UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
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UNION ELECTRIC COMPANY	)	Docket No. STN 50-483-OL
	)	
(Callaway Plant, Unit 1)	)	

JOINT INTERVENORS' PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW

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INTRODUCTION

This matter is before the Atomic Safety and Licensing Board for an initial decision on Contention One of Joint Intervenors Coalition for the Environment, St. Louis Region; Missourians for Safe Energy; and Crawdad Alliance. Joint Intervenors contend that there has been a failure of Applicant's quality assurance program, and that Applicant has not met its burden of proving that the Callaway Plant has been constructed in such a manner that it can be operated without endangering the health and safety of the public. Joint Intervenors' contention alleges:

> Surveillance and inspection functions of Applicant Union Electric Company, and others, including Bechtel Power Corp. (lead architect/engineer), Daniel International Corp. (construction contractor) and Code Authorized Nuclear Inspectors, failed to ensure the quality of safety-related material, structures, systems and components through all phases of their fabrication, construction, testing and inspection, contrary to the quality assurance criteria of 10 CFR Part 50, Appendix B. Many vendor-supplied components were on the construction site and were approved for installation before code-defined deficiencies and nonconformances were identified. During construction deficiencies and nonconformances were accepted against code requirements. Without effective surveillance and inspection by the Applicant, and others, of material suppliers, component vendors, and construction contractors, all safety-related material, structures, systems, and components must be considered of questionable integrity. Because effective surveillance and inspection were not performed, the safe operation of the Callaway Plant is in jeopardy and [it] should not be licensed.

Contention One then cites several "[d]eficiencies and nonconformances which evidence the failure of the quality assurance program," including the five items that are addressed below: embedded plates, SA-358 piping, SA-312 piping, preassembled piping formations, and honeycombing in the basemat.

I. EMBEDDED PLATES

A. SUMMARY AND OUTLINE

1. Embedded plates, or embeds, are structural devices used at the Callaway Plant to support steel floor beams, and critical piping systems necessary for a safe shut-down of the plant in case of an emergency. When the Callaway plant was approximately five and one-half percent complete, in June of 1977, it was discovered that structural steel plates (known as embedded plates), that had not yet been installed in the plant, were defective. Prior to that discovery, several hundred similar plates, manufactured in the same manner and by the same manufacturer as the defective plates, had been embedded in concrete in the plant, and, therefore, were not available for inspection. The condition of the plates installed prior to June 1977 is not known and has only been hypothesized based upon information generated from the inspection of plates that had not yet been installed after the discovery of the defects.

2. In its attempts over the past five years, to demonstrate the safety of the embedded plates that were installed prior to June 1977, Applicant has provided the NRC Staff and this Board with incomplete and misleading information. Some examples follow. **In the case of manually welded plates, Applicant and Bechtel, its lead architect/engineer, have represented that an engineering analysis proves that even if the installed embeds were more defective than those available for inspection, in every case the load capacity of the installed plate exceeds the actual load on that plate. On the contrary, Bechtel's own documentation demonstrates that in many cases the load capacity of the plate, if defective, would equal or be dangerously close to the load it must support** (see part F, paragraphs 36 to 37, below).[1] The significance of that misrepresentation is compounded by a second misrepresentation. Union Electric and

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[1] Proof of this fact depends on the Board's ruling on Joint Intervenors' Motion for Additional Evidence regarding the admission of proposed J.I. Ex. 78 submitted with that Motion.

Bechtel claim to have documentation from the manufacturer of the plates (Cives) that verifies that no plate inspected at the Callaway Plant was found to have a weld deficiency greater than that assumed in the engineering analysis to be the "worst case." Such documentation does not exist, either in the Cives inspection reports or in the letter Bechtel requested from Cives for that very purpose. A second set of inspection data was turned over to the NRC in November 1977 by the constructor of the plant (Daniel). The Daniel data indicate that deficiencies on the uninstalled plates were indeed worse than Bechtel's assumed "worst case." Union Electric and Bechtel then claimed they had no prior knowledge of that data, and, after conducting an analysis of the Daniel data, claimed that where the Daniel and the Cives data were inconsistent, the Cives data were more reliable. However, a Bechtel document shows not only that Bechtel was aware of the Daniel data in June 1977, but also that Bechtel had concluded then that where the Daniel and Cives data disagreed, the Daniel data were correct. In addition, Applicant has represented that tests performed on manually welded plates at Lehigh University were performed on plates representative of the "worst case" conditions. That also is not true.

3. Applicant's quality assurance program failed to prevent the manufacture of these defective plates, failed to identify the deficiencies before the plates were shipped by the manufacturer, failed to identify the deficiencies when the plates were received on site, and failed to identify the deficiencies before hundreds of the plates were installed in the plant. Moreover, in the course of attempting to determine the extent of the defects, Applicant's quality assurance program failed to assure proper documentation of inspections and failed to assure reporting of inspection results to appropriate levels of management. Applicant's quality assurance program also failed to prevent the inadvertent use of embeds that had been identified as being defective.

4. The proposed findings and conclusions pertaining to embedded plates are organized as follows:

A. Summary and Outline

B. Failure of Applicant's Quality Assurance Program to Identify Nonconforming Items: Initial Discovery of the Embed Problem and Issuance of Stop Work Orders

C. Earlier Indications of Problems with Cives

D. Defective Embeds Installed in the Plant

E. Inspections of Uninstalled Embeds and Other Indications of Deficiencies

F. Applicant's to Demonstrate the Safety of Embeds Installed Prior to Stop Work Orders

G. Conclusions Regarding Embeds

B. FAILURE OF APPLICANT'S QUALITY ASSURANCE PROGRAM TO IDENTIFY NONCONFORMING ITEMS: INITIAL DISCOVERY OF THE EMBED PROBLEM AND ISSUANCE OF STOP WORK ORDERS

5. On June 9, 1977, during a routine inspection, NRC inspector Naidu identified twelve embedded plates manufactured by Cives Corporation with machine welded studs "intended for use in safety related structures" which did not contain full 360 degree weld material (J.I. Ex. 28, NRC Report No. 77-05, p. 6). The plates were designated as EP-512E (Id.), indicating each plate is 12 inches by 60 inches in size and has 20 studs (Applicant's Ex. 4, Appendix B, Table 1).[2]

6. Bechtel was responsible at that time for performing a shop inspection of purchased materials prior to their shipment to the plant (J.I. Ex. 28, pp. 6-7, T. 501(14),

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[2] Applicant's statement in its proposed findings of fact (¶46) that the largest machine-welded plate is one foot by four feet with 16 studs is incorrect. Applicant's Ex. 4, Appendix B, Table 1 identifies machine welded plates as large as one foot by seven feet with 28 studs.

664, 854-55).[3] The documented procedure required Bechtel to inspect "each item" prior to shipment (J.I. Ex. 28, pp. 6-7). Prior to June 1977, however, Bechtel did not have a representative on site at Cives at all times (T. 855). In fact, it appears that Bechtel was only performing a "sampling inspection program involving approximately 20-25 percent of the materials" (J.I. Ex. 19). Daniel had the responsibility of performing inspections of materials upon receipt at the plant. However, in June 1977, and prior thereto, Daniel's receipt inspection was limited to verifying the quantity of materials received and checking for shipping damage, rather than determining conformance to procurement documents (J.I. Ex. 28, p. 6; T. 663-65, 1348-50). Daniel's receipt inspection checklist, however, did require verification that welds were in accordance with specified requirements (J.I. Ex. 28, p. 7). Thus, a serious deficiency existed, contrary to the documented procedures then in effect, with respect to the inspection of purchased materials to assure they conformed to applicable specification. Both Bechtel and Daniel were failing to live up to their responsibilities.

7. The failures of Bechtel and Daniel to identify the welding deficiencies on the embedded plates are violations of 10 CFR Part 50, Appendix B, Criterion X, and of the documented procedures, as found by the NRC inspector (J.I. Ex. 28, p. 7; T. 1322-23). Criterion X provides in part:

> A program for inspection of activities affecting quality shall be established and executed by or for the organization performing the activity to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity.

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[3]Transcript pages are designated herein with a "T". Pages from direct prefiled testimony are indicated in parentheses, following the transcript page after which they are incorporated.

In addition, Applicant's quality assurance program failed to conform to the basic requirement of Criterion II:

> [The quality assurance] program shall be documented by written policies, procedures, or instructions <u>and shall be carried out</u> throughout the plant life <u>in accordance with those policies, procedures or instructions</u>. (emphasis added)

The failure to identify the embed welding deficiencies also demonstrates Applicant's failure to abide by Criterion VII, which provides in part:

> Measures shall be established to assure that purchased material . . . conform[s] to the procurement documents. These measures shall include provisions, as appropriate, for . . . inspection at the contractor or subcontractor source, and examination of products upon deliver.

Applicant was also unable to produce for the NRC inspector full documentation regarding the manufacture of the embeds. The inspector determined this to be contrary to the documentation requirements of 10 CFR Part 50, Appendix B, Criterion VII (J.I. Ex. 28, p. 7).

8. Approximately one month after the NRC inspector discovered the welding deficiencies on the embedded plates and the inadequacy of Applicant's quality assurance program in connection with the inspection of purchased materials, Applicant directed Daniel to modify its receipt inspection practices to bring them in line with the existing documented procedures. Specifically, Daniel was directed to inspect all safety-related items "<u>in accordance with the existing checklist</u> included as part of the material control procedures." (T. 665-666 (emphasis added), 671, 1386A-87).

9. As a result of the NRC inspector's findings, Daniel issued two stop work orders on June 9, 1977 to prevent further installation of both machine and manually welded embedded plates (T. 1261(3)).

C. <u>EARLIER INDICATIONS OF PROBLEMS WITH CIVES</u>

10. Prior to June 1977 Applicant, SNUPPS, Bechtel and Daniel were all aware of deficiencies in materials manufactured by Cives, yet they failed to improve their quality assurance procedures. In mid-1976, when the initial shipments of miscellaneous

steel were being made by Cives, problems were identified with paint overspray onto areas which were not to be painted (J.I. Ex. 20, p. 1, ¶ 1). Sometime later, prior to November 1976, SNUPPS became concerned about the quality of materials manufactured by Cives. SNUPPS' concerns were based upon "a number of reports of misfabricated and discrepent materials" including deficiencies "such as mislocated studs; oversize holes in embedded frames; undercut welds; oversize pipe sleeves; door frames out of square and painting defects." (J.I. Exs. 19 and 20). SNUPPS wrote to Bechtel and indicated there appeared to be a "quality program problem" at Cives, and requested Bechtel to analyze Cives' quality assurance program and recommend any changes thought to be necessary (J.I. Ex. 20, p. 1; and J.I. Ex. 22). SNUPPS also wrote to Applicant and indicated a concern regarding the "acceptability of those materials delivered to the site which have been released for shipment without benefit of Bechtel end item inspection." (J.I.Ex. 19). SNUPPS suggested that Daniel "establish and implement plans for dimensional and visual inspection of selected shipments of materials previously deivered to the Callaway site." (Id.).

11. As a result of SNUPPS's expressions of concern regarding Cives' quality assurance program Bechtel analyzed the situation at Cives and decided "that Cives was a competent supplier with an effective QA/QC program." (J.I. Ex. 20, p. 1; and J.I. Ex. 21).

12. Daniel's inspection of Cives' products in response to SNUPPS' request consisted of inspecting ten percent (374 of 3740) of the materials received prior to November 15, 1976.[4] Four nonconforming items were identified, three embedded plates and one embedded frame, all with welding deficiencies (J.I. Ex. 18). Instead of drawing

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[4]Applicant's Answers to Interrogatories of Joint Intervenors (First Set) indicate that a larger number of embeds had been received at Callaway prior to November 15, 1976: 695 manually welded plates (Table 6(b)) and 4462 machine welded plates (Table 4(a)), for a total of 5157, or 1417 more than indicated by Daniel in J.I. Ex. 18.

the logical inference that since four items with deficient welds were identified in a ten percent inspection, forty such items could be deficient in the entire lot of items, no further inspections were performed of the remaining items on site at the time and no change in Daniel's receipt inspection practices were implemented (T. 673, 683-85).

13. Thus, the early indications of manufacturing and inspection deficiencies with respect to Cives' products failed to cause any change in procedures by either Bechtel or Daniel—changes that could have substantially reduced the embed problem by stopping the installation of defective plates six months earlier.

14. After Daniel's ten percent inspection and identification of four nonconforming items, one of the four, the embedded frame, was installed in concrete without any documentation of corrective action. This was determined by NRC inspector Naidu to be contrary to the requiremeents of 10 CFR Part 50, Appendix B, Criterion XV and documented quality assurance procedures (J.I. Ex. 28, p. 8).

D. DEFECTIVE EMBEDS INSTALLED IN THE PLANT

15. Prior to the discovery of the welding deficiencies and the issuance of the stop work orders, several hundred embeds were installed in the Callaway Plant. The total number of embeds in the plant prior to that time is not in the record. The record does reflect the following information regarding the number of machine welded embeds installed prior to June 9, 1977:

- 8517 machine welded embeds were received at Callaway by June 9, 1977 and 7543 were inspected by the Cives inspectors, leaving a difference of 974 that presumably were installed (Applicant's Answers to Interrogatories of Joint Intervenors (First Set), Table 4(a); Applicant's Ex. 4, p. 1);

- 576 were installed in the auxiliary, control and reactor buildings and the radwaste tunnel (Applicant's Ex. 4, Appendix B, Table 2);

- 481 were installed in safety-related buildings (Applicant's Proposed Findings of Fact ¶ 55);

- 459 were installed in Seismic I structures and systems (Applicant's Answers to Interrogatories of Joint Intervenors (First Set), no. 4(b)); and

- 255 or 204 were installed which support "safety-related" loads in the auxiliary, control and reactor buildings (Applicant's Proposed Findings of Fact ¶ 55).

For manually welded embeds installed prior to June 9, 1977 the following information is available:

- 739 were received at Callaway by June 9, 1977 and 405 were inspected by Cives inspectors, leaving a difference of 334 presumably installed;

- 259 were installed, consisting of 165 in the auxiliary building, 60 in the control building and 34 in the communications corridor (proposed J.I. Ex. 78);[5]

- 232 were installed in Seismic I structures and systems, consisting of 167 in the auxiliary building and 65 in the control building (Applicant's Answers to Interrogatories of Joint Intervenors (First Set), no. 6(c); and

- 225 were installed in safety-related buildings supporting safety-related loads (Applicant's Proposed Findings of Fact ¶ 66).

16. There is a reasonable likelihood that an additional 16 defective plates, 15 of which are "safety related" manually welded plates, were installed in the plant after the stop work orders. In January, 1978 Applicant notified the NRC that 16 embedded plates that had been rejected by Daniel inspectors, and which apparently had not been repaired or reworked, were missing. One of the missing plates was later "found installed as a support to [a] structural steel member in the Auxiliary Building." (J.I. Ex. 36, NRC Report No. 78-01, pp. 18-19). The 15 "safety related" plates were types EP-211, EP-311, EP-411, EP-511, EP-611 and EP-711, designations for manually welded plates containing from 6 to 15 anchor bolts and having rated load capacities from 25,000 to

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[5]Proposed J.I. Ex. 78 is the subject of Joint Intervenors' Motion for Admission of Additional Evidence, filed prior to these proposed findings of facts and conclusions of law.

200,000 pounds (Id.; Applicant's Ex. 4, Appendix B, Table 3). Assuming the accuracy of Bechtel's engineering analysis regarding the reduced load capacities of manually welded plates with undersized welds, a serious problem may exist with respect to at least three of the missing plates. Of the plates listed as missing on page 18 of NRC Report No. 78-01 (J.I. Ex. 36), three plates, according to Daniel inspectors, have average weld undersize equal to or exceeding one-eighth inch. According to Bechtel's engineering analysis those plates would have significantly reduced load capacities. The plates and the reported average weld undersize are set out below:

Plate Number	Average Undersize*
EP-311-A9-47	.131 inches
EP-511-6	.125 inches
EP-211-37	.129 inches

*one-eighth = .125

The load capacities of the two plates with average undersize exceeding one-eighth (.125) inch have not been determined by Bechtel, which assumed a "worst case" of only one-eighth inch. According to Bechtel, if the EP-211 plate had just one-eighth inch weld undersize its load capacity would have been reduced from 200,000 to 187,000 pounds. The EP-311 plate would have no reduction in capacity with just one-eighth inch undersize. The EP-511 plate, with one-eighth inch averge weld undersize, according to Bechtel, has a load capacity reduced from 75,000 to 60,000 pounds. (J.I. Ex. 12 (610 page Daniel inspection data) pp. 115, 150 and 489; Applicant's Ex. 4, Appendix B, Table 3).

17. In addition to creating serious concerns regarding the ability of the plant to be operated in a safe manner, the matter of "missing" defective embeds constitutes violations of several Appendix B quality assurance criteria. Criterion VIII requires that:

> Measures shall be established for the identification and control of materials, parts, and components. . . . These identification and control measures shall be designed to prevent the use of incorrect or defective material, parts, and components.

Criterion XV requires that:

> Measures shall be established to control materials, parts, or components which do not conform to requirements in order to prevent their inadvertent use or installation.

And if the missing embeds were, in fact, repaired or reworked, the failure to document that activity is a violation of Criterion XVI: ". . . the corrective action taken shall be documented. . . ."

18. Applicant claims to know "the precise location and the actual loads imposed" on each of the installed embeds (Applicant's Proposed Findings of Fact ¶¶55 and 66). Joint Intervenors are aware of no documentation in the record that fully supports that claim. For the machine welded plates Bechtel's first final report on embeds dated August 10, 1977, indicates: "A listing of all plates embedded in concrete . . . was prepared. Next each plate was identified by its location and the imposed load." (Applicant's Ex. 4, p. 2). The documentation included in that report, however, provides only summary information by type of plate and building (Applicant's Ex. 4, Appendix B, Tables 1 and 2). Similiarly, with respect to manually welded plates, the Bechtel report states: "A listing of plates with manually welded studs was prepared based upon field information on concrete placed prior to June 9, 1977. For each plate actual applied loads were determined." (Applicant's Ex. 4, p. 2). Again, however, the documentation provided in the report provides no information regarding plate locations or actual loads (Applicant's Ex. 4, Appendix B, Table 3).[6] The Daniel witnesses verified

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[6] The tables prepared by Bechtel that do contain detailed information regarding the location of and actual loads on manually welded plates installed prior to June 9, 1977 are contained in proposed J.I. Ex. 78. Those tables indicate that no information was known regarding the type of load applied on each plate, and only identify plates by type.

that the only plate location information available is by type of plate, not by specific plate identification (T. 1362).

