UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NEW REACTORS
WASHINGTON, DC 20555-0001

October 22, 2008

NRC REGULATORY ISSUE SUMMARY 2008-25 REGULATORY APPROACH FOR PRIMARY WATER STRESS CORROSION CRACKING OF DISSIMILAR METAL BUTT WELDS IN PRESSURIZED WATER REACTOR PRIMARY COOLANT SYSTEM PIPING

ADDRESSEES

All holders of operating licenses for nuclear power reactors, except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All current and potential applicants for an early site permit, combined operating license (COL), or standard design certification (DC) for a nuclear power plant under the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants.”

INTENT

The U.S. Nuclear Regulatory Commission (NRC) is issuing this regulatory issue summary (RIS) to inform addressees of the regulatory approach for ensuring the integrity of primary coolant system dissimilar metal (DM) butt welds containing Alloy 82/182 in pressurized-water reactor (PWR) power plants.

BACKGROUND

Reactor coolant systems (RCSs) in PWRs have a number of butt welds containing Alloy 82/182 materials that are used in joining components. Butt welds are full-penetration welds, in contrast to partial-penetration or J-groove welds used in vessel head penetration nozzles. Reactor pressure vessels, steam generators, and pressurizers are vessels constructed of ferritic steels. Welds containing Alloy 82/182 may be used in the butt welds that join ferritic vessel nozzles to stainless steel RCS loop piping. Welds between ferritic and stainless steel components are referred to as DM welds. Some PWR designs may use DM welds containing Alloy 82/182 to connect stainless steel clad ferritic reactor coolant loop piping to stainless steel branch piping, such as emergency core cooling system piping.

SUMMARY OF ISSUES

Operating experience has demonstrated that Alloy 82/182 materials exposed to primary coolant water (or steam) under the normal operating conditions of PWR power plants are susceptible to primary water stress-corrosion cracking (PWSCC). The NRC has previously issued generic communications regarding the emergence of this phenomenon and its effect on specific areas of PWR primary systems. The enclosure to this RIS lists the more significant operating experiences related to PWSCC in DM butt welds in PWRs.

Industry Actions To Address Primary Water Stress-Corrosion Cracking in Dissimilar Metal Butt Welds

The following information describes some of the industry's activities to address PWSCC in DM butt welds.

Growth Rate Studies

The incidence of PWSCC of Alloy 600 components in the PWR RCS highlighted the need for qualified equations for crack growth rates (CGRs) to evaluate flaws found by inservice inspection of thick-walled parts, including welds. In 2002, the industry's Materials Reliability Program (MRP) developed a recommended CGR curve for PWSCC of thick-wall components fabricated from Alloy 600 base material, such as reactor vessel head nozzles (MRP-55NP, Agencywide Documents Access and Management System (ADAMS) Accession No. ML023010510). The recommended MRP-55 curve, which was subsequently incorporated into Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) for flaw evaluation, can provide guidance on inspection intervals and repair or mitigation options for many PWSCC flaws. The MRP subsequently issued MRP-115NP (ADAMS Accession No. ML051450555) to extend the MRP-55 work to cover Alloy 82/182/132 welds following observations of cracking in RCS welds with high residual stresses, including J-groove welds attaching control rod drive mechanism nozzles to the reactor vessel upper head.

Initiative on Materials Degradation Management

In May 2003, the industry adopted an initiative on materials management and issued Nuclear Energy Institute (NEI) 03-08, "Guideline for the Management of Materials Issues." This initiative and the associated guidance document established policy, direction, oversight, and support for industry programs involving the management of materials issues. The initiative committed each nuclear utility to adopt the responsibilities and processes described in NEI 03-08.

Through the activities described in NEI 03-08, the industry stated that it would ensure that its management of materials degradation and aging would be forward-looking. In addition, the industry stated that it would continue to rapidly identify and effectively respond to emerging issues and would emphasize safety and operational risk significance. Guidelines developed for power plant licensees under NEI 03-08 address assessment, inspection, repair, mitigation, replacement, and regulatory interface.

