U. S. NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
REGION IV

IE Inspection Report No. 50-313/75-11 — Docket No. 50-313

Licensee: Arkansas Power & Light Company
Sixth & Pine Streets
Pine Bluff, Arkansas 71601 — License No.: DPR-51

Category C

Facility: Arkansas Nuclear One, Unit 1

Location: Russellville, Arkansas

Type of License: B&W, PWR, 2568, Mwt

Type of Inspection: Management Meeting, Announced

Dates of Inspection: October 10, 1975

Dates of Previous Inspection: September 23-25, 1975

Principal Inspector: _____ _____
D. G. Anderson, Reactor Inspector, IE:IV — Date

Other Accompanying Personnel:

_____ _____
G. L. Madsen, Chief, Reactor Construction & Operations Branch, IE:IV — Date

_____ _____
A. R. Herdt, Metallurgical Engineer, IE:II — Date

Reviewed By: _____ _____
G. L. Madsen, Chief, Reactor Construction and Operations Branch, IE:IV — Date

SUMMARY OF FINDINGS

A. Enforcement Action

None identified.

B. Licensee Action on Previously Identified Enforcement Items

Not inspected.

C. Design Changes

Not inspected.

D. Unusual Occurrences

Not inspected.

E. Other Significant Findings

Previously Unresolved Items

74-14/7 Reactor Building Spray Line Cracks

A complete packet of information with attendant suggested corrective action will be supplied by the licensee by October 31, 1975. This submittal will be considered by NRC (IE:IV) as APSL's final evaluation of this problem. (DETAILS, paragraph 5).

F. Management Exit Interview

On October 10, 1975, at the conclusion of this management meeting, the representatives of the NRC summarized the discussions concerning resolution of the problems related to the pipe cracks which have occurred in the Reactor Building Spray System with Mr. K. Cavanaugh, members of APSL staff, and representatives of Bechtel Corporation. The following items were discussed during the course of the exit interview:

1. The purpose of arranging this meeting. (DETAILS, paragraph 2)

2. The history of the pipe cracks in the Reactor Building Spray lines. (DETAILS, paragraph 3)

3. Sampling techniques and solution chemistry. (DETAILS, paragraph 4)

4. Anticipated commitments of the licensee toward resolution of the Reactor Building Spray Line crack problem. (DETAILS, paragraph 5)

(continued)

DETAILS

1. Persons Contacted

Arkansas Power and Light Company (AP&L)

W. Cavanaugh, Manager, Nuclear Services
N. A. Moore, Manager, Quality Assurance
G. H. Miller, Assistant Plant Superintendent
D. A. Rueter, Licensing Engineer
D. R. Sikes, Production Project Supervisor
D. Williams, Assistant Engineer
C. L. Bean, Quality Assurance Inspector
R. D. Lane, Assistant Production Project Supervisor
G. G. Young, Assistant Engineer

Bechtel Power Corporation

E. H. Smith
J. J. Oszewski
H. L. Leichter
Yun Chung

Nuclear Regulatory Commission

G. L. Madsen, Region IV
D. G. Andersen, Region IV
A. R. Herdt, Region II

2. Purpose of this Meeting

This meeting with the management of AP&L was scheduled in order to review the past history of action taken by the licensee with regard to Reactor Building Spray Line cracks (74/14-7) and to encourage a commitment on the part of AP&L to continued surveillance and future replacement of the defective piping at ANO-1.

3. Reactor Building Spray Line Crack Chronology

This problem was first noted during routine surveillance on November 8, 1974 (See Appendix A for reference material on this subject). The final reports on this problem were received from Bechtel and Southwest Research Institute on August 5, 1975. An analysis of the postulated failure of this piping has been conducted for Bechtel by Failure Analysis Associates. This report was reviewed during the management meeting and the licensee's representative indicated that a final version will be submitted to IE:IV by October 31, 1975. This analysis assumes a 2-inch long through wall crack in schedule 10 pipe with the material properties of the 80001 affected heat. Initial conditions assumed include stress levels needed to cause the existing crack to go critical. The results of this analysis

(continued)

indicate that stresses 12 times greater than those postulated would be necessary to cause failure. Also, for the stress levels postulated in this analysis, a 5.6-inch long crack would be necessary for the existing crack to fail. Three conditions were evaluated in this analysis:

Straight Accident
Operating Basis Accident
Design Basis Accident

The final report on this accident analysis will complete the licensee's evaluation of this problem area.

