UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE INSERVICE INSPECTION (ISI) PROGRAM

ARKANSAS POWER AND LIGHT COMPANY

ARKANSAS NUCLEAR ONE UNIT 1

DOCKET NO. 50-313

1.0 INTRODUCTION

Paragraph 10 CFR 50.55a(g)(4) states that throughout the service life of a pressurized water-cooled nuclear power facility, components which are classified as ASME Code Class 1, 2 and 3 shall meet the requirements set forth in certain referenced editions and addenda of ASME Section XI to the extent practical within the limitations of design, geometry and materials of construction of the components. Some plants were designed in conformance to early editions of this Code, consequently certain requirements of later editions and addenda of Section XI are impractical to perform. Pursuant to 10 CFR 50.55a(g)(5) the licensee, Arkansas Power and Light Company, identified in letters dated August 11 and October 27, 1988, certain ASME Code requirements that are not practical for his facility and provided supporting information. After evaluation of the licensee's determination, pursuant to 10 CFR 50.55a(g)(6)(i), the Commission may grant relief and impose alternative requirements as it determines are authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest giving the due consideration to the burden upon the licensee that could result if the requirements were imposed.

2.0 BACKGROUND

2.1 Examinations Performed During 1986

During the 1986 refueling outage the licensee conducted an inservice inspection of the "A" reactor coolant pump (RCP) casing weld using conventional radiography (RT). This examination was performed in conjunction with the complete removal of the RCP rotating assembly for other reasons. The RT indicated the presence of a flaw which exceeded the acceptance standards of ASME Section XI IWB-3000 for an allowable flaw size. The licensee described the indication as a series of slag inclusions located in the vertical weld which connects the upper and lower scroll welds of the pump casing. The weld is approximately 2.6 inches thick in this region. The licensee performed supplemental ultrasonic testing (UT) in the region of the flaw indication.

The licensee reviewed the original radiographs taken at the time of fabrication to determine whether the flaw existed prior to service and found five small inclusions that are part of the current flaw indication. However, these five inclusions were acceptable per the ASME Code during the preservice examinations. The original construction radiographs for the remaining three pumps were also

reviewed for preservice flaw indications or weak areas in film density. These areas were computer-enhanced in an attempt to identify any unacceptable flaws that were not identified previously.

From this review, "C" and "D" pump casings were determined to have no unacceptable preservice flaw indications. However, the computer enhancement of "B" pump revealed an unacceptable flaw indication, approximately 1.5" in length, in the same general weld area as the "A" pump. The original construction radiograph shows a flaw of 0.625" in length which was acceptable per ASME Code requirements at that time. The wall thickness in the area of the flaw indication is 3.1". Ultrasonic testing (UT) techniques were used in an attempt to better characterize the flaw. Due to the material of the pump casing (coarse grained statically cast stainless steel) and the small size of the indication, manual UT was not able to reliably dimension the flaw indication. From these examinations the flaw size was conservatively determined to be no larger than 1.5" long by 1.5" deep from the inside surface. However, for the fracture mechanics evaluation, the licensee assumed a size of 4.65" by 2.325". The staff's evaluation of the 1986 examinations is described in a letter dated December 11, 1986.

2.2 Ultrasonic Testing Development Program

The licensee was requested to use state-of-the-art external volumetric methods during the next inservice inspection. To accomplish this development program, the licensee did the following:

A) An unused (spare) reactor coolant pump casing, identical to the pumps in Unit One and Unit Two, was purchased.

B) Calibration blocks were cut out of two areas of the pump casing (torus weld and discharge nozzle) and sent to Southwest Research Institute for the purpose of implanting a slag inclusion in the vertical (torus) weld, similar to the slag inclusion found in the "A" and "B" RCP's. Drilled holes and EDM notches were also placed in these calibration blocks.

C) After the calibration blocks were returned, a total of eight NDE vendors were invited to the plant site to participate in a research and development program, with the goal being to locate and size the implanted slag inclusions, drilled holes and EDM notches by the UT method. Out of the eight vendors invited, three decided to participate. Only Babcock & Wilcox was able to locate and partially size the slag inclusion consistently.

D) Due to the configuration of the two scroll welds, it was decided to attempt double wall radiography using a 250 curie cobalt source. The spare pump casing and calibration blocks were shipped to Duke Engineering Services, where they have successfully performed double wall radiography of the two scroll welds except for approximately three feet of each weld in the pump discharge nozzle.

E) The pump casing and calibration blocks were then shipped to B&W at Lynchburg, Va. for the development of a means to mobilize the ultrasonic search units along the torus weld. A robot was used for automated scanning to reduce radiation exposure.

3.0 Relief Request

The staff has completed the review of the licensee's examination results from the 1988 ISI of the "A" and "B" RCP casings welds. A combination of examination methods were used as described in paragraph 2.2. The ultrasonic testing detected flaw indications in the "B" reactor coolant pump casing. In the letters dated October 27, 1988, the licensee requested relief from certain ASME Section XI requirements that he determined were impractical. The staff reviewed this information as related to the design, geometry and materials of construction of the components. The licensee's ISI Program is based on the requirements of ASME Section XI, 1980 Edition including Addenda through Winter 1981, and remains in effect until December 19, 1994.

