PLANNING, PREPARATION, AND EXECUTION OF ASME SECTION XI 10-YEAR REACTOR VESSEL EXAMINATIONS AT THE POINT BEACH NUCLEAR PLANT

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ABSTRACT
Performance of an American Society of Mechanical Engineers (ASME) Section XI-required reactor pressure vessel (RPV) examination is an infrequent evolution for utility personnel. This paper will address the planning, preparation, execution, and lessons learned by both utility and vendor personnel during the Point Beach Nuclear Plant’s (PBNP) 4th 10-Year RPV examinations on both units within approximately four (4) months of each other. The use of the “High Impact Team” (HIT) concept, as well as publication of the bid specification several years in advance of the scheduled examinations enabled both utility and vendor personnel time to carefully plan and execute the work in a safe manner.

BACKGROUND
ASME Section XI (Rules for Inservice Inspection of Nuclear Power Plant Components) requires that the RPV welds and interior components be examined on a periodic basis. The basis for ASME Code is a 10-Year Inservice Inspection Interval, which typically means that utilities to plan and perform their 10-Year RPV examination during the last refueling outage of the Interval. For most pressurized water reactors (PWR), this is the only time that the lower internals (core barrel) is removed from the RPV, which is a high risk evolution. Because of this, as well as the cost in outage “critical path” time (typically >$500,000 USD/day), planning for this type of work is a multi-year, multi-discipline process, requiring personnel from almost every organization (e.g., Maintenance, Operations, Security, Regulatory Services, Procurement/Accounting, and Engineering) to work closely with the chosen vendor as a team to ensure successful completion of the work scope with minimal additional impact to the site.

POINT BEACH SPECIFICS
Point Beach Nuclear Plant (PBNP) is located approximately 30 miles southeast of Green Bay, Wisconsin and has been owned and operated by NextEra Energy Resources since September, 2007. PBNP consists of two (2) Units, both Westinghouse-designed, 132 inch (335.28 cm) inside diameter (ID) two-loop PWR’s with 34-inch (86.36 cm) Outlet, 32-inch (81.28 cm) Inlet, two (2) 4-inch (10.16 cm) Safety Injection/Core Deluge (SI) Nozzles (Figure 1). Both units were designed and built in the mid- to late 1960’s and were some of the earliest PWR’s in the United States to commence commercial operation. Due to the large number of nuclear plant orders being processed by Westinghouse at that time, PBNP’s Unit 1 RPV was fabricated by Babcock and Wilcox, at their Mount Vernon, Indiana plant and the Unit 2 vessel was fabricated by Combustion Engineering, at their Chattanooga, Tennessee facility. The nozzle to Reactor Coolant System (RCS) and SI piping welds were made with stainless steel with a stainless steel “buttering” on the nozzle (i.e., no Alloy 82/182/600 material was used). Unfortunately, due to the age of these units (fabrication circa 1967-68), a great deal of detailed information on the welding and any repairs of the RPV nozzles and piping tie-in welds was apparently not considered important for archival records, and thus were not kept for reference.
Figure 1 3.5 inch (8.88 cm) ID Safety Injection/Core Flood Nozzle

PBNP Unit 1 commenced commercial operation on December 21, 1970 followed by Unit 2 on October 1, 1972. PBNP’s first full RPV examination was performed during the Unit 2 “pre-service” in the early 1970’s. This examination was performed with a flange-mounted RPV examination tool which was fabricated by Programmed and Remote (PaR) Systems and Southwest Research Institute (SwRI) and paid for in part by the Wisconsin Michigan Power Company (WMPCo) - the original owner of PBNP. The first tool was delivered to PBNP in February, 1971 and was originally named the ISI-2, Inservice Inspection Device. Over the years, it became more commonly known as the “PaR Device”.

