Florida
Power
CORPORATION
Crystal River Unit 3
Docket No. 50-302

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3F0896-16

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555-0001

Subject: Inservice Inspection (ISI) Report, Pressurizer Surge Nozzle Flaw

Reference: A. FPC to NRC Letter, 3F0994-02, dated September 2, 1994
B. FPC to NRC Letter, 3F1294-12, dated December 16, 1994
C. NRC to FPC Letter, 3N1094-15, dated October 19, 1994

Dear Sir:

The purpose of this letter is to report the results of the Refuel 10 augmented inspection of the pressurizer nozzle to lower head weld indication detected during Refuel 9.

Background:

A subsurface flaw exceeding ASME Code acceptance criteria was detected in the weld connecting the pressurizer nozzle to the lower head during Refuel 9 inservice inspections conducted in the Spring of 1994. In accordance with ASME Section XI, B&W Nuclear Technologies (BWNT) (now Framatome Technologies, Inc. (FTI)) prepared an analysis for Florida Power Corporation (FPC) to determine the acceptability of allowing the weld to remain in service. The initial BWNT analysis, submitted in Reference A, concluded that the flaw indication was acceptable and would not reach critical length during the next 1.6 effective full power years (EFPY). This analysis demonstrated the weld to be acceptable for service until approximately December 1995 allowing restart. The second BWNT analysis, submitted in Reference B, demonstrated the acceptability of the detected flaw until the end of the 40-year plant life. In Reference B, FPC committed to augmented inspections in accordance with Subsection IWB-2420.

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Although augmented inspection of the pressurizer surge nozzle to lower head weld was not required by ASME Section XI Subsection IWB-2420 until Refuel 11 in the Spring of 1998, an inspection was done during Refuel 10 in the Spring of 1996. Two inspections were performed using the same make and model transducer as used during Refuel 9 and a focused transducer developed specifically for assessing this indication. Using the focused transducer, this indication was re-sized below the ASME Section XI acceptance criteria of 2.7% a/t where "a" is a measure of the dimension of the flaw in the through wall direction and "t" is a measure of the pressure boundary thickness. Also, it was determined that the indication is a slag inclusion, not a linear defect as had been previously reported. Therefore, additional increased frequency inspections above that normally required in each ten year inservice inspection interval are no longer required.

Discussion:

A preservice inspection was performed on the pressurizer surge nozzle to lower head weld in 1975. Later, an inservice inspection was performed on this weld during the first inservice inspection interval in 1983. Neither inspection identified any recordable indications. A geometric reflector from the inside diameter due to the nozzle inside radius configuration was detected during the first inservice inspection. However, this geometric reflector did not correspond to the same location as the indication identified during Refuel 9 in the Spring of 1994.

An inservice inspection of this weld was performed for the second inservice inspection interval during Refuel 9. Two indications were identified. The first indication was identified to be a geometric reflector from the inside diameter bore that was determined to be acceptable. The second indication was identified to be a subsurface reflector from the weld. From a BWNT Level III evaluation of this second indication, it was determined to be 6.5% a/t per Table IWB-3512-1. The allowable a/t % for this indication was 3.3%. Therefore, this flaw was determined to be unacceptable without additional Section XI evaluation in accordance with IWB-3612.

An ASME Section XI analysis was performed to determine flaw acceptability. The initial analysis concluded that the flaw was acceptable and would not reach critical length during the next 1.6 EFPY. This analysis was submitted to the NRC with the 90 day ISI summary report. Subsequently, a revised analysis, which corrected for the lack of stress concentration factors in the initial analysis, was performed that concluded the flaw was acceptable to the end of the forty year licensed lifetime. This revised analysis was submitted to the NRC. A second revision to this analysis was performed in February 1996 to address seismic loads that were inadvertently omitted. This revision is currently under FPC review and has not been submitted for NRC staff review.

A review of the Refuel 9 volumetric examination report by FPC Nuclear Engineering staff identified several inconsistencies that warranted further investigation to supplement these ASME Section XI analyses. The size of the indication was significant, yet not documented in either the preservice or first inservice inspections. In an attempt to determine why the indication was not recorded in previous examinations, FPC and BWNT personnel reviewed inspection records comparing these examination techniques to those used during Refuel 9 when the indication was first detected. Also, possible degradation mechanisms that could yield a service induced flaw of this size were considered during the root cause investigation.

In April of 1995, FPC personnel traveled to Canton, Ohio to review the fabrication records retrieved from BWNT's (Framatome's) storage facility in Boyers, Pennsylvania. Available records were limited to surface examination results (MT and PT), radiographs (repair and final), and an ultrasonic (UT) examination on the final weld.

These radiographs were transported to Lynchburg, Virginia for more detailed review. Several repairs to this weld were documented indicating a high probability that a small manufacturing defect could have remained although no flaw indications were documented in the final preservice inspection records. However, the Construction Code of record allowed some elongated flaws to be considered acceptable and to remain in service. Additionally, the radiographs reviewed were over twenty years old and the film type and techniques used were not conducive to finding small tight flaws.

