Our risk algorithms consider both unique combinations of conditions shown to promote degradation, together with an assessment of the interaction effects between threat concerns, all of which have evolved significantly over the years based on our experience. Utilizing discrete pipeline knowledge along the length of pipe in your system provides a useful quantitative engineering tool for prioritizing pipe inspection, planning reinspection intervals, evaluating the benefit of risk reducing engineering project concepts, and even quantifying the benefit of the integrity management program within your organization.

Linking all pipeline data to a GIS platform also provides the secondary and promoting benefits of quickly creating maps for small and large projects like ILI /ECDA surveys, updating HCA boundary information based on operation changes or population growth, and locating pipe of similar design or installation configurations.

We have established quality control processes and procedures to assist companies with the upgrade of spreadsheet or other data platforms (including paper) into a robust data management solution within just a few months. Once on a common platform, the data will also become a valuable resource for you in support of the next wave of PHMSA regulations due out in 2015 – related to integrity verification programs.

CREATING A P91PIPING PROGRAM FROM SCRATCH


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FIRST-LEVEL ASSESSMENT OF GRADE 91 PIPING SYSTEMS TO DETERMINE CURRENT LIFECYCLE POSITION AND THE URGENCY FOR CONDITION ASSESSMENT

With the ASME B31 Code for Pressure Piping (B31.1 specifically for Power Piping) requiring a program be put in place for the assessment and documentation of all Covered Piping Systems, many utility engineers are challenged with how and when to start the program. Adding to the challenge for many newer plants is the complexity of creep strength enhanced ferritic steel material (typically Grade 91). Grade 91 steel offers excellent creep strength at elevated temperatures when handled properly. Unfortunately, it requires diligence and understanding of the proper fabrication and erection procedures to avoid detrimentally impacting its creep strength.

As shown in Figure 1, failures of piping systems can generally be grouped into three categories:

1. Early 'Infant Mortality' Failure
2. Constant (Random) Failure
3. Wear Out (end of life) Failures (e.g. Creep and Fatigue)

A prudent piping program should aim to preempt failures from all three categories and minimize risk, where possible, through preventive measures such as baseline NDE inspections, regular system support surveys, stress analysis, and life calculations. The general approach for identifying potential failures from the first two categories is based on typical issues identified at plants of similar design and age. In this article, we'll focus on starting a plan to address the third category – failures due to creep and fatigue.

A key starting point in predicting the timing of life-ending damage (specifically, creep and fatigue) is through basic life calculations for the base material and welds (girth welds, saddle welds and longitudinal seam welds, as applicable). Using information that is readily available from the plant design and operation, relevant material data, and reasonable estimations for parameters that are time-consuming or expensive to obtain, the calculations provide a conservative estimate of the point at which wear-out (Stage 3) is expected to begin to occur. From the results of this first-level assessment, plans for more targeted prioritizations of systems (or portions of systems), refined analyses, and/or condition assessments are developed to remove conservatism in calculations, minimize risk and maximize budget value.

In piping systems operating at elevated temperature, a primary damage mechanism is creep in weld heat-affected zones (Type IV cracking), particularly where stresses are oriented across the weld due to bending, axial loading or stress concentration (e.g. branch connections). This damage mechanism is common to other low alloy steels (such as the widely used Grade 22 steel). But with Grade 91 the creep strength reduction associated with the weld heat affected zone is much more significant than that for the more traditional low alloys steels. A further complication for Grade 91 steel is the possibility of weakened parent material due to improper heat treatment, either from the pipe mill or as a result of post-weld heat treatment during fabrication and erection. If Grade 91 steel is improperly heat treated, then its strength can be approximately half that of the desired condition (resulting in creep strength similar to a traditional low alloy steels such as Grade 22). The possibility of mal-heat treated base metal and large weld strength reduction factor (both commonly observed in Structural Integrity's experience) drive the approach for life assessment of Grade 91 piping systems (and associated components such as headers).

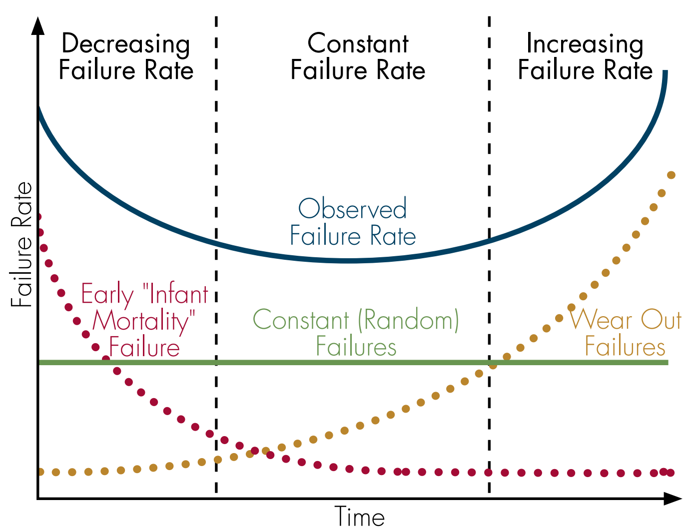


Figure 1. Lifecycle "Bathtub" Curve Illustrating Three Failure Rate Periods

Case Study: *First-Level Assessment of High Pressure (HP) Steam and Hot Reheat (HRH) steam piping at a typical ~600 MW combined cycle plant which includes 2 HRSGs feeding steam to a single steam turbine. The HP and HRH lines are fabricated from Grade 91 material.*

MALTREATED PARENT MATERIAL LIFE CALCULATIONS (CSEF SYSTEMS)

In order to provide a better understanding of the susceptibility to failure due to mal-heat treated Grade 91 material, some basic creep-rupture life estimates are performed to bound the likely failure time. Life calculations of this kind require several inputs including an inventory of pipe specifications throughout each system, knowledge of both the design and historical operating conditions, and an understanding of the appropriate stresses driving damage. Calculations are performed assuming design rated conditions and actual operating data, as well as two material thicknesses (design nominal and manufacturer's minimum). In addition, life prediction material strength correlations for "good" and "mal-heat treated" conditions are used based on extensive data from our research and from EPRI's research on Grade 91, which we have supported. By exploring these bounds on the key parameters, the timing for more detailed evaluations, and focus of those evaluations, can be established.

These preliminary evaluations do not consider the full piping system stresses resulting from deadweight and thermal expansion, but rather use the hoop stress which (at least in a well-designed system) provides a conservative basis. However, this will not always be the case depending on component geometry, thermal expansion effects, or unintended constraint such as that imposed by deficient hangers.

In some cases fatigue calculations are also required (e.g. for complex thick-walled parts such as valves or laterals that experience rapid thermal transients). However, in the present case,the focus was on the primary damage mechanism of creep and possible fatigue concerns were identified using a separate screening.

Actual operating temperature and pressure data was provided by plant personnel over a 1-year period in 1-hour increments. The data was reviewed to establish bounds on the actual operation of each piping system. In general review of operating data from HRSG units, it is important to note whether data was collected under part load, unfired or full-fired conditions, as the difference in pressures and subsequent life calculations can be significant. In addition, all plants should consider whether future operation will follow historical trends or deviate, including switches from daily cycling to base loading or expected increases in operating temperature and pressure.

A subset of the creep-rupture life estimates completed are presented in Table 1 (next page) to illustrate the sensitivity of life estimates to some of the key input parameters. Life estimates can vary by many orders of magnitude as different parameters are adjusted between possible bounds. To summarize some of the key trends:

- For the likely worst-case conditions (design maximum operating conditions, minimum wall thickness), all of the various piping specifications were "at-risk" of failure within the lifetime of the plant (<600,000 total hours to creep rupture).
- When actual operating conditions with minimum manufacturer's wall thickness were considered, only the piping in the HP steam line are "at-risk".
- Calculations at actual operating conditions with nominal wall thickness highlighted one of the four pipe specifications "at-risk".
- Switching between manufacturer's minimum wall thickness and nominal wall thickness resulted in an approximately 3.8 multiple in the creep life estimate.