19. In general, machine welded embeds are used to support structural steel framing; supports for heating, ventilation and air conditioning; supports for electrical cable trays; and steel pipe supports (see Applicant's Proposed Findings of Fact ¶ 55). Among the piping systems supported by machine welded embeds are those needed for safe shutdown of the plant, including the essential service water system, the component cooling water system, and the residual heat removal system. (T. 501(31)). The structural steel framing supported by machine welded embeds is for access platforms that allow personnel to gain access to equipment in the plant (T. 532-33). Machine welded embeds range in size from eight inches by eight inches with four studs, to 12 inches by 84 inches with 28 studs (Applicant's Ex. 4, Appendix B, Table 1).[7]

20. Manually welded embedded plates installed prior to June 9, 1977 are used exclusively for the attachment of structural steel framing, such as floor beams, to concrete. All support safety-related loads (see Applicant's Proposed Findings of Fact ¶ 66). Individual manually welded embeds have from 6 to 18 anchor bolts per plate, and are designed to carry loads of from 25,000 to 300,000 pounds (Applicant's Ex. 4, Appendix B, Table 3).

E. INSPECTIONS OF UNINSTALLED EMBEDS AND OTHER INDICATIONS OF DEFICIENCIES

21. Shortly after the June 9, 1977 stop work orders Applicant directed Daniel to perform a 100 percent inspection of the embeds on site and not yet installed in concrete. The inspection was to determine whether the embeds were or were not manufactured in conformity with the AWS Code, as incorporated in the Bechtel

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[7]Applicant's statement regarding the range of sizes of and numbers of studs on machine welded plates is contradicted by the cited table in Bechtel's first final report on embeds.

specifications, to provide a basis for accepting, or rejecting and reworking each item. The first recorded entry in the surveillance reports and supporting sketches produced by the Daniel inspectors is dated June 12, 1977. (T. 501(40), 722, 1378-80; J.I. Ex. 12). Daniel's project manager characterized the data collected as "professional" (T. 1358).

22. The results of the Daniel inspection are contained in a document of approximately 610 pages, designated as an attachment to a Nonconformance Report (NCR) 2-0831-C-B (J.I. Exs. 12 and 13). After two months of inspections Daniel reported the following findings to Applicant:

(a) Machine Welded Embed Plates

Approximate number inspected 5,220
Approximate reject rate less than 1 percent

(b) Manual Welded Embed Plates

Approximate number inspected 280
Approximate reject rate 90 percent (Weld criteria only)

(J.I. Ex. 39, attachment to DLUC 1788, letter dated August 18, 1977 from H. J. Starr, Daniel Project Manager, to Applicant). Three months later, after completing its inspection of the Cives embeds, Daniel again reported to Applicant, this time with numbers of studs only, with the following results:

Embedded Plates

Automatically Welded Studs Inspected	96472
Rejected Studs	106
Reject Rate	0.11%
Manually Welded Studs Inspected	6103
Number of Studs Rejected	2729
Reject Rate	44.72%

(J.I. Ex. 31, DLUC 2142, letter dated November 14, 1977 from H. J. Starr to Applicant). Daniel later indicated to Applicant that the total number of manually welded embedded plates rejected by its inspectors was 312 (J.I. Ex. 14, DLUC 2399). The total number of manually welded plates inspected by Daniel is not reported. If Daniel inspected approximately the same number as the Cives inspectors (405), the reject rate for manually welded plates inspected by Daniel would be 77 percent.

23. Examination of the data generated by Daniel in connection with NCR 2-0831-C-B indicates a total of 671 defective embeds of which there are 555 manually welded embeds containing multiple (two or more) defective stud welds. On 457 manually welded embeds, at least half of the stud welds are defective. The welding defects identified in the Daniel inspection data include undersize (US), overlap (OL), incomplete fusion (IF), slag inclusion (SI), weld splatter (WS), undercut (UC), linear porosity (LP), porosity (P), unacceptable weld contour profile (WC), and arc strike (AS). (J.I. Ex. 12).

24. At the same time that Daniel was performing its 100 percent inspection of embeds not yet installed in concrete prior to June 9, 1977, inspectors from Cives were doing essentially the same thing.[8] At the request of either Applicant or Bechtel one or two high ranking Cives employees reportedly inspected substantially all of the uninstalled Cives embeds at the Callaway plant. Inspection reports and testimony at the hearing indicate the task was performed by Alex Teed, Cives's quality assurance manager, surveillance department; and perhaps by Ted Totten, Cives's project manager for the SNUPPS project (Applicant's Ex. 4, Appendix A, Data Reports 7-13; J.I. Exs. 22 and 24; T. 796, 853). The Cives inspectors were given basically the same instructions as the Daniel inspectors, to determine whether the embeds contained deviations from the procurement specifications and applicable AWS Code requirements (T. 736-37, 795). The Cives inspectors, however, reported fewer deficiencies than the Daniel inspectors (T. 739; Applicant's Ex. 4; J.I. Exs. 12, 22 and 24).

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[8]All the companies who at one time or another were involved in inspecting the uninstalled embeds at Callaway — Applicant, Bechtel, Daniel and Cives — may have had a bias in favor of minimizing the defects. Cives, as the manufacturer, is undeniably an interested party (see T. 1230). To prevent such bias from interfering with quality control, NRC Quality Assurance Criterion X requires that inspections to verify conformance with documented instructions "be performed by individuals other than those

25. With respect to the machine welded plates, the Cives inspectors reported on the inspection of 7,543 plates. Of the 81,673 studs contained on those plates only 457 were reported to be visually deficient and only 66 of those 457 were reported to have failed a bend test (Applicant's Ex. 4). Those inspections took place in two distinct periods, from June 19 to 23, 1977, and from July 6 to 12, 1977. Curiously, although more plates and more studs were inspected in the second period, it was during the first period that 95% of the defective studs (436 of 457), and 88% of the stud failures (58 of 66) were identified (Id., Appendix A; J.I. Ex. 24). On two of the days in that second period, assuming that Mr. Teed was the only Cives inspector (as appears from the data reports), and that he worked an eight-hour day, he would have spent approximately one and one-half seconds to inspect each circumferential stud weld, not including record keeping (finding and writing down the plate number, recording the number of studs and the number of defects, drawing the stud configuration to show the location of each defective stud), and the time required to unstack and restack the plates, and to perform bend tests on the studs found to have less than 360 degree welds.[9]

26. The reports of the Cives inspection of the manually welded embeds indicate a total of 405 plates inspected, of which approximately 80 were rejected (Board Ex. 1, Enclosure 2 to ULNRC-238; J.I. Ex. 22). While only 80 plates were considered "rejectable," many more were identified as containing welding deficiencies. In fact, the Cives inspection data indicate that 111 manually welded plates contained multiple

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(cont.)
who performed the activity being inspected." 10 CFR Part 50, Appendix B.

[9]On July 6, 1977 a total of 18,888 studs was inspected, which, over an eight-hour period requires 1.52 seconds per stud. On July 7, 1977, 19,872 studs were inspected, for a period of 1.45 seconds per stud. (Applicant's Ex. 4, Appendix A, Data Reports 7-11). A Bechtel report on the Cives embed problem indicates that stacked plates must be unstacked to inspect the full circumference of the studs, and Mr. Schnell indicated the plates were probably stacked at the site during the Cives inspections and that Daniel craft personnel assisted in the moving of embeds (J.I. Ex. 20, p. 3; T. 703).

stud weld defects, and on 76 such plates, over half of the studs were defective (J.I. Ex. 22).

27. In addition to the Cives and Daniel inspection data, other indications of the number and extent of embed welding deficiencies include the facts that a large number of plates, after being inspected, were either repaired prior to their installation or returned to Cives. Union Electric claims it does not know the number of plates repaired (T. 731). However, some facts regarding repairs of manually welded plates are known. Cives indicated that the 80 manually welded plates it rejected as a result of its inspection were repaired (Board Ex. 1, Enclosure 2 to ULNRC-238). In addition, the calculation sheets prepared by Bechtel in its analysis of the Daniel data package, indicate over 140 manually welded plates were repaired, some more than once and some as late as September 1977 (Board Ex. 1, Enclosure 6 to ULNRC-238).

28. On June 27, 1977, 59 embeds were shipped from the Callaway plant back to Cives. That shipment contained 36 machine welded plates, 12 manually welded plates, and 11 sleeves and frames. Of the 12 manually welded plates returned to Cives on June 27, 1977, only two are listed in the Cives inspection reports from four days earlier, June 23, 1977. But the remaining ten plates are not listed in either the Cives inspection or the Daniel inspection reports.[10] The decision to return to a supplier defective items that could be reworked at the plant site, generally involves personnel from Union Electric, Daniel and Bechtel. Within Bechtel, the decision would be made in the procurement department, with input from engineering. Applicant's witnesses testified that welding deficiencies on embedded plates could always be repaired on site, and they did not know why the defective embeds were returned

[10] The ten manually welded plates that were returned to Cives and that do not appear on any inspection reports are EP511-A11, numbers 10 and 72; EP711-A4, numbers 6, 8 and 11; and EP711-A7, numbers 1, 5, 119, 221 and 233. (See J.I. Exs. 12 (Daniel data), 22 (Cives manual data), and 23 (shipping record).)

to Cives, except that Mr. Schnell stated it was done at the election of the Cives inspector. It is not evident how Mr. Schnell, who could not recall ever being involved in a decision to return an item to a vendor, knew how this particular decision was made. (T. 805-12). While the shipping form and the testimony indicate the returned embeds were defective, the number of weld defects and the extent and type of the deficiencies on the ten manually welded plates that are not listed on the inspection reports are not known (J.I. Ex. 23; T. 812). The Cives inspection records do indicate that the other two manually welded plates that were returned to Cives, have undersize welds on 13 of 15 studs and on 8 of 15 studs.[11]

F. APPLICANT'S FAILURE TO DEMONSTRATE THE SAFETY OF EMBEDS INSTALLED PRIOR TO STOP WORK ORDERS

29. It took Union Electric more than three years to convince the NRC Staff that the embeds installed at the Callaway Plant prior to the stop work orders on June 9, 1977 are safe. The embed issue was closed by the Staff in September 1980 (Staff Ex. 6, NRC Report No. 80-14). During those three years enormous efforts were invested in inspecting embeds, analyzing and rejecting adverse inspection data, computing probabilities of failures, calculating potential reduced load capacities, and performing elaborate experiments. Thus, Applicant has a variety of bases for its position that the embedded plates installed in concrete prior to June 9, 1977 are capable of supporting the loads imposed on them. With respect to the manually welded plates, Applicant's conclusion is based upon (1) the results of the Cives inspection and the joint inspection of Union Electric, Bechtel and Daniel; (2) Bechtel's engineering analysis; (3) the Lehigh University tests; and (4) Dr. Fisher's stated opinion (Applicant's Proposed Findings of Fact ¶86). With respect to machine welded plates, Applicant's conclusion is based

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[11] Those two plates are designated as EP311-A9-15 and EP311-A9-19, respectively (J.I. Exs. 22 (reports 101 and 102), and 23).

upon (1) both the Cives and Daniel inspection results, (2) Bechtel's probability analysis, and (3) the Lehigh University tests (Id., ¶ 64). The unreliability of each of the bases for those conclusions is demonstrated below, first for the manually welded embeds and then for the machine welded embeds.

Manually Welded Embeds

30. To view the issue of the safety of the manually welded embedded plates in its proper perspective one must consider the load that will be imposed on each plate and the load carrying capacity of that plate. That information was not put into the record by Applicant but is contained in a listing of plates compiled by Bechtel (Proposed J.I. Ex. 78). That list identifies each manually welded plate installed prior to June 9, 1977, its location in the plant, the capacity of the plate, the load on the plate, and the reduced capacity of the plate assuming the plate has average weld undersize of 1/8 inch. That list indicates that even if the manually welded plates contain no defects, in many cases the load on a plate is within 80 to 90 percent of the load carrying capacity for that plate. In one case the load on the plate is equal to the full capacity of the plate. (Proposed J.I. Ex. 78, e.g., 10th table, 12th entry). Thus, in the original design and selection of the manually welded plates, there was little, and in one case no, margin for error or safety factor.

30A. Applicant contends that the maximum extent of the welding deficiencies in the manually welded plates embedded in concrete prior to June 9, 1977 can be determined from the results of the Cives on-site inspection. Applicant makes the following claim in its proposed findings of fact:

> The nature and maximum extent of the welding deficiencies identified by Cives during its reinspection program were:
>
> (1) Insufficient weld (leg) size. . . . Most of the deficiencies were 1/16 inch undersize. The maximum undersize identified by the Cives reinspection was 1/8 inch and usually occurred only on the vertical leg of the weld. . . . The undersize rarely extended around the entire circumference of the weld.
>
> (2) Unequal leg size. . . . The vertical leg was usually shorter than the horizontal leg of the weld.
>
> (3) Unacceptable profile. The weld exhibited excessive convexity. . . .
>
> (4) Excessive undercut. The welding process undercut or reduced the thickness of the base metal (i.e., the plate or anchor rod). The maximum undercut was 1/16 inch, and usually extended only a portion of the way around the anchor rod. (Applicant's Proposed Findings of Fact, pp. 46-47, ¶69, emphasis added).

The Cives data simply do not contain the information that Applicant attributes to the Cives inspection (J.I. Ex. 22). The first Cives data reports, dated June 23, 1977, describe the defective conditions found as "undersize" and "undercut". For the undersize welds, in some instances the data indicate 1/16 undersize, for others the extent of undersize is not indicated. In no case is the extent of undercut listed. In no case, for either undersize or undercut, is there an indication of the extent of the circumference involved. There are no distinctions made between horizontal and vertical weld legs. Other Cives data reports, for July 11, August 9 and August 31, 1977, contain even less information than the June 23 reports about the nature and extent of the weld deficiencies. The only descriptions of weld conditions on those reports are: "accept," "reject," "lap," "u," "reject one end only," "profile," "undersize," "undercut," and "hornets," plus some illegible entries. Rarely is the amount of undersize indicated (approximately three times). And, as with the first day's data reports, no data reflect the amount of undercut, the extent that undersize or undercut extends around the rod circumference, and whether horizontal or vertical weld leg is involved (J.I. Ex. 22).[12]

31. In addition to not reflecting the kind of information that Applicant claims to get from it, the Cives inspection data are suspect for their failure to include ten manually welded plates that were shipped back to Cives a few days after the Cives inspection began (see part E, above).

32. In addition to purporting to rely on the Cives inspection results as evidence of the condition of the manually welded plates installed before June 9, 1977, Applicant relies on a joint inspection performed by itself, Bechtel and Daniel, on a limited number of embeds claimed to be "typical" of all the others (Applicant's Proposed Findings of Fact, p. 58, ¶81 and p. 62, ¶86). The document which describes that joint inspection belies the claim that the plates inspected were, in fact, "typical." That document, a report by Mr. Schnell submitted to the NRC on March 10, 1978, states:

> Finally, a group of 48 manually-welded embeds (containing a total of 54 plates) received soon after commencement of individual on-site inspection, has been placed on hold at Callaway in the as-received condition. These embeds are considered to typify the quality of Cives workmanship in manually-welded embeds received at Callaway. Although Daniel originally rejected these embeds because of perceived weld deficiencies, detailed examination of the welds on these embeds by a team of Union Electric, Daniel and Bechtel inspectors has confirmed that the deficiencies are less than originally reported. (Applicant's Ex. 6, ULNRC-238, attached report at p. 5)

The "individual on-site inspection" referred to above, commenced on approximately July 6, 1977, (T. 666), giving Cives a significant period of time after the discovery of

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[12]At the hearing, Bechtel's witnesses, Dr. Meyers and Mr. Parikh, were unable to glean from the Cives data the type of detailed information Applicant and Bechtel claim it reflects (T. 715-19, 855, 858-60).

defective manually welded plates at Callaway, and after the commencement of its own inspection (June 23), to improve both its manufacturing and shop inspection procedures.[13]

33. Bechtel's engineering analysis for manually welded plates is based on certain assumed worst case weld defects, and concludes that so long as the embeds installed in concrete prior to June 9, 1977 are no more defective than those assumed worst cases, "none of the plates . . . possess the potential to fail." (Applicant's Ex. 4, pp. 1-3, 5). The worst case assumptions were made with little or no regard to the actual weld conditions. The Cives data regarding manually welded plates were generated on four days in 1977: June 23, July 11, August 9, and August 31 (J.I. Ex. 22). On June 30, 1977, after one day's data regarding manually welded plates were available from Cives,[14] Bechtel personnel, after indicating that the matter of the machine welded studs, "is not considered a significant problem," expressed the following views regarding manually welded embeds:

> The manually welded studs is a different story. Approximately 25% of the embeds re-inspected at the site have been rejected because of improper welding of the studs. . . .
>
> Per my discussion with B. Meyers, Engineering does not consider these existing conditions to be detremental to the integrity of the embeds. Engineering is discussing how the specifications can be revised to allow more flexibility and accept the conditions that exist.

(J.I. Ex. 20, p. 4). It is not clear where Bechtel got the 25% rejection figure. The Cives data reports for June 23, 1977 indicate that 34% of the manually welded plates (14 of 41) were rejected. Moreover, ten additional manually welded plates, that are

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[13] Where the original Daniel inspection reports on these embeds are identifiable, the date of inspection is no earlier than August 27, 1977 (J.I. Ex. 12, pp. 400, 405-406, 408, 412-15, 425-26, 438-39, 494, 496; Board Ex. 1, Enclosure 9 to ULNRC-238).

[14] Although some of the Daniel inspection data also were available at this time, Bechtel claims it had no knowledge of that data until much later. That claim will be discussed below.

not listed on the Cives inspection reports for June 23, 1977 (or any other date), were shipped back to Cives on June 27, 1977 (J.I. Exs. 22 and 23).[15] Thus, by June 30, 1977 47% of the manually welded plates inspected by Cives (24 of 51), were rejected, and yet Bechtel engineering, prior to making its "engineering analysis," had decided that the defective conditions were acceptable.

