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SI Expands Turbine-Generator Inspection & Engineering Capability

Over the past few years, SI has enhanced a number of existing offerings and added others in expanding its turbine and generator inspection and condition assessment capabilities:

Non-Intrusive Inspection of Generator Rotor Slot Teeth

In 2004, SI and EPRI collaborated to develop non-intrusive ultrasonic inspection techniques to detect and size circumferential cracking that initiates on the undersides of the rotor teeth wedge lips (see EPRI Report No. 1008353). The inspection process addresses the cracking issues identified in GE TIL-1292 using state-of-the-art Linear Phased Array (LPA) ultrasonic inspection technology, and allows inspection of the dovetails without the need for expensive and time-consuming rotor disassembly. Unlike eddy current inspection, which requires rotor disassembly, the LPA ultrasonic inspection maintains a very low false call rate, while maintaining extremely good sensitivity. SI also provides analysis services for this application to integrate inspection results into a stress and fracture analysis and predict remaining life and/or reinspection interval.

Phased-Array NDE for Generator Shaft Keyway Cracking

SI has developed an advanced ultrasonic inspection technique to detect cracking of the type observed in these generator shafts, conducted from the outside surface without coupling disassembly. The approach uses a two-dimensional, phased array ultrasonic transducer to electronically steer the beam toward the crack location from the outer surface of the shaft. A compound angle is used along with the beam-steering feature of the phased array probe to arrive at the optimal beam angle for detection of very small keyway cracks. In addition, SI can provide the following related services:

• A transient torsional vibration monitoring system (TTVMS), developed by SI, can be installed to monitor the potential for future fatigue damage.
• We can perform stress and fracture mechanics analyses to determine acceptable levels of vibration, or to support a root cause analysis.
• We can provide metallurgical laboratory support for a root cause analysis.

Retaining Ring Inspection and Life Assessment

Although retaining rings made of alloys containing 18% manganese and 5% chromium (18-5) have had generally an excellent service record over the years, concerns with intergranular stress corrosion cracking (IGSCC) have caused utilities to increase inspections of these rings. SI has developed computerized data acquisition systems and software to provide the most comprehensive retaining ring assessment technology available in the industry. We

(Continued on page 2)
President’s Corner by Laney Bisbee

All of us who have been associated with the nuclear utility industry over the past few decades have been affected by the suspension in construction of new nuclear plants that occurred in the late 1970s and early 1980s. I know my career was shaped by it. I had just started my professional career at Combustion Engineering when the Three Mile Island accident occurred. Soon after, new nuclear component fabrication at CE slowed down as orders were cancelled. Eventually, this led to talk of layoffs, but before it could happen to me, I went to work for Duke Power. After being in the nuclear division there for a few years, I noticed a slow down of the construction of new nuclear plants across the industry, and Duke even suspended construction of the Cherokee Nuclear Plant, originally planned for 2 units.

It was time for me to move on again, this time into the world of consulting, specifically for nuclear plants. One of my first projects was the requalification of emergency diesel generators (D/Gs) in nuclear plants. The first was at the newly-built Shoreham plant. But as hard as we worked requalifying the D/Gs for operation after a component failure, Shoreham would never go operational. After working for almost a decade in new nuclear power, I then turned my consulting career to the fossil plants and for 15 or so years, that’s where I stayed. As my role at SI changed to president, I again become more involved with our nuclear industry.

Up to a couple of years ago, not much new had happened with new nuclear plant construction in the US; since then however, all that is changing. We are currently in a period that’s being termed the nuclear renaissance. In the past year or so, it has been reported that there are 33 nuclear reactors on the drawing board, including the restart of previously abandoned projects. Attendance at forums like the recent Regulatory Information Conference has tripled over the past few years in proportion to the level of new nuclear plant construction being discussed and considered.

Just the buzz about new construction has redirected some of the efforts of my daily activities. But if the scientific, economic, and political factors allow new nuclear plant construction to be a reality in the near future, I’m certain I will want to alter my daily activities. But if the scientific, economic, and political factors allow new nuclear plant construction to be a reality in the near future, I’m certain I will want to alter my daily activities.