The calculations reveal that mal-heat treated material could be a problem if the piping is at or near manufacturer's minimum wall thickness, even when actual operating conditions are considered. This is especially true for the HP Steam piping. If baseline inspections (such as hardness testing and wall thickness verification) were performed on the 18" Schedule 160 HP piping to verify that material properties are not at the worst-case, the life estimate could easily be extended to beyond the estimated lifetime of the plant. Alternatively, if the temperature utilized

Continued on next page

Table 1. Scoping life calculation results for Grade 91 applications

Piping Specifications				Design Max Cond.		Operating Cond.		Time to Creep Rupture (hr)			
								Design Max Cond.		Operating Cond.	
Section	OD (in)	Nom. Thk. (in)	MMWT (in)	Temp (°F)	Pressure (psi)	Temp (°F)	Pressure (psi)	MMWT (in)	Nom. Thk. (in)	MMWT (in)	Nom. Thk. (in)
HP- 12" Schedule 160 HRSG Outlet Manifold	12.75	1.312	1.148	1064	2355	1050	1902	11,500	49,000	196,000	687,000
HP - 18" Schedule 160 Piping from each HRSG	18.00	1.781	1.558	1064	2355	1050	1902	7,000	32,500	132,500	481,000
HRH - 20" Schedule 40 HRSG Outlet Manifold	20.00	0.594	0.520	1063	540	1046	426	57,000	192,000	>1,000,000	>1,000,000

in the life estimate was lowered by 10°F either through reductions in unit operation or a more detailed review of operating history, the life estimates of the same HP pipe section could similarly be extended a significant amount.

This highlights the importance of preliminary sensitivity studies to focus future efforts for lifetime management. In many cases, this upfront work can substantially reduce inspection workscope and may allow concerns about mal-heat treated material to be removed from consideration.

GIRTH WELD LIFE CALCULATIONS

As mentioned earlier, Grade 91 welds are also susceptible to creep damage in the heat affected zone (Type IV cracking). Estimates for lifetime associated with this HAZ damage (Type IV cracking) can be made based on data collected from cross-weld creep rupture tests. As part of our research, a life prediction model has also been developed for such damage.

General life calculations were performed for various stresses to estimate the potential range of lifetimes expected from Grade 91 weldments. These calculations are not intended to pinpoint or highlight specific weldments at risk, but rather to quantify a conservative stress threshold above which weldments would be at risk of Type IV cracking within the design lifetime of the plant. Calculations were performed using the actual operating temperature. The results presented in Table 2 show that with a relatively high, though still plausible, stress of 10+ ksi, Grade 91 weldments within the HP system would be considered “at-risk”.

σ (ksi)	Grade 91 Type IV, (hr)
6	>1,000,000
9	823,000
12	136,000
15	27,000

Table 2. Time to Failure for Type IV damage based on Applied Stress

The next step beyond first-level assessments for girth welds typically includes detailed piping stress analyses to identify weldments or areas at risk due to stress caused by deadweight, thermal expansion and design or support maintenance issues. Because these systems operate in the creep range, it is important to incorporate the effects of stress redistribution due to creep to provide accurate stress estimates for subsequent life predictions.

Also, a comprehensive Grade 91 program must recognize material risk factors beyond mal-heat treatment and weld strength reduction factors. Specifically, within the chemical compositional range permitted by Codes and Standards the material performance can vary substantially, exhibiting not only a range of strength but also significant variations in cracking susceptibility which can exacerbate damage formation, particularly at locations with complex stress states. The preliminary screening calculations described here provide a basis to select regions for more detailed analysis to establish the associated metallurgical risk factors.

Ultimately, all of these factors can be addressed in an overall risk ranking such as those leveraging our Vindex methodology, which can help determine specific component and weldment prioritization based on our 30+ years of industry experience.

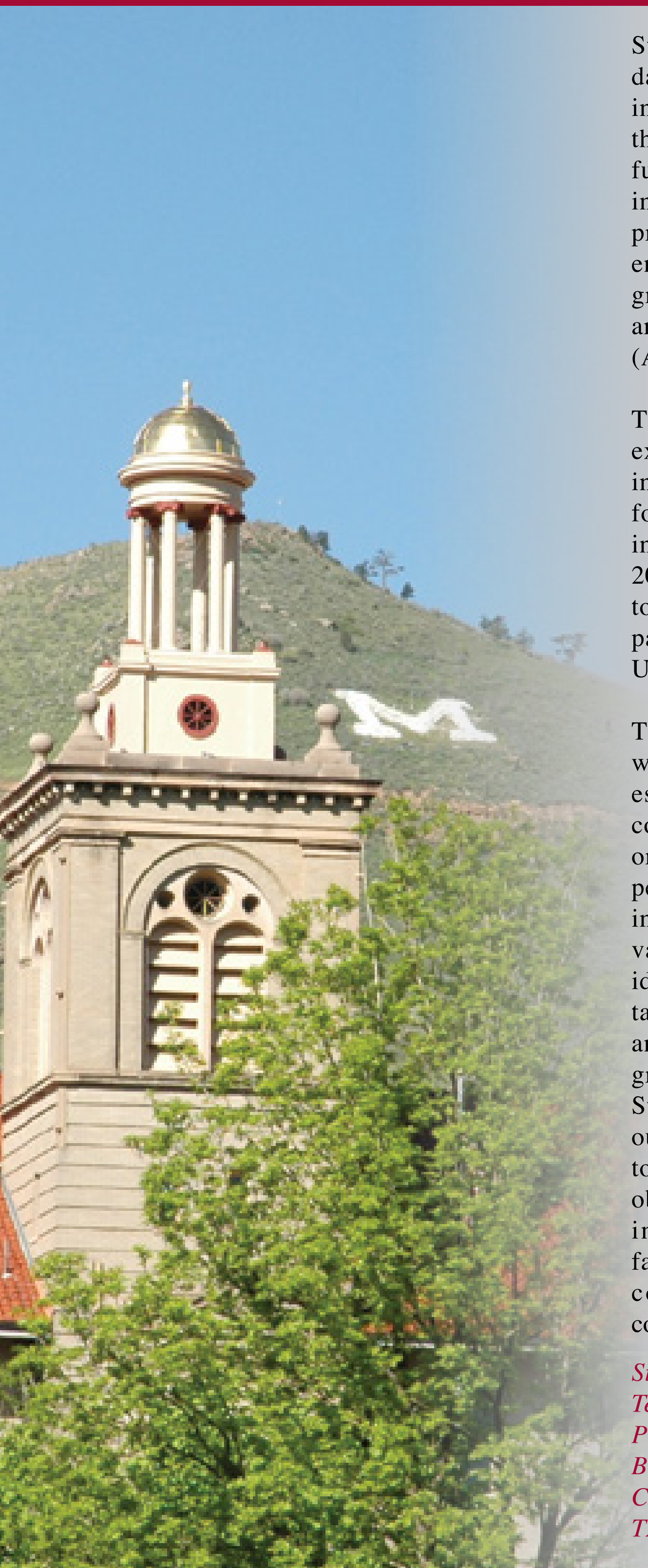
GENERAL RECOMMENDATIONS

This case study illustrates how screening life assessments can be used to refine subsequent analysis or inspection workscope. For example, it is reasonable to conclude that the plant should begin their condition assessment program with budgets particularly focused on the HP piping. The recommended inspection scope should aim to document actual wall thicknesses and hardness measurements in order to refine life estimates, which will subsequently refine future scope.