34. When Bechtel performed its engineering analysis on manually welded studs, no additional data were available. The engineering analysis is discussed in Bechtel's "Final Reort - Investigation of Welded Studs" dated August 10, 1977 (Applicant's Ex. 4). The four defective weld conditions listed as existing on June 30, 1977 are repeated on page one of the Bechtel report, but with greater specificity. The June 30, 1977 report lists the conditions as:

1. Undersized vertical fillet
2. Oversized horizontal fillet
3. Undercut
4. Excess convexity

(J.I. Ex. 20, p. 4).

The August 10, 1977 final report lists:

a. The vertical leg of the weld is undersized by up to 1/16"

b. The horizontal weld is oversized by up to 1/8 inch.

c. The profile and convexity of the welds are unacceptable according to AWS D1.1.

d. Some undercut in excess of that allowed by AWS D1.1 exists.

(Applicant's Ex. 4, p. 1).

35. The investigation pertaining to manually welded plates, documented by the August 10, 1977 report, consisted of the following two steps:

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[15] Additional details of the June 27, 1977 shipment of embeds to Cives are discussed in part E, above.

> A listing of plates with manually welded studs was prepared based upon field information on concrete placed prior to June 9, 1977. For each plate actual applied loads were determined.
>
> Reduced capacities of plates were then calculated by assuming the welds between studs and plates to be 1/8" and 1/16" undersized, respectively. In addition reduced capacities of the plates were established by assuming 1/16" undercut in studs. These reduced capacities were compared with the actual applied loads on each plate (see Table 3, Appendix B). (Applicant's Ex. 4, p. 2).

The report indicates that the assumptions were verified by inspection reports:

> From field reinspection reports it was verified that in no case did the undersize weld or the undercut in the stud exceed the maximum assumed values (i.e. 1/8" undersize and 1/16" undercut). (Applicant's Ex. 4, p. 3).

The referenced calculation sheet for reduced load capacities, Table 3, Appendix B, indicates it was prepared on July 5, 1977. Thus, the assumptions upon which Bechtel's engineering analysis was based, could only have been made with knowledge of the inspection results on the 41 plates that were listed as inspected on June 23, 1977, and possibly with knowledge of the defective conditions of the ten manually welded plates that were returned to Cives on June 27, 1977 but were not listed on any inspection reports (J.I. Exs. 22 and 23). Mr. Parikh, who performed the calculations at Bechtel, did not know the source of the assumptions he utilized, nor which, if any, of the Cives inspection reports were made available to him (T. 847-48, 855-56). It is extremely difficult to believe that the Cives inspection reports were the "field reinspection reports" that Bechtel's report says verified the assumptions of maximum weld deficiencies (J.I. Ex. 22; Applicant's Ex. 4, p. 3). As discussed above, the Cives's data reports do not reflect that the maximum undersize found was 1/8 inch and that the maximum undercut found was 1/16 inch.

36. The Bechtel report indicates that the comparison of the reduced load capacity of each manually welded plate installed in the plant prior to June 9, 1977 (calculated from the assumptions regarding undersize and undercut), with the actual applied load on each of those plates, "established that a sufficient design margin existed

and that none of the plates embedded prior to June 9, 1977 possess the potential to fail." (Applicant's Ex. 4, p. 5).[16] From all that is apparent, Applicant and Bechtel have misrepresented the results of that comparison. The tables which reflect the comparison between the calculated reduced plate capacity and the actual load on each plate indicate there is indeed a potential for plate failure. In many cases, for plates installed in the auxiliary building and the control building, the calculated reduced plate capacity is equal to or dangerously close to the actual load on the plate (proposed J.I. Ex. 78).[17] Thus, with respect to many of the manually welded plates installed prior

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[16]In its proposed findings of fact, Applicant states: "These reduced capacities were then compared with the actual applied loads on each plate. In all cases the recalculated load carrying capacity still exceeded the maximum intended design load." (Applicant's Proposed Findings of Fact, pp. 48-49, ¶71). Applicant's direct prefiled testimony on the same subject, by Dr. Meyers and Mr. Parikh of Bechtel (authors of the subject Bechtel report) stated: "These reduced capacities were then compared with the actual applied loads on each plate, and in all cases the load carrying capacity exceeded the design loads." (T. 501 (37-38)).

[17]Four plates will bear actual loads which are equal to the calculated reduced load capacity for the plate. Those four plates are located in the tables of proposed J.I. Ex. 78 as follows:

1. 10th table, 12th entry

2. 10th table, last entry

3. 11th table, 2nd entry

4. 12th table, 9th entry.

Even where the reduced load capacity does exceed the actual load on a plate, in fourteen cases, the actual loads are within one or two thousand pounds (96 to 98 percent) of the reduced load capacities. Those fourteen plates are located in the tables of proposed J.I. Ex. 78 as follows:

1-3. 5th table; last 3 entries

4. 6th table; 1st entry

5-7. 9th table; 10th, 11th and 13th entries

8-10. 10th table; 6th, 14th and 17th entries to June 9, 1977, Bechtel's engineering analysis leaves little or no margin for error. If Bechtel's calculations are wrong and the reduced load capacity is slightly lower, plate failure can be expected. If plates have conditions worse than the assumed "worst case" condition of 1/8 inch weld undersize or other significant defects, plate failure can be expected. As shown in the succeeding paragraphs, the Bechtel engineering analysis is flawed in several important respects.

37. The Bechtel engineering analysis was based in part on the assumption that the maximum averge weld undersize on a plate was 1/8 inch (Applicant's Ex. 4; Applicant's Proposed Findings of Fact, pp. 48-49, ¶71(1)).[18] The comparison of calculated reduced load capacities of plates with 1/8 inch undersize welds, to the actual loads each installed plate is required to bear, demonstrates that the actual loads, in many cases, are equal to or extremely close to the reduced load capacities (proposed J.I. Ex. 78). Therefore, if the average weld undersize on the installed plates exceeds 1/8 inch, plates can be expected to fail. There is no documentation that establishes that the maximum weld undersize is 1/8 inch and there is substantial evidence that a significant number of the manually welded plates inspected after June 9, 1977 have average weld undersize greater than 1/8 inch. The Cives data reports, which Applicant and Bechtel claim verify that the maximum extent of weld undersize is 1/8 inch, contain practically no information regarding the extent of weld undersize and clearly

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(cont.)

11-13. 12th table; 2nd, 3rd and 5th entries

14. 13th table; 3rd entry.

In many other cases actual load is within 90 percent of reduced load capacity.

[18] Dr. Meyers indicated weld undersize was "the critical weld parameter in this particular application." (T. 724). However, considering only average undersize does not seem entirely logical. The load on a particular plate can be concentrated on a portion of the rods. If the welds on those rods are significantly undersized those welds could fail, putting all of the weight on the remaining welds. Even if the remaining welds are not defective, there may not be a sufficient number to support the load.

do not verify that assumption (J.I. Ex. 22). Despite Bechtel's claim that the Cives data contain the specific information needed for their engineering analysis, and that the Daniel data do not, Dr. Meyers admitted that Bechtel was informed of the maximum extent of weld undersize found by the Cives inspectors in oral communications <u>after</u> the inspections had been completed:

> After the inspection was completed there were numerous communications with Cives Corporation by members of the Bechtel engineering staff asking them in an attempt to determine what the maximum deviation from specifications was. . . .
>
> Cives indicated to us that their inspectors did not find anything worse than an eighth of an inch undersize. We proceeded with our evaluation based on this information.
>
> When the 610-page document [Daniel data] became available to us, we asked Cives Corporation to verify this finding to us in writing. They did do that and there is a rec rd of Cives' findings. (T. 976; see also T. 724)

Dr. Meyers' testimony that Cives verified in writing that its inspectors found no weld undersize greater than 1/8 inch is not true. Cives verified only that its "inspection <u>records</u> do not indicate that any welds were more than 1/8 undersize," a fact readily apparent to anyone who would review the records (Board Ex. 1, Enclosure 2 to ULNRC-238, Cives letter to Bechtel dated February 10, 1978, emphasis added). Applicant's report to the NRC regarding documentation of the validity of the 1/8 inch undersize assumption also misrepresents Cives' letter. Mr. Schnell stated, in the report accompanying ULNRC-238:

> Although Cives authorized repair of approximately 80 manually-welded embeds following their reinspection at Callaway, <u>none of the deficient welds were undersize greater than 1/8". This is documented in Enclosure 2.</u> (Applicant's Ex. 6, attached report at p. 1, emphasis added).

38. Not only is there no documentation from Cives that its inspectors found no undersize greater than 1/8 inch, there is competent and substantial evidence that many of the manually welded plates inspected after June 9, 1977 had averge weld

undersize greater than 1/8 inch.[19] As discussed in part E, above, at the same time Cives was inspecting the embeds not yet installed as of June 9, 1977, Daniel was doing the same thing, and reported a greater number of rejectable embeds and more extensive defective conditions. Applicant and Bechtel claim that they did not learn of the Daniel inspection data until November 1977, after Bechtel's engineering analysis, contained in its August 10, 1977 report, was completed.[20] Bechtel admits to the existence of at least eight manually welded plates with average undersize in excess of 1/8 inch, but contends that it is too few to affect the validity of its engineering analysis (Applicant's Ex. 7, p. 3).[21] A Union Electric survey of the Daniel data indicates 10 plates have an average undersize greater than 1/8 inch (Board Ex. 1, Enclosure 8 to ULNRC-238, p. 2). Bechtel's review of the Daniel data indicated 26 plates have an average weld undersize exceeding 1/8 inch. Table 1 herein (following Embedded Plates discussion)

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[19]A distinction must be made between what Applicant claims Cives found to be the maximum undersize and what Applicant claims there is no reliable evidence for. Regarding the Cives data, Applicant claims not a single weld was undersized more than 1/8 inch. The fact it attempts to refute when dealing with the Daniel data, however, is that the average weld undersize for all the welds on a plate exceeds 1/8 inch. (See Applicant's Proposed Findings of Fact, pp. 46-47, ¶ 69(1) and pp. 54-55, ¶ 78 and n.25). In fact, Applicant acknowledges that 151 individual welds have undersize greater than 1/8 inch (Board Ex. 1, Enclosure 8 to ULNRC-238, p. 2).

[20]That claim and the evidence refuting it are discussed in the succeeding paragraph.

[21]Bechtel notes that five of the eight plates it acknowledges as containing average undersize exceeding 1/8 inch were inspected by the same person on two dates (August 27 and 29, 1977) in the laydown area. That occurrence, upon which Bechtel claims to make no judgment, does not affect the reliability of the Daniel data, as explained by Mr. Starr, Daniel's project manager. Mr. Starr pointed out to Applicant that the relatively high rate of rejection and amount of undersize reflected on some surveillance reports were due to the inspection of embeds that had been rejected prior to the stop work order and set aside for later corrective action. Mr. Starr explained:

> In general, these were embeds that would require a greater degree of rework to gain acceptance. In these instances it was felt that it would be more expeditious for construction purposes to replace rather than rework these items. (J.I. Ex. 14, DLUC 2399, January 19, 1978, p. 2).

reflects the following information regarding those 26 plates: plate number; page number of Bechtel's calculation sheet comparing Daniel and Cives data (Board Ex. 1, Enclosure 6 to ULNRC-238, Appendix V); Daniel page number (J.I. Ex. 12); inspector's name, inspection date, reason(s) for Bechtel's rejection of Daniel's data, and the Cives data where available for the same plate, according to Bechtel's review (from Board Ex. 1, Enclosure 6 to ULNRC-238, Appendix B). It should be noted that in 13 of the 26 cases the Cives data agree that all of the welds on the plate were undersize.

39. Both Applicant and Bechtel claim they were unaware of the Daniel data results until after Bechtel's engineering analysis for which the worst case weld undersize was considered to be 1/8 inch. After they "became aware" of the data, and of the fact that the data, if accurate, undermined the worst case assumption made by Bechtel in its engineering analysis, Applicant and Bechtel went to great lengths to discredit the Daniel data (Applicant's Ex. 6; Board Ex. 1). Bechtel's report on its analysis of the Daniel data indicates it did not obtain those data until early November, 1977 (Applicant's Ex. 7, p. 1 of report). In Applicant's Proposed Findings of Fact, Applicant claims it too was unaware of the Daniel inspection results until November, 1977, five months after it directed Daniel to conduct the inspection (pp. 53-4, ¶ 77; see also Board Ex. 1, Enclosure 4 to ULNRC-238, Attachment IV, last page, ¶ 5; Enclosure 6 to ULNRC-238, "Meeting Minutes - 12/12/77," 44th page; T. 722, 724, 797). Applicant's and Bechtel's claims that they were unaware of the Daniel inspection results until November 1977 is incredible. Daniel did not decide on its own to perform this investigation, Applicant requested it (T. 501(40), 1378-80), and presumably was interested in the results. In August 1977 Daniel provided Applicant with a summary of its inspection results indicating that 90 percent of the manually welded plates were rejectable, and made reference to "accumulated inspection reports retained in the QC office." Daniel also stated in the same report: "These reports are available for any further indepth review as may be deemed necessary." (J.I. Ex. 39, Attachment to

DLUC 1788). Indications that Bechtel was aware of the Daniel inspection data in June, 1977, and at that time believed that those data were more reliable than the Cives data, are contained in a Bechtel summary report written July 1, 1977. That report indicates that on June 16, 1977:

> Don Walls (St. Louis Area SQR) visited the Callaway jobsite to re-inspect stud welds on embedded plates that Daniels had written non-conformance reports. Don's inspection confirmed that the conditions described on the Daniels NCR's were accurately described (J.I. Ex. 20, p. 2)[22]

The same document reflects the following occurrence on June 27, 1977:

> Nick Husting (Regional Supv.-St. Louis Area) visited the Callaway site to inspect some Embed plates that Cives had inspected and accepted but Daniels rejected. Nick's inspection confirmed that the pieces were rejectable as indicated by Daniels. (Id., p. 3)[23]

On Table 1 herein, it is shown that prior to June 27, 1977 six plates were identified by Daniel inspectors as having average weld undersize greater than 1/8 inch, but that those plates were recorded by the Cives inspectors as having no weld defects. Thus, it appears that prior to performing its engineering analysis Bechtel not only was aware of the Daniel inspection, but was aware that the results of that inspection indicated a greater problem than the Cives inspection results indicated. It also appears that where the results of the two inspections were inconsistent the Daniel data were accepted as correct. Finally, it appears that prior to performing its engineering analysis, based on the assumption that maximum average weld undersize was 1/8 inch, Bechtel may have known that plates were being identified with greater welding deficiencies.

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[22]Don Walls is identified as a Bechtel employee on Board Ex. 1, Enclosure 9 to ULNRC-238. Bechtel's witnesses at the hearing were unable to identify the author of that document, but the initials are those of D. Trapold, identified in the report as Bechtel's Supplier Quality Manager (T. 689, 753-55).

[23]Two days later, on June 29, 1977 Mr. Husting met with Dr. Meyers to discuss the problem (Id.).

40. Applicant's and Bechtel's efforts to discredit the Daniel inspection data regarding manually welded plates began shortly after November 4, 1977, when the NRC Staff obtained copies of both the Bechtel Final Report of August 10, 1977 (in which it is assumed no welds were more than 1/8 inch undersized) and the Daniel data (which refute that assumption) (Applicant's Ex. 7, p. 1).[24] With the NRC aware of an inconsistency between the basic assumption underlying the Bechtel engineering analysis and Daniel's inspection data, Applicant and Bechtel began their investigation of the Daniel data. At that time only 39 of the hundreds of embeds inspected by Daniel and found to be defective remained in their as-received condition, all others having been repaired (Applicant's Ex. 7, p. 2). Therefore, for verification of most of the weld defects reported by Daniel, only the Daniel inspection reports themselves were available. As Applicant points out in its proposed findings: "Bechtel undertook a major effort to sort out and clarify the Daniel data package. It involved a complete review of every entry in the entire data package. Five Bechtel employees worked on this effort for approximately one month." (Applicant's Proposed Findings of Fact, p. 55, 79). It is important to note that no one at Bechtel ever performed the same sort of analysis on the Cives data to determine whether they supported the assumption made by Bechtel in its engineering analysis (T. 908-909). Only the data that refuted the assumption were subjected to scrutiny, and, not surprisingly, were found to be "inaccurate and

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[24]The NRC Staff was on site at Callaway from November 2-4, 1977 investigating allegations made by Bill Smart, which included several items relating to the inspection of embeds and the adequacy of the embeds installed prior to June 9, 1977. During this investigation the NRC obtained "[i]nformation relating to the manufacture, inspection, reinspection and placement of the embeds," and requested Bechtel "to revise and update their anaylsis of failure probability for those embeds installed prior to the reinspection effort." (J.I. Ex. 34, NRC Report No. 77-10, pp. 2, 3, 4-5, 7). The NRC noted: "This investigation attracted considerable news media interest."

suspect" (Board Ex. 1, Encl. 5, minutes of January 9, 1978, meeting, p. 2)..[25] Bechtel rejected and questioned Daniel data entries for the following reasons:

R-1 No weld repair report traceable to inspection report - rejected

R-2 Weld repair report date prior to inspection report date - rejected

R-3 Report not traceable - rejected

R-4 Inspection data not technically feasible - rejected

R-5 Duplicate record - rejected

R-6 Inprocess inspection - rejected

X-01 Inspection data disagrees with Cives reinspection - data questioned

R-7 No weld dimensions available - rejected

(Board Ex. 1, Enclosure 6 to ULNRC-238, Attachment V, "KEY").

It is not apparent, and no explanation is provided, as to why a data entry would be rejected for the reasons that no repair report was available, that the report was not traceable, that the entry reflected an inprocess inspection, or that no weld dimensions were available. It is interesting that at this time Bechtel was questioning the Daniel data where they disagreed with the Cives data, whereas in June 1977, when Bechtel apparently still had the plates available to determine visually which data were accurate, Bechtel determined the Daniel data were accurate (J.I. Ex. 20, p. 2 (June 16, 1977) and p. 3 (June 27, 1977)).[26] The major problem with the Daniel data, according to Applicant's

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[25]Bechtel's evaluation of the Daniel data is described and documented in Enclosure 6 to ULNRC-238 (Board Ex. 1).