SI Expands...

SI offers a full line of turbine-generator inspection and engineering services:

- **Rotor Bore Inspection and Analysis**, including machining services, visual inspection, concurrent ultrasonic and eddy current inspection, analytical assessment using EPRI SAFER, and metallurgical evaluation.
- **Solid Turbine Rotor Forging Inspection** and Analysis including linear phased array ultrasonic inspection, flexible disk scanner, analytical assessment, and metallurgical evaluation.
- **Turbine Disk Blade Attachment Inspections and Analysis**, including a computer-based data acquisition system, flexible disk scanner, analytical assessment (including EPRI’s LPRImLife, developed by SI), and metallurgical evaluation.

For more information please contact Larry Nottingham at (704) 597-5554 or lnottingham@structint.com.
Prepares for Large-Bore Weld Overlays

Building upon an industry-leading track record in pressurizer repairs, W(SI)² leadership continues in the preparation of weld overlay for the remaining Alloy 600 (82/182) butt weld locations. In Fall 2008, repair applications move beyond the pressurizer to larger nozzles, including reactor vessel nozzles, based on MRP-139 schedule guidelines. To date, weld overlay repairs of pressurizers have typically been performed without impact on outage critical path. However, remaining large-bore nozzle repairs will clearly affect outage critical path if the conventional approach to weld overlay repair is taken.

On this basis, W(SI)² is pursuing a three-pronged approach to substantially reducing weld overlay repair time impact, while preserving those quality and technology differentiators established by the team’s weld overlay record. These advancements include optimized or reduced thickness weld overlay designs (vs. full structural designs), increased deposition rate welding, and integrated tool sets specifically designed to ensure that nominal refueling outage activities are unimpeded.

Optimized or reduced thickness weld overlays (OWOLs) are being pursued with EPRI and the industry through the licensing of MRP-169. OWOLs potentially reduce full structural overlay thicknesses by 50% or more in a typical hot leg nozzle application (while the team’s proven linear phased array UT inspection reduces weld overlay length relative to that required for conventional UT). In May 2007, SI and industry representatives presented a path to the NRC for resolution of staff comments and approval of MRP-169 by Spring 2008.

Secondly, the team continues development of its weld process by increasing the deposition rate of each weld arc, while preserving its unmatched quality record, using the proven power ratio approach to weld process optimization. Innovative multi-arc welding equipment is also under development for large-bore applications to “multiply” weld deposition rate. Also, GMAW, a weld process with production rates shown to exceed that of GTAW by a factor of 4 or more, is also being evaluated in conjunction with EPRI for future weld overlay applications. State-of-the-art GMAW deposit quality has advanced rapidly in recent years based on commercially available power supply technology.

Lastly, prototype tooling is being designed to perform welding, contouring and inspection within the access confines associated with reactor vessel nozzles (based on actual plant design and walkdown data) to allow other refueling activities to proceed during weld overlay. By contrast, competitive technologies such as inlay and stress improvement necessarily impact outage critical path due to equipment access considerations.

For more information please contact Bud Auvil at (704) 597-5554 or bauvil@structint.com.

SI’s Recent Experience in License Renewal Activities

Since the Fall of 2006, License Renewal Applications (LRA) have been submitted for one BWR plant (Susquehanna) and three PWR plants (Wolf Creek, Harris, and Indian Point). SI has supported most of the LRA submittals to-date by developing the formal fatigue program necessary for NRC approval of fatigue-related activities, including environmental fatigue assessments. We have also been addressing reactor vessel embrittlement issues for several plants involved in the license renewal process. SI has been actively engaged in industry conversation on many time limited aging analysis (TLAA) issues, including the recent heightened scrutiny of TLAA sections of the LRA by the NRC. SI is currently involved in TLAA and cycle and fatigue-monitoring efforts at Cooper, Duane Arnold, Prairie Island, Kewaunee, TMI-1, and Palo Verde, as well as requests for additional information (RAI) responses and follow-on TLAA efforts at Wolf Creek, Vogtle, Vermont Yankee, and FitzPatrick.