PBNP is currently in its 4th 10-Year Inservice Inspection Interval and is committed to the 1998 Edition through the 2000 Addenda of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI, “Rules for Inservice Inspection of Nuclear Power Plant Components.” PBNP has been granted a 20-year extension to its original operating license. The period of extended operation for Unit 1 commenced on midnight October 5, 2010, and commences on midnight March 8, 2013 for Unit 2. PBNP’s 4th Inspection Interval for both Units ends on June 30, 2012.

SELECTION OF AN EXAMINATION VENDOR

In 2006, the Engineering Programs Group at PBNP sought out competitive bids from three (3) vendors capable of performing 10-Year RPV examinations. At the time the bid specification was issued, the examinations were scheduled in the Spring (Unit 2, Refueling 29) and Fall (Unit 1, Refueling 31) of 2008. After careful consideration, in December 2006, IHI Southwest Technologies (ISwT) of San Antonio Texas (formerly known as the Nondestructive Evaluation Division of Southwest Research Institute) was selected as the vendor of choice. This was based on a number of different technical factors such as time on vessel, technical approach to the bid, compliance with the bid specification, and familiarity with the issues known to exist in the PBNP RPVs – which ISwT (SwRI) had intimate knowledge of due to work in the development of focused-beam flaw sizing techniques with PBNP and the Ginna Nuclear Plant in New York.
York during the 1980’s. Separate from the technical review of the bids, which was performed by PBNP Engineering Programs personnel using un-priced bids, the Nuclear Management Company (NMC) corporate Contracts Administration Group performed a cost review, which also found ISwT to be the vendor of choice. Based on the technical and fiscal findings, the NMC issued a contract to ISwT in January, 2007, with an initial project kick-off meeting between PBNP Engineering Programs and ISwT personnel following immediately thereafter to begin laying the groundwork for the outages planned for 2008.

EXAMINATION EQUIPMENT SPECIFICS
ISwT used an offspring of the original PaR Device, known as the FastPaR™ (Figure 2), which is designed for remote change out of the examination end-effectors (transducer packages), thus requiring only a single move to the vessel prior to commencement and from the vessel upon completion of the examination activities. The “quick-change” unit allowed for an end-effector to be docked with an underwater docking mechanism, and then transported up to the operating floor, where it would be swapped out with a new, calibrated end-effector to continue examinations. This allowed examinations to continue with minimal interruptions (typically 30 to 45 minutes).

ISwT used two different ultrasonic (UT) data acquisition systems: the Enhanced Data Acquisition System II (EDAS-II™), and the Zetec Tomoscan III/PA 32/128 phased array (PA) system (T-III). Both EDAS-II™ and the T-III equipment and procedures had been fully demonstrated through ASME Section XI, Appendix VIII, as implemented by the Performance Demonstration Initiative (PDI). The RPV shell welds were examined using conventional UT (EDAS-II™) while the nozzle-to-shell from the nozzle bore and the nozzle-to-piping system dissimilar metal (DM) welds were examined using PA (T-III). During the 1998/1998 10-Year RPV examinations, PDI techniques were used on the RPV shell welds only, as demonstrations of the nozzle-to-shell and nozzle-to-piping system welds had not been performed by any vendor.

One area that PBNP has a relatively unique challenge is the examination of the SI nozzles and DM welds. Since the inside diameter of the nozzle/piping is approximately 3 ½ inches (8.88 cm), any tooling/end-effectors have to be extremely small and built to very close tolerances. In addition, due to the center mast design of the ISwT FastPaR tool, the end-effector had minimal clearance when maneuvering around the SI nozzle extension. This end-effector was required to extend into the SI nozzle approximately 18 inches blind (i.e. no visual validation of the search unit location). This meant that ISwT personnel had to rely solely on the encoded positional readouts and UT data (0-degree profilimetry and PA) to validate that they were at the correct position inside the nozzle to perform the nozzle-to-shell or DM weld examination. In addition, due to the challenges involved in the original PDI testing, the scanning time required for the SI nozzle to shell and DM welds was almost four hours per nozzle.

The visual examination portions of the examination scope were completed using cameras mounted on the FastPaR and on the PBNP-owned Deep Ocean Engineering, Phantom 150 remotely operated vehicle (ROV).