3.1 Code Requirements

Paragraph IWB-2430 Additional Examinations states:

"a. Examinations performed during any inspection that reveal indications exceeding the allowable indications standards of IWB-3000 shall be extended to include an additional number of components (or areas) examined initially during the inspection."

"b. If the additional examinations reveal further indications exceeding the allowable standards, the remaining number of similar components (or areas) within the same examination category shall be examined to the extent specified in Table IWB-2500-1."

Paragraph IWB-2420 Successive Inspection states:

"b. If flaw indications are evaluated in accordance with IWB-3122.4 and the component qualifies as acceptable for continued service, the areas containing such flaw indication shall be reexamined during the next three inspection periods listed in the schedules of the inspection programs of IWB-2410."

"c. If the reexamination required by (b) above reveal that the flaw indications remain essentially unchanged for three successive inspection periods, the component examination schedule may revert to the original schedule of successive inspections."

3.2 Code Relief Requested

3.2.1 The licensee requests relief from the provisions of paragraph IWB-2430. The licensee considers performing additional volumetric examinations of "C" or "D" RCP to be impractical.

3.2.2 The licensee requests relief from the provisions of paragraph IWB-2420 The licensee considers impractical the disassembly of RCPs A" or "B" for the sole purpose of performing successive inservice radiographic examinations.

3.3 Licensee's Basis For Relief

The licensee based his requests on nondestructive examination (NDE) results, a fracture mechanics evaluation and a stress analysis.

3.3.1 Nondestructive Examination Plan

To meet the requirements of ASME Section XI, the licensee committed in the August 11, 1988 letter to the following actions during the 1988 refueling outage:

A) The vertical (torus) welds in the "A" and "B" pumps will be examined using B&W's Accusonix System which digitizes the UT data into a top view, side view and end view for analysis purposes. An enhancement technique will be used which improves the ultrasonic signal and eliminates the bulk of noise signals caused by the pump grain structure.

B) The upper and lower scroll welds in the "B" pump will be examined using double wall radiography. However, if this technique is unable to produce meaningful results in an approximate three foot length of both welds in the pump discharge nozzle area and if the ultrasonic method is also unable to produce meaningful results in this area, then it may be necessary to request relief from examining these two, three foot areas of weld.

C) The results of this examination will determine what actions should be taken with regard to "C" and "D" RCP casings.

D) After the IR8 (1988) Refueling Outage, when the Unit One ISI Technical Manual is scheduled to be revised, the "A" pump will be scheduled for augmented inspections during IRIO and IR12 Refueling Outages.

3.3.2 Nondestructive Examination Results

A) The ultrasonic testing of both the "A" and "B" reactor coolant pumps in the areas with known RT indications revealed no flaw indications. Using threshold values that just exceeded the average noise level from the pump casing material for both straight beam and angle beam measurements minimum detectable indications of approximately 1/8" wide and 3/4 long through the maximum wall thickness can be detected. The fact that the previous slag indications are not detectable with UT most likely indicates that they are very small, occupy very little volume, and are below the limit of detection for present-day UT technology.

B) Sections of the upper and lower scroll welds near the discharge end of the pump, which could not be successfully radiographed to meet ASME Code film density requirements, along with the remainder of vertical weld were examined by UT. In the lower scroll weld several indications were detected (using ACCUSONEX) in an area bounded by a rectangle with a length of 4.1" and thickness of 1.8" at a depth of 0.9" below the outer weld surface in a region where the weld is 4.75" thick. These indications are considered to be slag inclusions located approximately 0.5" to 0.75" from the weld centerline.

The upper scroll weld could not be examined with ACCUSONEX due to insufficient access for the robot; however, a manual scan was performed which identified three indications. The composite size was conservatively determined to be no larger than a 4.5" long by 1.25" deep rectangle at a depth of 1.35" from the outside surface. The weld is also 4.75" thick in this region. This indication is located approximately on the weld centerline to 0.6" from the centerline. It is also considered to consist of slag inclusions resulting from the original construction welding process and not a service induced condition.

C) The double-wall radiography showed no rejectable indications. The factory radiographs and the low density radiographs of these areas taken during this outage were computer enhanced. The analysis of these enhanced radiographs showed no rejectable indications in the welds.

D) These indications are considered to be small preservice slag inclusions based on the following:

The indications are detectable with UT transducers at both 0 degree and 45 degree examination angles, and based on their specular reflectivity the indications are characteristic of slag inclusion rather than weld cracking.

2. The UT data shows that the inclusions are within the weld metal and not through wall. Cracking rarely initiates in the weld volume, but propagates from the surface.

3. Factory radiographs do not show the indications detected by UT. This indicates that the respective volumes of the slag inclusions are so small as to be radiographically indistinguishable as compared to the thickness of the weld in that area.

