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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Calvert Cliffs Nuclear Power Plant, Unit 1
Facility Operating License No. DPR-53
NRC Docket No. 50-317

Subject: Report Concerning Dissimilar Metal Weld Flaw in Pressurizer Safety Relief Nozzle-to-Safe-End Weld

Examinations performed during the current refueling outage at Calvert Cliffs Nuclear Power Plant, Unit 1 have identified a change from previous examinations in an axial flaw in a pressurizer safety relief nozzle-to-safe-end dissimilar metal weld that was mitigated by the Mechanical Stress Improvement Process (MSIP®) in 2006. These examinations were performed to meet ASME Code Case N-770-1 and 10CFR50.55a(g)(6)(ii)(F) requirements.

10CFR50.55a(g)(6)(ii)(F)(6) states the following: "For any mitigated weld whose volumetric examination detects growth of existing flaws in the required examination volume that exceed the previous IWB–3600 flaw evaluations or new flaws, a report summarizing the evaluation, along with inputs, methodologies, assumptions, and causes of the new flaw or flaw growth is to be provided to the NRC prior to the weld being placed in service other than modes 5 or 6."

This report satisfies this requirement. Please note that the conclusions presented herein are preliminary as the station will be performing a root cause evaluation for this issue.

The station is examining all twenty-seven (27) dissimilar metal (DM) butt welds within the scope of ASME Code Case N-770-1 during the current refueling outage using examination techniques demonstrated in accordance with ASME Section XI, Appendix VIII, Performance Demonstration for Ultrasonic Examination Systems. The affected weld will be repaired by full structural weld overlay during the current outage.

There are no regulatory commitments in this letter. If you have any questions concerning this letter, please contact Tom Loomis at (610) 765-5510.

Respectfully,

David T. Gudger
Manager - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Attachment: Report Concerning Dissimilar Metal Weld Flaw in Pressurizer Safety Relief Nozzle-to-Safe-End Weld

cc: Regional Administrator, Region I, USNRC
USNRC Senior Resident Inspector, CCNPP
USNRC Project Manager [CCNPP]
S. T. Gray, State of Maryland

Purpose of Evaluation

During examinations performed to meet ASME Code Case N-770-1 and 10CFR50.55a(g)(6)(ii)(F) requirements, a change was observed from previous examinations in an axial flaw in a pressurizer safety relief nozzle-to-safe-end dissimilar metal butt weld that was mitigated by the Mechanical Stress Improvement Process (MSIP®) in 2006.

10CFR50.55a(g)(6)(ii)(F)(6) states: "For any mitigated weld whose volumetric examination detects growth of existing flaws in the required examination volume that exceed the previous IWB–3600 flaw evaluations or new flaws, a report summarizing the evaluation, along with inputs, methodologies, assumptions, and causes of the new flaw or flaw growth is to be provided to the NRC prior to the weld being placed in service other than modes 5 or 6."

Evaluation Summary

ISI Weld 4-SR-1006-1, (pressurizer safety relief nozzle-to-safe-end weld), also designated as line 4" CC10-1006 (W1) and 18-405A, was examined as required by the Inservice Inspection (ISI) Program during refueling outage CC1R23 per ASME Code Case N-770-1, Inspection Item E, and 10CFR50.55a(g)(6)(ii)(F). The examination was a fully encoded Phased Array Ultrasonic examination (PAUT) and was qualified to ASME Code Section XI, Mandatory Appendix VIII, Performance Demonstration for Ultrasonic Examination Systems, to detect and, length and depth size circumferential and axial flaws within the specified examination volume from the outside surface. The examination met all additional industry NEI 03-08 guidance for examination of dissimilar metal piping welds susceptible to Primary Water Stress Corrosion Cracking (PWSCC). Full examination coverage was achieved to meet the requirements of ASME Code Case N-770-1 as conditioned by 10CFR50.55a and as indicated in Table 1 below.