PLANNING
Due to the enormous impact on the overall schedule of the planned refueling outages, the 10-Year RPV examination received an extremely high level of attention from management both at the site, and the NMC corporate offices. Approximately two months after contract award in January 2007, two things occurred: (a) WE Energies (the owner of PBNP) and the NMC, announced the sale of PBNP to FPL Group (now known as NextEra Energy) which would occur in late 2007; and (b) PBNP station management commenced the High Impact Team (HIT) process for the Spring 2008 outage (U2R29). Due to their familiarity with both ASME Section XI and the overall job scope, the PBNP NDE Level III and Inservice Inspection Coordinator Bardo were chosen as the HIT Lead (Day Shift) and Back-up (Night Shift Lead), respectively.
The HIT consisted of personnel from Operations, Maintenance, Radiation Protection, Security, Nuclear Supply Chain, and Production Planning (Outage Scheduling), as well as several personnel from Engineering Programs. In addition to the formal members of the HIT, a number of other personnel were engaged, including the head of the Refueling Services HIT, the Yard Coordination HIT, Containment Coordination HIT, and the In-Processing (Security/Badging/Training) HIT. These groups were recognized as playing an integral part of the overall success of the 10-Year examination. HIT meetings were initially held approximately once every three weeks, with a plan to increase the frequency to weekly approximately 3 months prior to the outage (about December, 2007). However, shortly after the acquisition of PBNP by the FPL Group, the schedule for the 10-Year examination was challenged by FPL Group personnel based on other work that was scheduled during the same outage timeframe. Due to this challenge, PBNP Engineering Programs personnel spent several weeks validating that the examinations could be moved from 10 years to almost 12 years since the last examination.

In spite of the approximately 18 month delay in the examination schedule, PBNP and ISwT personnel continued the HIT meetings, but only on a monthly basis. In addition to the HIT meetings on site, the PBNP ISI Coordinator, NDE Level III, and the Authorized Nuclear Inservice Inspector attended a three day training class in data acquisition and analysis on both EDAS-II™ and the T-III equipment, as well as a demonstration of the cameras that would be used to perform the enhanced visual examination (EVT-1) of the nozzle inside radius sections (IRS) in accordance with ASME Code Case, N-648-1, “Alternative Requirements for Inner Radius Examination of Class 1 Reactor Vessel Nozzles, Section XI,
Division 1,” as modified by United States Nuclear Regulatory Commission (USNRC) Regulatory Guide 1.147. In addition to training on the equipment, techniques, and procedures, PBNP and ISwT personnel carefully reviewed all areas of previously recorded indications in both the RPV shell welds and the nozzle-to-piping systems welds. There were several areas of concern noted in both Unit 1 and Unit 2’s piping welds, which PBNP personnel felt could pose a risk of being considered inside surface (ID) connected due to their proximity and the rules of Section XI, as well as a nuance of the PDI demonstration.

Since no vendors had successfully demonstrated the capability to meet the through-wall sizing acceptance criteria of Appendix VIII, Supplements 2, 3, and 10 [0.125 inch (3.175 mm)] root mean square (RMS), the USNRC issued Regulatory Issue Summary (RIS) 2003-01, “Examination of Dissimilar Metal Welds, Supplement 10 to Appendix VIII of Section XI of the ASME Code” on January 21, 2003. After RIS 2003-01 was issued, a compromise position was reached between U.S. utilities and the USNRC regarding how to deal with the issue of non-qualified sizing. The compromise was the use of a request for relief (RR) from the requirements of the U.S. Code of Federal Regulations (CFR) governing inservice inspection [10 CFR 50.55a(g)(4)].