SI is extremely well qualified to provide license renewal services. Our experience in the areas of fatigue management, material evaluation, and fracture mechanics is unmatched in the industry, including any associated NRC support.

For more information please contact Gary Stevens at (303) 792-0077 or gstevens@structint.com, or Dave Gerber at (408) 978-8200 or dgerber@structint.com.
Revised P-T Curve Methodology

The final ("A") NRC version of SI’s BWR Pressure-Temperature (P-T) Curve Methodology Licensing Topical Report (LTR) was transmitted by the BWR Owners’ Group (BWROG) to the NRC on April 30th. This report represents the only currently available methodology for BWR P-T curves that is NRC-approved. A copy of the LTR is available to all participating BWROG utility members through their BWROG representative.

SI has been working for the past two years on this LTR, which allows utilities to remove their P-T curves from the plant Technical Specifications, in accordance with NRC Generic Letter 96-03. This will eliminate the need for licensing amendments to plant Tech Specs as a part of future P-T curve submittals.

Consider this methodology now available for your use to get your P-T curves out of your Technical Specifications.

For more information please contact Gary Stevens at (303) 792-0077 or gstevens@structint.com.

First Webinar A Success!

On Wednesday, June 27th, Structural Integrity held its first webinar on Pressure Temperature (P-T) Limits: The Basics of P-T Curves, hosted by Gary Stevens. For those of you that missed the webinar, check our website for a full audio/visual recording available for playback at your convenience. Nearly 100 utility folks from around the world registered for this event, and feedback from the attendees was that this type of forum is very effective for training and communication.

Given that feedback, Structural Integrity is planning to continue quarterly webinars, with topics to be announced soon. Monitor our website for details!

Guidelines & Workshops for Grade 91

SI has formed a working group to provide technical expertise in Creep Strength-Enhanced Ferritic (CSEF) metallurgy, assessment methodology, materials characterization and applicable predictive technology. As part of this effort, SI is holding regional workshops to discuss in detail some of the problems that have been encountered, and to more fully explain SI’s comprehensive approach to the successful implementation of the CSEF steels. More details on the workshops are available at our website, www.structint.com.

Deficiencies in the processing of Grade 91 and other CSEF steels have been implicated in several well-publicized failures, forced outages, construction extensions, and premature component replacements. Recent inspections at several US power plants have
detected an alarming number of improperly processed welds and components, and called into question the future reliability of similar critical components. The effect of deficient material can be severe, as failures can be catastrophic, replacement material is difficult to procure, and refurbishment of major components requires serious disruption of plant operation. Continued operation with components in degraded conditions is advisable only after performing specific material tests and conducting an analysis that conservatively predicts its behavior using actual plant operating data.

Many of the difficulties are the direct result of a failure to modify entrenched design, manufacturing, and construction practices developed for the successful control of the traditional power station materials, such as Grades 11 and 22. Compared to those materials, the metallurgical character of the CSEF steels is more complex. The formation of one specific condition of microstructure is essential in realizing the material’s enhanced creep strength, and any disruption of that microstructure will substantially compromise the alloy’s elevated temperature performance. It is essential, therefore, that at every stage of processing, from original material production to final installation of the component, rigorous control of the material condition is maintained.

SI’s comprehensive Life Cycle asset management program for CSEF materials provides guidance at every step of implementation, from design, through procurement, to installation and operation, including:

- Review of component and system design to insure that the unique behavior of the CSEF materials are properly accounted for in design (e.g., the effect of the “Type IV” region on long-term weldment performance)
- Development or review of purchasing/processing specifications, welding programs, and QC programs
- Vendor evaluation and on-site monitoring
- All aspects of advanced component inspection and testing
- Life assessment and life optimization through operations review

For more information please contact Jeff Henry at (423) 991-8842 or jhenry@structint.com.
SI has installed 48 accelerometers, 8 pressure transducers and delivered a 56 channel VersaDAS™, SI's customized data acquisition system, to support a vibration data collection effort at Point Lepreau Generating Station in New Brunswick, Canada. The gathered data was used to characterize a long-standing main steam line vibration issue. In the future, the same instrumentation will be used to verify the effectiveness of vibration control measures.