4. Chemical Analysis

The licensee indicated that a procedure supplied by Allied Chemical Corporation is being used to measure the concentration of chlorides in the spray solution in the building spray lines. The licensee indicated confidence in the results of chloride concentration using this procedure. The licensee indicated that sampling and flushing of these lines is routinely performed on a quarterly basis. If chloride concentration exceeds 10 ppm, then the lines are flushed until additional sampling results indicate a chloride concentration less than 10 ppm.

5. Anticipated Licensee Action

The licensee indicated at the conclusion of this management meeting that a complete packet would be submitted to IE:IV by October 31, 1975 containing the following information:

a. The failure analysis final report.

b. A surveillance program consisting of quarterly requirements of flushing and sampling the affected lines, an annual NDT of the affected welds on a sampling basis, and visual inspections of the affected pipe on a once per shift basis.

c. Commitment to replacing the affected pipe in the event any additional leaks appear.

The inspectors indicated that this additional information would be considered as the final evaluation by AP&L on this problem and would be reviewed by IE:IV prior to submittal to DRL with our comments for action.

DETAILS II

Prepared by: A. R. Herdt 10/31/75
A. R. Herdt, Metallurgical Engineer Date
Engineering Section
Facilities Construction Branch

Dates of Inspection: October 10, 1975

Reviewed by: L. L. Beratan 11-3-75
L. L. Beratan, Senior Inspector Date
Engineering Section
Facilities Construction Branch

1. Persons Contacted

a. Arkansas Power and Light Company (AP&L)

G. H. Miller - Assistant Plant Superintendent
W. Cavanaugh - Manager, Nuclear Services
C. L. Bean - QA Inspector

b. Contractor Organization

(1) Bechtel Corporation (Bechtel)

E. H. Smith - Project Manager
J. J. Oszewski - Field Engineer
H. L. Leichter - Metallurgical Engineer
Y. Chung - Metallurgical Engineering Specialist

(2) Southwest Research Institute (SwRI)

H. C. Burghard, Jr. - Senior Research Engineer*
*Meeting on May 19-20, 1975

2. Scope of Inspection

The purpose of this inspection was to meet with AP&L management to discuss the investigation of the cracked welds in the 10-inch schedule 10 (0.165 wall) Type 304 stainless steel piping of the Reactor Building Spray System in the Arkansas Nuclear One, Unit No. 1. The primary items discussed were: the metallurgical investigations performed by Battelle Columbus Laboratory, Bechtel Corporation and Southwest Research Institute; and the proposed corrective action by AP&L.

This report covers the inspection made at Southwest Research Institute on May 19-20, 1975, to view the metallurgical examinations being conducted as a result of these cracked welds and the meeting with AP&L management personnel at Little Rock, Arkansas, on October 10, 1975.

3. Metallurgical Investigations

a. Background

As previously reported in IE Report Nos. 50-313/74-14 and 50-313/74-15, leaks were discovered in the Reactor Building Spray System B loop pump suction piping of Arkansas Nuclear One Unit No. 1. This was reported in Abnormal Occurrence Report No. 50-313/74-11B. Since the leaks involved the same heat (No. 800201) of stainless steel material, the licensee initiated a program of examination of welds including the heat affected zone of the pipe of the above heat number. In addition, an increased visual surveillance program was initiated to search for additional leaks. A random selection of areas adjacent to 46 welds (both shop and field) in the same heat of pipe in the reactor building spray and decay systems was examined by radiographic methods. This is discussed in detail in IE Report No. 50-313/74-15. Metallurgical examinations of these cracks was performed by Battelle Columbus Laboratories and Bechtel Corporation with Southwest Research Institute performing some metallurgical examination under contract to Bechtel Corporation.

b. Battelle Columbus Laboratories (Battelle)

Battelle Columbus Laboratories, under contract W-7405-Eng-92, to the Nuclear Regulatory Commission, performed an independent metallurgical examination of a portion of the cracked welds in the 10-inch Type 304 stainless steel piping taken from the Reactor Building Spray System. The leak examined was a portion of number 2 as related to Bechtel interim report. The purpose of Battelle's independent examination was to verify and audit the metallurgical examination provided by the licensee. The inspector visited Battelle on December 13, 1974, as described in IE Rpt. No. 50-313/74-15, Details II, paragraph 3.C.