Table 1
Required Volumetric Examination Coverage Achieved – 2016 Exams

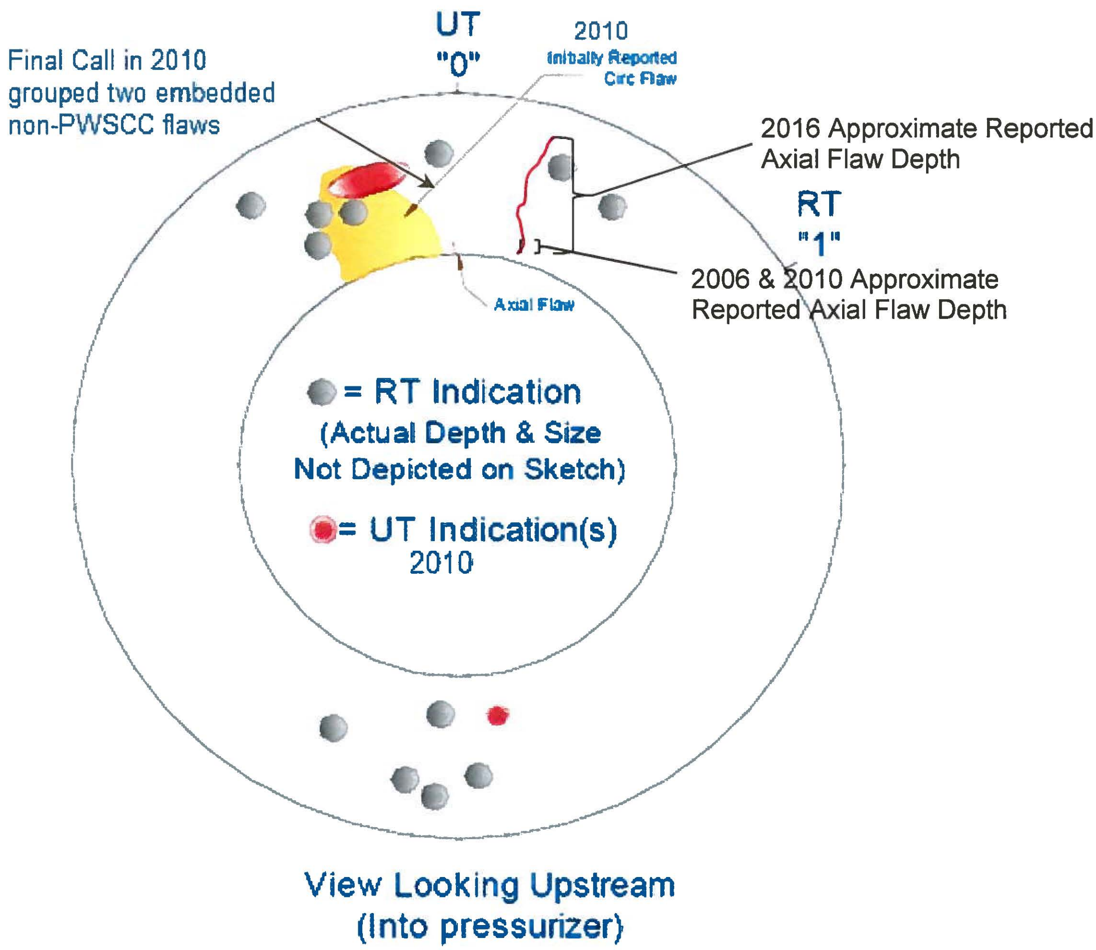
Applicable Material	Circumferential Flaw Coverage	Axial Flaw Coverage	Combined Coverage Assessment
PWSCC Susceptible (Inconel Alloy 82/182)	100%	100%	100%
SA-182 F-316 SS Safe-end	100%	100%	100%
Carbon Steel SS Clad Nozzle (SA-508, CL 2)	100%	100%	100%

The evaluation of the recorded Ultrasonic Testing (UT) data identified one axially oriented flaw, which is contained within the weld material, exhibiting characteristics indicative of PWSCC. The measured depth of the flaw was 81.6% through-wall including clad thickness.

In addition, eight indications characterized as embedded fabrication flaws were detected during the data evaluation. These are similar flaws to those reported during the last examination in 2010.

Figure 1 is a graphic representation of the indications in this weld as reported in 2010 along with an approximation of the reported 2016 axial flaw characteristics. A second ultrasonic examination was performed by another NDE vendor using a manual encoded phased array UT examination system and it confirmed the automated examination results.