Known industry problems such as at and downstream of attemperators, near locations of support deficiencies (past and present), HRSG outlet link/riser piping, drain pots, etc. are practical starting points for inspections because many of these features are not only controlled by the creep damage mechanisms discussed above. Inspections of such features, and associated base metal, can provide valuable information (such as material composition) that can aid in determination of metallurgical risk that can, in turn, be factored into the overall life assessment for the piping system. Also, the results of such local inspections provide data to enhance (or degrade!) confidence in overall material supply and quality of fabrication.

SHAPING THE NEXT GENERATION OF CORROSION TECHNICIANS

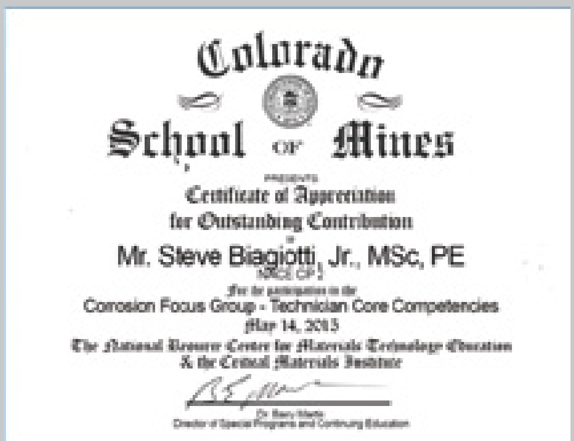
Linking Theory and Practice



Structural Integrity's Sr. Associate Steve Biagiotti participated in a half-day brainstorming session at his alma mater the Colorado School of Mines in May 2015 on corrosion education needs. The meeting was facilitated by the National Resource Center for Materials Technology Education, an NSF funded materials education/workforce training center. The focus group was intended to identify workforce needs (strategic alignments), industry best practices (with view to education and training programs), and related research enterprises that would generally strengthen and sustain the pipeline. The group is working toward building a matrix (and verticals) in the corrosion arena similar to the Advanced Technology Environmental and Energy Center (ATEEC) defining environmental technology gaps and needs.

This national/international meeting was a rare opportunity to sit with industry experts and educators and identify the skills and knowledge they want to see in future graduates. The corrosion focus group outcome will begin to set a foundation (help in the instructional design process by analyzing corrosion information) for a Materials Education (MatEdU) conference in November 2015 (http://www.materialseducation.org/). This conference is expected to attract many students, faculty and industry members as presenters and participants in a critical materials workforce conference and will be held at UC Irvine.

Through this unique industry/academia collaboration, the experts present worked to define corrosion education concepts and components (the essence of skills and competencies critical for workforce success, industry competitiveness and organization high performance). This interaction, helped validate, revise, and identify performance task, knowledge, skills, and attributes needed by graduates of the program. Starting with relevant outcomes, we were able to identify learning objectives, performance indicators, success factors, and demonstrable competencies for corrosion content areas.



Steve was the 2013-2015 NACE Technical Coordination Committee (TCC) C2 Technology Coordinator, responsible for the direction and oversight of "Corrosion Prevention and Control for Pipelines and Tanks, Industrial Water Treating and Building Systems, and Cathodic Protection"; holds a NACE certification as a Cathodic Protection Level 2; and is a Registered Professional Engineer in CO, TX and FL.

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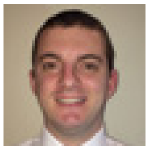

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First SIPEC™ Dynamic Pulsed Eddy Current Project is a Success

Structural Integrity – in cooperation with strategic partner Diakont Advanced Technologies, Inc. – recently completed the industry's first pulsed eddy current inline inspection utilizing Structural Integrity's Pulsed Eddy Current (SIPEC) nondestructive testing technology and Diakont's robotic inline inspection crawler. SIPEC was developed for the detection and characterization of corrosion through thick internal liners, sludge, scale, or other build-up. SIPEC is capable of collecting data at much higher acquisition rates than traditional pulsed eddy current technologies, enabling dynamic data acquisition at scan speeds up to 10-in/s for inline inspection applications.

The recent SIPEC inspection was performed on a 36-in nominal outer diameter, 0.42-in thick carbon steel gas transmission pipeline with a thin epoxy internal liner. In addition to SIPEC, ultrasonic thickness testing with Electromagnetic Acoustic Transducers (EMATs) and Visual Measurement Inspection (VMI) were also completed on portions of the pipe with the following objectives:

- Detect, characterize, and quantify the actual pipe wall thickness and any internal or external volumetric wall loss, such as from corrosion,
- Detect and characterize other anomalies of interest within the inspection area,
- Survey the pipeline as-built features.

Throughout the course of the in-line inspection, the RODIS ILI tool traversed two 45° horizontal bends to deliver the SIPEC and other examination technologies to the inspection areas, providing a total of approximately 90 linear feet of inspection coverage on what would otherwise be considered "unpiggable" pipe; meaning that traditional flow-controlled ILI tools would not have been able to inspect this section of piping. As seen from the onboard video feed in Figure 1, no internal cleaning of the pipe was performed and the inspection was able to be completed through a significant amount of accumulated sludge.

Figure 2 shows an example of the SIPEC data that was obtained on one section of the targeted inspection area. While there was no volumetric wall loss detected by any of the technologies applied over the entire inspection area, the example SIPEC data clearly shows the detection of the seam weld at approximately 70° from the Top Dead Center (TDC) of the pipe. Figure 3 shows an "unrolled pipe display" of the same data presented in Figure 2, showing the excellent signal-to-noise ratio (SNR) obtained and an obvious indication from the seam weld.

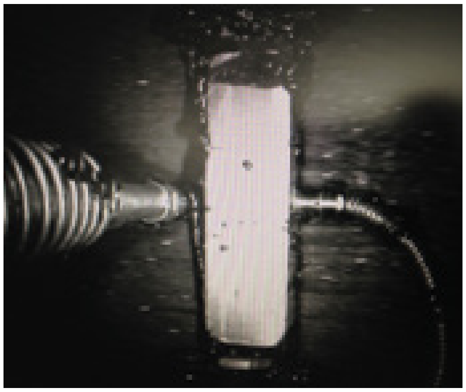

Figure 1. Still frame from onboard camera video feed showing the SIPEC sensor scanning through significant sludge accumulation.

A total of approximately 90 linear feet of pipe was inspected with three different technologies over a one-and-a-half day period. No volumetric wall loss was detected that would correspond to wall loss less than 80% of the nominal wall thickness and there was no conflicting data obtained in any of the areas that were inspected with multiple technologies. This inspection marks the first application of a dynamic pulsed eddy current technology for the inspection of an operating pipeline in the Oil & Gas industry, though the pipe was removed from service for the inspection. Even with the significant

For more information on SIPEC
click here

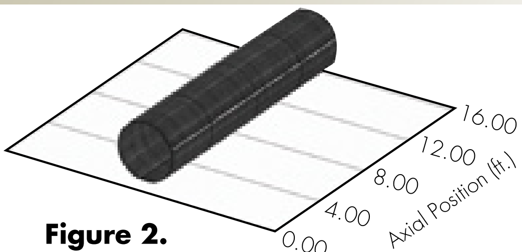

Figure 2. Rolled pipe display showing SIPEC data obtained over a portion of the inspection area. The white linear indication at approximately 70° is the pipe seam weld.

Figure 4. Photograph of the RODIS ILI crawler outfitted with SIPEC technology preparing for pipe entry.