Development and Implementation of Inspection Program (MRP-139)

Section XI of the ASME Code, which is incorporated into the NRC regulations in Title 10, Section 50.55a, "Codes and Standards," of the *Code of Federal Regulations* (10 CFR 50.55a), specifies examination requirements for RCS components and DM welds. These regulations require volumetric, surface, and visual examinations to ensure the integrity of the reactor coolant pressure boundary and the safe operation of the power plant.

In September 2005, MRP issued MRP-139, “Materials Reliability Program: Primary System Piping Butt Weld Inspection and Evaluation Guideline,” that all PWR plants agreed to implement under the industry’s proactive management of materials degradation initiative, NEI 03-08 (the nonproprietary version is located under ADAMS Accession No. ML052150196). MRP-139 provides industry guidance for the volumetric and visual inspections of butt welds in PWR primary systems. The MRP-139 inspections augment inspections of these locations already required by Section XI of the ASME Code.

This guideline applies to DM butt weld locations containing Alloy 82/182 in PWR RCS piping of 25 millimeters (1 inch) in diameter or greater. The guideline specifies that piping with normal operating temperatures equal to or greater than the cold leg temperature is within the scope of the guideline. It specifies a timeframe for completion of a baseline or initial inspection of all welds within its scope. The baseline inspections are ordered on the basis of temperature and are to be completed over the next couple of years. The hottest weld locations are the pressurizer nozzle DM welds, and the baseline inspections of these welds have all been completed, as verified by NRC inspections. In addition to completing these baseline inspections, at the time of the issuance of this RIS, industry reports indicate that approximately 90% of the domestic pressurizer DM welds containing Alloy 82/182 have been mitigated as well. Next are inspections of hot leg temperature welds, followed by cold leg temperature welds. In general, the inspection of smaller hot leg welds has a higher priority than inspection of the larger hot leg welds, since larger pipes have greater flaw tolerance (that is, greater resistance to failure for a flaw of a given size). The volumetric inspections have been or will be performed using ultrasonic examination techniques qualified to meet the requirements of Appendix VIII to ASME Code, Section XI.

The requirements for subsequent examinations are organized by category of weld according to the location of the weld in the RCS and the type of mitigation applied to the weld. The industry has used several methods to mitigate PWSCC. These methods include replacement of the Alloy 82/182 materials with Alloy 52/152 materials, structural weld overlays with Alloy 52/152 materials, and stress improvement processes that place the susceptible materials in compression to prevent crack initiation and growth. The industry is working on mitigation techniques involving isolation of the susceptible Alloy 82/182 material from the reactor coolant environment by applying Alloy 52 cladding or inlays to the inside of the pipe.

In general, welds for which an ASME-qualified examination cannot be performed have to be made “inspectable.” For example, a weld having a contour that precludes performing an ASME-qualified examination may be mitigated by a structural weld overlay. This has the beneficial effect of reducing the residual stresses on the inside region of the pipe and makes a qualified examination possible.

The NRC staff sent a letter to NEI dated October 12, 2005, which contained a request for clarifications together with NRC staff comments on MRP-139 (ML052720290). On November 1, 2007, the MRP issued two interim guidance letters (ML080300474 and ML080300478) related to inspection of small diameter RCS piping. These interim guidance letters address those NRC staff comments with near term implications.

NRC Staff Actions To Address Primary Water Stress-Corrosion Cracking in Dissimilar Metal Butt Welds

The industry actions to develop and implement the MRP-139 inspections allowed the NRC staff to pursue a process to codify requirements involving all stakeholders rather than to initiate other regulatory actions. The NRC staff concluded that the approach of working with ASME to revise inspection requirements and subsequently revise 10 CFR 50.55a was both necessary and in the best interest of protecting public health and safety. This process also has the benefit of improving public openness.