[26]Bechtel noted that some entries on the Daniel data were obviously erroneous. Both Dr. Meyers and Mr. Parikh mentioned at the hearing the example of a rod reported as having undersize larger than the intended weld (T. 534, 727; see J.I. Ex. 12, p. 145). While Daniel may have expressed generally its agreement with Bechtel's analysis of Daniel's data, the statement of Daniel's welding QC engineer, P.E. Johnson, with respect to that particular erroneous entry, may be more indicative of Daniel's attitude about the attack on its data:

> It might be noted however, that although the inspector mis-entered the

witnesses at the hearing, was that they lacked the specificity required for an engineering analysis; in particular, the exact extent of undersize and undercut (T. 550, 732, 735, 871).[27] The lack of specificity, which is claimed to be a problem with the Daniel data, is far more evident in the Cives data (J.I. Ex. 22). If the validity of the engineering analysis were to be determined by the quality of the data upon which it is allegedly based — the Cives data -- and judged by the same standards imposed on the Daniel data, the engineering analysis would have to be entirely disregarded. There is sufficient reliability to the Daniel data, and, therefore, in the fact that a significant number of embeds have average weld undersize greater than 1/8 inch, to conclude that the Bechtel engineering analysis was based on an erroneous assumption.

41. In addition to undersize, the only other weld condition considered in the Bechtel engineering analysis is undercut.[28] Bechtel assumed a worst case condition of 1/16 inch undercut and concluded that that condition would have no effect on the load carrying capacity of the manually welded plates (Applicant's Ex. 4, Appendix B, Table 3b). The rationale for this conclusion is that the effective load carrying area of the rod is reduced by the threading at the top of the rod, to a greater extent than the reduction in area due to 1/16 inch undercut at the unthreaded base of the rod (Id., Appendix C, 5th page: "Justification for Change Notice 21-77", ¶ iv; Staff's Ex. 6, Attachment A, ULNRC-349, p. 3, ¶ 12). Assuming the threading at the top of the rod is deeper

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(cont.)

amount undersize, that a nonconforming condition did definitely exist. (Board Ex. 1, Enclosure 3 to ULNRC-238, p. 2).

[27] Mr. Schnell complained, for example, that indications of the percent of weld circumference that was undersized or undercut were "almost invariably" lacking (T. 732-33). A review of the Daniel data, however, indicates a tremendous number of embeds for which those percentages are recorded (J.I. Ex. 12, pp. 194-7, 210, 211, 216, 264-76, 279-81, 291, 312, 313, 337, 346, 347, 356-59, 363, 364, 371, 373, 374, 379, 442, 561-64, 567-73, 575, 577-89, 592-99, 601-05, 608, 610).

[28] Undercut is significant even if it does not involve the entire circumference of the rod (T. 695-96).

than 1/16 inch, that is a logical conclusion. There are, however, manually welded embeds with completely unthreaded anchor rods, a fact confirmed by the NRC Staff and Applicant in the Staff's review of the embed issue (Staff's Ex. 6, Attachment A, ULNRC-349, p. 3, ¶ 12; T. 536). The Bechtel engineering analysis failed to consider the reduced load capacity, due to undercut, on those plates (Id., Staff's Ex. 6, Attachment B, ULNRC-354, p. 4, ¶ 12). Applicant's response to the NRC's inquiry regarding this deficiency is wholly unsatisfactory. Applicant stated only that the relaxed welding requirements that were to apply to installations after June 9, 1977 did not apply to the unthreaded manually welded rods (Staff's Ex. 6, Attachment B, ULNRC-354, p. 4, ¶ 12).[29] That does not address the question whether the embeds installed prior to June 9, 1977 are capable of supporting the loads imposed on them. Undercut on an unthreaded rod would reduce the effective area of the rod and, therefore, the rod's load carrying capacity. Bechtel's failure to consider that fact in its engineering analysis is a signficant deficiency.

42. To summarize the preceding paragraphs regarding the Bechtel engineering analysis of manually welded plates, the analysis is deficient in the following respects. The basic assumption upon which it is based, that no plates installed prior to June 9, 1977 have average weld undersize greater than 1/8 inch, is not verified by any documentation. It is not documented in the Cives inspection data, and Cives was not willing to document that its inspectors found no such welds. Second, the load carrying capacity of many of the plates installed prior to June 9, 1977, reduced by the effect of average 1/8 inch weld undersize (the assumed worst case), is equal to or only slightly higher than the actual loads on the plates. Third, uninstalled manually welded plates

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[29]Contrary to Mr. Schnell's statement, there is no indication, either in the change to the PSAR or the revision to the welding requirements of the technical specification (10466-C131), that the allowance of 1/16 inch undercut applies only to threaded rod anchors (Applicant's Ex. 4, Appendix C; J.I. Exs. 70 and 71, Technical Specification 10466-C131, Revisions 8 and 9, respectively, p. 5, ¶ 8.4 in each revision).

were found to have average weld undersize greater than the assumed worst case of 1/8 inch (8 to 10 acknowledged by Applicant and Bechtel; a far greater number found by Daniel), which means that the load carrying capacities of some of the installed plates are likely to be insufficient to hold the actual loads imposed on them. Fourth, the reduced load carrying capacity due to undercut, on plates with unthreaded anchor rods, was not considered. Therefore, the Bechtel engineering analysis provides no support for Applicant's position that the manually welded embeds installed prior to June 9, 1977, are adequate.

43. In addition to relying on the engineering analysis to prove the adequacy of the manually welded plates installed prior to June 9, 1977, Applicant and Bechtel use it to justify a relaxation of the AWS Code requirements (Applicant's Ex. 4, p. 5 and Appendix C; T. 846). Part of the justification for relaxing the code requirements is the claim that they are intended to apply only to linear welds, and not to circular welds attaching clusters of anchor rods to a plate (Id., Appendix C, Justification for Change Notice 21-77). This claim was refuted by Mr. Gallagher of the NRC Staff after he discussed it with a representative of the AWS and others within the NRC ("NRR and I&E HQ people") (Staff's ex. 7, Attachment A, ULNRC-349, p. 1, ¶ 1). Because the Bechtel engineering analysis was deficient, as discussed above, and because the claim that the AWS Code requirements are not intended to apply in this situation has not been established, the relaxed welding requirements are not justified. This is of particular concern with respect to the relaxation of the undercut provision, which appears to apply to both threaded and unthreaded anchor rods, although the effect of 1/16 inch undercut on unthreaded rods has not been determined, as discussed above. Thus, even the safety of the embeds installed after June 9, 1977, which have been manufactured and inspected to the relaxed specifications, has not been demonstrated by Applicant.

44. Apparently because they were not satisfied that the inspection data and the Bechtel engineering analysis were sufficient to establish the adequacy of the manually welded plates installed before June 9, 1977, the NRC Staff requested Applicant to perform physical tests to demonstrate the strength of defective welds (Staff's Ex. 6, p. 9; see also Applicant's Ex. 5, p. 1). As a result, in 1980 Applicant and Bechtel engaged consultants from Lehigh University to assist Bechtel in testing a total of 12 welds on manually welded anchor rods. Bechtel's report on the testing and Applicant's Proposed Findings of Fact claim that the rods tested were examples of the "worst case" conditions (Applicant's Ex. 5, p. 1, ¶ 1 and p. 5, "Summary and Conclusions," ¶ 2, Applicant's Proposed Findings of Fact, pp. 60-61, ¶¶ 83 and 84). However, the rods chosen for testing were clearly not as bad as the worst case found by the Daniel inspectors and were not even as bad as the assumed worst case upon which Bechtel based its engineering analysis. None of the rods had weld undersize of 1/8 inch for the full circumference of the weld, and many of the rods had very little undersize or none at all.[30] Not only were the rods tested not as defective as some that may have been installed prior to June 9, 1977, the tests performed did not deal with the kind of loads that those plates have to support. The Lehigh consultants were not informed by Bechtel and did

[30]The rods tested were selected from the plates held in storage at the plant which had been reinspected by the team of Union Electric, Daniel and Bechtel inspectors (Applicant's Ex. 5, Appendix A, "Detailed Procedure" p. 3, ¶ 4.1). Those plates were "received soon after the commencement of individual on site inspection," which began in early July, 1977 (Applicant's Ex. 6, p. 5; T. 666). Applicant's Ex. 5 contains a list of the 12 rods tested in Appendix A, p. 3, ¶ 4.1 of the "Detailed Procedures" and the inspection reports for those rods, Appendix B. A comparison of those two portions of the report indicates the conditions of the welds that were tested and shows that one of the rods that was bend tested had no weld deficiencies (EP 611 A24-1, rod #5, specimen B5) and that several other rods had only a minor amount of undersize involving only fraction of the circumference of the weld. While the rods that were tension tested appear to be more defective than those that were bend tested, there is no reason why Bechtel could not have tested rods with 1/8 inch and greater undersize extending 360 degrees around the circumference of the weld, even if it had to manufacture them specially for the tests (as it did in the evaulation of SA-312 piping containing centerline lack-of-penetration welding deficiencies).

not know to what loads the plates would be subjected in the plant.[31] Embeds that are installed in walls and support floor beams or piping conduits have as their primary load force, a shear force, downward and parallel to the plate (T. 983, 989-91, 1052). For Bechtel's engineering analysis, it based its calculations "on a combination of shear and bending moment" (Staff's Ex. 6, Attachment B, ULNRC-354, p. 4, ¶ 12). However, the two tests performed at Lehigh on manually welded rods were tension tests and bending tests. Tension tests measure the ability of the plate to withstand a tensile or pulling force, perpendicular to the plate (T. 983). The bend tests were characterized by Dr. Fisher in the following manner: "I frankly don't think it means very much." (T. 1063). Thus, the Lehigh tests reveal little or no information relevant to the capacity of the manually welded plates at Callaway.[32]

45. The final basis for Applicant's contention that the manually welded embeds installed prior to June 9, 1977 are adequate to support the loads imposed on them, is "Dr. Fisher's assessment that even greater reductions in weld size would have no adverse effect" (Applicant's Proposed Findings of Fact, p. 62, ¶ 86). Dr. Fisher expressed the opinion that even if the Daniel inspection data were correct, the embeds would be safe (T. 742-45, 1135-36). Dr. Fisher's opinions are based upon no knowledge of the actual

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[31]Dr. Fisher stated: "Now I am not really qualified to tell you the loads that these plates were subjected to, because I have never seen a diagram, nor have I had described to me the forces that are acting on these plates." (T. 991; see also T. 1050-51).

[32]Even if the Lehigh test results were relevant to Callaway, they would be suspect for two reasons. First, both the Lehigh consultants have had relationships over the past twenty years or more with Nelson Stud Welding Company. Dr. Fisher has been a consultant for Nelson Stud Welding Division of TRW since 1965, and served as an assistant to Dr. Ivan Vies, starting in 1958, in Dr. Vies' capacity as a consultant to Nelson (T. 948, 951). Dr. Slutter has worked over the past twenty years on projects at the Lehigh University Fritz Laboratory which were sponsored in part by Nelson (T. 984-85). Bechtel indicated at the hearing that it normally investigates the prior relationships of outside consultants, and presumably, therefore, knew of the backgrounds of Drs. Fisher and Slutter (Dr. Fisher's vita reflects his relationship with Nelson Stud Welding) (T. 501 (Attachment 4)).

loads imposed on the embeds in the Callaway Plant, and upon no formal analysis or study. The views stated by Dr. Fisher contradict the finding of the Bechtel analysis that with 1/8 inch undersize many of the plates would be loaded to or nearly to their full capacity (Applicant's Ex. 4; proposed J.I. Ex. 78). Under the circumstances, Dr. Fisher's opinions are simply too extreme to be credible. At the conclusion of his testimony on redirect Dr. Fisher stated:

> [I]n my opinion all of the discontinuities that were cited in the Daniel reports were completely acceptable. There should not have been any of those anchors repaired for the purposes cited. It was a complete waste of funds.
>
> If an investigation — if some experiments had been carried out when that problem was first revealed it would have clearly demonstrated what we showed in 1980, that the design was completely capable of being satisfied with even the discontinuities and deviations described in these Daniel inspection reports for the manually-produced embedments.
>
> Q [Galen]: Dr. Fisher, just so I make sure I understand those last comments of yours, is it your testimony that if you take the Daniel data and Joint Intervenors' Exhibit Number 12, the 610-page document, at face value and assume that the worst weld deviations indicated therein extend 100 percent around the circumference of the anchor rods, it would have no effect on the load-carrying capacity of the manually-welded embeds or upon the required margin of safety?
>
> A That is exactly correct.

(T. 1136, emphases added)

That testimony demonstrates either Dr. Fisher's ignorance of the extent of the weld deficiencies in the Daniel data or his willingness to exaggerate. The tests he performed in 1980 clearly were not performed on welds with deficiencies as great as the worst cases in the Daniel data. They were not performed on welds even as deficient as the worst case assumed in Bechtel's engineering analysis (1/8 inch undersize extending around the full circumference). Dr. Fisher and Applicant would have this Board ignore code requirements where an engineer says they are not necessary or that they are in the process of being revised. NRC regulations, however, require that "welding . . . be accomplished in accordance with applicable codes." 10 C.F.R. Part 50, Appendix

B, Criterion IX. The decision regarding the question whether over 200 potentially defective manually welded embeds are adequate to support safety-related loads in the Callaway Plant should not be based upon the opinion of one man, especially where that opinion is based neither upon a thorough knowledge of the conditions at Callaway nor upon formal testing or analysis.

46. The NRC Staff's conclusion that the manually welded embeds installed prior to June 9, 1977 are structurally adequate is based on acceptance of the evidence presented by the Applicant and discussed above, plus the Staff's visual inspection of some of the installed embeds.[33] It is importent to note that the NRC Staff's decision to close the embed issue and accept Union Electric's contentions was made substantially by Eugene Gallagher, formerly of Region III (T. 1297-98). The only item upon which the NRC staff relied that is not discussed in the preceding paragraphs is the staff's inspection of installed plates. The Staff's report indicates that in June 1980 a visual inspection was performed of manually embedded plates "substantially loaded by the floor slab dead loads" (Staff's Ex. 7, p. 5). That the plates may be able to hold dead loads provides no assurance of their adequacy to support live loads over the operating life of the plant. Dead loads are only those imposed by the weight of the structural system and what it supports. Live loads include all transient effects, such as earthquakes and vibrations that can be expected during the operating life of the plant (T. 1143-44). Thus, the NRC Staff's acceptance of Applicant's contention that the manually welded embeds are safe, is entitled to no more weight than the bases relied upon by Applicant to support its position in this matter. The Staff's decision was a low level decision and was not based on any independent testing or analysis.

33The Staff's conclusion is contained in NRC Report No. 80-14 (Staff's Ex. 6, pp. 9-10). Five bases are listed: (1) the reinspection of stored embeds, (2) the Bechtel engineering analysis, (3) NRC inspection of 47 plates on hold at Callaway, (4) the Lehigh tests, and (5) NRC inspection of substantially loaded embeds.

MACHINE WELDED EMBEDS

47. Applicant's contention that the machine welded embeds installed prior to June 9, 1977 are safe is based upon three factors: the results of the Cives and Daniel inspection, the Bechtel probability analysis regarding the likelihood of plate failure, and the results of tensile load tests conducted in consultation with Lehigh University (Applicant's Proposed Findings of Fact, p. 44, ¶ 64). The inspection results are discussed in part E, above. It is interesting to note that where the Daniel inspection data are substantially consistent with Applicant's position they are championed as being reliable data, whereas where the Daniel data are inconsistent with Applicant's position, as in the case of manually welded embeds, they are called unreliable. The probability analysis and Lehigh tests will be discussed in the succeeding paragraphs.

48. Bechtel's probablity analysis, part of its first Final Report on the embed issue published August 10, 1977, concludes that the probability of the failure of a machine welded plate is less than 10^{-11}, or one in one hundred billion (Applicant's Ex. 4, p. 5). Applicant apparently is not sufficiently confident in that result to include it in its proposed findings of fact, but instead reports the probability as less than one in one billion (p. 41, ¶ 60). The NRC Staff does not rely on that probability analysis in its conclusion regarding the safety of the machine welded plates (Staff's Ex. 6, pp. 5-6). "The NRC was suspicious of this analysis" and it has never been reviewed by a member of the NRC Staff with expertise in the area of probability analyses (Staff's Ex. 6, Attachment A, ULNRC-349, p. 2, ¶ 8; T. 1327-28). One major deficiency in the probability analysis is that it uses the data developed by Cives from the inspection of plates not yet installed as of June 9, 1977. No consideration was given to the fact that a majority of the defective plates was manufactured during a particular five month

period during the early period of fabrication.[34] Thus, there has been no attempt to determine how many of the plates installed before June 9, 1977 were manufactured during that period and what loads such plates are required to support. A second deficiency in the ability of the probability analysis to predict plate failure is that it assumed only one stud failure per plate (T. 788-89). Applicant claims that multiple stud failures would only be significant if adjacent studs were involved, and in that case, the overall probability would, at worse, double — thus, it would be two chances in one hundred billion (Staff's Ex. 6, Attachment C, BLUE-700, p. 5). The fallacy of the probability analysis is further demonstrated by the fact that if all of the studs on the machine welded plates are rejectable, the probability analysis would tell us that the chances of a major safety hazard in the power block is roughly 10^{-8}, or one in one hundred million. The result is obtained by substituting the figure 81,673/81,673 for the figure 66/81,673, assuming all other probabilities remain the same (See Applicant's Ex. 4; Staff's Ex. 6, BLUE-700, p. 5).