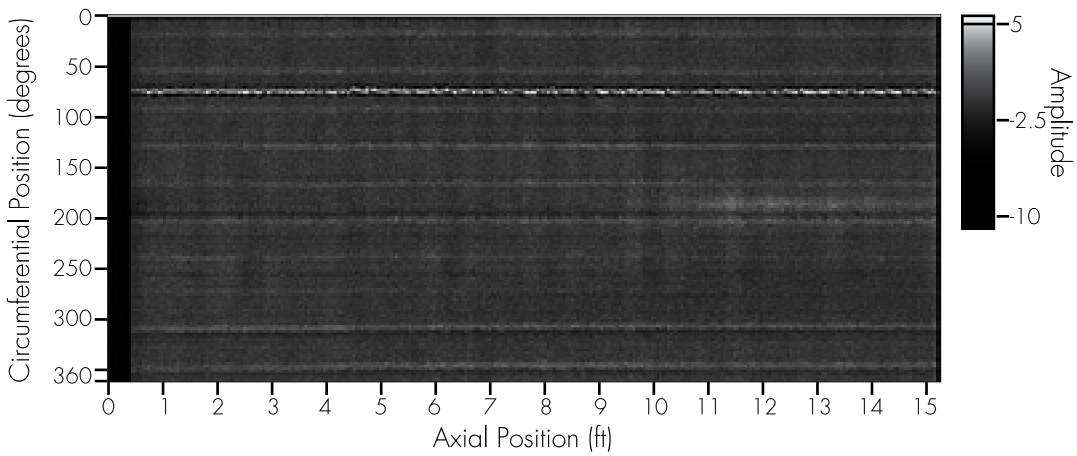

Figure 3. An "unrolled pipe display" of the same data presented in Figure 2, showing the seam weld indication and the excellent SNR achieved during the SIPEC inspection.

accumulation of sludge within the pipe, the SIPEC technology performed as expected, producing good data with an excellent SNR; and that agreed with results obtained by other proven technologies.

The SIPEC dynamic pulsed eddy current technology performance has been qualified according to American Petroleum Institute (API) 1163, In-line Inspection Systems Qualification Standard, which references qualification standards for general (not just ILI) standards MIL-HDBK-1823A and ASTM E2862. Finally, it should be noted that the SIPEC dynamic pulsed eddy current technology can also be applied from outside of the pipe to inspect through insulation and weather jacketing, though the current specification has been developed specifically for the delivery of the SIPEC technology aboard Diakont's RODIS ILI crawler.

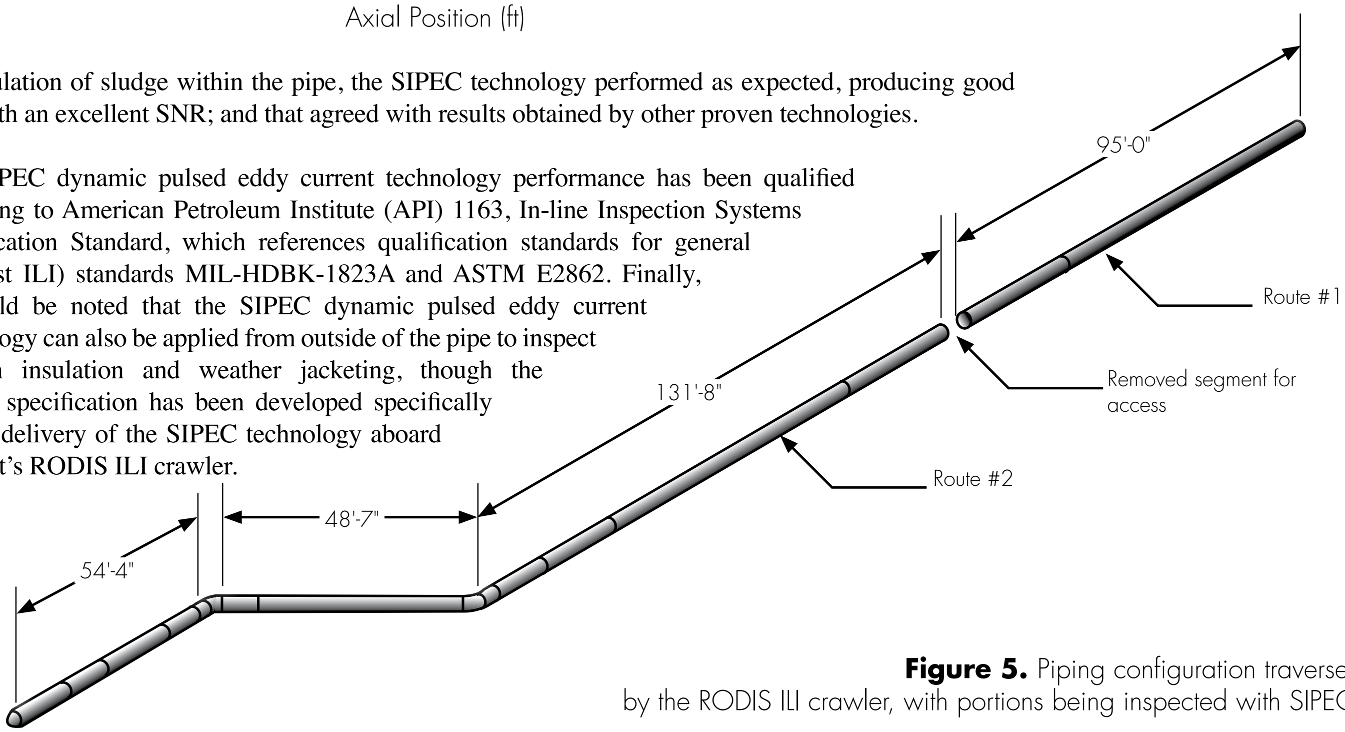

Figure 5. Piping configuration traversed by the RODIS ILI crawler, with portions being inspected with SIPEC.

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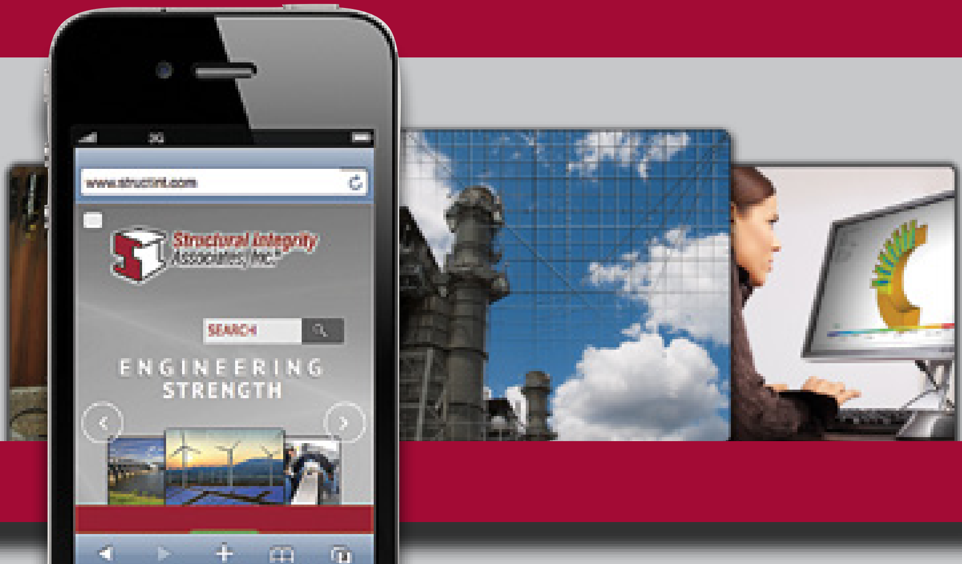

By: VICKI DOUGLASS
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Staying abreast of what's going on in the industry can be challenging, so we've expanded our new website, www.structint.com, to be an improved resource for you. Some new features include:

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Visit our website today to familiarize yourself with all the things we can do to help you. We appreciate the opportunity to serve you.

OHIO OFFICE IS ON THE MOVE

Structural Integrity will move its Ohio office from its current location in Rootstown to Green, Ohio, just south of Akron.

If you routinely work with our Ohio staff, please note the new address of our Akron office, effective October 1:

Structural Integrity Associates, Inc.
1525 Corporate Woods Parkway, Suite #300
Uniontown, Ohio 44685

The phone and fax numbers for the Akron office have not changed:

Toll Free:	**(877) 4SI POWER**
	(877) 474-7693
Phone:	(330) 899-9753
Fax:	(330) 899-9755

We look forward to continuing to work with you.

