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

REGION III

Report No. 50-331/78-23

Docket No. 50-331 License No. DPR 49

Licensee: Iowa Electric Light and Power Company
IE Towers
P.O. Box 351
Cedar Rapids, Iowa 52406

Facility: Duane Arnold Energy Center

Inspection At: Duane Arnold Site, Palo, Iowa; Chicago Bridge & Iron, Houston, Texas; General Electric Company, San Jose', California

Inspection Conducted: June 23, 28-30, July 7, 11-12, and 17, 1978.

Inspectors: C. C. Williams — 10/17/78

W. J. Key — 10/18/78

K. D. Ward — 10/18/78

Approved by: D. H. Danielson, Chief — 10/18/78
Engineering Support Section 2

Inspection Summary

Special Inspections on June 23, 28-30, July 7, 11-12, and July 17, 1978 (Report No. 50-331/78-23)

Areas Inspected: As reported in PN-III-78-55 on June 18, 1978, a 4" long through-wall crack was found on the reactor vessel recirculation inlet nozzle N2-A safe end. Subsequently, on June 23, 1978, NRC inspectors examined the nondestructive test activity (radiography and ultrasound) being performed by the licensee and its agents on all eight of the existing reactor vessel nozzle N2 safe ends and the related fabrication records and other history as was then available at the site. On June 28-30, 1978, NRC inspectors examined design, procurement, fabrication and related QA

records for the Duane Arnold N2 nozzle safe-end assemblies at the Chicago Bridge and Iron (CB&I), Houston, Texas facility (June 28 and 29) and the General Electric Company (GE), San Jose, California facility (June 30). On July 11-12, 1978, NRC inspectors examined fabrication and related QA records at the Lenape Forge Company facility (safe-end forging supplier) located in Lenape, Pennsylvania. On July 17, 1978, an inspection was conducted at the Duane Arnold site relative to the N2 nozzle safe-end removal plans and to review the latest NDE of the existing N2 nozzle safe ends. The inspection involved a total of 80 inspector-hours on site by three NRC inspectors.

Results: This inspection of the N2 nozzle safe ends established that: (1) the N2-A safe end had a 4" long through-wall crack with subsurface cracking indicated for 270°; five other N2 safe ends were indicated to be cracked by ultrasonic testing; (2) the CB&I and GE QA/QC records are sufficient to establish a complete and useful history of the design, procurement, and fabrication of the Duane Arnold safe-end assemblies; (3) the CB&I Duane Arnold safe-end fabrication records were found to meet specified requirements. Moreover, as-built fabrication records not normally maintained in CB&I QA files, are available from CB&I, Birmingham; (4) the available fabrication (forging) records at the Lenape Forge facility, although not required to be maintained at this time, were sufficient to demonstrate that: (a) the subject safe-end forgings met the procurement requirements specified by CB&I, (b) the safe-end forging machining error, which necessitated a major weld repair on all eight safe-end forgings, was caused by a dimensional error in a Lenape Forge Company rough machine drawing, (c) this error was properly reported by Lenape Forge Company and reviewed by CB&I and GE, (d) the repair welding made necessary by this machining error was approved by GE and performed by CB&I, (e) radiographic records of the repair weld show that the repairs were found to be acceptable by CB&I and GE, (f) review of this same radiography at this time by NRC, revealed several indications and conditions which are questionable and whose relevancy has not been established; (5) the licensee and its agents have concluded, from "post crack" NDE results, that all eight of the existing N2 nozzle safe-end assemblies have to be removed and replaced with new safe-end assemblies of a different design configuration; (6) plans to implement the removal of the existing safe-ends and design considerations for the replacement safe-end assemblies have been initiated, (7) the licensee plans to perform comprehensive metallographic studies of the cracked nozzles to determine cause; and (8) NRC plans to select one of the cracked nozzles for independent metallographic studies and evaluations to determine the cause of this failure and its implications.

No items of noncompliance or deviations were identified.

DETAILS

Evaluation of Nondestructive Testing of Recirculation System Riser Pipe Crack (Reactor Vessel N2 Nozzle Safe End) - June 23, 1978

Persons Contacted (Iowa Electric Light & Power Company)

E. Hammond, Chief Engineer
D. Mineck, Assistant Chief Engineer
J. Gebert, Maintenance Supervisor
R. Rinderman, Quality Supervisor
D. Wilson, Technical Writer
J. Vinquist, Electrical Maintenance Supervisor
G. Fulford, Assistant Mechanical Maintenance Supervisor

1. On June 17, 1978, the licensee informed the RIII office of the identification of a 4" long through-wall crack in the 10" diameter "B" loop recirculation inlet nozzle safe end. This nozzle is designated N2-A. Investigation revealed that primary reactor coolant was squirting from this apparent 4" circumferential crack. There are eight N2 safe ends in the inlet recirculation piping system; four each in loops A and B. This piping supplies the driving coolant for the reactor vessel jet pumps.