The ASME Code inspection requirements, incorporated by reference in 10 CFR 50.55a, provide a regulatory foundation for ensuring the integrity of pressure-retaining components. The current ASME Code requirements for inspection of Alloy 82/182 butt welds are not frequent enough to ensure that ASME Code-allowable limits will continue to be met in the event that PWSCC initiates. This conclusion is based on CGRs developed by the Electric Power Research Institute/MRP and on the ASME Code maximum flaw depth allowable limit of 75 percent through-wall. This issue is being addressed by the MRP-139 examinations. However, the NRC staff concluded that the ASME Code requirements needed to be revised to provide a regulatory framework for ensuring that ASME Code-allowable limits would not be exceeded, leakage would not occur, and potential flaws would be detected before they challenged the structural or leakage integrity of piping welds.

On December 20, 2005, the NRC sent a letter to ASME requesting it to address the inspection of RCS DM welds for PWSCC. At an ASME meeting on February 13, 2006, representatives from the NRC staff and industry presented their views on the codification of inspection requirements for these welds. On February 14, 2006, the Executive Committee of ASME Subcommittee XI agreed that the ASME Code requirements needed to be revised and approved the development of an ASME Code Case on appropriate inspection frequency requirements for the RCS butt welds containing Alloy 82/182. Since that time, Section XI has been working on a Code Case that contains proposed requirements for the inspection of these DM welds. This Code Case is nearing completion. When that occurs, the NRC will review the Code Case to determine if it is appropriate for incorporation by reference in 10 CFR 50.55a, as part of the periodic rulemaking updating that section.

On October 13, 2006, the Wolf Creek Nuclear Operating Corporation performed pre-weld overlay inspections using ultrasonic testing (UT) techniques on the surge, spray, relief, and safety nozzle-to-safe end DM and safe end-to-pipe stainless steel butt welds. The licensee's inspection and weld overlay activities were being performed to satisfy the MPR-139 guidelines. The inspection identified five circumferential indications in the surge, relief, and safety nozzle-to-safe end DM butt welds containing Alloy 82/182 that the licensee attributed to PWSCC and that were significantly larger and more extensive than previously seen in the industry.

During public meetings with the industry on November 30, 2006, and December 20, 2006, the NRC staff presented the results of a fracture mechanics based scoping study that assessed the safety significance of the UT indications found at Wolf Creek. As a result of these analyses, the staff concluded that there may be little or no time margin between the onset of leakage and rupture in pressurizer nozzle Alloy 82/182 DM butt welds containing flaws similar to those found at Wolf Creek. The staff assessed a number of options regarding what regulatory action to take to address this issue and concluded that licensees needed to complete inspections or mitigations of the pressurizer nozzle Alloy 82/182 welds by the end of 2007, consistent with the baseline inspection schedule in the MRP-139 guidelines. The staff also concluded that licensees needed to implement interim enhanced leakage monitoring, and reinspect unmitigated pressurizer DM butt welds once every four years versus once every five years as permitted by MRP-139.

In March 2007, the NRC staff issued Confirmatory Action Letters (CALs) to the licensees of 40 PWR power plants confirming commitments from those licensees to resolve concerns regarding potential flaws in specific RCS DM butt welds by the end of 2007. The remaining 29 PWR plants had either completed the requisite actions or do not have pressurizer welds susceptible to PWSCC.

Nine of the plants receiving CALs did not have outages scheduled in 2007 and were planning to mitigate the DM butt welds during the spring 2008 refueling outages, based on a process allowed by NEI 03-08 to extend the schedule. These plants committed to the NRC staff to accelerate outages into 2007 if the industry was not able to demonstrate an adequate level of safety to the NRC. The nine plants are Braidwood 2, Comanche Peak 2, Diablo Canyon 2, Palo Verde 2, Seabrook, South Texas Project 1, V. C. Summer, Vogtle 1, and Waterford 3.

By letter dated February 14, 2007, the Nuclear Energy Institute indicated that the Electric Power Research Institute (EPRI) MRP would be undertaking a task to refine the crack growth analyses pertaining to the Wolf Creek pressurizer DM weld ultrasonic indications. These additional advanced finite element analyses (FEA) were performed to address the NRC staff's concerns regarding the potential for rupture without prior evidence of leakage from circumferentially-oriented PWSCC in pressurizer nozzle welds. The goal of these studies was to demonstrate that PWSCC in pressurizer DM butt welds would progress through-wall and exhibit detectable leakage prior to causing a possible rupture event. These studies reduced unnecessary conservatisms and some of the uncertainties in previous analyses.