Also, comparison of the techniques used to examine the weld identified changes in equipment and inspection procedures that could explain why the indication was first detected during Refuel 9. First, the transducer was upgraded. During Refuel 9, a transducer shoe with a smaller "foot print" and a larger "beam spread angle" was used. Second, using a transducer shoe with a smaller foot print allowed it to be moved closer to the "crotch" of the weld before lifting off the surface breaking contact with the component. This allowed more sound beam energy to penetrate the area prior to shoe liftoff than had been possible in previous examinations. Additionally, this transducer had twice the beam spread angle with the beam being skewed toward the entry surface of the material. This permitted even more sound beam energy to enter the area where the indication was located.

Therefore, these two changes in transducer properties allowed more sound beam energy to interact with the flaw, such that the reflected sound energy was above the minimum threshold to detect a recordable indication during the Refuel 9 examination. However, the previous examinations were performed with a transducer shoe of a size and beam spread angle that did not allow sufficient sound beam energy to interact with the flaw to the extent necessary to produce a recordable indication.

Both reviews of manufacturing records and inspection techniques support the assumption that the indication could have been present at the time of manufacturing, but not detected until the Refuel 9 examination. The remaining consideration that must be addressed in the root cause investigation is whether any credible damage mechanisms exists which could produce a service induced flaw of this type and size.

Refuel 9 ultrasonic examination sited the indication approximately two inches below the outside surface of the weld, following the plane of the weld prep on the lower head. This places the indication approximately in the middle of the nozzle wall. Fatigue or stress-induced cracks usually initiate in high stress areas, which for piping and pressure vessels is the inside or outside wall, not a mid-plane position. The mid-plane area of a wall cross section is typically a zero or extremely low stress location.

For a flaw to appear in this area, one of two mechanisms must be at work. The first mechanism that could create a mid-plane flaw is high temperature creep typically occurring at temperatures in excess of 900-1000°F. However, temperatures in this range are not credible in this weld area since pressurizer temperature is less than 700°F during normal operation. The second mechanism

that could create a mid-plane flaw after many years of service requires two distinct problems to occur simultaneously. First, an original construction defect smaller than minimum detectable must have existed. Second, the combination of inservice fatigue and piping loads on this nozzle must have caused the indication to propagate to a size that was above the minimum acceptance criteria of ASME Section XI.

However, the BWNT analysis performed on the indication used design loads and fatigue cycles to determine that the indication would not propagate over the remaining life of the plant. From the results of this analysis, it must be concluded that the inservice loading would not have caused the flaw to grow to a detectable size. Therefore, the second mechanism for creating a mid-plane flaw would not appear to be credible unless inservice loads are greater than assumed in the design configuration of the Nuclear Steam Supply System (NSSS). Given the scrutiny that has surrounded the pressurizer surge line due to temperature stratification problems, the probability that the design loading conditions are in error is extremely remote.

Based on a review of manufacturing and inspection records for the indication, comparison of inspection techniques, and consideration of the low probability that a credible degradation mechanism produced this mid-plane indication, it is concluded that the indication is most likely the result of a small manufacturing defect and is not a service induced flaw.

Due to the divergent nature of the sound beam produced by transducers typically used for ASME Section XI inspections, ASME Section XI sizing techniques yield conservatively high estimates for flaw sizes. Therefore, to ensure that the pressurizer surge nozzle to head weld indication could be sized as accurately as possible, a Focused Transducer System (FTS) was developed with specialized pulsers, receivers, and shoes to produce a convergent sound beam with a fixed focal distance. Focused ultrasonic systems have been developed and used successfully in a number of different applications where more realistic estimates of flaw size are desired. Focused transducers are a proven technology, with each application unique in its combination of geometry, flaw depths, and material.

FPC personnel worked with Framatome to develop the Focused Transducer System used specifically for the Spring 1996 Refuel 10 re-inspection of the weld indication identified during Refuel 9. The pressurizer surge nozzle to head weld removed by the B&W Owners Group from the Midland plant was used for mockup of the indication and to qualify the system for use at CR-3.

The first ASME Section XI examination performed during Refuel 10 intentionally duplicated the Refuel 9 examination that recorded the indication. Both the Refuel 9 and Refuel 10 examinations used a 2.25 MHZ 1/2" x 1" standard 60 degree transducer and the same inspection procedure. There were several reasons for taking this approach:

- FPC desired to assess the accuracy of the Refuel 9 examination. The Refuel 9 examination, while performed by a BWNT qualified Level II examiner to appropriate procedures, was not repeated by an independent inspector to confirm the validity of the examination results. Root cause analysis did not identify any credible damage mechanism that could have produced the inservice mid-plane flaw as reported. Manufacturing records also indicated considerable rework on

the weld during initial fabrication that could have resulted in the presence of a flaw at the time of initial service. Therefore, there was basis for FPC to question the validity of Refuel 9 reported examination results.