ACADEMY OF DISTINGUISHED ALUMNI

RASHID INDUCTED INTO ACADEMY OF DISTINGUISHED ALUMNI

At a ceremony being held on campus October 8, our own Dr. Joe Rashid will join an elite group with his induction into the University of California, Berkeley's Civil and Environmental Engineering (CEE) Department Academy of Distinguished Alumni.

Every year, the Academy honors CEE alumni whose outstanding professional accomplishments have contributed greatly to societal well-being and development.

After founding ANATECH Corporation in 1978, Joe led the company to become the foremost authority in structural seismic performance. Today, as a wholly-owned subsidiary of Structural Integrity Associates, Joe and the ANATECH team continue to provide world-class seismic services.

We are proud to have Joe on the Structural Integrity team and congratulate him on this well-deserved honor.

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ADVANCED NDE ON HDPE

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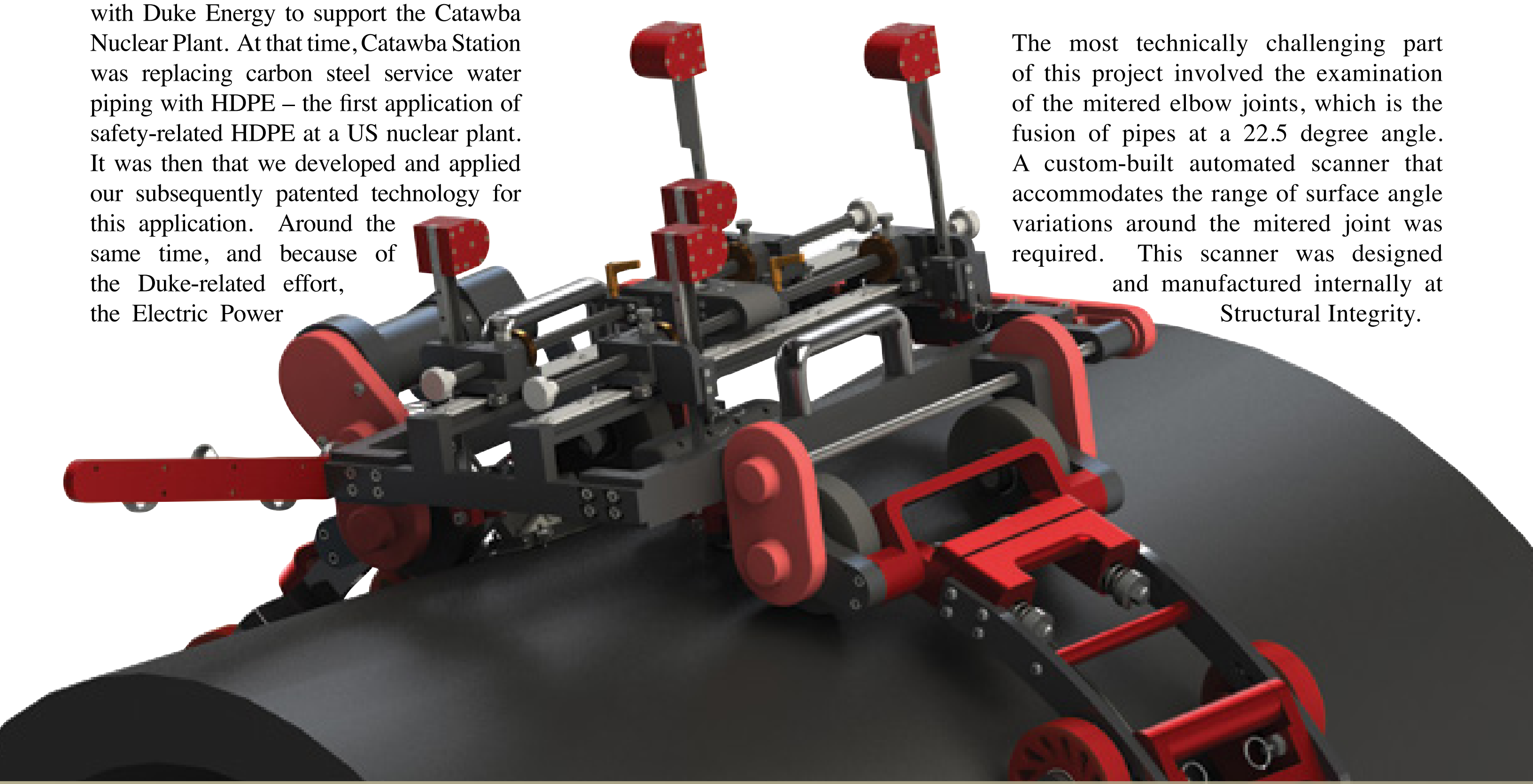
Structural Integrity is known for being a pioneer of first-of-a-kind advanced Non Destructive Examination (NDE) methods for inspection of power plant equipment. Recently, we added to our accomplishments a technique to inspect the largest safety-related installation of High-Density Polyethylene (HDPE) piping at a nuclear power plant. This project, at Barakah Nuclear Power Plant in the United Arab Emirates (UAE), involves applying Phased Array UT (PAUT) on nearly 300 butt fusion joints in the UAE, as well as mitered elbow joints and HDPE flange adapters in fabrication shops in the United States.

We have been actively developing PAUT on HDPE since 2009 with a collaboration with Duke Energy to support the Catawba Nuclear Plant. At that time, Catawba Station was replacing carbon steel service water piping with HDPE – the first application of safety-related HDPE at a US nuclear plant. It was then that we developed and applied our subsequently patented technology for this application. Around the same time, and because of the Duke-related effort, the Electric Power Research Institute (EPRI) engaged us to perform a number of laboratory tests on a large sample set of HDPE butt fusion joints to support EPRI's efforts to establish an HDPE exam testing protocol.

Since those early projects, we have provided leadership in the industry's development of standards for HDPE design and examination within the ASME code. We subsequently gained experience on a number of field projects for various nuclear and non-nuclear clients, further perfecting the readiness of our procedures, equipment, and personnel for HDPE examinations. In early 2014, this accumulated experience led to Structural Integrity's contract to support the industry's first HDPE installation of new piping for the Barakah Nuclear Power Plant.

For this project, we were a subcontractor to ISCO Industries, which is the US manufacturer responsible for supplying HDPE piping to these new Korean-designed APR-1400 units. The Barakah application is for the Essential Service Water system, which is comprised of 36" IPS DR17 for pipe (2.12" wall) and 36" IPS DR13.5 for elbows (2.67" wall). Structural Integrity is implementing our proprietary PAUT technique and procedure for the examination of all joints, including the straight butt fusion joints, mitered fusion joints, and flange adapter base material inspections.

The most technically challenging part of this project involved the examination of the mitered elbow joints, which is the fusion of pipes at a 22.5 degree angle. A custom-built automated scanner that accommodates the range of surface angle variations around the mitered joint was required. This scanner was designed and manufactured internally at Structural Integrity.



For more information on HDPE Inspection click here

The examination procedure for the Barakah project was demonstrated for a 5% flaw detection threshold across a wide range of temperatures due to anticipated field conditions (e.g., ambient temperatures have reached 125 degrees-F with heat indices over 140 degrees-F). Extensive planning and testing was involved prior to deploying to the site due to these extreme temperature and sand environment conditions. The equipment, including scanners, probes, wedges, UT instruments, and couplant material all needed to be considered when working in the desert of the UAE.