Industry completed these analyses and documented the results in MRP-216, Revision 1, "Advanced FEA Evaluation of Growth of Postulated Circumferential PWSCC Flaws in Pressurizer Nozzle Dissimilar Metal Welds: Evaluations Specific to Nine Subject Plants" (ML072410235). These results were provided to the NRC staff by letter dated August 13, 2007.

The NRC staff completed independent analyses to enable review and critique of the industry's analyses and to extend the scope of the industry's analyses. The staff's assessment, issued on September 7, 2007 (ML072430836), used advanced FEA of the fabrication, loading, and postulated flaw growth in the pressurizer nozzle welds to assess crack growth rates and shapes based on an array of starting flaw sizes. The staff concluded that PWSCC, if present in pressurizer DM butt welds of the nine plants analyzed, would progress through-wall and exhibit detectable leakage prior to causing a possible rupture event. Therefore, the conclusion of the NRC staff's safety assessment was that there was reasonable assurance that the nine plants addressed by the evaluation could operate safely until their next scheduled refueling outages in the spring of 2008. The licensees for all nine plants mitigated the welds and completed inspections during the spring 2008 refueling outages.

Based on operating experience, the NRC staff believes that MRP-139 and the MRP interim guidance letters, with the exception of the reinspection interval for unmitigated pressurizer DM butt welds as addressed by the CALs, provide adequate protection of public health and safety for addressing PWSCC in butt welds for the near term pending incorporation by reference into 10 CFR 50.55a of an ASME Code Case containing comprehensive inspection requirements.

In conjunction with the activities discussed above, the NRC staff is monitoring the implementation of MRP-139 through its regional inspection program. The NRC issued Temporary Instruction 2515-172, "Reactor Coolant System Dissimilar Metal Butt Welds," in February 2008, to support staff oversight of DM butt weld mitigation and inspection activities that licensees are implementing in accordance with the industry MRP-139 guidelines. The NRC staff is monitoring the industry's MRP-139 inspections and operating experience and will use this information to determine if any additional regulatory actions are necessary.

CONCLUSIONS

Operating experience has demonstrated that Alloy 82/182 materials exposed to primary coolant water (or steam) under the normal operating conditions of PWR plants are susceptible to PWSCC. In 2005, the MRP issued the MRP-139 guidelines for the examination of DM butt welds. Industry has been implementing this inspection guideline and mitigating welds to address PWSCC. The NRC staff has reviewed the MRP-139 guidelines and the MRP interim guidance letters. The NRC staff believes that MRP-139 and the MRP interim guidance letters, with the exception of the reinspection interval for unmitigated pressurizer DM butt welds as addressed by the CALs, provide adequate protection of public health and safety for addressing PWSCC in butt welds for the near term pending incorporation by reference into 10 CFR 50.55a of an ASME Code Case containing comprehensive inspection requirements. The NRC staff is monitoring the industry's MRP-139 inspections and operating experience and will use this information to determine if any additional regulatory actions are necessary.

BACKFIT DISCUSSION

This RIS requires no action or written response. This RIS informs addressees of an acceptable regulatory approach for ensuring the integrity of primary coolant system DM butt welds in PWR power plants. The short-term approach involves monitoring and assessing the industry program that is currently underway. The NRC staff will use information on the implementation of the industry program to determine if any additional regulatory actions are necessary. As in other areas involving NRC staff oversight, this monitoring approach does not involve or constitute a backfit. In the longer term, the NRC staff plans to incorporate ASME requirements into 10 CFR 50.55a, once ASME develops and issues them and the NRC staff determines that they are acceptable. Any backfitting issues associated with incorporation by reference into 10 CFR 50.55a of the ASME Code Case will be addressed in that rulemaking, which will be published for public comment.