Monticello Nuclear Generating Plant received three VersaDAS™ systems to support their Extended Power Up-rate (EPU) project. All three systems are capable of recording acceleration data and one also contains 32 strain gage channels. Two of the systems are synchronized such that one system will automatically start the second system. In addition, SI provided strain data reduction services to help identify loading on their steam dryer.

SI is providing strain gage data reduction and interpretation services to Tennessee Valley Authority in support of Browns Ferry Nuclear (BFN) Unit 1 restart project. The restart of BFN Unit 1 is being done in conjunction with raising power to EPU levels. The strain gage data is used to indirectly measure the dynamic pressure fluctuations inside the main steam lines. The dynamic pressure fluctuation data is used as input to determine the loads on the steam dryer.

For more information please contact Karen Fujikawa at (303) 792-0077 or kfujikawa@structint.com, or George Szasz at (303) 792-0077 or gsasz@structint.com.
BWR Shroud Repair Evaluations

In the mid-1990s, several Boiling Water Reactor (BWR) plants installed shroud repair assemblies designed by GE. These assemblies consisted of four core shroud stabilizer tie rods that structurally replaced all of the shroud circumferential welds that were susceptible to intergranular stress corrosion cracking (IGSCC). In many cases, the shroud repairs were installed on a preemptive basis prior to performing any shroud weld volumetric examinations.

In 2006, cracking was discovered in the tie rod upper supports during visual inspection at one BWR. During recent Spring 2007 outages, three other utilities who were also potentially susceptible to tie rod upper support cracking asked SI to perform third-party review of the analyses performed by the vendor for the replacement stabilizer components. SI performed detailed stress and fracture mechanics analyses of the upper support and other selected components for all three plants. The analyses covered both the original design installed in the mid-1990s and the improved design that was created in response to the observed cracking. Of particular interest was the adequacy of the finite element mesh and all relevant boundary conditions on the ability of the models to predict the peak stress for comparison against IGSCC susceptibility criteria. Therefore, the SI analyses were focused on the modeling details in the regions of high stress. Our efforts resulted in improved accuracy of the analyses performed by the replacement hardware vendor.

In addition, SI supported contingency shroud horizontal weld examinations for one plant with an early Spring outage due to unavailability of replacement tie rod hardware. SI also supported analyses for two of the plants with later spring outages, which had difficulty removing portions of the 1990s tie rod hardware. In one case, the difficulties caused the utility to abandon removal of the old hardware and to justify one cycle of operation with portions of the old shroud repair assemblies left in place.

Post-Accident Performance of a Fouled Heat Exchanger

In cooperation with EPRI and an independent water chemistry expert, SI was able to quantify the present and historical degradation of heat exchanger (HX) performance for the essential cooling water (EW) system at Palo Verde (PV) for the time period during and after a design basis accident (DBA). The EW heat exchangers are cooled with an open recirculating cooling system comprised of spray ponds, pumps, piping, and heat exchangers to support cooling of safety related heat loads in each of the three PV units.

Several years ago, the chemistry of the spray ponds was augmented to mitigate corrosion. However, interactions among the treatment chemicals (as well as changes in chemical vendors) produced fouling due to chemical precipitation that caused unexpected levels of HX performance degradation. To address the numerous permutations of water chemistry, initial HX performance capability, and spray pond temperature, SI developed a thermal hydraulic model to study the effect of concentration of several foulants on the HX heat removal capability, and used conservative assumptions to determine an initial overall heat transfer coefficient (U). We also used a thermodynamically based model from the water chemistry consultant to predict the increase in scale deposits over the 26-day period following a DBA, then calculated the variation in U over that time period.

For the worst case, U was shown to decline about 9.5% over the DBA period. Although the degraded U values were below the design basis value, they were still more than 12% above the required U value calculated by plant personnel for the post accident scenario.