2. During this inspection it was established that the through-wall crack on safe end nozzle N2-A was open at the surface in the fusion zone of a weld which extends for the entire circumference of the N2-A safe-end forging. This weld is approximately 1½" wide. Available records at the site show that the subject weld was made to restore the forging section thickness which was erroneously undercut during fabrication machining operations. The depth of this weld is reported to be about 3/8". The forging thickness in the area of this weld is about ½". All eight of the Duane Arnold N2 nozzle safe ends were mismachined and weld repaired.

3. The licensee reports that General Electric Company (GE) QA/QC records show that this weld was designated as a major fabrication repair and was implemented by Chicago Bridge and Iron (CB&I). The safe-end forgings material is reported to be in accordance with ASTM B 166-63 (Inconel).

4. At this time, the licensee, through its agents Nuclear Energy Services, Incorporated (NES), CONAM Inspection Division, and Lambert-MacGill-Thomas, Incorporated (LMT), are in the process of performing radiographic (RT) and ultrasonic (UT) examination of the N2 nozzle safe ends in the vicinity of the forging undercut weld repair. This volume of material includes the attachment weld for the thermal sleeve which is on the ID of the safe-end forging, almost directly opposite the undercut repair weld on the OD of the forging.

5. Due to the extraordinary conditions under which radiography was performed, the image quality of the radiographs was compromised. However, the radiographic results are considered to be of very useful quality in terms of assessing the subject welds in combination with the ultrasonic test results.

6. Specifically, the radiographs are unusual in that the ambient radiation at the OD of the subject piping was about 2 R/hr, and the pipe was full of reactor coolant water. In the case of the nozzle (N2-A) with the through-wall crack, the radiography was further complicated by the significant amount of water leaking through the crack.

7. Moreover, the various degrees of accessibility and changes in radiation level from nozzle to nozzle added additional complexities to the radiography.

8. With adjustment of the radiographic technique (as indicated by interim results) useful radiography was produced. In the NRC inspector's opinion, the RT results represent a "best effort" and substantially indicate the extent of cracking in safe end nozzle N2-A (through-wall crack). This crack, with 4" open to the surface, is in the heat affected zone of the repair weld and was shown to have extensive subsurface cracking for approximately 270° of the safe-end circumference. (approximately 18" in length).

9. The remaining seven N2 nozzle safe-end forgings (N2-B through N2-H) were also radiographed. While no further cracking was shown by these radiographs, safe ends N2-B, D, E, F, and H were shown to have significant linear indications (slag-like), nonfusion, and porosity which appear to involve both the thermal sleeve to safe end weld and the safe-end "undercut" repair weld. "Significant linear indications", in the context of the NRC inspector's evaluation, means that had these indications been detected during fabrication, they would have been cause for further evaluation and/or rejection due to weld quality considerations. (It is recognized that the thermal sleeve to safe end weld was not required to be radiographed by the applicable fabrication requirements). The detailed radiographic interpretation is available in Duane Arnold site records.

10. To complement the above described radiographs and their interpretation, the licensee also had its agent (LMT) perform ultrasonic examination

of these welds. The NRC inspector discussed the UT procedural considerations with the licensee and its agents and found every aspect of their approach technically sound.

11. LMT developed a standard calibration block with a configuration representative of the volume of the safe end thermal sleeve weld and repair weld complex. This Inconel standard block was machined and did not contain any welds. It did contain a reference notch. This configuration was used primarily to establish sound beam path and the feasibility of the examination. It was further used in conjunction with references to the known through-wall crack in safe end N2-A, to establish reference amplitudes and "crack" evaluation data. The UT procedures were adjusted, as necessary, by the evaluation of N2-A.

12. A significant finding was that the known crack in nozzle N2-A could be detected ultrasonically only when the transducer scan direction was such that the sound propagated away from the reactor vessel, i.e., up-stream relative to coolant flow in the safe end. Even when the transducer was centered with the through-wall crack, the crack could not be detected when sound propagation was directed towards the vessel, i.e., same direction as the coolant flow.

13. Subsequently, UT was completed on all eight N2 safe ends. The results showed that:

    a. Safe end N2-A (through-wall crack) had subsurface cracking for about 270° of the safe-end circumference which was in good agreement with the radiographic results.

    b. Safe ends N2-B, N2-D, and N2-E had linear indications (crack-like) intermittently for 360°.

    c. Safe end N2-F had a spot indication at the 8 o'clock position.

    d. Safe end N2-H had a linear indication between the 3 and 5 o'clock positions.

    e. Safe ends N2-C and N2-G did not show any indications.

    NOTE: The above reports were made available on June 25, 1978.

14. During this inspection, the NRC inspector was informed by the licensee and the GE representative (a Senior Materials Engineer) of their considerations for metallographic examination for the known crack in safe end No. N2-A. The first consideration was for boat sampling; however, this decision was deferred.