As of this writing, we are wrapping up our first deployment of the Barakah HDPE project in the UAE. Future phases of this project are on the schedule, as well as additional nuclear power plant HDPE activities. Southern Company's Hatch Plant is slated to begin a project to replace some of its buried Plant Service Water piping with HDPE. Structural Integrity is under contract to support Southern Company with relief request support, fabrication of flawed specimens and calibration standards for this HDPE replacement effort. This project will also include the qualification of a UT inspection system and procedure, primary service water HDPE examinations at the fabrication facility, and on-site HDPE installation examinations.

Given our technical leadership, proven reliability, and incomparable experience delivering sophisticated automated HDPE examinations, we look forward to a bright future supporting regulatory acceptance of HDPE applications in the nuclear, as well as commercial fields.

SECOND LICENSE RENEWALS: MEETING THE CHALLENGE

By: TERRY HERRMANN
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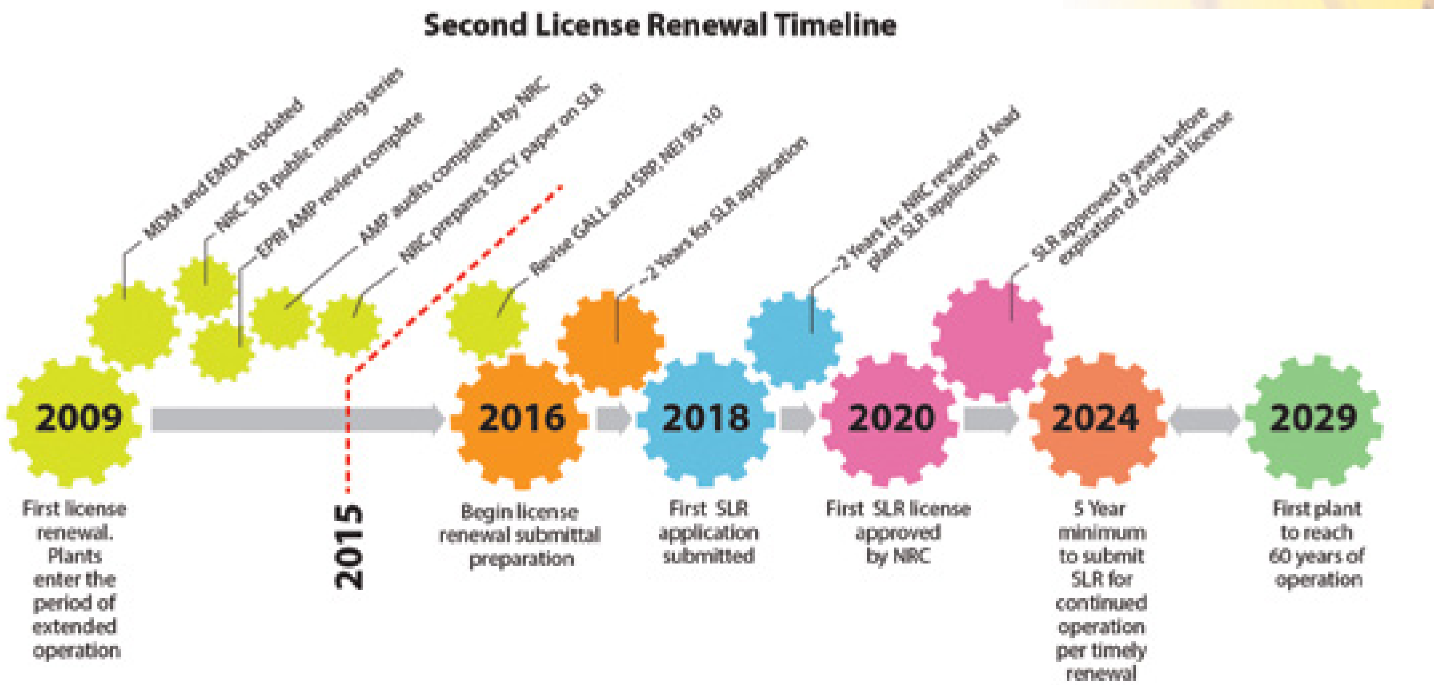
As a safe, efficient and clean source of electricity, nuclear energy continues to play an important role in meeting the ongoing demand for electric power. To make the most of this valuable resource, most nuclear plant owners in the United States will seek to renew their operating licenses. 74 reactors have already renewed their licenses to 60 years of operation, 10 additional plants have submitted applications, 5 plants have indicated an intent to submit an application, and owners are looking to operate some plants for an additional 20 years - termed Second License Renewal or SLR.

However, the decision to pursue SLR is less straightforward than the decision to pursue an initial license renewal due to changes in the electricity market conditions and the potential for greater expenditures to maintain critical assets. Accordingly, SLR decisions necessarily involve a cost vs. benefit evaluation where the benefit of an additional 20-year operating license (i.e., to 80 years) is evaluated against the cost associated with subsequent preparation, review and approval of a License Renewal Amendment (LRA). Implementation costs also need to be considered. These costs include the range of activities needed to ensure critical plant components do not unduly restrict plant operating performance, or result in unmanageable repair and replacement costs.

Since the scope of plant equipment for license renewal has not changed and new rulemaking is not required, the focus of SLR will depend on the guidance to be used for the SLR LRA submittal and approval as well as the technical challenges associated with reduced design margins. For plants that received initial approvals prior to issuance of the GALL report (NUREG-1801) or with earlier GALL report revisions, more effort may be needed to bring the LRA and associated AMPs (aging management programs) up to current standards and NRC expectations. The NRC expects plant owners to demonstrate the effectiveness of aging management programs during the initial period of extended operation (PEO) and to meet revised GALL guidelines, expected to be issued in draft form by the end of 2015 (see graphic).

The Industry is focusing more on preparing for SLR through EPRI's Long Term Operations (LTO) program, the Department of Energy (DOE) Light Water Reactor



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Sustainability (*LWRS*) program, and ongoing Nuclear Energy Institute (NEI) License Renewal Task Force (LRTF) *SLR efforts*. EPRI report *3002000576* identified eight specific GALL aging management program (AMP) gaps for focused research and development that are being addressed through collaborative efforts by EPRI, the Department of Energy (DOE), NRC and industry. NEI has issued two industry guideline documents, NEI 14-12 for Aging Management Program Effectiveness and NEI 14-13 for use of Industry Operating Experience to address age-related degradation and aging management programs. Structural Integrity is actively supporting all of these activities.

Clearly, the most cost-effective approach for long-term management of the current fleet of operating plants is to take a proactive approach in advance of submitting a LRA for SLR. Several utilities are already taking such action. In 2014, we began assisting utilities with evaluating the technical challenges associated with SLR. This included additional 20-year projections of time-limited aging analyses (fatigue and reactor embrittlement), and providing specific recommendations based on these projections and anticipated regulatory challenges.

Structural Integrity was founded in 1983 to help utilities build and operate nuclear plants safely with a focus on the prevention and control of failures. Our understanding of degradation mechanisms and how to manage them, including our work with ASME, NACE, ASNT and other standards organizations matters when it comes to addressing plant operation for 80 years and more. Through our addition of Anatech, our advanced NDE capabilities and in partnership with others, the range of our License Renewal and SLR services has grown significantly over time and covers nearly every aspect of License Renewal / SLR. We have been a key consultant to nearly every U.S. utility that has sought to extend their operating licenses. We look forward to assisting with these challenges while ensuring plants continue to operate reliably and safely every day.