Battelle completed their independent examination on February 7, 1975, and the report is included as an Attachment to these details. Battelle's results indicate that the leaks were the result of intergranular stress-corrosion cracking that was

initiated on the inside of the piping and propagated intergranularly through the sensitized microstructure of the heat-affected zone adjacent to the weld. The probable source of stress was excessive residual stress from weld repairs or high heat input during welding. Chemical analysis revealed the piping was within chemical specification, even though the carbon content was near the upper limit for Type 304 stainless steel. Battelle performed a semiquantative ion microprobe analysis of selected areas on pieces from the 10-inch pipe, namely the heat affected zone, center of the weld and the fracture surface. This microprobe as well as the scanning electron microscope analysis revealed up to 1000 ppm chloride ion at the heat affected zone on the inner surface of the pipe as well as on the fracture surface itself. Appreciable quantities of sodium, aluminum, silicon, and calcium were also found. Battelle stated in their report that the probable corrodent was the chloride ion, however, the source is not definitely known.

c. Southwest Research Institute (SwRI)

The inspector met with Herman Burghard, Jr., Senior Research Engineer, Department of Materials Engineering, SwRI on the May 19-20, 1975, to review his metallurgical investigation plan and results to date. There were no representatives from Bechtel or Arkansas Power and Light Company present during the inspection.

(1) Background

SwRI has been retained by Bechtel to act as an independent third party in this thin wall pipe cracking problem. SwRI has been retained to perform the following work:

(a) Review the analysis performed in the Bechtel laboratory.

(b) Establish a program to examine, in the field, pipe surface conditions and to identify pipe that has experienced chemical attack due to excessive pickling.

(c) Perform an independent metallurgical examination of cracks 4, 5 and 6 as well as radiographic indications following removal of the crossover pipe. In addition, a sample of a shop fabricated weld and a field fabricated weld exhibiting no cracking characteristics will also be metallurgically examined. These samples are from the crossover section.

(d) The surface of the pipe will be examined in the field for carbide precipitation. It is noted that the work performed in November 1974, was premature since carbide precipitation was noted only at mid-wall. The ID and OD surfaces exhibited no carbide precipitation. Based on these results, trepan and ring samples were taken from existing pipe of the reactor building spray system and decay heat system to determine whether carbide precipitation existed, and to determine the base metal characteristics.

Item (a) had been completed with regard to the review of the metallographic results on Leaks 1-3 and was incorporated in the supplemental report forwarded to the NRC on February 5, 1975. SwRI concurred that contributing factors to the cracking were base metal pickling, high carbon content and base metal sensitization.

Item (b) had been completed and the results indicate that all pipe examined regardless of size, heat number or manufacturer exhibited some pickling attack.

Items (c) and (d) was presently being performed. The status and details of these items are discussed below:

(2) Metallurgical Results

(a) Crack Samples

SwRI performed a detailed metallurgical examination of cracks designated 4, 5 and 6 as well as one weld that showed an indication of a crack in the radiography performed in November 1974. In addition, a sample of a shop fabricated weld and a field fabricated weld exhibiting no cracking characteristics to be classified as typical was also metallurgically examined. All are from the crossover area.

Upon receipt of these samples, SwRI took laboratory radiographs of all the samples and performed a liquid penetrant inspection of approximately half of these samples to determine whether by these nondestructive test methods cracking could be observed. Cracks were detected on all the samples by both of these methods. The inspector reviewed the radiographs and the cracks could be easily identified located adjacent to the weld running circumferentially in the heat affected zone. In most cases the cracking was continuous in nature.

SwRI had begun the metallographic investigation on crack 5, radiographic indication, the shop and field fabricated weld samples. Preliminary results showed that the four samples exhibited cracking from the ID toward the OD, intergranular in nature, in the sensitized heat affected zone and the base metal contained a mid-wall sensitized zone. There is no difference metallurgically from what is seen in these samples and what has been previously reported by Battelle and Bechtel. Crack 5 and the radiographic indications showed through-wall cracks while the field fabricated and shop fabricated welds showed cracking approximately 3/4 through the tube wall.

The inspector reviewed the metallurgical data including the metallography and concurred with these preliminary findings.

(b) Base Metal Samples

As previously stated, trepan and ring base metal samples have been taken from existing pipe of the reactor building spray system and decay heat system. These samples are of different sizes and heats as well as the original heat in question, SWEPCO Heat No. 800201. A preliminary listing shows ten heats and six different pipe sizes.