15. During this part of the inspection, the inspector examined the radiographic procedures, personnel qualification documents and other QA/QC requirements relative to this nondestructive testing effort. No discrepancies were noted. The licensee's NDE technical representive (Ken Harrington) directed and coordinated this work. The following radiography specifics were evaluated:

    a. The radiography contractor, (NES) NDE personnel qualification documents for Level II inspectors John Brown, Jeff McIntos, and Tom Yeager were reviewed.

    b. Duane Arnold's basic radiography procedure No. RT-1-NP, Revision 1, dated June 20, 1978, was reviewed.

    c. The radiographic techniques and the necessary variations were reviewed.

    d. Final radiography for safe end N2-A (through-wall crack) and safe end N2-D were examined. (The results of the remaining radiography were reported on June 25, 1978, by the licensee and, subsequently, reviewed by NRC.)

    e. The N2 nozzle safe ends were radiographed using the "contact" double-wall technique. One hundred and two curies of Iridium-192 were used as the source. The effective size of the source was .144 inches square. The source to film distance was approximately eleven inches in the area of interest. Manual development of the radiographic film was used. The exposure time was approximately 12 minutes. The expected "fogging" of the film from the background radiation and the effects of the coolant in the piping (safe end) were observable and minimized by the RT technique. This RT is considered by the NRC inspector to represent a useful "best effort".

16. The following ultrasonic testing considerations were examined and discussed.

    a. At the time of this inspection the licensee's agent (LMT) for UT was in process of establishing procedures for testing and instrument calibration. LMT is the agent who performed the

recent in-service inspections at this site and quality assurance considerations in this regard were verified by NRC and documented in IE Inspection Report No. 50-331/78-10. However, the inspector did review LMT personnel certification and instrument calibration records. No discrepancies were noted. The inspector examined the calibration reference standard LMT fabricated for these UT examinations. It appeared appropriate for this task.

b. The LMT NDE data acquisition system (UT test device, with brush and tape recorders which record all information presented on the CRT) is such that the entire inspection experience can be reproduced at any time and a "permanent record" is available. The final examination tapes for all eight N2 safe end nozzles were subsequently reviewed by the NRC inspectors. No discrepancies in the records were noted.

17. The only records available at the site relative to the vendor fabrication of the N2 safe ends were CB&I's repair traveler "card sets" for the major weld repair of the safe end machined undercut. The inspector reviewed "repair travelers" that indicated all N2 safe ends had a groove machined incorrectly around the outside diameter by the supplier. This document further stipulated that welding Procedures G-RP-6, Revision 1, and MRP-3, Revision 0, be used to make the repairs, that necessary grinding or machining be done, and that the finished repair be liquid penetrant inspected in accordance with CB&I's Procedure RTP-6, Revision 1. This document was dated April 21, 1971. Traveler reports, numbered 269 through 276, were reviewed.

    Other than the above references to the procedures used, no other documentation was available at the site.

18. During this part of the inspection, the NRC inspector initiated arrangements with the licensee for NRC inspection of the safe end fabrication records maintained at CB&I, Houston, Texas, GE, San Jose, California and the forging supplier's facilities in Lenape, Pennsylvania. This was necessary in that the Code required and other quality records are maintained at these locations.

19. At the conclusion of this site visit the licensee discussed the arrangements being made to evaluate the full scope of this problem and effect a repair. NRC indicated that their inspection would extend to the vendor facilities and requested arrangements be made to facilitate these inspections. The licensee acknowledged this request.

Inspection of June 28-29, 1978 - CB&I, Houston, Texas

Persons Contacted

V. H. Gill, Records Center Supervisor
F. C. Clapp, CQA Department
T. G. Doran, C.E.P., Birmingham
T. M. LeVasseur, GE QC Representative

20. On June 28-29, 1978, NRC inspectors conducted an inspection/examination of the CB&I maintained records relative to the procurement and fabrication of the Duane Arnold recirculation inlet nozzle safe end forgings. The observed cracking (4 inches long) in nozzle N2-A is located adjacent to and within the heat effected zone of an apparent safe end forging repair weld which extends for 360° of the forging circumference. All eight Duane Arnold N2 nozzle forgings were repaired in this manner.

21. The primary purpose of this examination was to:

    a. To determine the detailed reasons why the observed 360° major repair weld on the subject safe end forgings was necessary and acceptable.

    b. To determine if the subject repair was made in accordance with the code, quality assurance and contract requirements.

    c. To review the radiography and other NDE records involved in this repair.

    d. To determine if repair welds other than the identified "Major Repairs" were made on the subject forgings.

    e. To examine the contractors considerations given to the repair weld on the N2 nozzle safe end forgins relative to their intended service conditions.