- FPC also desired to repeat the standard ASME Section XI examination that identified the flaw during Refuel 9 so that should the examination results be confirmed as valid, FPC would have comparable inspections to allow for assessment of growth during Cycle 10.

Unlike the Refuel 9 examination, the Refuel 10 examination was witnessed and reviewed in the field by an independent certified Level III examiner contracted with an independent consultant, Nuclear Inspection Consultants (NIC). This gave FPC a higher confidence level in the accuracy of the Refuel 10 inspection. The Refuel 10 examination confirmed the presence of the indication, but resulted in a decrease in the estimated flaw depth, which is a critical characteristic used to determine the acceptability of an indication. The re-examination confirmed the presence of the flaw, but determined it to be smaller than the size reported by the Refuel 9 examination.

The Refuel 9 examination estimated the depth of the flaw to be 0.62", while the Refuel 10 examination estimated the depth of the flaw to be 0.4". Since the acceptance criterion changes as the estimated flaw size changes, the acceptance criterion for Refuel 10 re-examination using the standard 60 degree transducer was 2.7% a/t. The results of the Refuel 9 examination revealed a 6.5% a/t indication compared to an acceptable 3.3% a/t. The Refuel 10 examination revealed a 4.15% a/t indication compared to an acceptable 2.7% a/t. Therefore, the conclusion of the Refuel 10 re-examination using the standard technique was that the indication was confirmed to exist and was larger than the ASME Code acceptance criterion. However, it is smaller than originally reported during Refuel 9. FPC has more confidence in the Refuel 10 sizing than Refuel 9 because of the high visibility of the examination, which produced good attention to detail by the examiner, and the independent oversight of the Level III analyst. Also, FPC can assume that no growth of the indication occurred during Cycle 10.

The second Refuel 10 re-inspection of the indication was performed using a FTS custom made to have a focal distance that matched the sound path from the surface to the flaw, as determined by the examination that originally sized the flaw. Ultrasonic Examination procedures used to size indications set up the examination such that size can be determined from the amount of movement of the transducer from the time the reflected signal from the indication is first picked up, to a procedurally defined point where the reflected signal's amplitude is reduced to a prescribed level. The through-wall projection or depth is then calculated using trigonometry and the length is simply measured.

Since the time at which the reflected signal is first picked up and the time at which the amplitude is reduced is dependent upon the spot size of the sound beam produced by the transducer, the design of the transducer lenses significantly influences the accuracy of sizing. Larger spot sizes or beam spread produced from standard transducers yield conservatively large size estimates and are fine as a general sizing technique. Smaller spot sizes offer much more resolution of the scund beam and allow a more accurate measurement of the actual indication size. For these reasons, FPC believes the FTS technique to be more accurate and reliable than the standard technique used in Refuel 9 and for the first

inspection in Refuel 10. This FTS inspection sized the indication at 1.9% a/t, which is below the ASME Section XI acceptance criteria of 2.7% a/t. From the focused array inspection, it was also determined that the indication is actually a slag inclusion and not a linear defect as had been previously reported. This determination is consistent with the root cause investigation performed prior to Refuel 10 which determined that the indication was likely a manufacturing defect.

Conclusions:

Based on a root cause analysis and results of the augmented inspection, the following conclusions are made:

- The indication identified during Refuel 9 is a defect that has been present in the weld since original manufacture.

- The "no growth" assumption in the BWNT fracture mechanics analysis has been verified, since the Refuel 10 augmented inspection using the same transducer and technique as Refuel 9 resulted in an indication smaller than previously recorded.

- The Refuel 9 and 10 examination results were oversized because of the type of transducer used, the transducer skewed beam spread angle, and the examination technique. As determined by the focused transducer examination, the size of the manufacturing defect is less than the ASME Section XI Code allowable. Thus, it is concluded that the indication was never outside ASME Section XI allowable limits.

- Since the FTI fracture mechanics analysis was based on a larger flaw size than actually exists, it is bounding and provides additional confirmation beyond the ASME Code acceptance criteria that the weld is acceptable to remain in service.

As a result, the pressurizer surge nozzle to head weld will be removed from increased frequency monitoring and placed back on its normal schedule for inservice inspection as required by Inspection Program B of ASME Section XI. The specific schedule for re-inspection will be submitted with the CR-3 Inservice Inspection Program Update. Additionally, regulatory review of the fracture mechanics analysis under TAC No. M90489, as specified in Reference C, is no longer required since the actual indication size is less than ASME Section XI allowable.

Sincerely,

P. M. Beard, Jr.
Senior Vice President
Nuclear Operations

PMB/JLO

xc: Regional Administrator, RII
Senior Resident Inspector
NRR Project Manager