FEDERAL REGISTER NOTIFICATION

A notice of opportunity for public comment on this RIS was not published in the *Federal Register* because the RIS is informational and does not represent a departure from current regulatory requirements. In addition, the NRC staff had a number of public meetings with stakeholders on the regulatory approach discussed in this RIS.

CONGRESSIONAL REVIEW ACT

The NRC has determined that this action is not a rule under the Congressional Review Act.

PAPERWORK REDUCTION ACT STATEMENT

This RIS does not contain information collections and, therefore, is not subject to the requirements of the Paperwork Reduction Act of 1995 (44 U.S.C. 3501, et seq.).

CONTACT

This RIS requires no specific action or written response. Please direct any questions about this matter to the technical contact listed below.

/RA/

Michael Case, Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Technical Contact: Edmund Sullivan
(301) 415-2796
Ted.Sullivan@nrc.gov

Enclosure: Summary of Operating Experience Related to Primary Water Stress Corrosion Cracking in Dissimilar Metal Butt Welds

Note: The NRC's generic communications may be found on the NRC public Web site, http://www.nrc.gov, under Electronic Reading Room/Document Collections

.

PAPERWORK REDUCTION ACT STATEMENT

This RIS does not contain information collections and, therefore, is not subject to the requirements of the Paperwork Reduction Act of 1995 (44 U.S.C. 3501, et seq.).

CONTACT

This RIS requires no specific action or written response. Please direct any questions about this matter to the technical contact listed below.

/RA/

Michael Case, Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Technical Contact: Edmund Sullivan
(301) 415-2796
Ted.Sullivan@nrc.gov

Enclosure: Summary of Operating Experience Related to Primary Water Stress Corrosion Cracking in Dissimilar Metal Butt Welds

Note: The NRC's generic communications may be found on the NRC public Web site, http://www.nrc.gov, under Electronic Reading Room/Document Collections.

ADAMS ACCESSION NO.: ML081890403

OFFICE	NRR/ADES/DCI	Tech Editor	DCI/CPNB	NRR/ADES/DCI	NRR/ADES/DCI
NAME	TSullivan	See attd. email	TChan	JLubinski	MEvans
DATE	7/24/2008	7/11/2008	7/29/2008	8/1/2008	8/20/2008
OFFICE	NRR/ADRO/DORL	NRR/ DIRS/IOEB	NRR/DIRS/IR	RES/DE/CMB	NRO/DE/CIB1
NAME	JGitter	BWhite	TKobetz	TLupold	DTerao
DATE	8/20/2008	8/26/2008	8/22/2008	9/16/2008	8/21/2008
OFFICE	OE	OGC/CRA	OGC/NLO	NRR/PMDA	OIS
NAME	ASapountzis	MSmith	MBaty	LHill	GTrussell
DATE	9/25/2008	10/15/2008	10/14/2008	10/20/2008	10/26/2008
OFFICE	LA: PGCB	PGCB	BC: PGCB	D: DPR	
NAME	CHawes	AMarkley	MMurphy	MCase	
DATE	10/22/2008	10/21/2008	10/22/2008	10/22/2008	

Summary of Operating Experience Related to Primary Water Stress-Corrosion Cracking in Dissimilar Metal Butt Welds

V.C. Summer

In 2000, a large accumulation of boric acid deposits observed during a refueling outage at V.C. Summer led to the discovery of cracking in the “A” hot leg pipe-to-reactor-pressure-vessel (RPV) nozzle nickel-based alloy weld. The weld had a through-wall axial flaw with a small circumferential component and other small part-through-wall axial flaws. Based on destructive examinations of the piping and the weld material that was removed, the licensee determined that primary water stress-corrosion cracking (PWSCC) caused the flaws. The low-alloy (ferritic) steel and the stainless steel at the ends of the weld arrested the axial crack growth of the flaw. The circumferential flaw grew a short distance through the nickel-based alloy weld but, because of its location, was arrested when it ran into the low-alloy steel nozzle. Because the sizes of the axial and circumferential cracks were bounded, it would not have been possible for these cracks to lead to a piping rupture. The safety significance of this occurrence was limited to leakage of a small amount of primary coolant. If a circumferential flaw had initiated closer to the center of the weld, it could have caused a more safety-significant situation.