22. This examination of the CB&I records showed that all of the required documentation relative to the fabrication of the safe ends is available and easily retrievable. CB&I purchased the eight Duane Arnold safe end nozzle forgings from the Lenape Forge Company, (Lenape), on CB&I contract number 68-2967 (Purchase order number B-100148-2967). The Lenape Material Certification dated March 5, 1971, indicated that the safe end forgings were manufactured to the requirements of ASTM B-166, CB&I drawing M14 Revision 2, and Specification M16, Revision 5. The eight forgings (Lenape 280A-1 through 8) were produced from material heat numbers Y6Y4S, Y6Y7S and Y6Y8S. The

chemical analysis and mechanical properties reported conform to to the requirements. The material certification further states that "the material heat treatment consisted of treatment at 1800°F ± 25°F of 1/4 hour total and water quenched". Lenape heat treat procedure number Ht-10, Revision 2, was implemented.

23. The QA/QC records available at CB&I confirmed that "due to an engineering department error at Lenape in the preparation of the preliminary machining drawings, the final machine configuration (of the safe end forgings) was infringed upon on the outside diameter completely around the parts." All eight forgings were similarly mismachined. The discrepancy was approximately 1-1/8 inch long with a maximum depth of 5/16 inch. Review of CB&I records disclosed the following:

    a. CB&I records (dated February 16, 1970) stated that the cause of this discrepancy was that during manufacture at Lenape the ""Preliminary machining drawing was not checked by Engineering prior to being issued to the shop."

    b. The above CB&I document specified corrective action, included "all drawings are to be checked by someone other than person who made the drawing before they are released by Engineering".

    c. The above CB&I records further stated "CB&I to repair if repair procedure is approved by customer (GE) and do necessary NDE work".

    d. GE subsequently authorized CB&I to accept the discrepant Lenape forgings and to make the necessary repair welds. QA/QC records indicate that GE participated as appropriate in the entire repair process.

    e. The NRC inspector determined that Lenape properly documented this discrepancy and reported it to CB&I. CB&I likewise established the required documentation and informed GE of the identified discrepancy.

24. The inspector reviewed the CB&I repair traveler cards maintained by CB&I for each of the subject safe end forgings. These records identify the specific safe end forgings, reference an as-built sketch of the deficiency, provides step by step instructions with reference to the specific procedures, and provides for witness signatures indicating that these operations were accomplished. The GE representative signed off on each appropriate repair operation.

For example: CB&I repair traveler (card set No. 274) dated January 26, 1971, shows the repair and nondestructive testing history for N2 nozzle piece mark 31-3F (same as safe end N2-F or 280A-7). This documentation characterized the activity as a major repair, and specificed the CB&I weld repair procedures GRP-6 and MRP-3 be implemented. It further specified that CB&I liquid penetrant procedure number PTP-4, Revision 3, and RT procedure RTP-6, Revision 1, be used to examine the repair. Each of the referenced procedures were reviewed and found to conform to the requirements. The repair traveler cards for each of the eight Duane Arnold N2 safe end forgings were reviewed by the NRC inspector. No discrepancies were noted.

25. The reported identification numbers for the safe end forgings vary from company to company, however, traceability has been maintained. The following correlations are established by CB&I as-built drawing number R8, Revision 4, and Lenape mil-certifications:

Vessel Nozzle Number	Piece Mark	Lot Number	Heat Number
N2-A	31-3A	280A-6	Y6Y8S
N2-B	31-3B	280A-1	Y6Y7S
N2-C	31-3C	280A-3	Y6Y7S
N2-D	31-3D	280A-2	Y6Y7S
N2-E	31-3E	280A-5	Y6Y8S
N2-F	31-3F	280A-7	Y6Y8S
N2-G	31-3G	280A-4	Y6Y7S
N2-H	31-3H	280A-8	Y6Y4S

26. The repair welding was done manually using shielded metal arc (stick weld) in its entirety. The filler material used was Inco 182 (ENiCrFe-3). CB&I weld procedure qualification records were examined and found to conform to the requirements. Records for weld procedure qualifications were examined for CB&I procedures numbers 654 (June 6, 1967), 692 (October 4, 1967), 693 (September 25, 1967) and 697 (September 13, 1967). The CB&I general repair procedure No. 6 Revision 1, referenced the 1968 ASME Boiler and Pressure Vessel Code, Section III and IX. Heat treat operations were not required for these repairs.

27. Review of the liquid penetrant (LP) test records indicated that the examination and test results conformed to the requirements. LP was performed prior to repair welding and at the completion of the weld.

28. The NRC inspectors examined the CB&I radiographic examination reports relative to the subject eight safe end forging repair welds. Each of the CB&I radiographic test reports indicate that the repairs were acceptable. This CB&I radiography was performed in March 1970. The details of this examination are as follows:

a. The NRC inspector examined these radiographs without benefit of having the forgings available for visual verification of the film images. Therefore, in some instances the relevancy of areas of the inspectors concern could not be verified.

b. At this time the NRC inspector found the subject radiography film quality to be marginally acceptable. It is recognized that the subject film is about eight years old. Moreover, the usefulness of this film is compromised, in the judgement of the inspector, by fairly extensive water marking, scratches, light leaks and other superficial artifacts. Further, it is noted that this radiography was performed prior to the attachment of the thermal sleeve. While this presents a less complex area of radiographic interest, it also results in a large change of section thickness in the primary area of interest (relative to the repair weld) which makes it difficult to interpret the repair weld quality in this area.