Figure 1
Annotated Figure 6-1 from 2010 EPRI Report Showing 2016 Flaw Approximate Size and Location



This weld was mitigated by a MSIP® application in 2006. The UT examination prior to the application of MSIP® identified an axial flaw in the same location as the 2016 flaw but was reported to be 8% through-wall. The UT examination immediately following the MSIP®

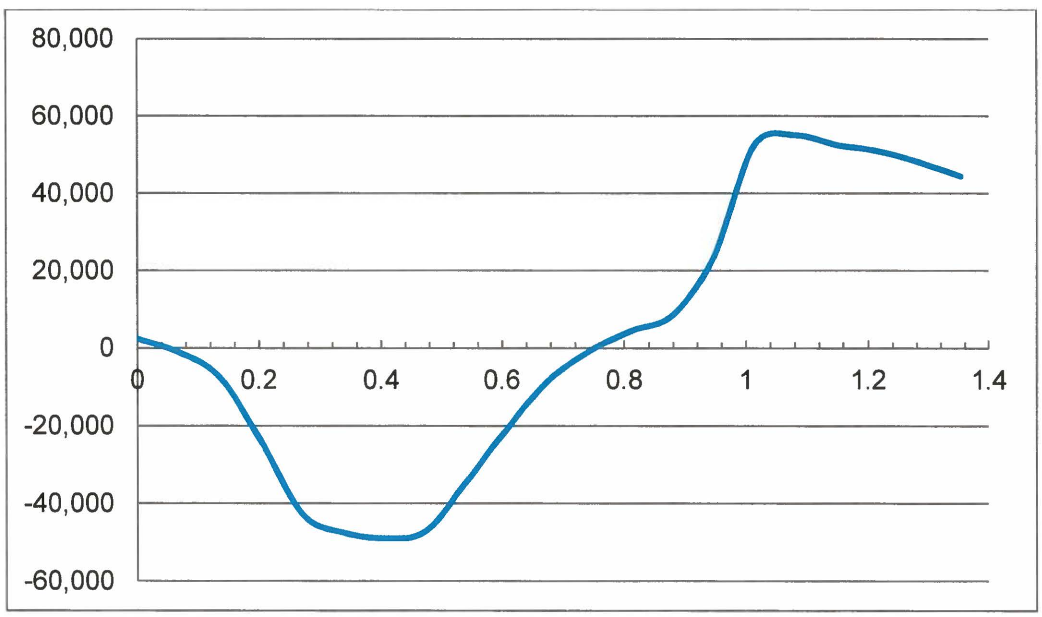
application confirmed the flaw was still present and at the same 8% through-wall depth. The Inservice examinations in 2010 reported essentially no change in through-wall depth.

Inputs

Following the examination in 2006 and application of MSIP®, a flaw evaluation of the axial flaw was performed and submitted to the NRC. A non-linear finite element analysis using the ANSYS Program was performed for the application of MSIP®. This analysis confirmed that an axial PWSCC flaw of 8% depth would be contained within the compressive hoop stress zone of the post-MSIP® stress profile at operating conditions. The post-MSIP® stress profile is compressive from the ID of the pipe wall to an extent of approximately 50% of the through-wall depth. As shown in Figure 2, the hoop stress then becomes tensile out to the OD, reaching tensile stress values of about 55 ksi at 80% through-wall and reducing to about 44 ksi at the OD of the pipe.