The licensee replaced the “A” hot leg dissimilar metal butt weld, and there were no ultrasonic testing (UT) indications in the remaining portion of the loop “A” hot leg. A UT examination of the remaining nozzle-to-pipe welds in all the loops found no flaws.

The licensee performed eddy current examinations (ET) of the vessel nozzle-to-pipe welds from the inside surface of the pipe. This technique is sensitive enough to find surface flaws but is not capable of determining their depth in thick-walled piping. Small axial and circumferential flaws were identified in the “B” hot leg pipe-to-RPV nozzle nickel-based alloy weld; a small circumferential flaw was identified in the “C” hot leg pipe-to-RPV nozzle nickel-based alloy weld; and a small circumferential flaw was found in both the “A” and “C” cold leg pipe-to-RPV nozzle nickel-based alloy welds.

The staff of the U.S. Nuclear Regulatory Commission (NRC) reviewed the evaluation submitted by the licensee to justify the continued operation of V.C. Summer without repairing existing ET indications in the “B” loop and “C” loop welds. The Westinghouse evaluation concluded that V.C. Summer could be operated for at least two fuel cycles without repairing existing ET indications. The staff performed an independent evaluation using a bounding PWSCC growth rate and concluded that V.C. Summer could be operated with ET indications in the “B” loop and “C” loop hot leg welds for one fuel cycle. The staff’s evaluation, issued on February 20, 2001, is available at Agencywide Documents Access and Management System (ADAMS) Accession No. ML010510338. The UT and ET examinations performed by the licensee in subsequent refueling outages found no evidence of crack growth.

Ringhals, Unit 4

In 2000, at Ringhals, Unit 4, in Sweden, UT found a hot leg pipe-to-RPV nozzle nickel-based alloy weld with four axial part-through-wall flaws. Portions of the welds were physically removed and destructively examined. The examination results showed that PWSCC caused the cracking. The material removed was replaced with Alloy 52 weld material.

Tsuruga, Unit 2

During an annual inspection begun in September 2003 at Tsuruga, Unit 2, in Japan, a visual inspection of the pressurizer safety and relief nozzles, with insulation removed, found boric acid deposits on the pressurizer relief nozzle.

A subsequent UT examination performed on the pressurizer safety and relief nozzles revealed linear indications in the nozzle-to-safe-end weld metal on the relief nozzle and on safety nozzle "A," one of the three safety nozzles.

All of the flaws found were axially oriented and located in the welds; that is, the flaws did not extend into the base metal. The samples removed for destructive examinations contained the entire weld and a portion of the base metal on each side of the weld. Radiography performed on the severed pieces confirmed the linear flaws. Metallurgical failure analysis performed on these samples showed that the cracks initiated from the inside surface and were axially oriented. The conclusion of the metallurgical analysis was that the nozzle failures were caused by PWSCC in the nozzle weld. Because of the axial orientation of the flaws, the adjacent materials arrested the flaw growth. The safety significance of this occurrence was limited to leakage of a small amount of primary coolant. NRC Information Notice 2004-11, "Cracking in Pressurizer Safety and Relief Nozzles and in Surge Line Nozzles," dated May 6, 2004, contains additional information on this event.

Three Mile Island, Unit 1

In 2003, during a scheduled inservice inspection at Three Mile Island, Unit 1, UT found that the pressurizer surge line-to-hot-leg nozzle weld had an axial part-through-wall indication in the dissimilar metal (DM) butt weld. The licensee attributed the indication to PWSCC and characterized it as spanning the width of the weld on the inside surface, extending about 50 percent through-wall at the deepest location of the flaw. The above-mentioned NRC Information Notice 2004-11 also contains additional information on this event.