c. Nevertheless, the NRC inspector evaluated the repair weld quality with reference to the applicable as-built CB&I and GE drawings. As is reported herein (paragraphs 5 through 9) radiography performed at the Duane Arnold site on June 23-24, 1978, showed significant slag and porosity inclusions. Based on the CB&I and GE drawings showing the as-built and nominal configurations of the safe end, thermal sleeve, and repair weld complex, the indicated location and size of the subject welds led the NRC inspector to the conclusion that, possibly, a significant portion of the slag inclusions and porosity noted in the Duane Arnold site post crack radiograhpy, were actually located in the repair weld.

d. The CB&I radiography, while not showing the large slag like indications obvious at the site, was interpreted by the NRC inspector to contain in specific instances porosity and barely discernible linear indications in the area of the repair weld, whose relevancy could not be established. These discontinuities were not noted on the documented CB&I RT report.

e. Subsequent to the identification of this concern, all eight of the subject safe ends were removed from the Duane Arnold vessel. Therefore, this issue has become a moot point.

f. It has subsequently been shown by destructive examination of safe end nozzle N2-E that all of the large (greater than 3 inches in length) slag indications are in the thermal sleeve to safe end weld. The dimensions of the thermal sleeve weld in the four areas destructively examined by NRC appear to be more than twice the width indicated by the nominal dimension (width) shown on the CB&I drawings. Therefore, the inspector concludes that all the significant slag and porosity indications noted at the Duane Arnold site in the remaining safe end nozzles (N-2-B, C, D, F, G and H) are confined to the thermal sleeve to safe end weld. (i.e. not in the safe end repair weld)

g. The N2-E safe end repair weld did not visually appear to contain any slag like discontinuities when subsequently destructively examined by the NRC.

h. Radiography was not a fabrication requirement for the thermal sleeve to safe end weld. This weld was examined by liquid penetrant testing only.

i. CB&I radiographic reports for repair weld on safe ends numbered 280A-1 through 8 (dated variously between March 13, 1970, and April 1, 1970) were a part of this examination. Each of these documents had been witnessed and concurred with by the GE Quality Control representative.

29. The NRC inspector found that the required records and information was available for the identified major repair welds on the safe end forgings at CB&I. However, there is no record or indication that minor weld repairs did not occur on the subject forging. The CB&I representatives indicated that it was their understanding that no welding (minor or major) was performed by the forging supplier (Lenape). Further, neither their (CB&I) records nor Lenape fabrication practices include any provision for minor or undocumented repair welding on the subject forgings.

30. The inspector asked the CB&I representatives if any documentation was available which would describe the basis for the decision to use the repaired safe end forgings in consideration of the complexity of the end use of this product. The CB&I representatives indicated that their records do not contain such information. Further, their records demonstrate that the repair met the requirements of the ASME Code and the GE specification requirements.

Inspection of June 30, 1978 - GE, San Jose, California

Persons Contacted

Werner C. Cohn, Manager Quality Control Engineering
Robert Longerbeam, Principal QC Engineer
Jay Erbes, Operating Plant Engineer
Gail C. Ross, Manager Area Product Services

31. On June 30, 1978, this inspection was continued at the GE San Jose facility. The primary goal of this activity was to:

    a. Examine and evaluate the GE QA/QC record system relative to documentation for the Duane Arnold N2 nozzle safe end - thermal sleeve assemblies.

    b. To discuss and evaluate the GE technical justification for accepting the repaired forgings for use at Duane Arnold.

    c. To determine if minor undocumented weld repairs had occured at any time during the fabrication of the Duane Arnold safe ends.

32. The inspector reviewed and examined the QA/QC records maintained at the GE Documentation Center located in San Jose. The GE records comprehensively identified the major repair weld to the Duane Arnold N2 nozzle safe end forgings. These records adequately provide traceability to the actual documentation maintained by CB&I (Houston) and further demonstrate that the repair work was accomplished under the full cognisance of the GE Engineering Department.

33. The GE representative pointed out that at the time (1968-1970) of Duane Arnold's safe end fabrication, a comprehensive system of record keeping was not required. However, currently a documented and planned system has been established and implemented for the maintenance of these fabrication records. To the extent possible the GE record system has been "back fitted" for vessels fabricated prior to the present requirements. In some instances these records may not be complete. In the case of the Duane Arnold N2 safe ends these records were complete

34. Currently the maintenance of vessel fabrication and QA/QC records at GE is governed by their Procedure No. 43, titled "Quality Assurance Engineered Equipment and Installation Administrative Guide". This guide contains or references a procedure titled "Instructions for Completing QA Product Quality Check List on Reactor Pressure Vessels", Revision 2, dated October 24, 1977. The inspectors review of GE procedures and documentation disclosed the following:

    a. This instruction provides guide lines for the completion of QA/QC check list which is essentially a method of documenting GE Quality Control Department's Verification of the

vendor or manufacturers' satisfactory completion of quality related contractural requirements for Boiling Water Reactor pressure vessels.