49. The Lehigh tests performed in 1980 on machine welded embeds installed prior to June 7, 1977 are questionable for several reasons. First, the selection of the plates for testing does not indicate that they are a representative sample. The plates were selected on the basis of their accessibility and the feasibility of mounting test equipment on them. Only two of seven different types of machine welded plates were tested, four EP 512 plates (two with four studs each, one with 12 and one with 16 studs) and two EP 912 plates (each with four studs). The EP 512 plates all had 3/4 inch studs and the two EP 912 plates had 7/8 inch studs. Other machine welded plates at Callaway have from four to 28 studs, and stud sizes of 3/8 inch, 1/2 inch, 3/4 inch

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[34] A Cives letter to Bechtel indicates fabrication commenced in February 1976 and that 378 of the 457 defective studs, and 39 of the 66 failed studs, occurred on plates manufactured between April and August, 1976 (Applicant's Ex. 4, Appendix A, SL:128, p. 1).

and 7/8 inch. (Applicant's Ex. 4, Appendix B, Table 1; Applicant's Ex. 5, Appendix A, p. 5, and Appendix C). In addition, there was no determination whether any of the tested plates was manufactured during the five-month period when the highest frequency of welding defects occurred (See preceding paragraph). In addition, the tests are suspect because of the possible bias of the Lehigh University consultants due to their relationships with Nelson Stud Welding Company (discussed above with respect to the Lehigh tests on the manually welded plates), and the possibility that a dry run was made for these tests in 1978 which perhaps convinced Bechtel and Applicant that these 1980 tests would be successful. The 1978 Lehigh tests were also tension tests on machine welded plates installed in the Callaway Plant performed in the same manner as the 1980 tests (T. 1096). Mr. Schnell and Dr. Slutter testified the 1978 tests were performed to determine the suitability of plates installed with studs bent as much as 45 degrees (T. 1080, 1086-87). Drs. Meyers and Fisher, however, testified that the tests were performed to test a mathematical model that Drs. Fisher and Slutter had developed for the prediction of plate capacity (T. 1083, 1084-85). Dr. Meyers testified that this 1978 test was the only instance he knew of in which Bechtel had conducted a performance test on purchased equipment after its installation at one of Bechtel's nuclear reactor sites (T. 1085). Primarily because there has been no demonstration that the machine welded plates tested at Callaway in 1980 are representative of all those installed prior to June 9, 1977, the Lehigh University tests do not provide an acceptable basis for forming a conclusion regarding the suitability of those machine welded plates.

G. CONCLUSIONS REGARDING EMBEDS

50. The evidence pertaining to the deficiencies in embedded plates, the manner in which they were discovered, and the efforts to evaluate and correct the deficiencies, demonstrates the failure of Applicant's quality assurance program to comply with the requirements of 10 C.F.R. Part 50, Appendix B, in several important respects. First, in the design of the plant there was a failure to select appropriate materials. The use

of manually welded embedded plates as a connection device between concrete and steel is peculiar to nuclear power plants (Applicant's ex. 4, Appendix C, "Justifiction for Change Notice 21-77"). Problems with embedded plates in the construction of such plants is not unique to Callaway. Mr. Gallagher of the NRC Staff was able to name three other plants where problems have been experienced with embeds: the Perry Plant in Ohio; the Hope Creek Plant in New Jersey; and the Washington Public Power Supply System in Washington (T.1320-21). Dr. Fisher's vita indicates he has consulted with Bechtel in the evaluation of embeds at two other plants, the Salem Plant and the Limerick Plant (T. 501 (Attachment 4, p. 8)). Applicant's direct testimony states that the detailed welding requirements of the AWS Code, which were specified in Bechtel's purchase order, are "almost impossible" to satisfy (T. 501 (35-36)). Thus, the selection of manually welded embeds and the specification that they conform to impossible code requirements are contrary to Appendix B, Criterion III. That Criterion provides in part:

> Measures shall also be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essentail to the safety-related functions of the structures systems and components.

Second, there were serious deficiencies in Applicant's inspection program. Documented procedures required both Bechtel and Daniel to inspect the welds on all embeds produced by Cives both prior to shipment and upon receipt (J.I. Ex. 28, pp. 6-7). Prior to the discovery of defective embeds by the NRC, only samples were inspected by Bechtel at the shop, and no receipt inspection for conformance to specifications was performed by Daniel. The failure to inspect embeds constitutes a violation of Appendix B, Criterion VII. Criterion VII provides in part:

> Measures shall be established to assure that purchased material, equipment, and services, whether purchased directly or through contractors and subcontractors, conform to the procurement documents. These measures shall include provisions, as appropriate, for source evaluation and selection, objective evidence of quality furnished by the contractor or subcontractor, inspection at the contractor or subcontractor source, and examination of products upon delivery.

Third, if as they claim, Applicant and Bechtel were unaware of the results of the Daniel inspection and Applicant is unaware of the number of embeds repaired, there was a serious communication breakdown, contrary to Criterion XVI:

> The identification of the significant condition adverse to quality, . . . and the corrective action taken shall be documented and reported to appropriate levels of management.

Fourth, the documentation upon which Applicant and Bechtel purport to rely for the condition of both machine and manually welded embeds — the Cives data — fails to satisfy the requirements of Criterion XVII:

> Sufficient records shall be maintained to furnish evidence of activities affecting quality. The records shall include at least the following: . . . Inspection and test records shall, as a minimum, identify the inspector or data recorder, the type of observation, the results . . .

Fifth, Applicant's failure to prevent the installation of 15 safety related defective embeds constitutes a violation of Criterion VIII — "identification and control measures shall be designed to prevent the use of incorrect or defective material, parts, and components" — and Criterion XV — "[m]easures shall be established to control materials, parts, or components which do not conform to requirements in order to prevent their inadvertent use or installation."

51. In addition, Applicant failed to submit a 50.55(e) report to the NRC regarding the defects discovered in the manually welded embedded plates.[35] The welding defects

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[35]Perhaps a 50.55(e) report was not necessary with respect to the machine welded plates because the discovery of their defects was made by a NRC inspector. It is noteworthy that when the adequacy of embeds with studs bent as much as 45 degrees was in question, Applicant filed a 50.55(e) report (J.I. Ex. 25).

discovered by the NRC were only on machine welded plates. Applicant, however, immediately undertook an inspection program covering manually welded plates as well (Staff's Ex. 6, p. 4). On the first day of inspection by Cives, June 23, 1977, 34 percent of the manually welded plates were rejected (J.I. Ex. 22). Four days later, although no additional inspections were reported, an additional ten defective manually welded plates were shipped back to Cives, bringing the rejection rate to 47 percent. Applicant clearly should have recognized at that time that several of the reporting criteria of 10 C.F.R. §50.55(e) were met. That section imposes the following requirements, among others, on holders of construction permits:

> [T]he holder of the permit shall notify the Commission of each deficiency found in design and construction, which were it to remain uncorrected, could have affected adversely the safety of operations of the nuclear power plant at any time throughout the expected lifetime of the plant, and which represents:
>
> (i) A significant breakdown in any portion of the quality assurance program conducted in accordance with the requirements of Appendix B to this part; or
>
> . . .
>
> (iii) A significant deficiency in construction of or significant damage to a structure, system, or component which will require extensive evaluation, extensive redesign, or extensive repair to meet the criteria and bases stated in the safety analysis report or construction permit or to otherwise establish the adequacy of the structure, system, or component to perform its intended safety function; or
>
> (iv) A significant deviation from performance specifications which will require extensive evaluation, extensive redesign, or extensive repair to establish the adequacy of a structure, system, or component to meet the criteria and bases stated in the safety analysis report or construction permit or to otherwise establish the adequacy of the structure, system, or component to perform its intended safety function.

Even under Dr. Meyer's interpretation of §50.55(e) the embed issue was reportble as "a significant length of time [had] to be taken to do the evaluation" (T. 255).

52. In determining the issue of the adequacy of the manually welded embedded plates installed prior to June 9, 1977, the importance of Applicant's misrepresentations

and misleading statements cannot be minimized. If the embeds were truly safe Applicant and Bechtel ought to have been able to prove it with a straightforward factual presentation of evidence. Instead, the results of Bechtel's engineering analysis were misstated; the Cives inspection data were claimed to provide the kind of specific information needed for an engineering analysis, when in reality practically no specific information is provided in those data; the welds tested at Lehigh University were claimed to represent the "worst case" weld deficiencies, when in reality no weld tested at Lehigh had 1/8 inch undersize around its circumference and some welds had either minor deficiencies or no deficiencies at all.

53. The chronology of events pertaining to the efforts to determine the adequacy of the manually welded embeds that had been installed prior to June 9, 1977 suggests a decision was made before the extent of the deficiencies was known or a formal analysis was conducted. That decision was adhered to without regard to the evidence that was developed later. In late June, despite the fact that at least 25 percent of the manually welded plates were known by Bechtel to be defective, (but most of the plates had not yet been inspected), Bechtel decided the problem was not in the plates, but in the specifications and the code (J.I. Ex. 20). To prove its hypothesis Bechtel assumed certain "worst case" defects and performed an engineering analysis. The analysis showed that many of the installed plates, if defective as assumed, would be required to support loads equal to or danerously close to their full capacities (proposed J.I. Ex. 78). Despite those findings Bechtel reported that none of the installed plates possessed the potental to fail and that a significant margin of safety still existed (Applicant's Ex. 4). Evidence then became available to the NRC showing there were plates found by Daniel inspectors with defective conditions worse than the previously assumed "worst case." If that evidence were to be accepted, the engineering analysis could not have been relied upon. Rather than assume a new "worst case" and perform a new analysis — which would have shown that some plates are overloaded — Bechtel

and Applicant set out to discredit the Daniel data. The Daniel data — that in June 1977 were found by Bechtel to be more accurate and reliable than the Cives data — were rejected in November 1977 in favor of the Cives data. When the NRC still was not satisfied with Applicant's demonstration, performance tests were conducted. But the performance tests were not performed on welds as deficient as the assumed "worst case" in the engineering analysis, or on welds with deficiencies as severe as the "worst case" in the Daniel data. Nevertheless, Applicant and Bechtel characterized the tested welds as typical of the "worst case" welding deficiencies. Finally, it is significant that while some of the machine welded plates that had been installed at Callaway prior to June 9, 1977 were tested in situ, no such in situ tests were performed on the manually welded plates.

54. Assuming Applicant is correct that one isolated embed failure won't cause an entire floor to collapse, Applicant has not demonstrated, in either a formal or informal manner, precisely what will happen in the event of the failure of one manually welded embedded plate. One failure may cause a floor to sag. The failure of one embedded plate would undoubtedly cause additional loads to be placed on other embedded plates. Those other plates may have been loaded already to their full capacities or dangerously close to their capacities. The result of those events could be the collapse of an entire floor, but the evidence presented by Applicant does not address that question. Moreover, Applicant cannot eliminate the possibility of two or more plate failures occurring at the same time, for example, as the result of some external force, such as an earthquake, or some unusual force, such as the vibrations of a malfunctioning pump. Without knowing which of the plates installed before June 9, 1977 contain welding deficiencies there can be no assurance that several adjacent plates are not defective and carrying loads equal or close to their capacities. Such a configuration could result in a chain reaction of failures, like falling dominoes. And while Applicant

claims one plate failure won't cause a catastrophy, it does not indicate how many simultaneous or consecutive failures will cause a catastrophy.

55. Applicant admits that a single failed embed could cause the failure of a piping system whose operation is necessary for a safe emergency shutdown of the plant. Again, however, Applicant's evidence does not rule out the possibility that an earthquake could cause two defective embeds to fail — each supporting one of two redundant piping systems. The potential failure of only one of two redundent systems has its own safety signficance. Removal of redundency is an undesirable event.

56. In conclusion, Applicant has not sustained its burden of proving that the manually welded and machine welded embedded plates installed before June 9, 1977 are adequate to support the loads that will be imposed on them. Moreover, the evidence indicates a broad spectrum of serious quality assurance deficiencies that have implications beyond the issue of embeds.

TABLE 1

MANUALLY WELDED EMBEDDED PLATES WITH AVERAGE WELD UNDERSIZE GREATER THAN 1/8 INCH

Plate Number	Board Ex. 1, Encl. 6 to ULNRC-238 Appendix V Calc. Sheet Page No.*	J.I. Ex. 12 Daniel Page No.	Inspector's Name	Inspection Date	Reason(s) for Bechtel's Rejection **	Cives Data***
EP711-A7-25	p. 1 - entry 12	p. 164	Stuckey and Broxon	6-27-77	R-5	None
EP711-A7-124	p. 2 - entry 31	p. 426	Sabrowsky	8-27-77	X-1	All 6 O.K.
EP711-A7-185	p. 3 - entry 44	p. 426	Sabrowsky	8-27-77	X-1	1 U.S.
EP611-A3-1	p. 5 - entry 1	p. 433	Sabrowsky	8-27-77	R-4, X-1	All 8 U.S.
EP611-A6-5	p. 5 - entry 4	p. 423	Sabrowsky	8-27-77	R-4, X-1	All 8 U.S.
EP611-A6-42	p. 5 - entry 14	p. 425	Sabrowsky	8-27-77	R-1, X-1	All 8 U.S.
EP611-A6-62	p. 6 - entry 17	p. 187	Bryant	7-6-77	R-1, R-4	None

Plate Number	Board Ex. 1, Encl. 6 to ULNRC-238 Appendix V Calc. Sheet Page No.*	J.I. Ex. 12 Daniel Page No.	Inspector's Name	Inspection Date	Reason(s) for Bechtel's Rejection **	Cives Data***
EP611-A6-65	p. 6 - entry 19	p. 426	Sabrowsky	8-27-77	X-1, R-4	All 8 U.S.
EP611-A6-91	p. 6 - entry 23	p. 428	Sabrowsky	8-27-77	Not rejected	None
EP611-A6-117	p. 6 - entry 30	p. 424	Sabrowsky	8-27-77	R-4, X-1	All 8 U.S.
EP611-A6-127	p. 7 - entry 35	p. 424	Sabrowsky	8-27-77	X-1	All 8 U.S.
EP611-A8-11	p. 7 - entry 36	p. 434	Sabrowsky	8-27-77	X-1, R-4	All 8 U.S.
EP511-A11-3	p. 9 - entry 2	p. 429	Sabrowsky	8-27-77	X-1	All 10 U.S.
EP511-A11-22	p. 9 - entry 9	p. 446	Sabrowsky	8-29-77	R-4	None
EP511-A11-33	p. 9 - entry 10	p. 446	Sabrowsky	8-29-77	X-1, R-4	All 10 U.S.

Plate Number	Board Ex. 1, Encl. 6 to ULNRC-238 Appendix V Calc. Sheet Page No.*	J.I. Ex. 12 Daniel Page No.	Inspector's Name	Inspection Date	Reason(s) for Bechtel's Rejection **	Cives Data***
EP311-A9-38	p. 13 - entry 12	p. 488	Broxson	8-31-77	X-1	All 15 U.S.
EP311-A9-44	p. 13 - entry 13	p. 488	Broxson	8-31-77	X-1	All 15 U.S.
EP311-A9-47	p. 13 - entry 14	p. 489	Broxson	8-31-77	X-1	None
EP311-A9-51	p. 13 - entry 15	p. 488	Broxson	8-31-77	R-1	All 15 U.S.
EP211-A5-6	p. 16 - entry 5	p. 484	Waggoner	8-31-77	R-1	All 15 U.S.
EP211-A5-18	p. 16 - entry 10	P. 485	Waggoner	8-31-77	X-1	7 out of 15 U.S.
EP711 Pl.No.18	p. 19 - entry 18	p. 144	Sabrowsky and Bryant	6-24-77	R-2, R-5	None
EP711 Pl.No.19	p. 19 - entry 19	p. 145	Sabrowsky and Bryant	6-24-77	R-2, R-5	None

Plate Number	Board Ex. 1, Encl. 6 to ULNRC-238 Appendix V Calc. Sheet Page No.*	J.I. Ex. 12 Daniel Page No.	Inspector's Name	Inspection Date	Reason(s) for Bechtel's Rejection **	Cives Data***
EP611 Pl.No.10	p. 23 - entry 3	p. 116	Stuckey	6-22-77	R-1	None
EP311 Pl.No.15	p. 27 - entry 4	p. 58	Kisner	6-18-77	R-1	None
EP211 Pl.No.37	p. 29 - entry 4	p. 150	Stuckey	6-24-77	R-1	None

*Starting with the first calculation sheet after calculation sheet key

**See "Key," Board Ex. 1, Encl. 6, Appendix V

*** Number of undersized welds indicated in Cives data according to to Board Ex. 1, Encl. 6, Appendix V

II. SA-358 PIPING

A. SUMMARY AND OUTLINE

57. A piece of SA-358 piping, at the point of installation in the emergency core cooling system at the Callaway Plant, was discovered by a pipefitter to be defective. The pipe in question was manufactured without adequate control and documentation of welding activities. Despite the defective condition of the pipe, Applicant's quality assurance program failed to prevent its being approved for shipment from both the manufacturer of the pipe and the vendor that had assembled it into a pipe spool, and failed to cause it to be rejected upon receipt at the plant site until it was in place for final installation. After discovery of the defective condition the nonconformance was not dispositioned in accordance with documented procedures by Applicant and its contractors. The NRC staff had to rely on communications from a confidential source, and media and citizen involvement, in order to be fully apprised of and to fully evaluate the matter. With that input, the NRC Staff's investigation resulted in the issuance of a notice of violation based upon Applicant's violation of an NRC quality assurance criterion. The evidence fails to establish the safety to the SA-358 pipe in question and demonstrates the failure of Applicant's quality assurance program to identify and properly disposition nonconformances.

The proposed findings and conclusions pertaining to SA-358 piping are organized as follows:

A. Summary and Outline

B. Description of SA-358 Piping, its Manufacture, and Defective Conditions

C. Failure of Applicant's Quality Assurance Program to Identify SA-358 Defects

D. Failure of Applicant to Properly Disposition SA-358 Nonconformances

E. Conclusions Regarding SA-358 Piping

B. DESCRIPTION OF SA-358 PIPING, ITS MANUFACTURE, AND DEFECTIVE CONDITIONS

58. SA-358 is a material specification from the ASME Code for welded stainless steel pipe. The pipe is manufactured by forming and rolling a plate into a tube and then welding the resulting longitudinal seam from both the inside and outside (T. 1537(4), 1545-46). In the case of the pipe in question, the welding was done by the submerged arc welding process. That process involves the use of an electrically charged, continuously fed wire, which creates an electric arc between the end of the wire and the seam of the pipe, melting the end of the wire to act as filler metal for the weld. The arc is submerged beneath a granulated flux which is continously poured over the weld groove. The flux is also melted by the heat from the arc and generates gas which acts as an inert cover for the weld to prevent its contamination by the interaction of air with the molten weld metal (T. 1546-47).