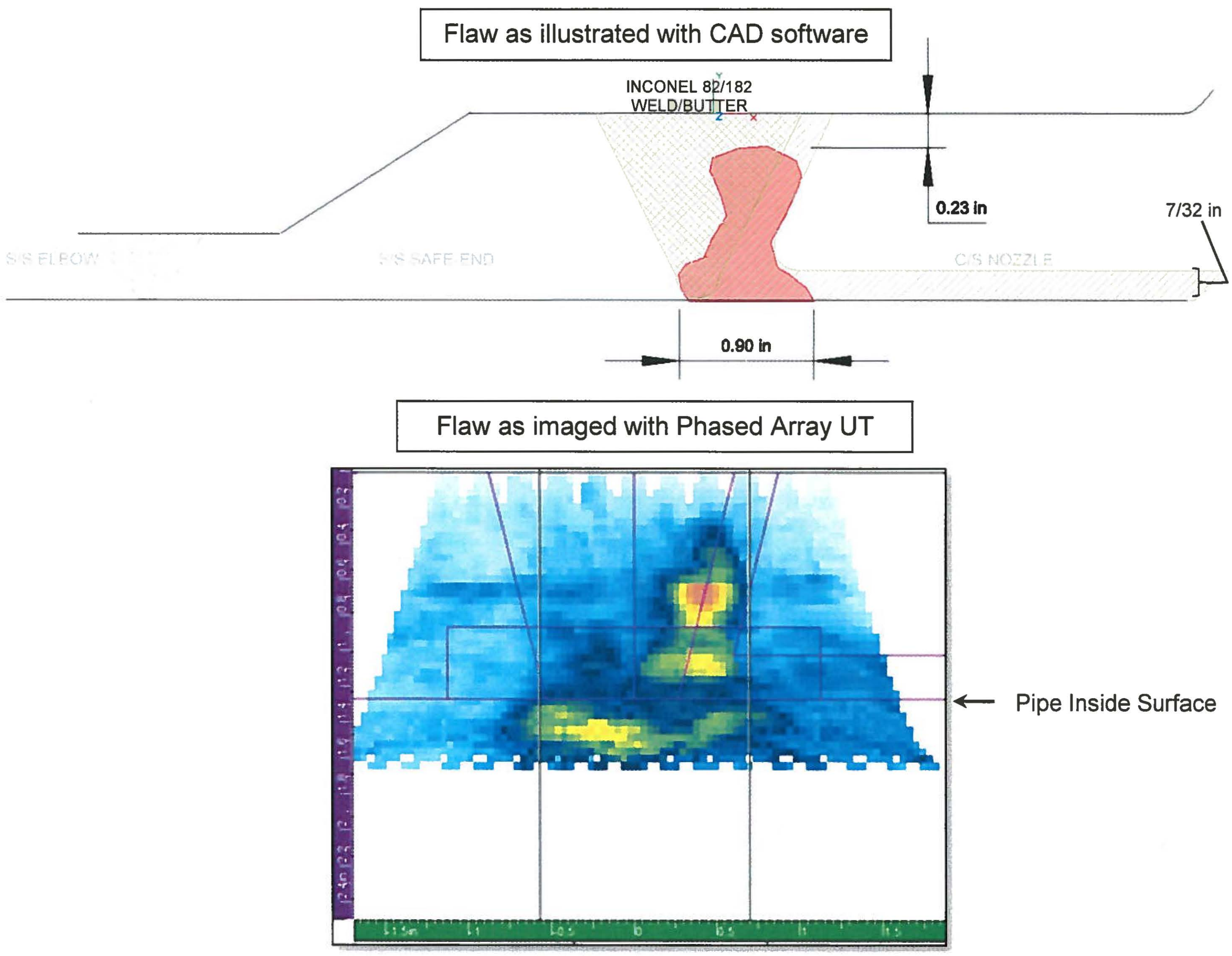
Figure 2
2006 Post MSIP®+Operating Stress Calculated Hoop Stress Through Wall at Nominal Flaw Position (Path along butter/weld interface)

PATH DIST (inch)	HOOP STRESS (psi)
0.000	2,278
0.068	-1,124
0.135	-7,546
0.203	-24,114
0.271	-42,931
0.338	-47,583
0.406	-49,002
0.473	-47,203
0.541	-34,280
0.609	-20,561
0.676	-8,410
0.744	-815
0.812	4,423
0.879	8,477
0.947	23,657
1.014	52,552
1.082	54,937
1.150	52,411
1.217	50,809
1.285	47,982
1.353	44,350



The results of the phased array encoded NDE examination performed in 2016 show that the axial flaw is widest at the ID (lower ~1/3rd of the flaw), narrower in the center ~1/3rd of the flaw, and becomes wider in the top ~1/3rd of the flaw (see Figure 3 below). The axial flaw is narrower and consequently produces a weaker reflection in the middle through-wall range of the flaw where the compressive stress is the highest.