b. While the records required by the above procedures adequately provided traceability to base documents for major repairs, they do not address the disposition of possible minor repairs. When questioned the GE representative indicated that it is their understanding that the supplier (Lenape) did not perform any weld repair on forgings and their (GE) specification required that all weld repairs on forgings be reported to GE prior to any welding activity. This specification requirement was confirmed by the NRC inspector.

c. The NRC inspector requested to review any GE documentation that specifically documents the technical basis and rational for their decision to repair and use the discrepant Lenape safe end forging, especially in view of the fairly complex end-use and configuration of the complete thermal sleeve assembly. In response, the licensee's QA/QC representatives indicated that such documentation was not available. However, a General Electric engineer who participated in these original evaluations indicated that at that time they concluded that a ASME Code conforming repair was demonstrated to be possible, was endorsed by GE and implemented by CB&I at GE's direction.

d. The NRC inspector requested to review the detailed stress analysis of the thermal sleeve safe end forging assembly including associate piping. The GE representative indicated that these records were not immediately available.

35. At the close of this part of the inspection the NRC inspector stated that NRC was considering an inspection of Duane Arnold records that may be available at Lenape including any documentation outlining the Lenape fabrication practices at the time of the manufacture of the Duane Arnold safe end forging. In response the GE QC representative indicated that they would make the necessary arrangements through CB&I to facilitate the NRC inspection at Lenape.

Iowa Electric, GE and CB&I Meeting at NRC Headquarters - July 7, 1978

36. The NRC Region III inspector participated in a meeting between IE, NRR, Iowa Electric Light and Power Company and their consultants on July 7, 1978, to discuss the crack in the N2-A inlet recirculation nozzle, indication of cracking in other N2 safe ends, repair plans for this cracking, and plans to determine the cause of this cracking.

37. Among other things, a synopsis of the design, fabrication repair and final installation of the N2 safe ends was reported by the licensee and its consultants GE and CB&I. The N2 safe end repair plans and associated considerations were presented and discussed. The licensee indicated that all eight of the existing safe end forgings would be removed and replaced. Considerations for the metallurgical determination of the cause of the cracking were discussed.

38. The details of this presentation and IE comments are documented in IE Headquarters memorandum dated July 10, 1978 (N. C. Moseley/ R. W. Woodruff).

Inspection at Lenape Forge (Gulf Western Company) Safe End Forging Supplier-July 11-12, 1978

Persons Contacted

F. P. Fetterolf, Manager QA/Lenape Forge
D. L. Mowry, Assistant Director CQA/CB&I
T. M. Levasseur, QCEI Representative GE (NED)

39. The purpose of this portion of the inspection was to (a) establish to the extent possible the Lenape manufacturing control practices implemented during the manufacture of the Duane Arnold safe end forgings, (b) examine any available documentation relative to the machining error which resulted in the herein previously identified machine undercut on the N2 nozzle safe ends, (c) determine to the extent possible if Lenape performed any other weld repairs on the subject forgings prior to machining, and (d) examine any available documentation addressing the corrective action relative to the fabrication controls which lead to the safe end forging machining error.

40. During discussion with the Lenape QA Manager and the CB&I and the GE representatives, each of whom were personally involved with the manufacture of the Duane Arnold safe end forgings between 1969 and 1970, the following information was provided:

    a. At the time (1969-1970) when the Duane Arnold safe end forgings were being manufactured at the Lenape plant, neither the ASME Boiler and Pressure Vessel Code nor contractural provisions required Lenape to maintain a documented quality assurance/control program. Neither were there requirements for the maintenance of documented administrative practice or material control procedures. Consequently, such records and documents were not available.

b. The procurement and manufacture of these forging conformed to the ASME Boiler and Pressure Vessel Code Section III 1965 Edition through Summer 1967 Addenda. The Lenape representative who was a member of the Metallurgy Department at that time, verbally related their method of operation to the NRC inspectors. The description of the order and materials handling practices given by the Lenape representative outlined fabrication practices which in the judgement of the NRC inspector were representative of standard industrial practices. The Lenape representative further indicated that their methods of order and material handling has not changed significantly since 1968. However, currently their QA/QC and fabrication operation are prescribed and documented in accordance with the ASME Boiler and Pressure Vessel Code requirements. Lenape currently maintains ASME material manufacturers certifications ("U" certificate #11,406 and "N"-1950).

c. The Lenape QA representative stated that Lenape does not make welding repairs, major or minor on forgings. Their practices during the manufacture of the Duane Arnold N2-safe end forgings and as currently documented, does not include welding repair of forgings. The applicable GE Procedure No. M-16, Revision 5, Section 8.3.1 precluded inadvertent repair in that it states that "all weld repair shall be done by CB&I in the fabrication process. . ." Therefore, the NRC inspector concludes that other than the forging repair welds made by CB&I, the N2 nozzle safe ends have not had weld repairs in any other areas.

d. The Lenape QA representative stated in part that in 1968-70 a materials order was entered in their system through their Production Scheduling Department, then passed to their Manufacturing Engineering Department wherein typical drawings etc. were developed. After this the documents were sent to their QA/Metallurgy Department wherein quality assurance/control provisions and metallurgical instructions were provided. Then these documents were sent to their Process Engineering Department wherein specific manufacturing instructions are developed and issued to control the work.