When originally designed, the PDI ID examination test specimens were fabricated with flaws which all originated at the ID surface, since that is obviously the concern from an inservice inspection standpoint (i.e. – service induced cracking). Unfortunately, the technologies that all U.S. PWR RPV examination vendors used found other, non-inservice related flaws (e.g., slag, lack-of-fusion, clad-to-base metal indications, etc.). Operating experience from a number of utilities who had performed their 10-Year RPV examinations within 2-3 years prior to PBNP showed that there were a large number of indications which were “buried”, but were recorded and had to be evaluated through the requirements of ASME Section XI, IWB-3500.

Based on the requirements discussed above, on March 13, 2008, PBNP submitted RR-21 to use the alternatives covered under ASME Code Case N-695, “Qualification Requirements for Dissimilar Metal Piping Welds Section XI, Division 1,” along with documentation through EPRI of the actual RMS error (RMSE) of the vendor. The NRC granted PBNP’s request on August 25, 2008 with no additional restrictions.

Due to the risks involved in the examination of the DM welds, contingency planning was required by PBNP and NextEra Energy corporate management. This planning included putting contracts in place with the Original Equipment Manufacturer (OEM) for engineering support and validation of the PBNP “Flaw Evaluation Handbook”, as well as a contract amendment with ISwT for the deployment of an eddy current (ET) end-effector in case UT indications were recorded near the inside surface of the DM welds. The use of ET would assist PBNP personnel in validating that any indications recorded were not connected to the “wetted surface” (i.e. – ID of the pipe), and thus were fabrication-related indications and not service-related flaws.

PBNP Engineering Programs personnel also utilized the delay in the examination schedule to walk down areas in the specific containments to validate information provided in the bid specification and to ensure that the ISwT equipment would all fit in the area(s) designated by the Containment Coordination HIT. These walk downs allowed Engineering Programs and ISwT to have a higher level of comfort with the plans which had been previously made and validated many assumptions that had been used for planning the work. This additional outage prior to the examination assisted greatly with making the overall project flow more smoothly.

Another change in the way business was done at PBNP was the use of Refueling Services vendor for a number of tasks that had previously been performed by PBNP Maintenance and Operations personnel since the start of commercial operation. This was a large change for those organizations, as well as Engineering Programs and required dealing with a whole new group of individuals. During the six months prior to the Fall 2009 refueling outage (U2R30), a number of meetings were held with the Refueling Services vendor representatives in an attempt to ensure that the non-site personnel would understand the needs of ISwT and Engineering Programs.

While PBNP personnel were preparing for the Fall outage, ISwT personnel were also busy with preparations for the job. During the Summer of 2009, ISwT personnel completely disassembled the
FastPaR and rebuilt/refurbished most components. In addition, based on Operating Experience from another utility/vendor where an RPV examination tool broke and parts fell into the cavity/RPV, ISwT performed visual and liquid penetrant examinations of all the welded parts of the FastPaR. These examinations revealed some areas which, although not structurally defective, were repaired to ensure that no issues would occur. ISwT also performed a number of check-outs on the SI nozzle tool, as it was a first-of-a-kind (FOAK) deployment of this tool design.

During the final two months prior to U2R30, additional challenges were hurled at Engineering Programs, including a lack of site power for the ISwT data acquisition trailer, which was to be positioned just outside the radioactive controlled area (RCA) fence. During the previous Unit 2 10-Year examination (Winter 1998/99), power was run from a warehouse approximately 75 feet (22.86 meters) away. This power receptacle was unavailable due to the replacement of the three main transformers as part of the long-term Power Uprate Project. Due to the small footprint of the PBNP site, there was only one transport path for these transformers to follow, that that cut between the warehouse and the ISwT trailer location. Because of this challenge, Programs Engineering personnel had to rent a temporary diesel generator and arrange for fueling services for the entire time that ISwT would require power to their acquisition/analysis trailer.