SwRI has started the metallurgical investigation on nine samples for base metal analysis. To date the only heat to show mid-wall sensitization is Heat No. 800201; the 10-inch diameter pipe of this heat is the only size that has been examined at this point in time. The inspector reviewed these preliminary findings with no differences being uncovered.

(c) Summary

The SwRI metallurgical report was included in the "Investigation of Pipe Leakage, Reactor Building Spray System Piping, Arkansas Nuclear One, Unit 1 Final Report" dated August 15, 1975, forwarded by AP&L letter dated August 29, 1975. Besides the independent third party work performed by SwRI, the metallurgical investigation performed by Bechtel was also included.

The inspector reviewed and analyzed both of these metallurgical investigations as well as the Battelle report. The conclusion reached by all three studies are metallurgically similar and are as follows:

1 The mode of failure of the Type 304 stainless steel was found to be stress-assisted corrosion cracking propagating intergranularly through the sensitized microstructure of the heat-affected zone adjacent to the circumferential welds.

2 The sources of the stress were residual stresses associated with welding; sentization in the heat-affected zones near welds produced by welding heat, possibly high heat input; and chloride ions and/or sulfur oxide ions as a corrodent.

3 Other factors in the stress-assisted corrosion cracking failure were: high carbon content of the piping material at the maximum permitted by the specification, and partial sensitization of the piping material (HT 800201, SWEPCO).

In summary, the metallurgical reports are in agreement as to the piping failure mode. With regard to the metallurgy, there are no major questions or additional metallurgical suggested work required.

4. Management Meeting

The inspector together with representatives from IE:IV met with AP&L management and their representatives in Little Rock, Arkansas, on October 10, 1975. The major area of concern is the corrective action proposed by AP&L; periodic surveillance for leaks in pipe containing sensitized structure (HT 800201 and 2P-3352); whether the piping will be eventually replaced; and the licensee's overall corrective action program.

The inspector stated that the metallurgical reports were in general agreement as to the cause and mode of the weld failures and cracking. The licensee reported that the final report would be submitted to the NRC by October 31, 1975.

The licensee stated that this final report would include as a minimum the following:

a. The extensive study by Failure Analysis Associates on a postulated crack in the Schedule 10 piping under design stresses.

b. Full description of the walk-through surveillance including the procedure, frequency, and records.

c. Sampling of the borated water in the Reactor Building Spray System including the chloride acceptance level with its justification, the sampling procedure and assurance a representative sample is taken.

d. Periodic volumetric inservice inspection programs including the procedure frequency and method for the piping systems containing material from Heat No. 800201 and the section of sensitized piping associated with Heat No. 2P-3352. The inspector point out that if radiographs are used as the volumetric inspection that the baseline radiographs meet code requirements and that the effectiveness of the radiography as to defect size be discussed.

The Office of Inspection and Enforcement will evaluate this final report and make any necessary recommendations.

APPENDIX A

1. Abnormal Occurrence Report No. 50-313/74-11, J. D. Phillips, AP&L to N. C. Moseley, RO/II, November 18, 1974.

2. RO Inspection Report No. 50-313/74-14, November 29, 1974.

3. IE Inspection Report No. 50-313/74-15, January 6, 1975.

4. Abnormal Occurrence Report No. 50-313/74-11A, J. D. Phillips, AP&L to N. C. Moseley, IE/II, February 5, 1975.

5. Examinations of portions of the Reactor Building Spray System Piping from the Arkansas Nuclear Plant No. 1, Battelle Laboratory Report dated February 7, 1975 (26 pp).

6. IE Inspection Report No. 50-313/75-2, May 2, 1975

7. Followup Report - Abnormal Occurrence Report No. 50-313/74-11, W. Cavanaugh, AP&L to N. C. Moseley, IE/II, April 11, 1975.

8. IE Inspection Report No. 50-313/75-04, May 23, 1975.

9. IE Inspection Report No. 50-313/75-06, July 3, 1975.

10. Investigation of pipe leakage, Reactor Building Spray System Piping, Arkansas Nuclear One, Unit 1, Final Report Bechtel Corporation, August 15, 1975.

11. Metallurgical Investigation of cracking in reactor safety-related piping system, Arkansas Nuclear One, Unit 1, Final Report, Southwest Research Institute, July 11, 1975.

12. Abnormal Occurrence Report No. 50-313/74-11B, J. D. Phillips, AP&L to B. C. Rusche, HQ/NRR, August 29, 1975.