41. Although there is no requirement for Lenape to maintain manufacturing records of the Duane Arnold N-2 nozzle safe end forging at this time, a comprehensive scope of documentation was made available for the inspector's review. These records were determined to be compatible in each detail with the forging QA/QC records maintain in CB&I files in Houston, Texas. The following details were reviewed:

a. Lenape documentation of the machining error which led to the major repair performed by CB&I was reviewed. This document DAR No. 9-63 referenced the forging purchase order No. B10148-2967, contract No. 68-2967, Lenape Shop order No. 0719-0, Mill order No. 280A and the heat numbers of the 8 safe end forgings. Each of these documents were reviewed. No discrepancies were noted.

b. The above DAR stated that "Due to an engineering department error in the preparation of preliminary machining the final configuration was infringed upon. . ." In addition, this DAR stated that the cause of this error was that the "Preliminary machining drawing was not checked by engineering prior to being issued to the shop".

The drawing attached to this DAR showed the details of the error and was dated 1968, signed by Mr. E. P. Fetterolf of Lenape.

c. During discussion, Mr. Fetterolf explained that at that time it was the Lenape practice to rough machine forgings prior to ultrasonic examinations. These rough machining instructions and drawings were provided by their combined QA/Metallurgical Department. In this instance these instructions and drawings were implemented prior to any verification of the drawing correctness by persons other than those who made the drawings, i.e., their "Process Engineering Department". There was no documented instruction specifically requiring that such drawings by checked by someone other than the originator prior to implementation. Mr. Fetterolf stated that normally such verification would occur within the QA/Metallurigical Department.

d. Lenape purchased the forging stock from Huntington Alloy Products Division. The available Material Certifications were reviewed and no discrepancies were noted. The Huntington Certification dated October 28, 1969, for heat code No. NX-9987 (Y6Y4) referenced ASME Section III, 1965 Edition including Summer 1967 Addenda, SB-166. The associated Lenape purchase order (No. 48817) is dated October 14, 1969.

e. The inspector reviewed CB&I Drawing No. M-14, Revision 2, for contract No. 68-2967, titled "Safe End Details" for nozzles N2A/H and N5A/B dated June 16, 1969, and drawing No. M-17, Revision 9 for nozzles N2A/H and N5A/B, titled "Safe End Extension".

f. The inspector examined Lenape heat treatment records for the safe end forgings (Mill Orders No. 280A and 281A). This record dated December 20, 1969, stated that the forgings were heat treated at 1800 degrees F for one-quarter hour then water quenched.

g. The inspector reviewed the Lenape "corrected" material certification for the safe end forgings (Shop order No. 0719-0, dated February 19, 1970). This report is compatible with the suppliers material certification (Huntington Alloy) dated October 28, 1969, for heat NX 9987.

h. The NRC inspector examined the Lenape Metallurgical Instruction specifying the heat treatment of the safe end forgings (Mill Orders 280A and 281A).

i. The NRC inspectors examined the Lenape ultrasonic test procedure, test report and personnel qualification documents. The safe end ultrasonic test report is dated March 3, 1970, and Lenape Procedure No. UT-69-5, Revision 2, was implemented. The previously identified machining error occurred during preparation of the forgings for this ultrasonic testing.

No discrepancies were noted during the above review.

42. The Lenape DAR 9-63, which documents the identification and resolution of the safe end machining error, specifies as part of its corrective action that all such drawings will be "checked" by others prior to implementation. In response to questioning the Lenape representative reported that this was implemented but there are no documented instructions showing this as it was not, at that time, a requirement to document these provisions.

The NRC inspectors noted that the current Lenape documented QA/QC program as documented in "QC Manual, Serial No. L-006, does not make a clear provision for independent verification of a drawing's accuracy prior to its use.

43. In summary this portion of the inspection has demonstrated that although a machining error occurred at Lenape it was properly documented and reported to CB&I and GE. Further, both the Lenape fabrication policies and the GE instructions were such that there is little possibility that unreported weld repairs were made on the Duane Arnold safe end forgings. Lastly, the Lenape fabrication practices, though undocumented, were typical of the industry practice at that time, 1968-70.