**U2R30 - EXECUTION AND SUCCESS**
In October 2009, U2R30 commenced. While faced with a myriad of minor issues, such as coordination of the various support groups required to move the examination equipment from the yard into the Unit 2 containment, the overall examination process went well. The equipment was moved into containment, set-up, placed on the RPV, and ran throughout the examination process with no significant problems. The two areas of concern – the FOAK deployment of the SI Nozzle Tool and the DM weld end-effectors worked as planned with few problems. There were several indications which required some additional analysis time, including consultation with the Electric Power Research Institute’s (EPRI) PDI Administrator for validation. However, the indications were all deemed allowable in accordance with ASME Section XI with no analytical evaluations required (IWB-3600). There were, unfortunately, a minor injury (a finger prick with safety wire) and a single, low-level, personnel contamination event (PCE), which spoiled an otherwise flawless execution. However, radiation exposure was excellent, with just over 400 mR (0.0040 sv) expended with over 1,400-person hours logged in the RCA.

**U1R32 - EXECUTION AND CHALLENGES**
After U2R30, both PBNP and ISwT personnel felt that only minor adjustments to execution plans were required. Unfortunately, in spite of all efforts to the contrary, they were mistaken. Between U2R30 and U1R32, ISwT performed preventative maintenance on the FastPaR and associated equipment again to ensure that it was completely ready for the outage in March, 2010. This maintenance included tear-downs and re-builds of most components, replacement of some parts, and re-assembly and check-out of the entire FastPaR at ISwT’s facility in San Antonio. These check-outs revealed no problems, and the equipment was then disassembled, boxed up, and shipped to PBNP approximately one week prior to the outage.

Based on lessons learned from U2R30, PBNP requested that ISwT ship the equipment a week early in order to be able to affect a modified move-in sequence. The majority of the equipment required inside containment could be moved through the upper (personnel) airlock. Because of this, as well as the support required from PBNP Maintenance for forklift, crane operators, and riggers; Engineering Programs personnel arranged for that equipment to be moved into the “truck bay” located in the Primary Auxiliary Building (PAB) located between Unit 1 and Unit 2 containments. The equipment was then surveyed by RP and rigged/lifted across the spent fuel pool to a mezzanine level inside the PAB. It was then stored in a fan room just outside Unit 2 containment, where it was out of the way. Once the Unit 1 containment was open for equipment move-in, it was shuttled back across the mezzanine and into the Unit 1 fan room on carts and offloaded into the contaminated area for transport into containment. This worked very well for
all parties involved (RP, Maintenance, and ISwT) and allowed other work to continue until the final three pieces of equipment were ready to be moved in through the lower airlock (equipment hatch).

**Challenges**

During the final equipment move-in process, several challenges arose – the first of which were questions by the Operations Team Room regarding the ability to close the lower airlock within the time-to-boil “window” that existed at the time (approximately 30 minutes). Based upon discussions with ISwT, the Day Shift Lead could not guarantee that, during the movement of the final piece of equipment (the FastPaR mast), the containment closure time could be met. This required an adjustment to the overall schedule to wait until the time-to-boil issue was not a concern. The second challenge was the fact that, during move-in, the “lower unit” of the FastPaR was found to have one of the transport bolts jammed, which caused a delay of almost an hour to remove the bolt. The third move-in challenge was the fact that the Unit 1 lower airlock elevation layout was slightly different than Unit 2. There was an air duct that extended a greater distance out into the “free zone” than Unit 2, which caused the riggers and crane operator to question if the mast could be moved in. Personnel from ISwT, the Containment Coordinator, and the Day Shift Lead, along with the crane operator and riggers stopped the work and discussed a lift plan that would address the concerns. This caused another delay, but it brought the mast up to the refueling floor (66 ft. elevation) safely.