This analysis was one of the tools that were used in the station’s successful presentation to the NRC.

For more information, please contact Gary Stevens at (303) 792-0077 or gstevens@structint.com, or Scott Rodamaker at (408) 978-8200 or srodamaker@structint.com.
Casebook: Hydrogen Damage

SI was asked to examine four tube sections from the front waterwall deflection and rear nose arch tubes of a boiler for hydrogen damage, to assess the extent of the damage, and determine factors that contributed to the damage. Ultrasonic (UT) inspection had detected hydrogen damage ranging from moderate to severe.

Ring sections were cut through the damaged regions from each tube section, and prepared for examination with a metallurgical microscope. Initially, no obvious hydrogen damage was observed, but closer examination of three tubes revealed possible hydrogen damage. The hydrogen damage consisted of partial separation of the ferrite grain boundaries.

A sample was removed from the hot side of one of the tubes and bent until the internal surface was changed from concave to convex, then mounted and prepared for metallographic examination. The grain boundary fissuring became much more evident because the bending caused the fissures to open. The hydrogen damage had penetrated about halfway through-wall.

The internal surfaces exhibited general underdeposit corrosion; however, significant corrosion or gouging was absent. The internal deposit loading was high, and increased with the severity of the hydrogen damage. The appearance of the hydrogen damage was not typical. The damage consisted of discrete grain boundary fissures, which initially were not readily discernible. The tube microstructures exhibited the onset of decarburization of the pearlite colonies, but not the severe decarburization that usually accompanies this level of hydrogen damage.

A major factor contributing to the hydrogen damage is the heavy internal deposit buildup. The influence of the deposit buildup on the formation of hydrogen damage has three effects. First, it acts as a concentration site for corrodants; second, it shields the corrosion site so that the hydrogen atoms are not washed away; and third, it acts as a thermal barrier, which increases the metal interface temperature, thus increasing the corrosion rate.

SI recommended replacing all severe and moderate-severe damaged tubes and then chemically cleaning the unit to remove the very heavy deposit buildup and help eliminate the future hydrogen damage in the unit.

For more information please contact Wendy Weiss at (512) 553-9191 or wweiss@structint.com.

Exelon G-Scan™ Inspections

Exelon has developed a long range plan to inspect buried and above ground piping systems, and one of the primary technologies they are using is SI’s G-Scan™ system. SI will be conducting G-Scan™ inspections at all ten active Exelon nuclear sites in 2007. The G-Scan™ system uses long range guided wave ultrasonics to identify cross sectional thickness changes in pipe wall. Greg Lupia, Exelon Buried Pipe Corporate Program Manager said, "Guided wave is what I term a non-intrusive technology that fits well with our Long-Term Management plan for buried piping and raw water piping systems."

When completed, Exelon will have inspection information on miles of piping systems. SI has conducted G-Scan™ inspections within the Exelon system on above and underground piping systems on pipe diameters from two to sixty inches. G-Scan™ is a proven, reliable technology to accurately assess long segments of piping systems for wall loss from various corrosion mechanisms.

For more information please contact Ken Rach at (630) 728-2094 or krach@structint.com.
Upcoming Workshops:

- **2007 Guidelines & P91 Workshop**
  A Two-Day Workshop July 17-18, Chicago, IL
- **2007 Nuclear Power Services Workshop**
  A Two-Day Meeting August 28-29, 2007, Plymouth, MA
- **2007 Guidelines & P91 Workshop**
  A Two-Day Workshop October 30-31, Atlanta, GA
- **Introduction to Plant Vibration Solutions**
  A Two-Day Course September 5-7, Colorado Springs, CO

See [www.structint.com](http://www.structint.com) for details

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Scott Lebsack, Account Executive for SI Pipeline Services, and his 13-year-old daughter Amanda ran the Houston Marathon this year, Scott’s third time, and their first time as a father-daughter team. Their 5 hour 38 minute time placed Amanda in third place for her age group. “After 18 miles, Amanda’s feet were sore to the point that every step was painful, but she toughed it out,” says Scott. “Her determination to finish has made me a very, very proud father.”