Inspection at Duane Arnold Plant Site - July 17, 1978

Persons Contacted (Iowa Electric Light and Power Company)

Harry Sheaver, Project Engineer
K. Meyer, Licensing Administrator
Phillip Ward, Nuclear Design Engineer
K. V. Harrington, Supv. Construction Engineer

44. On July 17, 1978, NRC inspectors reviewed the initial drafts of the Iowa Electric procedures, instructions and drawings associated with the planned removal and replacement of the eight reactor pressure vessel recirculation inlet nozzle safe ends designated N2-A/H. While it is recognized that these procedures were still in process of development, the NRC inspectors made two specific observations which Iowa Electric stated would be more clearly addressed in the final revision of the subject instructions. The observations were: (1) The procedures should include specific direction relative to avoiding any possible contamination of the N2-A safe end crack with chemical agents used to positively identify welds in the area of the proposed safe end removal cuts, and (2) It appeared that additional support may be needed during the cutting operation for the riser elbow portion of the inlet nozzle piping.

45. The specific documents reviewed as referenced in Paragraph 44 were as follows:

    a. GE "Design Change Request No. 800-"A" dated July 14, 1978, titled "RPV Recirculation Inlet Line Nozzle Safe End Replacement", and its associated safety evaluation.

    b. GE specification for the safe end removal described in the above design change request. (Identified as Attachment A to DCR 800-A" and dated July 14, 1978).

    c. Iowa Electric "Interim" drawings and notes associated with DCR-800-"A".

46. Interim Nondestructive Examination of Existing Safe Ends.

    The NRC inspectors reviewed the ultrasonic and radiography test reports and all associated instructions. No discrepancies were noted. In summary, the following results were obtained by the licensee:

    a. Safe End N2-A

    Radiographic Test Results

Location	0 - 9	No indication
Location	9 - 18	Crack
Location	18 - 27	No indication
Location	27 - 0	No indication

Ultrasonic Test Results

Scan (3) Scan toward vessel - No indication
Scan (4) Scan away from vessel - strong traveling indications at leak and beyond. Indications appear on or near both the ID and OD calibration range with the minimum range approximately .30" at leak. Linear indications extend to approximately 270°.

b. Safe End N2-B

Radiographic Test Results

Location	0 - 9	approximately 1/4" slag near 0
Location	9 - 18	No indication
Location	18 - 27	No indication
Location	27 - 0	approximately 1/4" slag near 0

Ultrasonic Test Results

Scan (3) - No indication
Scan (4) - Intermittent indications for full 360° max. indication extends to approximately 3/4" from OD

c. Safe End N2-C

Radiographic Test Results

No indication

Ultrasonic Test Results

No indication

d. Safe End N2-D

Radiographic Test Results

Location	0 - 9	No indication
Location	9 - 18	No indication
Location	18 - 27	No indication
Location	27 - 0	Single slag pocket at 0.

Ultrasonic Test Results

Scan (3) No indication
Scan (4) - Intermittent traveling linear indications for full 360°. Max. depth of indication was 1/2" from OD surface and was detected with the tip of the transducer at approximately 7" from centerline of first pipe weld.

e. Safe End N2-E

Radiographic Test Results

Location	0 - 9	Slag pockets 0-2; single pocket between 5 and 6
Location	9 - 18	No indication
Location	18 - 27	Linear slag line at 20, slag line (22-26)
Location	27 - 0	Slag (30-31); (32-33); intermittent slag (33-0)

Ultrasonic Test Results

Scan (3)	No indication
Scan (4)	Intermittent traveling indications for full 360°. Indication at approximately 0400 begins at ID to less than 1/2" from OD. Tip of transducer was approximately 7" from center of first pipe weld at the 0400 scan.

f. Safe End N2-F

Radiographic Test Results

Location	0 - 9	Non fusion or slag (0 -1)
Location	9 - 18	No indication
Location	18 - 27	No indication
Location	27 - 0	See indication (0 - 1) better on this film.

Ultrasonic Test Results

Scan (3) - No indication
Sacn (4) - Spot indication at approximately 0800. Had no travel. Also indication at approximately 1200 which may have been the RT indication at 0 - 1.

g. Safe End N2-G

Radiographic Test Results

No indication

Ultrasonic Test Results

Scan (3) - No indication
Scan (4) - A few spots that were too small to classify as linear.

h. Safe End N2-H

Radiographic Test Results

Location	0 - 9	No indication
Location	9 - 18	No indication
Location	18 - 27	Faint linear indication at 27. Has a transverse direction.
Location	27 - 0	No indication

Ultrasonic Test Results

Scan (3) - No indication
Scan (4) - Has linear indications with greatest amplitude at 3-5 with transducers near the top of slope on safe end. Begins at safe end inner surface and extends to approximately 3/4" of outer surface.

Note: Scan (4) is parallel to the longitudinal axis of the pipe and up stream relative to coolant flow. Disontinuities detecable only in Scan number 4.

47. The results of the continuing Duane Arnold N-2 nozzle safe end repair activity and associated Metallurgical studies relative to the cause of the pipe cracking will be documented in subsequent NRC Reports.

Exit Interview

At the close of each portion of this special inspection the NRC inspectors related their findings to the participants as documented herein (Persons Contacted).