3.3.3 Fracture Mechanics and Stress Analysis

A fracture mechanics and stress analysis of "B" RCP was submitted based on ASME Section XI paragraph IWB-3122.4. These evaluations concluded that no significant flaw growth would occur over the life of the pump, and the casing is capable of maintaining its structural integrity with these sized flaws for

the life of the pump. These analyses demonstrated compliance with the acceptance criteria of IWB-3612.

Since flaw indications were previously identified initially for "A" RCP, IWB-2430(b) requires an examination of the remaining components ("C" and "D" RCPs).

4.0 STAFF EVALUATION

The staff's evaluation of the 1988 examination of the reactor coolant pumps included the following:

A) A Region IV site inspection that observed ultrasonic testing with the automatic data acquisition and imaging system (Inspection Report 50-313/88-34).

B) A public meeting with the licensee in Rockville, MD on October 18, 1988 (Meeting Summary dated October 26, 1988).

C) A followup plant visit to the B&W facility in Lynchburg, Va on November 2, 1988 (NRC Consultant's Trip Report attached).

D) Review of the licensee's submittals dated August 11, 1988 and October 27, 1988.

Based on this information, the staff determined that the automatic ultrasonic testing system represents state-of-the-art technology for this application. Other NDE inspection agencies have similar capabilities to the system described in paragraph 2.2.

The automated UT system used by the licensee significantly exceed the requirements of ASME Section XI. The flaw indications are embedded mid-plane reflectors. The staff agrees with the licensee that the indications originate from the fabrication process and probably are isolated slag inclusions. The inspection results do not show evidence of service-induced degradation nor flaw growth of the fabrication-related conditions.

The staff reviewed the fracture mechanics analysis performed by Babcock & Wilcox (B&W Report 32-1173431-01) related to the flaw indications detected in the "B" RCP casing. The methodology used is consistent with the report (B&W Report 32-1167147-00) reviewed by the staff in 1986 for the "A" RCP. In both submittals, the licensee concludes that significant flaw growth will not occur over the life of the pump.

The pump case is fabricated from ASTM A351-69, type CF8M stainless steel. Material properties are available for type CF8A base metal which has slightly higher tensile strength than type CF8M, but has similar Charpy values at room temperature. B&W assumed that the fracture toughness properties for types CF8M and CF8A weldments are equivalent and the J of this material is 1171 $in\text{-}lb/_{in^2}$. The Electric Power Research Institute published a report entitled

"Evaluation of Flaws In Austenitic Steel Piping," NP-4690-SR, July 1986. The EPRI report contained values for submerged arc welding and shield metal arc welding of J_{IC} = 650 in-lb/$_{in^2}$ and J_{IC} = 990 in-lb/$_{in^2}$, respectively.

The staff assumed the fracture toughness properties recommended by EPRI in its review. The staff determined that the conclusions of the licensee's fracture mechanics analysis is still valid, that significant flaw growth will not occur and the pump casing will maintain its structural integrity with these size flaws for the design life. The staff also recognizes that the dimensions assumed by the licensee for the flaw indications are extremely conservative with respect to the actual size of the flaws.

5.0 CONCLUSION

Based on the foregoing information, the staff concludes that the combination of ultrasonic testing and radiography performed during the 1988 refueling outage, as described in paragraph 2.0, fulfills the licensee's commitments that resulted from the 1986 inservice inspection. The staff has determined that the disassembly of a reactor coolant pump for the sole purpose of performing a volumetric examination of the pump casing weld is not practical. The process of removal of the pump shaft results in considerable exposure of personnel to radiation and a significant outage time for assembly. The industry operating experience with cast stainless steel pressure vessels has been good. The staff is not aware of any detrimental service-induced degradation to pump casing welds that has been detected by inservice radiography, internal visual examination, external surface examination or external ultrasonic testing.

The staff finds the licensee's actions during the 1988 outage to be acceptable. The staff concludes that relief may be granted from the requirements of ASME Section XI paragraphs IWB-2430 and IWB-2420 provided that the licensee conducts the following augmented inservice inspection program:

A) The successive inspections required by IWB-2420 on "A" and "B" RCPs are completed in the areas containing the flaw indications. External ultrasonic testing may be used as the examination method.

B) Single-wall radiography is performed based on IWB-2420 and IWB-2430 in the event that any reactor coolant pumps are completely disassembled for maintenance, repair or examination.

C) During this inspection interval the staff will not require additional examinations based on IWB-2430 or any reactor coolant pump casing weld unless these examinations detect actual flaw growth or service-induced degradation.

D) In the future, the licensee should use the most conservative published values for fracture toughness properties unless a technical justification is provided for a higher value.

The staff concludes that the augmented inservice inspection program will provide an acceptable level of quality and safety. Therefore relief from the ASME requirements is granted pursuant to 10 CFR 50.55a(g)(6)(i). The relief is authorized by law and will not endanger life, property, or the common defense and security, and is otherwise in the public interest; and is granted giving due consideration to the burden on the licensee that could result if the requirements were imposed on the facility.

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