59. The depth or thickness of the weld is determined by the setting of welding parameters, including the travel speed of the weld head over the seam, and the amperage (T. 1547-48). An increase in travel speed would create a thinner weld, while a decrease in travel speed would create a thicker weld (T. 1548). An increase in amperge would cause the weld arc to be hotter and would result in a relatively thicker or deeper weld (Id.).

60. The subject SA-358 pipe was welded first from the inside of the pipe with one pass of a welding machine over the length of the seam (T. 1548-49). The resulting weld would range in width from one-eighth inch to one and one-half inches, and in depth from one-eighth to one-half inch (T. 1549-50).

61. After the initial, inside welding pass is made, backgouging or grinding is performed along the outside seam of the pipe (T. 1550). Backgouging is a grinding operation performed at the bottom of a grooved area on the outside of the longitudinal seam of the pipe, usually by a hand-held grinder (T. 1550-51). The purpose of backgouging

is to grind the weld metal, that was deposited by the inside pass, down to sound metal before the outside welding is performed (T. 1550).

62. After backgouging, the outside of the longitudinal seam of the pipe is welded by one or more passes. In the first welding pass from the outside, weld metal is deposited directly on top of the weld that was made from the inside (T. 1553). The depth of penetration of that first outside welding pass could be in the same range as the inside weld — one-eighth to one-half inch (T. 1554).

63. One of the defective conditions present in the SA-358 pipe in question is excessive reinforcement (or excessive weld metal) on the inside of the pipe, which may have resulted from "melt-thru" or "drop-thru" (T. 1537(9); see Staff's Ex. 7 (pp. 8, 9; Ex. 1, pp. 11, 17)).[36] It was alleged to the NRC, by a confidential source:

> The weld appeared to be a single welded butt joint in which the root pass had fallen through. By fall through I mean that the internal weld bead drooped down or protruded into the pipe an excessive amount and did not fuse uniformly into the plate surface. (Ex. II, p. 1, of Staff's Ex. 7)

The Affidavit of William Key, an NRC inspector, dated September 30, 1981 and submitted in support of the NRC Staff's motion for summary disposition on this issue agrees with

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[36]The terms "melt-thru" and "drop-thru" are defined by the American Welding Society as follows:

> **melt-thru:** Complete joint penetration for a joint welded from one side. Visible root reinforcement is produced (See Fig. 17C).
>
> **drop-thru:** An undesirable sagging or surface irregularity, usually encountered when brazing or welding near the solidus of the base metal caused by overheating with rapid diffusion or alloying between the filler metal and the base metal.

(J.I. Ex. 46, pp. 9, 18, 61)

the alleger, stating: "I reviewed the shop radiographs of the seam weld. In one location I identified some drop through in the root."[37]

64. Conditions that would allow melt-thru or drop-thru to occur in the manufacture of SA-358 pipe are not properly controlled or documented so as to prevent such occurances. Applicant's witnesses concede that melt-thru can occur in the manufacture of SA-358 pipe when the first outside pass is made over the inside weld (T. 1554, 1558). There are no documented instructions or acceptance criteria that apply to the backgouging operation (T. 1551-53). There are no specifications regarding how much backgouging is to be done, or how deep the remaining metal from the inside weld is to be after the backgouging (Id.). The remaining weld metal from the inside pass, onto which the first outside pass is deposited, could be as little as one-eighth or one-sixteenth of an inch thick (T. 1553). Obviously then, if the first outside pass penetrates one-eighth to one-half inch (T. 1554), drop-thru or melt-thru can result.

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[37] Mr. Key's later attempts to abandon that position are highly questionable. After the submission of that affidavit, and during the preparation of direct testimony for the hearing on this issue, the NRC Staff attorneys questioned Mr. Key about his use of the term "drop through":

> Q. In your affidavit, you used the term "drop through" to describe excess weld material in the root of the seam weld. Do you believe that "drop through" was the appropriate term or description to use?

Mr. Key testified that he changed his mind about the existence of drop-thru as the result of his reexamination of the radiograph in early November, 1981 (T. 1729). When asked why he reexamined the radiograph Mr. Key twice evaded the question (T. 1729, 1730), and then stated he wanted to recheck what he had seen before (T. 1731). When asked whether the question regarding the term "drop through" was initiated on his own or by someone else, Mr. Key indicated it was initiated in his own mind (T. 1731). However, Mr. Key finally admitted that the question regarding the "drop through" was submitted to him by the staff attorneys before he reinspected the radiograph in November (T. 1733). Furthermore, Mr. Key's testimony that there was no "drop through" was based on his incorrect understanding of the welding process. In Mr. Key's direct testimony he explained why he then believed there was no "drop through" and states: "In the automatic welding process used on this seam, the weld is prosecuted from both sides at the same time." (p. 2). At the hearing, however, Mr. Key indicated, that to his knowledge, this type of welding is never done simultaneously on the inside and outside (T. 1734-35).

65. The significance of drop-thru or melt-thru is that it can result in the exposure of moten weld metal to the air and thereby affect the mechanical properties of the weld (See Applicant's Answers to Interrogatories of Joint Intervenors (Second Set), No 26(d): "Exposure of the weld puddle to the atmosphere could affect the mechanical properties."). If the mechanical properties of the weld metal were adversely affected, the removal of the excess reinforcement by grinding, the only corrective action taken on the pipe in question, could not restore the mechanical properties and, therefore, could not correct a potentially weak weld (see Staff's Ex. 7 (pp. 9-10)).

66. It also has been alleged that the pipe in question is substantially out-of-round. Out-of-roundness, or ovality, is determined by measuring the diameter at several points on the outer circumference of the pipe and comparing the largest diameter to the smallest diameter (T. 1659, Staff's Ex. 7, p. 15-16). Material Specification SA-358 allows the variance between diamaters to no more than 1% (Staff's Ex. 7, p. 16). Neither Applicant nor the NRC Staff have determined that the ovality of the pipe is within the acceptable standard. The first attempt at determining ovality resulted in a maximum variance between diamaters of 0.125 inches, or more than 1% - a rejectable condition (Staff's Ex. 7, p. 15). One of those diametral measurements was taken directly on the seam weld, so a second set of measurements was taken, resulting in a maximum variance between diameters of 0.092 inches, or 0.0155 inches less than 1% (Staff's Ex. 7 (pp. 15-16); T. 1727). No other measurements were taken (T. 1727-28). All of the measurements were taken on one plane or cross-section of the pipe, 14 inches from one end (Staff's Ex. 7, pp. 15-16; T. 1721).[38] It is likely that some other

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[38]There was a great amount of confusion regarding how ovality is to be determined, and how it was determined in this instance. Applicant's witnesses thought the measurments were taken at the end of the pipe, but they were actually taken 14 inches from the end (T. 1659-60, 1675). While the NRC Report indicates measurements were taken at several planes, only one plane was actually measured (Staff's Ex. 7, pp. 15-16; T. 1674-76, 1719-23). And the selection of the one plane that was measured was not made in any sort of scientific manner (T. 1720-24). Finally, there are apparently

plane or cross-section of the pipe is more oval than the one measured plane (T. 1727-28). In fact, the plane that was measured was selected because it appeared to be round (T. 1720-21).

67. Another of the welding deficiencies identified on the subject SA-358 pipe was a condition of overlap or incomplete fusion (Staff's Ex. 7 (p. 8; Ex. 1, pp. 11, 17)). Incomplete fusion of a weld is a rejectable condition under the ASME Code (T. 1590; Staff's Ex. 7 (3rd page: "Notice of Violation")). Applicant, its contractors and its witnesses at the hearing, used the term "overlap" to describe the same condition (T. 1537 (11-12), 1591-92; Staff's Ex. 7 (Ex. 1, p. 17)). Unlike "incomplete fusion," "overlap" is not identified as a rejectble condition under the ASME Code (T. 1537 (12), 1592).[39]

C. FAILURE OF APPLICANT'S QUALITY ASSURANCE PROGRAM TO IDENTIFY SA-358 DEFECTS

68. Without regard to the issue whether the subject SA-358 pipe is safe to use in its repaired condition, the failure of Applicant's quality assurance program to identify the defective conditions prior to installation of the pipe, is of great concern.

69. Contrary to 10 CFR Part 50, Appendix B, Criterion IX, radiographic indications of incomplete fusion and excess reinforcement, rejectable weld defects, were judged acceptable. This resulted in the issuance of a Notice of Violation, addressed

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(cont.)
no documented procedures that explain how to measure for ovality, or that indicate the first set of measurements, which included one diameter on the seam weld, was improper (T. 1724-25).

[39] Applicant's witness from Bechtel, Mr. Stuchfield, attempted to explain the use of "overlap" rather than "incomplete fusion" merely by blaming Daniel personnel for the choice of the term (T. 1592-93). He did not satisfactorily explain, however, why in Applicant's direct testimony only the term "overlap" is used to describe this condition (Id.). Applicant's other witness, Mr. Laux, testified, based entirely on hearsay, that on the pipe in question the conditions of overlap and incomplete fusion were two separate conditions found on two different areas in the pipe (T. 1593-94). Mr. Laux's explanation is contradicted by the NRC report on the subject (Staff's Ex. 7 (p. 14, ¶ 14)).

to Union Electric Company, dated 6/25/81, and signed by James G. Keppler (Director, NRC Region III):

> 10 CFR Part 50, Appendix B, Criterion IX, states, "Measures shall be established to assure that special processes, including welding, heat treting, and nondestructive testing, are controlled and accomplished by qualified pesonnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements."
>
> Pipe piece No. 5P, part of the accumulator discharge line from accumulator TEPOIA, was manufactured to material specification ASME SA-358. Specification SA-358 requires "Radiographic Examination in Accordance with . . . ASME . . ." Section I, Paragraph PW-51.
>
> ASME Code, Section I, Paragraph PW-51 states "Sections of weld that are shown by radiography to have any of the following types of imperfections shall be judged unacceptable and shall be repaired . . ."
>
> > 51.3.1 Any type of crack, or zone of incomplete fusion or penetration.
>
> Contrary to the above, on March 6, 1981, the inspector determined from review of radiographs of the seam weld on pipe piece No. 5P at film location markers 13-14 that the film indicated apparent incomplete fusion and excess reinforcement and yet the pipe piece had not been judged unacceptable or repaired.

70. The same radiographs on which the NRC inspector identified rejectable weld conditions of incomplete fusion and excess reinforcement had been examined by ARMCO, the manufacturer of the pipe, and by Dravo, the assembler of the spool piece, and judged acceptable (T. 1640-41). Despite the discovery of welding defects by visual inspection at the point of installation, the fact that efforts were underway between 1979 and 1981 to determine the extent and significance of the defects, and the relevance that those radiographs have in making those determinations, no one from Union Electric, Bechtel or Daniel looked at the radiographs in the course of their investigation (T. 1639-41).

71. As discussed above, conditions of melt-thru or drop-thru, and out-of-roundness or ovality, are unacceptable conditions in welded SA-358 pipe. Yet contrary to 10 CFR Part 50, Appendix B, Criterion XVI, no measures were established by

Applicant to assure identification of these deficiencies. Criterion XVI states in part: "Measures shall be established to assure that conditions adverse to quality, such as . . . deficiencies, deviations, defective material . . . and nonconformances are promptly identified. . ."

72. In 1979, when these defects were discovered, the quality control procedures in effect at Callaway for the visual inspection of weld reinforcement, QCP-508, did not contain any reference to melt-thru or drop-thru (T. 1585-88). A later revision (1981) of the same quality control procedure, apparently in an attempt to correct that omission, contains "burn-through" as a rejectable condition (T. 1588-89).[40]

73. Applicant's witnesses were unaware of the quality control procedures employed by the pipe manufacturer, ARMCO, to identify ovality or out-of-roundness, and after the pipe leaves the manufacturer no quality control procedures require any examination for out-of-roundness (T. 1597-1601). The same is true for minimum wall thickness (T. 1599-1601).

74. Weld defects identified through photographs of the weld as fissures or cracks were not identified as a nonconformance, contrary to 10 CFR Part 50, Appendix B, Criteria IX. Criterion IX states:

> Measures shall be established to assure that special processes, including welding, heat treating, and non-destructive testing, are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

NRC IE Report No. 50-483/81-04 states: "Three photographs of the internal weld condition prior to grinding were still available in a QC inspector's file. These three photographs clearly show excessive weld reinforcement and overlap, with two fissures or cracks in the excessive reinforcement (Exhibit X)." (Staff's Ex. 7 (pp. 4, 14)). None

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[40]The American Welding Society defines "burn-thru" as "[a] term erroneously used to denote excessive melt-thru or a hole." (J.I. Ex. 4-6, p. 4).

of the nonconformance or deficiency reports related to this pipe piece cite cracks or fissures as a defect, contrary to Appendix B, Criterion IX. (See Staff's Ex. 7 (Ex. I, pp. 11, 13, 17).

D. FAILURE OF APPLICANT TO PROPERLY DISPOSITION SA-358 NONCONFORMANCES

75. Numerous violations of 10 CFR Part 50, Appendix B, Criterion XV exist in connection with the dispositioning of the various deficiencies and nonconformances in the subject SA-358 pipe. Criteria XV states in part: "Nonconforming items shall be reviewed and accepted, rejected, repaired or reworked in accordance with documented procedures." Applicant and its contractors failed to follow documented procedures in dispositioning the SA-358 pipe deficiencies and nonconformances.

76. Contrary to Criterion XV a nonconformance involving a minimum wall violation (NCR 2SN-0496-P (Staff's Ex. 7, Ex. I, p. 13)) was not dispositioned in accordance with documented procedures when the cause of the nonconformance was identified by an inspector rather than the Project Discipline Engineer. Daniel Administrative Procedure AP-VII-02, Exhibit A, page 3, in paragraph 10, states: "Cause of Nonconformances and Action to Prevent Recurrence - The Project Discipline Engineer shall identify the cause of the nonconformance . . ." (J.I. Ex. 47, emphasis in orginal). NRC IE Report 50-483/81-04, page 16, paragraph 17.b states, "In the 'Cause of Nonconformance and Action to Prevent Recurrence' on the NCR, the QC inspector stated (in part) 'ovality in pipe not recognized by vendor prior to machining counter bore.' This was the inspector's conclusion . . ." (Staff's Ex. 7, p. 16, emphasis added; see T. 1594-97, 1737).

77. Contrary to Criterion XV, Deficiency Report No. 2SD-0699-P, pertaining to the defective conditions of excess reinforcement, and overlap or incomplete fusion (Staff Ex. 7, Ex. I, p. 11), does not define the cause of the nonconformance, as required by documented procedure. Daniel Administrative Procedure AP-VII-02, paragraph 4.4,

page 12, (J.I. Ex. 51) under the heading "PROJECT DISCIPLINE ENGINEER," states, "Define the cause of the deficiency . . ." Deficiency Report No. 2SD-0699-P gives no indication or statement to indicate the cause of the deficiency, but only indicates the pipe was defective when received on site, and that Bechtel should notify the vendor. Bechtel, however, while not determining the cause of the deficiency itself, did not notify the vendor (T. 1645).

78. The nonconformances of overlap and excess reinforcement cited in DR No. 2SN-0501-P were errantly dispositioned contrary to documented procedures when Bechtel returned the report without disposition and the report was superseded by DR No. 2SD-0699-P (Staff's Ex. 7, Ex. 1, pp. 11, 17). Daniel Administrative Procedure AP-VII-02, page 2, differentiates NCR's and DR's as follows:

> 3.4 - Nonconformance Reports (NCR's) shall be used to document material nonconformances which are dispositioned "USE-AS-IS" or "REPAIR." All NCR's required Lead A/E approval or, if NSSS equipment is involved, approval by the NSSS A/E.
>
> 3.5 - Deficiency Reports (DR's) shall be used to document material deficiencies (including procedural violations or quality-related problems) that are dispositioned "REWORK" or "REJECT FOR THIS USE." DR's do not require Lead A/E approval and are considered approved when all required Daniel signatures are obtained.
>
> 1. The Deficiency Report may also be used to initiate correction of either suspected or actual deficiencies in supplier materials or equipment in accordance with the provisions of Reference 2.11. (J.I. Ex. 50)

NCRs are dispositioned by Bechtel, the architect/engineer, whereas DRs are dispositioned in-house by Daniel (T. 1613-14). Thus, when Bechtel returned the NCR to Daniel, Bechtel removed itself from the dispositioning process on this matter (T. 1614). The Glossary to AP-VII-02, Appendix I, page 1, defines "repair" and "rework" as follows:

Repair - A disposition which is imposed when it can be established that a nonconforming characteristic can be restored to a condition such that the capability of the item to function reliably and safely is unimpaired even though that item still may not conform to the original requirement.

Rework - A disposition which is imposed when it can be established that a nonconforming item or activity can be made to fully conform to a prior specified requirement. Nonconforming items (materials) shall be dispositioned as "Rework" when conditions 1 and 2, condition 3 below are satisfied.

1. Correction of the nonconforming item can be accomplished by using the same or equivalent processes specified in the drawing and specification requirements.

2. The end condition of the item will be unchanged from that specified in the drawing and specification requirements; particularly, regarding physical or chemical properties, and especially stress/strain properties.

3. When provided for in the applicable specification, correction of the nonconforming item can be accomplished using a procedure which has been approved by the responsible design organization. (J.I. Ex. 44, emphasis added)

Thus, both repair and rework require that specific conditons "can be established." When NCR 2SN-0501-P was superceded by DR 2SD-0699-P the onus of responsibility to establish the conditions for a DR rework disposition was placed by Daniel International Corp. onto Bechtel. The NCR states under the heading "Statement of Corrected Action," "This NCR is superceded by DR #2SD-0699-P per Bechtel disposition (See attach B) which states this is not a NCR category item." However, Bechtel's disposition and letter to support it do not establish that the items are not NCR category items, or that they are DR items, contrary to AP-VII-02. NRC IE Report 50-483/81-04 states, on page 9, as follows:

The Nonconformance Report (NCR 2SN-0501-P) documenting overlap and excessive reinforcement was also sent to Bechtel for disposition. By letter dated June 1, 1979, the report was returned by Bechtel to the Callaway site without disposition. The reason for this action was a conclusion that the observed conditions did not "fall under NCR category." It should be noted that to return a Nonconformance Report without disposition is not equivalent to a disposition to "use-as-is." Such a response can indicate that (1) the NCR is in error, or (2) disposition by other means such as a Deficiency Report is more proper.