Figure 3
2016 Axial Flaw Characteristics



Methodologies

The fabrication and examination history of weld 4-SR-1006-1 was reviewed to confirm fabrication repairs, construction examination results, and inservice examination results. The inservice examinations from 2006 (pre- and post-MSIP®), 2010, and 2016 were reviewed to confirm if the flaw observed in 2016 was present and not accurately sized in the previous years. See Table 2 for a summary of exams performed. The post-MSIP® stress profiles were reviewed both in 2006 and 2010 to confirm the extent of the compressive stress region and effectiveness of the MSIP® application. Physical measurements were also performed in 2010 and again in 2016 to confirm the MSIP® parameters were met.

Table 2
4-SR-1006-1 DM Weld Inspection History

Year	Radiography	Visual	Liquid Penetrant	Manual UT	Auto UT	Comments
1972	Yes		Yes			ASME III; 1 PT surface repair
1973		Yes	Yes	Yes		ASME XI Pre-Service Exam
1980			Yes	Yes		ASME XI Inservice Exam
2004		Yes				MRP-139
2006		Yes		Yes	Yes*	MRP-139, conventional manual non-encoded & auto encoded pre- and post-MSIP
2010		Yes		Yes	Yes	MRP-139, manual non-encoded PAUT, conventional auto encoded; surface preparation
2016		Yes		Yes	Yes	Code Case 770-1, Automated Encoded PAUT, confirmed with Manual Encoded PAUT

* Circumferential scans only. Used for sizing of axial flaw.

Assumptions

No analytical assumptions are being made as part of this report.

Causes of New Flaw/Flaw Growth

Please note that the conclusions presented herein are preliminary as the station will be performing a root cause evaluation for this issue.

Three potential causes of the change in reported axial flaw through-wall extent from previous examinations were investigated:

1) The MSIP® application was ineffective allowing the existing axial flaw to grow,
2) A new flaw developed in the weld, or
3) Prior NDE did not detect or accurately size a pre-existing flaw larger than 30% through-wall prior to MSIP® (either ~80% through-wall or some value between ~30% and 80%)

The first potential cause was ruled out due to extensive reviews of the MSIP® implementation documentation and by obtaining independent field measurements to confirm the required parameters were met. The second potential cause was ruled out since the MSIP® application was found to have been performed correctly. It is not plausible that a new ID flaw could initiate and grow through the compressive stress region to the currently observed flaw depth. Also, this axial flaw is in the same location as the previously identified axial flaw just with a larger through-wall extent, so it would not be considered a new flaw.

The third potential cause is considered to be the most likely cause for the change in the axial flaw's reported through-wall extent from 2010 to 2016. A review was performed of the pre-MSIP and post-MSIP UT data collected in 2006, the UT data collected in 2010, and the current 2016 UT data.

Due to limitations with the data collection during the 2006 pre-MSIP® examination, the upper portion of the flaw (which was outside the MSIP® compressive zone) was not detected. After MSIP® was applied, the data quality was improved and some indications above the ID connected flaw were identifiable that were not in the pre-MSIP® data, but there was no clear connection between the two, thus they were treated as two unrelated indications. The stress profile indicates that the material between the inside surface connected flaw and the indication above is in compression, which could potentially reduce or eliminate the ultrasonic responses. This would produce the appearance that they are not connected. If this is true, the flaw would have been larger than originally thought and the flaw tip would have been outside of the compressive stress zone.

In 2010 a PDI-qualified manual non-encoded phased array procedure was used to depth size the reported axial flaw. The vendor reported that the flaw had remained unchanged from what was previously recorded during the previous encoded examinations. The vendor did report the presence of an indication, which was attributed to the acoustic interface of a repair region which is believed to be near the current reported axial flaw upper extent, however, the reviewers have been unable to correlate the location of this acoustic interface indication in the examination report. It is possible that these responses may have actually been from the features of a deeper flaw.

The 2016 examination PDI qualified technique included a larger aperture search unit, additional angles, lower frequency, beam skewing, and enhanced focusing. This data imaged the previously reported axial flaw with a deeper extent. After carefully reviewing the data it was determined that this optimized technique provided sufficient data to detect the connection of the two flaws that were previously seen in the other examinations. Adjacent fabrication flaws and an OD repair area also challenged the depth sizing in the previous examinations.