AUTOMATED ULTRASONIC EXAMINATION AT BWR PLANTS

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Structural Integrity recently provided both manual and automated, encoded examination services for a domestic Boiling Water Reactor (BWR) plant in April 2015. The featured portion of the work scope included automated, encoded examinations of dissimilar metal (DM) welds of both piping and nozzle-to-safe end configurations. Additionally, various Reactor Pressure Vessel (RPV) shell-to-nozzle and associated piping system weld manual examinations were conducted. The automated, encoded DM weld ultrasonic examination work scope included welds of the following configurations:

- Reactor Water Cleanup (RWCU) – (6″ OD) Pipe-to-pipe welds - Examination Category (B-J)
- N5 – Emergency Condenser (EC) (11.6″ OD) Nozzle-to-safe end weld - Examination Category (B-F)
- N9 – CRD-HYD Return (5″ OD) Nozzle-to-safe end weld - Examination Category (B-F)

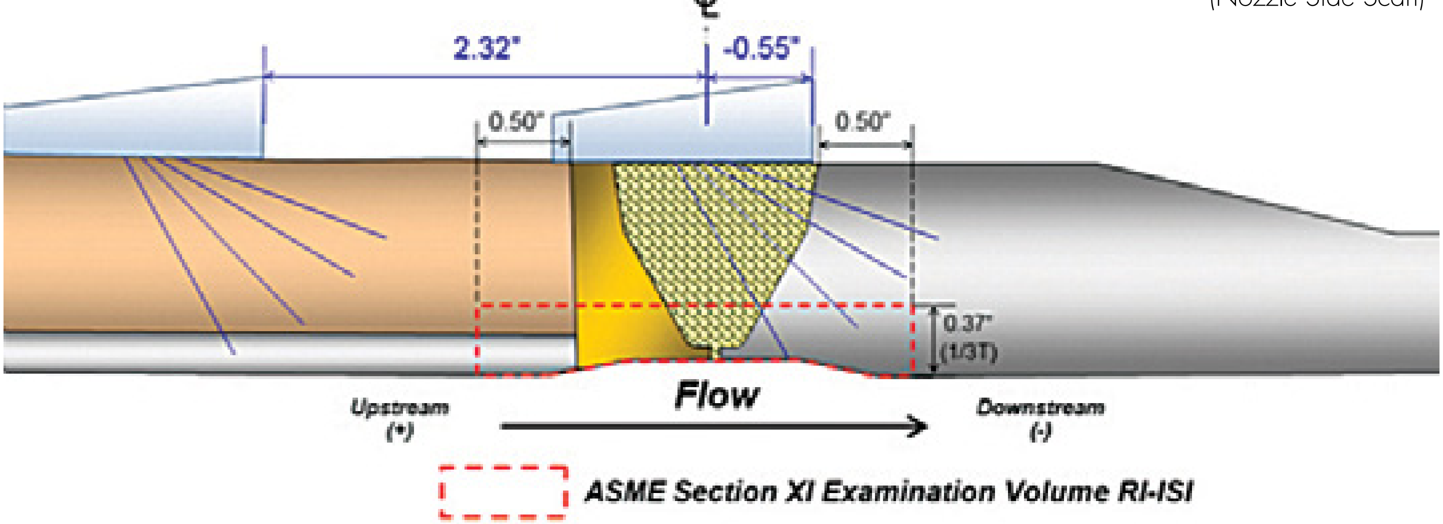
In preparation for the outage, the following activities were performed by SI:

- An evaluation of customer supplied design drawings to generate detailed full-scale, material specific NDE sketches, which formed the basis for the UT scan plans;
- Thorough review of proposed examination procedure and PDQS documents to confirm procedure applicability and to develop the correct examination parameters for each weld;
- Generation of phased array focal laws and UltraVision examination setups;
- Procurement of the required qualified phased array probes and wedges; and
- Hands-on, project-specific training of the entire NDE crew.

Development of detailed scan plans that define:

- The as-built component configuration (NDE sketch)
- RI-ISI examination volume
- Identification of phased array probes and wedges
- Required (qualified) examination angles and skew angles
- Required data acquisition intervals
- Required search unit travel to achieve full examination coverage

Excerpt from N5A DM Weld Scan Plan
(Nozzle Side Scan)



Prior to field ultrasonic examinations, an onsite demonstration was conducted using a full scale mockup that simulated in-plant configurations and conditions. Plant personnel representing Safety, Radiation Protection and NDE were present observing the demonstration and offer suggestions to improve the performance of the in-plant examinations. The following activities were evaluated during the practice session:

- UT system unpacking from shipping containers
- Installation of Structural Integrity custom designed and fabricated scanning assembly, umbilical cabling and data acquisition computer system
- System calibration, data acquisition and data quality screening of the acquired UT data

Additionally, site NDE personnel discussed and approved the process for ultrasonic data analysis and independent data review, which includes, if necessary, the performance of IWB-3500 flaw evaluations. A process for dealing with the review of suspected flaw indications and timely notification of site personnel, along with the desired schedule for the generation and review of project reports was also established.

Upon completion of the pre outage activities and demonstration, but prior to the first onsite implementation, we participated in a customer-directed pre-job brief. Subsequently, these client directed briefings were held prior to each shift and emphasized the following important human factors:

- Six NDE Improvement Focus Group (NFIG) NDE Tools
- General plant physical and radiological environments
- Safety considerations
- Component location and surroundings
- Potential conflicting work evolutions
- Procedure compliance and quality of work
- Steps for effective problem resolution

Our experienced NDE staff, the ability to design and manufacture tooling solutions in-house, our industry recognized engineering expertise, along with developing collaborative relationships with our clients, allows us to provide our clients integrated, turnkey solutions for your most complex and challenging examintations.

Structural Integrity's custom designed and in-house fabricated scanning system is shown mounted on an N5 Nozzle-to-Safe End DM weld

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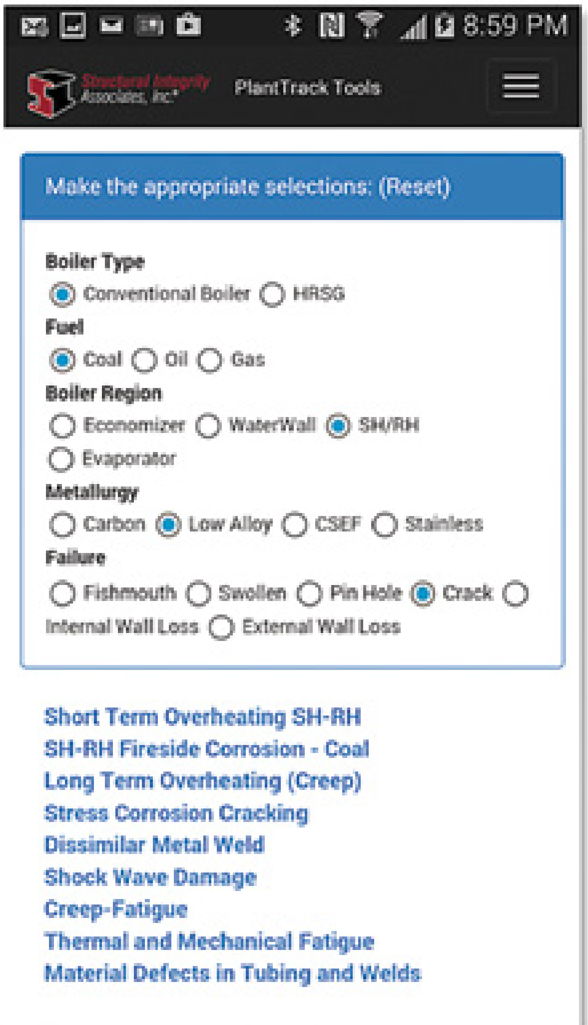
New PlantTrack™ Tools

PlantTrack™ , Structural Integrity's data and knowledge management program for plant equipment, is also the platform on which we are building diagnostic and prognostic tools. These tools allow us to share our power plant experience to help the power industry make faster, more informed decisions. The tools can leverage the data that is typically stored in PlantTrack™ , but can also tie into plant historians to leverage both online and offline data for review and analysis. In addition to leveraging the data for quantitative analysis, PlantTrack™ tools are also available to provide expert knowledge on specific industry issues.