The June 1, 1979, Bechtel letter addresses both observed nonconforming conditions, excessive weld reinforcement and overlap (See Exhibit B of Investigation Report No. 50-483/80-10). The paragraph regarding reinforcement height requirements appears to be incorrect in that it references sections of ASME III, whereas Paragraph 5.2.3 of material specification ASME SA-358 should have been identified as the applicable specification for a vendor weld, allowing 1/8 inch of reinforcement.

The paragraph in the June 1, 1979, Bechtel letter regarding overlap contains an incorrect observation that material specification ASME SA-358 references ASME section VIII, Paragraph UW-51(b). SA-358 references ASME Section I, Paragraph PW-51. The reference to ASME Section VIII is likewise in error as seciton VIII does not pertain to the piping covered by Section III. However, the wording of both Sections is virtually identical (the Code often duplicates Sections) and neither refers to "overlap" as a rejectable condition for radiography. This error is not considered significant. What was significant was the apparent acceptance of overlap as a weld condition. (Staff's Ex. 7, p. 9).

and

[I]t is of concern that the Architect-Engineer's failure to disposition the Nonconformance Report reflected a misinterpretation of Code requirements. (Id.; see also T. 1623-25)

From these facts it is clear that the conditions required by AP-VII-02 to establish a DR disposition were not met and, therefore, that the nonconformances involved were not repaired or reworked in accordance with documented procedures as required by Criterion XV.

79. In addition to the errors in the June 1, 1979 Bechtel letter, a great deal of confusion apparently existed in the dispositioning of the overlap and excess reinforcement deficiencies covered by NCR 2SN-0501-P and DR 2SD-0699-P. For example, on NCR 2SN-0501-P (Staff's Ex. 7, Ex. I, p. 17) there are four boxes which

can be checked on the right-hand side of the recommended disposition section of the form: "Rework," "Repair," "Use-as-is," and "Reject." Three of the four boxes were checked at one time or another: "Repair," "Use-as-is," and "Reject," indicating either some indecision regarding what to do with this pipe, or a lack of understanding regarding the proper use of the NCR form (T. 1602-06). The only unchecked box on the NCR form — "Rework" — ended up as the disposition that was finally decided on after the matter was transferred to a deficiency report, DR 2SD-0699-P (Staff's Ex. 7, Ex. I, p. 11).

E. CONCLUSIONS REGARDING SA-358 PIPING

80. Questions remain regarding the safety of SA-358 piping at the Callaway Plant. As indicated in Part B, above, several defective conditions were identified in one four foot piece of Sa-358 pipe in the emergency core cooling system at the plant. The full extent of the out-of-roundness or ovality condition has not been determined. More importantly, however, the cause of the deficiencies has not been established.[41] If the excess reinforcement, overlap and fissures or cracks in the weld were caused by melt-thru, or drop-thru, the weld metal could have been contaminated by the air inside the pipe, and surface grinding would not have restored the pipe to prior specified requirements. If the defects were caused by melt-thru or drop-thru, all of the weld metal would have been deposited from the outside of the pipe. The pipe in question was supposed to have been double-welded, and grinding the surface of the weld could not bring the weld in compliance with that requirement. If the defects were not caused by melt-thru or drop-thru, they may have been caused by inadequate control of welding parameters by the manufacturer of the pipe (amperage, travel speed, backgouging).

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[41]On the deficiency report that pertains to the excess reinforcement and overlap conditions, DR 2SD-0699-P, the only indication of the cause of the nonconformance is that the pipe was received on site in its defective condition (Staff's Ex. 7, Ex. I, p. 11). In direct testimony Applicant's witness merely describes the possible causes of "such a condition" and states that "burn-thru" — an erroneous term for excessive melt-thru which results in a hole — could not have been the cause (T. 1537 (12-13)).

81. There is a reasonable possibility of the existence of defects of a similar nature in other SA-358 pipe at the plant. As noted by the NRC Staff in the Notice of Violation, radiographic film of the defective area "indicated apparent incomplete fusion and excess reinforcement and yet the pipe piece had not been judged unacceptable or repaired." (Staff's Ex. 7, 3rd page). Since the manufacturer (ARMCO) and the spool piece assembler (Dravo) did not judge this area unacceptable, it is reasonable to believe other similar areas would be judged in the same manner. The identified defects were located near the end of a spool piece, close to a field weld preparaton. Their accessible location facilitated their discovery. Less accessible defects may remain undiscovered. Dravo's craft personnel and inspectors could not easily avoid seeing the defective area of the pipe piece during assembly of the spool piece, yet they did not report it as a nonconformance. It is reasonable to believe they would not report similar defects. Finally, although Bechtel itself did not determine the cause of the defects, it did not even communicate the matter to Dravo or ARMCO for their opinion of the cause, or to try to prevent recurrence of the problem.

82. Without a determination of the cause of the nonconformance, in a system necessary for safe shutdown of the plant in the event of emergency, Applicant cannot meet its burden of proving that SA-358 piping can be used without endangering the health and safety of the public. 10 CFR Part 50 Appendix B, Criterion XVI provides in part: "In the case of significant conditions adverse to quality, the measures shall assure that the cause of the condition is determined and corrective action taken to preclude repetition."

83. The numerous quality control deficiencies regarding the identification and the dispositioning of the SA-358 pipe nonconformances, described above in Parts C and D, respectively, indicate the overall unreliability of Applicant's quality assurance program to assure that all "structure[s], system[s] [and] component[s] will perform satisfactorily in service." 10 CFR Part 50, Appendix B, Quality Assurance Criteria, Introduction.

These deficiencies demonstrate Applicant's failure to establish measures adequate to assure that purchased material conforms to all necessary specifications (as required by Criterion VII), and to establish measures adequate to assure that nonconformances are discovered, and once discovered, that they are properly corrected or otherwise dispositioned (as required by Criterion XVI).

84. Not only does the evidence regarding SA-358 piping establish the inadequacy of Applicant's quality assurance program, it establishes deficiencies in the NRC Staff's investigation and enforcement functions. With the combination of a weak quality assurance program and less than adequate regulatory inspection and enforcement activities, confidence in the safe construction of the plant is lacking. The performance of the NRC Staff in connection with the SA-358 pipe demonstrates its unreliability as a back-up to Applicant's quality assurance program. Were it not for the efforts of an alleger who operated with a promise of confidentiality, together with the media and Kay Drey, the NRC Staff would have had no knowledge of the SA-358 nonconformances and would not have conducted the investigation that led to the issuance of a Notice of Violation regarding Applicant's quality assurance program (T. 1686-90; J. I. Ex. 53).

III. SA-312 PIPING

A. SUMMARY AND OUTLINE

85. SA-312 piping, installed in the emergency core cooling system and other safety-related systems at the Callaway Plant, was manufactured without adequate control of welding parameters. This lack of control resulted in a defective condition of incomplete fusion in the longitudinal weld of the pipe, known as centerline lack-of-penetration (CLP). Because nondestructive examination methods are unable to detect it, the extent of the CLP defect in any particular piece of pipe is unknown. The evaluation and acceptance of this substandard piping were inadequate and were not performed in accordance with the ASME Code. The evidence fails to establish the safety of the SA-312 piping installed in the plant, and indicates the inadequacy of Applicant's quality assurance program.

The proposed findings and conclusions pertaining to SA-312 piping are organized as follows:

A. Summary and Outline

B. Description of SA-312 Piping and its Manufacture

C. Location and Function of SA-312 Piping Installed at Callaway

D. Cause of the Defect: Inadequate Control of SA-312 Welding Parameters

E. The Extent of the Defect in SA-312 Piping at Callaway is Unknown

F. Inadequate Evaluation and Acceptance of SA-312 Piping

G. Conclusions Regarding SA-312 Piping

B. DESCRIPTION OF SA-312 PIPING AND ITS MANUFACTURE

86. A description of SA-312 pipe and how it is manufactured is contained in Applicant's direct testimony on this issue:

> SA-312 is an ASME material specification for both seamless and welded stainless steel pipe. Welded SA-312 pipe is made from plate by forming and rolling the plate into a tubular shape. The longitudinal seam is then autogenously welded (without filler metal) by the gas tungsten method. The weld is made from both the inside and outside surfaces for double welded pipe, and from the outside for single welded pipe. (T. 1773 (16); see also J.I. Physical Exhibit D)

The particular defect with which we are concerned is centerline lack-of-penetration (CLP), which occurs only in double-welded pipe (T. 1773(17)).

87. In addition to straight lengths of pipe, SA-312 welded material is also made into fittings such as elbows, T fittings and reducers, in accordance with ASME material specification SA-403 (T. 1777; see J.I. Physical Exhibits E, F and G, respectively). Elbows are manufactured from SA-312 pipe by bending a straight length of pipe into the desired shape (T. 1778-79). T fittings are made by piercing the SA-312 pipe and either forging the T protrusion from the SA-312 material or welding the protrusion to it (T. 1779-80). Reducers are made by increasing the diameter of one end of a straight length of SA-312 pipe by spinning or pressing (T. 1780).

C. LOCATION AND FUNCTION OF SA-312 PIPING INSTALLED AT CALLAWAY

88. NRC IE Bulletin No. 79-03, dated March 12, 1979 (Ex. XI to Staff Ex. 7), which reported the discovery of longitudinal weld defects in SA-312 pipe manufactured by Youngstown Welding and Engineering Co., required licensees and construction permit holders (such as Applicant) to determine and report the use and planned use of such material at their plants. In response, Applicant submitted to the NRC a letter, ULNRC-314, dated May 11, 1979 (Applicant's Ex. 10). Enclosure 5 to that letter identified 65 pipe spools that contained the subject pipe (Id.). Those pipe spools had been installed or were planned for installation in four systems in the Callaway Plant, designated EJ, EM, EC and BN (Id.)

89. The EJ designation refers to the Residual Heat Removal (RHR) system (T. 1786, lines 23-25). The RHR system contains 56 of the 65 pipe spools initially identified

as containing the subject SA-312 pipe (Applicant's Ex. 10). The two functions of the RHR system are "to remove residual heat from the reactor core during normal shutdown of the plant" and to inject low pressure coolant into the core following a loss of coolant accident as part of the emergency core cooling system (ECCS) (T. 1783). At times, the RHR system contains primary coolant (T. 1973).

90. The EM system is the high pressure coolant injection system, which is also a part of the ECCS (T. 1987-88).

91. The EC system is the fuel pool cooling system (T. 1782-83). The function of the pipe spools containing SA-312 pipe in that system is to drain the refueling canal following a loss of coolant accident or a steamline break accident (T. 1785-86).

92. The BN designation refers to the refueling water storage tank system, which provides a volume of borated water, for the ECCS and for filling the refueling canal during normal refueling operations (T. 1783, 1787).

93. Some of the pipe spools at Callaway containing SA-403 fittings made from SA-312 welded material were identified by Applicant in response to a request by Joint Intervenors (T. 1789; J.I. Ex. 59 and 60). The identified fittings are contained in pipe spools in the EJ system (residual heat removal), and the EP and BG systems (J.I. Ex. 59 and 60).

94. The EP system is the accumulator injection system, a component of the ECCS comprised of four accumulator tanks containing borated water, and piping to inject that water into the reactor coolant system in the event of pressure loss (T. 1785, 1792).

95. The BG system is the chemical and volume control system (CVCS), which "provides a method for controlling the chemistry of the reactor coolant system" and "a mechanism for controlling the volume of the reactor coolant system by making up and letting down as required." (T. 1792-93). The CVCS at times contains primary coolant (T. 1793).

96. The ECCS is comprised of four subsystems: the residual heat removal system, the high pressure coolant injection system, the refueling water tank storage system and the accumulator injection system (T. 1788). As set forth in the preceding eight paragraphs, all four of those subsystems contain the subject SA-312 pipe, either in straight lengths, SA-403 fittings, or both.[42]

D. CAUSE OF THE DEFECT: INADEQUATE CONTROL OF SA-312 WELDING PARAMETERS

97. The welding imperfection or defect with which we are concerned is centerline lack-of-penetration (CLP) in double-welded SA-312 pipe manufactured by Youngstown Welding and Engineering Co. (IE Bulletin 79-03, Ex. XI to Staff's Ex. 7). The manufacturing process involved rolling a plate into a tube and then welding the seam along the length of the tube from both the inside and the outside (T. 1794). Before welding, the seam consists of two square, flat edges of plate which are butted together (T. 1794-95). CLP results when the inside weld and the outside weld do not meet in the center of the seam, leaving an unwelded plane inside the pipe wall (T. 1773(17) and (Figure 1), 1798-99).

98. The cause of the CLP defect in the subject SA-312 pipe was inadequate control of welding parameters by Youngstown Welding and Engineering Co., the manufacturer of the pipe (T. 1799; IE Bulletin No. 79-03, p. 2, Ex. XI to Staff's Ex. 7).

99. The documented welding procedures in effect at Youngstown when the subject SA-312 pipe was manufactured are contained in Welding Procedure Specification (WPS) No. 750 (the first two pages of J.I. Ex. 61; T. 1800).

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[42]The accumulator injection system also contains the piece of SA-358 pipe that is the subject of Joint Intervenors' Contention One, part II.A.1.

100. The parameters controlled by WPS No. 750 that would effect the depth of penetration of the welds along the seam, and, therefore, which could cause CLP if improperly controlled, are (1) amps, (2) travel speed and (3) oscillation (T. 1800-01).

101. The range of amps allowed by WPS No. 750 is 80 to 425 (J.I. Ex. 61, p. 2). As amperage increases the heat of the weld increases causing the depth of penetration to increase as well (T. 1801).

102. The range of travel speeds allowed by WPS No. 750 is six (6) inches to 26 inches per minute (J.I. Ex. 61, p. 2). As travel speed increases, causing the weld arc to move faster over the seam, shallower penetration results (T. 1801).

103. Oscillation refers to the movement of the weld head as it travels along the length of the seam (T. 1801-02). The range of oscillation allowed by WPS No. 750 is 0 to 25 oscillations per minute (J.I. Ex. 61, p. 2; T. 1802). Lower oscillation frequency results in deeper weld penetration (T. 1802).

104. WPS No. 750 is applicable to SA-312 pipe with wall thicknesses ranging from 1/16 to 3/8 of an inch (J.I. Ex. 61, p. 1; T. 1800). The parameter ranges described above for amps, travel speed and oscillations apply to the entire thickness range of the pipe (J.I. Ex. 61; T. 1802). Therefore, WPS No. 750 allows for welding of the thickest pipe (3/8 inch), at parameter settings which would result in the shallowest weld penetration - lowest amps, fastest travel speed and highest oscillation frequency (T. 1803).

105. Another factor or parameter that determines weld penetration in the seam is the alignment of the welding arc over the seam to be welded (T. 1804). Misalignment of the arc over the seam would cause CLP when the resulting misaligned weld beads do not meet in the center of the seam (Id.). A photograph showing a portion of a cross-section of Youngstown SA-312 Pipe with CLP which resulted from misalignment of one of the welding arcs is contained in the 1979 Aptech report, figure 1.1, p. 1-2 (T. 1807; Applicant's Ex. 12; see also Applicant's Ex. 11, p. 6, which appears to be a

better reproduction of the same photograph). Misalignment can occur in two different ways: either mechanically, when the operator has misaligned the welding head with the seam; or electrically, when the welding arc is drawn away from the seam by stray electric currents or magnetic fields (T. 1808). In addition, electrical misalignment can occur along with mechanical misalignment, further removing the welding arc from the center of the seam (T. 1882).

106. After a weld has been made with a grossly misaligned arc, so long as the weld bead covers the outer edge of the seam, it is impossible to determine visually that there was any misalignment (T. 1805).

107. There is no documentation of and Applicant's witnesses had no knowledge of how Youngstown controlled for alignment of the welding arc over the seam (T. 1804-05, 1808). Despite the fact that misalignment is known to exist, known to cause CLP and impossible to detect visually, the Youngstown documents which govern this welding procedure "assume" perfect alignment (T. 1805).

E. THE EXTENT OF THE DEFECT IN SA-312 PIPING AT CALLAWAY IS UNKNOWN

108. Applicant is unable to state the maximum amount of centerline lack-of-penetration (CLP) that could be produced under the welding procedure (WPS No. 750) that governed the manufacture of the SA-312 pipe in question. All that applicant can state is that the maximum amount of CLP discovered is 26% of the wall thickness of the pipe (Applicant's Answers to Interrogatories of Joint Intervenors (Second Set), September 10, 1981, No. 24(b); T. 1811).

109. There is insufficient evidence to support Applicant's claim that CLP of 26% of pipe wall thickness is the maximum amount of CLP in SA-312 pipe at Callaway. That greater amounts of CLP may exist is based upon the facts that (1) nondestructive examination methods do not detect CLP; (2) none of the SA-312 pipe at Callaway, and only a small sample of the SA-312 pipe manufactured by Youngstown has been inspected

for CLP; (3) the amount of CLP can vary significantly along the length of a pipe; and (4) the wide range of documented welding parameters, especially when coupled with the undocumented misalignment factor, creates a potential for great amounts of undetected CLP.