Calvert Cliffs, Unit 1

In 2006, during the spring outage season at Calvert Cliffs, Unit 1, a 25 percent through-wall circumferential indication was found in a surge line-to-hot-leg weld, a 20 percent through-wall circumferential indication was located in a hot leg drainline weld, and a shallow axial part-through-wall flaw was found in a pressurizer relief valve nozzle weld. The licensee addressed the potential for further growth of these flaws by PWSCC by application of the Mechanical Stress Improvement Process (MSIP®) to these welds.

Davis-Besse

During the 2006 spring outage season at Davis-Besse, an axial indication of undeterminable depth was found in a cold leg drainline. Geometric interference prevented the UT from measuring the depth of the flaw. The licensee assumed the flaw was the result of PWSCC. The licensee subsequently completed a full structural weld overlay repair. Due to the nature of the phenomenon, PWSCC at cold leg temperatures has a lower probability of initiating than at hot leg temperatures.

Wolf Creek

On October 13, 2006, the Wolf Creek Nuclear Operating Corporation performed pre-weld overlay inspections using UT techniques on the pressurizer surge, spray, relief, and safety nozzle-to-safe-end DM and safe-end-to-pipe stainless steel butt welds. The inspection identified five circumferential indications in the surge, relief, and safety nozzle-to-safe-end DM butt welds that the licensee attributed to PWSCC and that were significantly larger and more extensive than previously seen in the industry. The licensee subsequently completed full structural weld overlay repairs.

Farley, Unit 2

The licensee performed manual UT of the pressurizer DM butt welds during a refueling outage in April 2007. Examinations scanning the surge nozzle for axially oriented flaws detected an unacceptable axial indication. The licensee performed examinations for circumferentially oriented indications but did not complete the manual data analysis, deciding rather to perform phased array UT, which is better suited to the analysis of complex geometries. Subsequently, the licensee performed phased array UT examinations on the pressurizer surge nozzle butt weld. The scan for axially oriented flaws revealed an axial indication in the same area as the manual call, characterized with a depth of 7.9 millimeters (0.31 inches), which is approximately 20 percent through-wall. The scan for circumferentially oriented flaws detected an unacceptable circumferential indication, approximately 15 centimeters (6 inches) from the axial indication. It identified the circumferential indication as approximately 7.5 centimeters (3 inches) long (outside diameter dimension), with a maximum depth of 12.7 millimeters (0.5 inch), which is approximately 33 percent through-wall, and located the indication at or near the butter-to-DM weld interface at or near the inside diameter surface. The licensee then performed a confirmatory manual UT that revealed the circumferential indication; however, the complex geometry and microstructure factors made resolution of circumferentially oriented indications more complicated to resolve with manual UT. Because the indications were in PWSCC-susceptible material, the licensee based its corrective action on the assumption that the indications were the result of PWSCC. Examinations detected no indications in the other pressurizer DM butt welds.

Davis-Besse

On January 4, 2008, while in cold shutdown with the reactor head in place and fuel in the reactor vessel, the licensee began to install a weld overlay on the decay heat removal (DHR) drop line from the reactor coolant system (RCS). The RCS was in a drained condition. During the first weld pass on the drop line weld located in the containment, the welding operator noticed water seeping from the weld. Visual inspection revealed a small leak. Surface examinations before welding showed no abnormal conditions or leakage. The licensee subsequently determined that the leak was from an axial through wall flaw that the licensee attributed to PWSCC. The licensee subsequently completed a full structural weld overlay repair.

Crystal River, Unit 3

During a March 2008 outage to replace a degrading reactor coolant pump seal at Crystal River, Unit 3, the licensee identified two circumferential indications in a weld that joins the DHR system drop line to an RCS hot leg. Further evaluation of the DHR hot leg nozzle connection determined that the two circumferential indications were actually one indication about 38 centimeters (15 inches) long. The UT measured the maximum through-wall depth of the flaw at

65 percent in one localized area. The licensee's fracture mechanics evaluation of the circumferential indication on the DHR drop line determined that the requirements for pipe in ASME Code, Section XI, were maintained. The licensee subsequently completed a full structural weld overlay repair.