One of the most common industry issues that afflicts fossil power plants is boiler tube failures. Identifying the damage mechanism for the tube failures is one step in determining root cause and the actions needed to avoid repeat failures. In an effort to help plant engineers determine the damage mechanisms, we have made available PlantTrack™ Tools for boiler tube failures https://planttrack.structint.com/tools. This free web application includes a boiler tube failure mechanism identification guide, as well as tube temperature and basic tube life calculators.

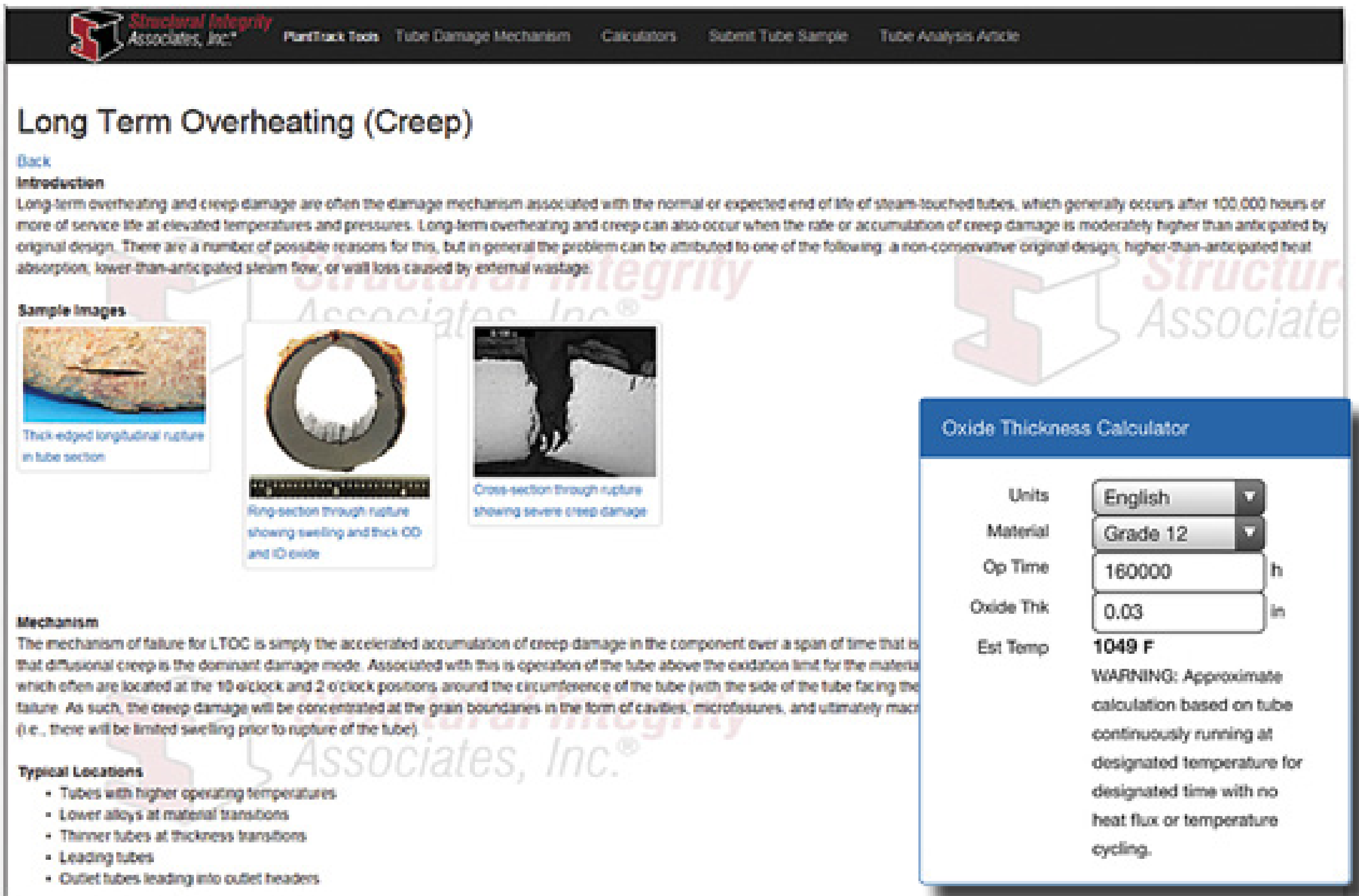
Our failure mechanism diagnostic tool presents the user with various questions, as shown on the figure to the left. As you answer questions, the list of mechanisms is narrowed to only those that are applicable based on the answers. In the example shown, the list of possible damage mechanisms was narrowed to nine from the original list of over two dozen. To learn more about each damage mechanism, the user can click on the title to open another page with details.

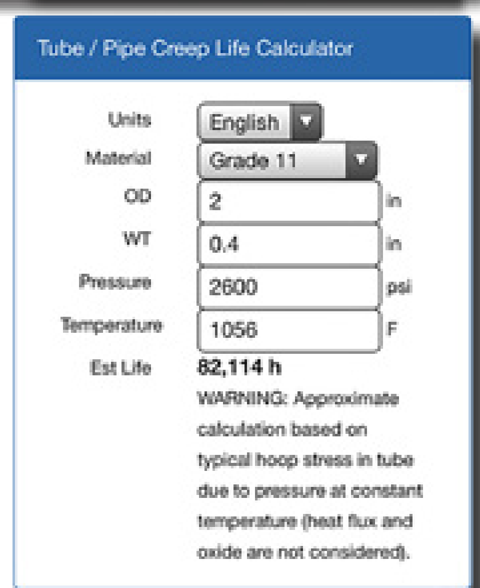
The tube failure mechanism guide provides:

- Sample images
- Mechanism Overview
- Typical Locations
- Features
- Root Causes
- Corrective Actions

PlantTrack™ Tools also includes a tube temperature calculator based on the tube material type, operating time, and measured oxide thickness values. In addition, there is a tube life estimator based on the material type and size, and operating conditions.

PlantTrack™





Our PlantTrack™ Tools web site is accessible from any computer or mobile device at https://planttrack.structint.com/tools

As PlantTrack™ continues to increase its user base both in North America and internationally, we continue to add tools to the platform. A recent part of this effort, the PlantTrack™ Web API has been developed to allow PlantTrack™ to access SQL databases, plant historian applications, and other document management programs, and to provide the results of searches within web browsers and mobile devices. One of the newest modules using this feature is for on-line Hanger Monitoring, which allows the user to view hanger displacement history from the plant historian together with design limits and results from previous walkdown and analyses. This application will be discussed in detail in a future issue of News and Views.

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TRADESHOWS

Deep Offshore Technology Conference
Woodlands, TX *October 13 - 15, 2015*

ASNT Annual Conference
Salt Lake City, UT *October 26 - 28, 2015* Exhibit

ANS 2015 Winter Meeting and Nuclear Technology Expo
Washington, DC *November 8 - 12, 2015* Exhibit and Present

BWRVIP Mitigation Committee
St. Pete Beach, FL *December 7 - 11, 2015* Present

ATC -Seismic Performance Conference
San Francisco, CA *December 10 - 12, 2015* Present

Visit **www.structint.com/resources/events** for a more complete list.

TRAINING **www.structint.com/training**

Corrosion and Microbiologically Influenced Corrosion Control - San Jose, CA *October 27-28, 2015*
Corrosion and Corrosion Control in Light Water Reactors - San Jose, CA *November 2-6, 2015*

Fuel Rod Performance Modeling - San Diego, CA *November 5, 2015*

Spent Fuel Integrity Analysis in Transportation Casks - San Diego, CA *November 6, 2015*

Flaw Evaluations - ASME Code Case N-513 - Denver, CO *November 10-11, 2015*

Fracture Mechanics - San Jose, CA *November 10-11, 2015*

NonDestructive Examination for Engineers and Managers - Charlotte, NC *December 1-3, 2015*

High Energy Piping Seminar
Calgary, Canada *January 26 -28, 2016* Hosting

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