The next area that was challenged was the equipment itself. During assembly of the FastPaR on the 66 ft., a break device was identified as malfunctioning. The device was swapped out and assembly continued. Unfortunately, that was not the last challenge. There was a Foreign Material Exclusion (FME) zone event due to a spool of safety wire falling into the open refueling cavity, and then there were several computer/software issues that slowed data acquisition also. The major issue occurred though when the PaR Operator inside containment noticed that the device did not appear to be operating correctly. It was placed in a safe condition and removed from the RPV. When it was removed, it was quickly determined that the device had come off center from its internal guides. This repair was a FOAK evolution for PBNP and took over 24 hours to plan and execute. After the repair was completed, the device was checked-out and returned to the vessel to continue scanning. The device performed well and data was collected on all welds with the exception of the SI nozzles. There were some problems with the SI Nozzle tool, including binding and water intrusion in the air-operator lines. Trouble-shooting happened over a number of hours in parallel with the other examinations, but finally the SI nozzle work had to get started. During the start of the first examination, the SI nozzle tool became partially lodged in the nozzle. A plan was then formulated to “rescue” the tool using PBNP Reactor Engineering poles and other plant-supplied equipment. The tool was extracted from the nozzle without a great deal of problems, but the extension function which was required to reach the DM weld would not work. It was finally determined by the Day Shift Lead that the nozzle-to-shell welds would be examined and the SI DM welds would have to be examined during the next Unit 1 outage in 2011. This was a blow to the entire 10-Year RPV team, but it was felt that no additional time could be expended on the vessel, as it was coming close to impacting the critical path of the outage.

The examinations revealed one (1) indication of concern. On the “A” Inlet Elbow to Nozzle DM weld (RC-32-MRCl-AIII-03), an indication was recorded that was close enough to the inside surface to fall within the “surface by proximity” rules when the RMSE was applied in accordance with PBNP Relief Request RR-21. This meant that the ET end-effector needed to be deployed in order to validate that the indication was not ID connected. This activity was scheduled just before the work on the SI nozzles (discussed above), and in the meantime, personnel from Westinghouse and NextEra/FPL Group corporate headquarters were provided information on the flaw and multiple discussions were had regarding how to deal with the indication. Ultimately, the indication required acceptance by Analytical Evaluation per IWB-3600, which was then communicated to the USNRC via conversations with the Senior Resident Inspector as well as the Regional Inspector and then followed up with written notification.
From a radiological and industrial safety standpoint, the Unit 1 outage was very successful. There were no injuries and no personnel contamination events. In spite of the problems encountered, the radiation exposure to personnel was less than 450 mR (0.0045 Sv) with over 1,400 person-hours logged in the RCA.

CONCLUSIONS
10-Year Reactor Vessel examinations are an infrequently performed task for most utility personnel and planning cannot start soon enough. Based on the experiences over the past three years, the following items should be considered when planning for such an activity:
1. The bid specification should clearly state all site requirements and how the bidder will address them, including any procedure review/revisions, training, demonstrations, or meetings that should be considered as basic “in-scope” work. In addition, the bids should clearly have any site support requirements identified as well as the site’s expectations for Foreign Material controls, Security/Badging requirements, and any penalties that would be imposed upon the vendor for violation of those requirements.
2. The use of the High Impact Team concept that includes various work groups on site as well as the examination vendor is an excellent method to ensure that neither the implementing organization (Engineering Programs at PBNP) nor the vendor are complacent with their planning and preparation.
3. The vendor should be considered a team member and not treated as someone who will just show up, do a job, and leave. Communication to vendor personnel by the site should occur frequently and they should understand how important their job is to the overall success of the outage, as well as the future of the plant.
4. A clear communication plan for both vendor-to-site contact communication as well as project-to-outage control center communications. This helps keep rumors to a minimum and helps keep personnel in the field from being distracted by non-project personnel wanting status updates.
5. Site project personnel should become intimately familiar with the equipment, procedures, and processes so that when challenges arise, they can understand some of the bases for recommendations that may come from the vendor.

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REFERENCES
3) ASME Code Case N-695, “Qualification Requirements for Dissimilar Metal Piping Welds Section


6) USNRC Letter to Mr. Larry Meyer, Site Vice President, “Point Beach Nuclear Plant, Units 1 and 2 – The Fourth 10-Year Interval Inservice Inspection Program Plan Requests for Relief No. RR-21 (TAC Nos. MD8319 and MD8320), Washington, D.C., August 25, 2008.