110. The ASME Code requires that all SA-312 welded pipe be nondestructively examined by any one of several methods (T. 1773(16), 1828). The usual method chosen by manufacturers is the ultrasonic method (T. 1773(16)). The ultrasonic and radiographic methods are the only two of the nondestructive examination methods specified by the Code which are designed to detect internal, as opposed to surface, discontinuities, such as CLP (T. 1773(10)). Nondestructive examination methods are now known to be inadequate for detecting CLP in SA-312 pipe (T. 1773(34), 1797, 1828). The Bechtel report on SA-312 pipe (Applicant's Ex. 11, p. 3) contains the following conclusions:

> 1. Radiographic (RT) examinations cannot detect centerline lack-of-penetration (CLP) in double welded ASME SA-312 pipe when the two unfused plate edges are in intimate contact. When some discrete gap exists between the unfused faces, radiographic examination can detect CLP. The size of gap necessary in order to detect CLP by radiography has not been determined.
>
> 2. Conventional ultrasonic (UT) examination techniques cannot detect CLP in double welded ASME SA-312 pipe either when the two unfused plate edges are in intimate contact, or when there is a discrete gap between them.
>
> It was found in this investigation that conventional shear wave UT may indicate an acceptable weld in accordance with ASME Section III, even when the CLP exceeds 50 percent of the wall thickness. (Emphasis added)

These conclusions were confirmed by the NRC in IE Bulletin No. 79-03A (Ex. XII to Staff's Ex. 7, p. 1):

> It has been determined that conventional ultrasonic testing (UT) and radiographic testing (RT) techniques (as required by ASME Section III) are not adequate to detect centerline lack of weld penetration (CLP). Conventional radiography and UT examinations may detect the presence of CLP under special conditions, but neither can be considered reliable enough to detect CLP even when significant percentages exist.

Therefore, the required examination and testing that was performed by the manufacturer on the SA-312 pipe shipped to Callaway provides no reliable information regarding the extent of CLP in that pipe. Mere operator error in the setting of welding parameters could produce extreme amounts of CLP, which could not be detected.

111. To determine the maximum amount of CLP in SA-312 pipe, Bechtel examined only 71 cross-sections of 520 feet of pipe that had been manufactured by Youngstown Welding and Engineering Co. and shipped to Pullman Power Products, not Applicant (T. 1773(24), 1813, 1816; Applicant's Ex. 11, pp. 2 and 20). Youngstown, however, manufactured approximately 25,000 feet of SA-312 pipe over a period of at least 3 1/2 to 4 years, using the same deficient welding procedure (WPS No. 750 (J.I. Ex. 61)) (T. 1818). Thus, only 2% of the subject pipe was selected for examination and no documentation exists to correlate the Pullman pipe with the Callaway pipe. In addition, there is no evidence that the 71 cross-sections that were examined provided a reliable sample of the 520 feet of pipe that were selected for examination. Applicant's witnesses were unable to state how the 71 cross-sections were selected (T. 1817). It is possible that some of the cross-sections were actually two ends of the same cut, or in other words, the exact same point on the pipe (T. 1817-18), a factor that could reduce the number of cross-sections examined by as much as one-half.

112. The unreliability of the small sample of examined SA-312 pipe to predict the "worst case," or the maximum amount of CLP in SA-312 pipe at Callaway is further demonstrated by the fact that the extent of CLP is not constant, but may vary, along the length of a pipe (T. 1816). CLP may exist in the center of a pipe which contains no CLP at the ends (T. 1817). Applicant's witness, Mr. Stuchfield, testified on redirect

that the "maximum" amount of CLP variation along a length of pipe would be plus or minus four or five percent (T. 1879). On recross-examination, however, Mr. Stuchfield acknowledged that a variation of nine percent was observed in the small sample that had been examined by Bechtel, and admitted that in the large amount of SA-312 pipe that was manufactured, variations may even exceed nine percent (T. 1882-83).

113. Finally, the wide range of ducmented welding parameters (WPS No. 750 (J.I. Ex. 61)), and the undocumented factor of misalignment of the welding arc on the seam, create a potential for CLP which may greatly exceed the 26% found by Bechtel. Applicant bases its conclusion that no more than 26% CLP exists in SA-312 pipe at Callaway on the assumption that the pipe shipped to Callaway was manufactured in the same manner as the pipe examined (T. 1813-14) and the assertion that in order to manufacture SA-312 pipe with more than 26% CLP the documented welding parameters of WPS No. 750 (J.I. Ex. 61) had to be exceeded (T. 1811-12; see also T. 1773 (24-25)). Applicant's conclusion essentially ignores the issue of misalignment. The only support for the assumption that the unexamined SA-312 pipe at Callaway was manufactured in the same manner as the SA-312 pipe that was examined is the fact that the same written welding procedure (WPS No. 750 (J.I. Ex. 61)) was in effect at Youngstown for the manufacture of both. However, Applicant is aware of no documented or undocumented procedure in effect at Youngstown controlling the alignment of the welding arc over the seam, which, as discussed above, was one of the factors that caused the CLP (T. 1804-05, 1808). Moreover, there is no way to visually detect the existence of misalignment after the welding is complete (T. 1805). Applicant has no documentation or quantitive estimate of the extent of misalignment in the SA-312 pipe produced at Youngstown Welding and Engineering (T. 1882). With no control for misalignment, no way to visually detect it, no documentation or estimate of its extent, there can be no assurance that gross misalignment, resulting in extreme CLP, did not occur in the manunfacture of the SA-312 pipe for Callaway. Applicant's assertion that

to produce CLP greater than 26% the Youngstown welding parameters had to be exceeded is not documented (T. 1839-41). More importantly, that assertion is totally meaningless because misalignment also causes CLP, but was not one of the parameters considered in producing the samples of CLP that exceeded 26% (T. 1811-12).[43] Applicant simply has not provided reasonable assurance that some combination of parameters — low amperage, high travel speed, high oscillation frequency, and misaligned welding arcs — did not produce, in SA-312 pipe at Callaway, CLP greatly exceeding 26%.

114. As part of the Aptech analysis of the inspection data developed by Bechtel, in which a maximum of 26 percent CLP was discovered, Aptech concluded by statistical analysis that the maximum extent of CLP that could be expected to be found in all the pipe examined by Bechtel (520 feet) was 36 percent (Applicant's Ex. 13, Summary p. 3, Section 4 p. 4, Section 9 ¶5). This statistical finding was denied at the hearing (T. 1813).

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[43] Applicant claims that misalignment is insignificant when the other parameters are causing shallow weld penetration because the weld is flat rather than bell shaped (T. 1815-16; Applicant's Proposed Findings of Fact, p. 119, ¶162, fn. 73). That claim may be valid, but it does not answer the question of how much CLP could be produced when deep weld penetration occurs, but, because of misalignment, the penetration is not centered on the seam. An example of misalignment causing CLP is contained in Applicant's Ex. 11, (Figure 1, p. 6). On that photograph the top (outside) weld is obviously misaligned to the right. The total pipe wall thickness (in the photograph) is 58 millimeters; the top weld penetrates 14 mm on the seam; the bottom weld penetrates 33 mm; leaving 11 mm of the seam unwelded; and producing CLP of 19%. A few simple hypothetical variations demonstrate that extreme amounts of CLP can result from misalignment. First, if the misalignment of the arc producing the top weld were more extreme, causing penetration on the seam of only 5 mm, a space of 20 mm would remain unwelded and CLP would be 34.5%. Secondly, if the bottom arc were misaligned to the same extent as the top arc in the photograph, penetration would be 14 mm from the top and 14 mm from the bottom, leaving 30 mm unwelded or CLP of 52%. Finally, there is no reason to exclude the extreme case where misalignment of both arcs would result in only 2 mm of penetration from both the top and bottom, leaving 54 mm unwelded, and CLP of over 90%.

F. INADEQUATE EVALUATION AND ACCEPTANCE OF SA-312 PIPING

115. Evaluation and acceptance of welded SA-312 pipe for a nuclear power plant are required to be accomplished in accordance with the ASME Code (T. 1821-23).[44] The specific examination requirements and acceptance criteria for SA-312 welded pipe for Class 2 systems are contained in part NC 2550 (T. 1821-23; J.I. Ex. 63; Applicant's Ex. 15). The pipe in question was not rejected by the manufacturer because the testing method it employed, ultrasonic examination, was unable to detect CLP (T. 1827). The Code acceptance criteria, however, require rejection of pipe found to contain significant amounts (up to 26%) of CLP (T. 1823-26, 1842-43).[45]

116. Since the test methods prescribed by the ASME Code were found to be ineffective in detecting CLP, Applicant substituted another nondestructive method, the etch test, to detect CLP on a sample of SA-312 welded pipe and found up to 26% CLP (T. 1773(24), 1811, 1813, 1816; Applicant's Ex. 11, pp. 2 and 20). The etch test is not recognized by the ASME Code for this purpose and, therefore, no Code acceptance criteria are established for it (T. 1842). However, the etch test is similar to the liquid penetrant examination in that both methods allow visual detection of an unwelded gap in the cross-section of a pipe wall, after the surface to be examined has been treated — by chemical etching in the etch test, and by application of a dye in the liquid penetrant test (T. 1773(11), 1842). While the liquid penetrant method won't detect CLP unless there is a gap between the unwelded surfaces (T. 1841), the Code acceptance

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[44] NRC Quality Assurance Criteria, 10 CFR Part 50, Appendix B, provides in part:

IX. CONTROL OF SPECIAL PROCESSES

Measures shall be established to assure that special processes, including welding, heat treating and nondestructive testing, are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

[45] Any amount of CLP detected by radiography requires rejection of the pipe (T. 1823-4, 1824-25).

criteria for the liquid penetrant test would be applicable to the etch test (T. 1842). Those acceptance criteria require rejection of 3/8 inch SA-312 pipe with CLP in excess of 15% (T. 1843; J.I. Ex. 63, sec. NC 2546.3). Thus, as indicated in this and the preceding paragraph, CLP of 26% is clearly unacceptable according to the ASME Code.

117. In addition to the nondestructive examination required to be performed on <u>all</u> SA-312 welded pipe pursuant to NC 2550, small samples of such pipe are required to be mechanically tested, in a destructive manner, pursuant to the material specification, SA-312 sec. 10 (T. 1773(16); J.I. Ex. 67; Applicant's Ex. 17). Material specification SA-312 sec. 10 requires a tension test, a flattening test and a hydrostatic test (J.I. Ex. 67; Applicant's Ex. 17). The Bechtel report states that "[a]ll of the mechanical property requirements of ASME SA-312 were met with CLP up to 26 percent." (Applicant's Ex. 1, p. 2). Tension and hydrostatic testing was performed by Bechtel on SA-312 pipe with 26% CLP, but the third Code-required mechanical test, the flattening test, was not performed on such pipe (T. 1845-46). Thus, the above-quoted statement by Bechtel is not substantiated. That the flattening tests were performed in the ordinary course of events by Youngstown on its production pipe in no way relates to the significance of the CLP problem. The amount of CLP, if any, in those flattening tests was not known (T. 1845-46).

118. Applicant relies in part on hydrostatic burst tests performed on SA-312 pipe with varying amounts of CLP in concluding that the pipe in question is acceptable. Those burst tests were performed by Youngstown Welding and Engineering, the manufacturer of the pipe in question (T. 1864-65).[46]

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[46]Criterion X of 10 CFR Part 50, Appendix B, provides in part:

A program for inspection of activities affecting quality shall be established and executed by or for the organization performing the activity to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity. <u>Such inspection shall be performed by individuals other than those who performed the</u>

119. Two separate analyses were performed by Aptech on the issue of CLP in SA-312 pipe (Applicant's Exs. 12 and 13). Assuming the analyses were technically correct, any conclusions they drew are suspect because the assumptions made for those analyses regarding the extent of CLP were based upon the small sample of data inspected by Bechtel which has not been correlated with the SA-312 pipe at Callaway and upon the results of the burst tests performed by Youngstown (Applicant's Exs. 12 and 13). One of the conclusions of the Aptech analyses relied on by Applicant is that by fracture analysis it was determined that the critical CLP size, the amount above which catastrophic failure can occur, is greater than the wall thickness of the pipe (Applicant's Proposed Findings of Fact, ¶ 164). That conclusion suggests the absurd result that completely unwelded pipe would be acceptable.

120. Bechtel concluded and recommended to the NRC staff that for piping systems subject to design hoop stresses of less than 85% of allowable ASME Code stresses, SA-312 welded pipe manufactured by Youngstown could be used without further examination (T. 1773(35), 1829). Hoop stress is the outward force exerted on the inner wall of the pipe, primarily due to the internal pressure of the fluid in the pipe (T. 1829-30). The ASME Code deals with hoop stress in prescribing minimum pipe wall thickness (T. 1830-31). Bechtel relied on "efficiency factors" contained in an appendix to ASME Article NC 2000 in making its 85% hoop stress recommendation (T. 1773(36), 1830-31). Applicant and Bechtel interpret footnote 3 to Table I-7.2 (J.I. Ex. 63, p. 96) to allow the use of SA-312 welded pipe, which has not been nondestructively examined by any of the required methods, so long as the pipe will be subject to only 85% of allowable hoop stress. (T. 1773(36-37), 1831-34; Applicant's Proposed Findings of Fact, p. 125, ¶ 168). Thus, Applicant's and Bechtel's interpretation of that footnote allows an exception to the examination requirements of ASME section NC 2551, which is

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(cont.)
activity being inspected. (Emphasis added.)

entitled "Required Examinations," and which by its own terms allows for no exceptions: "the welds shall be examined by one of the methods of (1) through (4) below." (J.I. Ex. 63, p. 21).

121. Bechtel admits that its interpretation of footnote 3 to Table I-7.2 is inconsistent with the nondestructive testing requirements of NC 2550 (T. 1833). Since another interpretation of that footnote is consistent with NC 2550, Bechtel's interpretation cannot be the correct interpretation. The language of the footnote on which Applicant and Bechtel rely is as follows:

> . . . For materials welded without filler metal, ultrasonic examination in accordance with NC-2550 or eddy current examination in accordance with NC-2550 shall provide a longitudinal weld efficiency factor of 1.00. . . . Other longitudinal weld efficiency factors shall be in accordance with the following:

Type of Joint	Efficiency Factor
. . .	. . .
Butt, without Filler Metal	0.85
. . .	. . .
. . .	. . .

(T. 1834; J.I. Ex. 63, p. 96). The first sentence quoted above mentions two of the four nondestructive examination methods of NC-2550 and establishes an efficiency factor of 1.00 for pipe examined in accordance with either of those methods. Bechtel interprets the phrase, "[o]ther longitudinal weld efficiency factors," to allow the use of welded pipe which has not been examined by any of the four methods prescribed in NC-2550. The correct interpretation, however, must be that the phrase "[o]ther longitudinal weld efficiency factors" refers to welded pipe which has been examined by one of the other methods prescribed in NC-2550. It is inconceivable that one section of the ASME Code would, without exception, require nondestructive examination of all welds (NC-2550), and another section - dealing not with examination requirements at all, but with determination of allowable stresses and thicknesses of pipe wall - would eliminate the examination requirement so long as a slight penalty in allowable stress is taken. Table I-7.2 concerns design allowable stress values, and footnote three relates design values to examination specifications so that allowable stress values are determined, or in some cases limited, by an examination specification. Bechtel attempts to turn this relationship around, so that design stress determines or removes an examination requirement. This is a perverse interpretation of the Code which is not substantiated by the language of note 3 or good sense (see part G, below).

122. **There has been no detailed evaluation of the CLP problem in SA-403 fittings which were made from SA-312 welded pipe.** Fittings are subject to different stresses than straight lengths of pipe (T. 1854-56). The first Aptech report states: "This report assesses the significance of the defects <u>in straight pipe</u> under internal pressure only." (Applicant's Ex. 12, p. 1-3). In discussing the sources of stress which could affect CLP in a longitudinal seam weld, that report states:

> For the individual piping systems of interest, these additional stress conditions [other than hoop stress] may need to be examined. In particular, fittings such as elbows and tees may be subject to several of these contributions and will require separate evaluation. (Applicant's Ex. 12, p. 4-1).

The second Aptech report cautions:

> The results calculated in this study can be accurately applied to straight lengths of piping away from discontinuities such as piping tees, elbows, and penetrations. Although the approach presented can also be used to evaluate these regions, special care must be taken in the stress description of discontinuity regions to ensure that a conservative analysis is performed. (Applicant's Ex. 13, 12th page (2nd page of Summary, last paragraph)).

Despite the above indications, according to Applicant's witnesses, a decision was made in undocumented discussions between Aptech and Bechtel personnel that detailed separate evaluations of SA-403 fittings were not necessary (T. 1876).

123. The NRC staff's acceptance of the conclusions and recommendations made by Bechtel was made with incomplete information, a fact that was apparently unknown to the decisionmakers in the NRC. In its analysis of the CLP issue the NRC staff requested detailed information regarding all piping systems containing SA-312 pipe — "system, pipe location, pipe size and design pressure/temperature requirements."

(NRC IE Bulletin No. 79-03, Ex. XI to Staff's Ex. 7, p. 3). The NRC staff intended the response to include, and believed Applicant's response did include, all pipe products made from SA-312 welded material, including SA-403 fittings (T. 1902). However, Applicant's response was limited to systems containing straight lengths of SA-312 pipe and did not include all systems containing SA-403 fittings. (T. 1902-04; Applicant's Ex. 10; J.I. Exs. 59 and 60). Therefore, the NRC staff's evaluation of the CLP problem, and its acceptance of Bechtel's conclusions and recommendations, at least with respect to SA-403 fittings, are of no value.

G. CONCLUSIONS REGARDING SA-312 PIPING

124. **An underlying philosophy of a quality assurance program and the ASME Code is that the quality of a product is assured by (1) appropriate manufacturing procedures, followed by (2) inspection and testing of the finished product** (see T. 1889). This philosophy is reflected in NRC Quality Assurance Criterion II:

> The [QA] program shall take into account the need for special controls, processes, test equipment, tools, and skills to attain the required quality, and the need for verification of quality by inspection and test. 10 CFR Part 50, Appendix B, Criterion II.

In the case of SA-312 welded pipe manufactured by Youngstown, inappropriate welding procedures were used which resulted in a defect, and the inspection and testing methods employed were unable to detect the defect. Thus, both prongs of good quality assurance are absent: the manufacturing process was not properly controlled and no verification of quality is possible. In these circumstances, the burden of proof on Applicant to show that this pipe can be utilized without adversely affecting the health and safety of the public must be a heavy one.[47]

125. Numerous violations of 10 CFR Part 50, Appendix B, Quality Assurance

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[47] The magnitude of the burden on Applicant — "beyond a reasonable doubt," "by clear and convincing evidence," etc. — should be determined by the gravity of the matter in controversy. In the Matter of Virginia Electric and Power Co. (N. Anna Power Station), ALAB-256, 1 NRC 10, 17, n. 18 (1975).

Criteria exist with respect to SA-312 welded pipe at Callaway. First, the manufacturing process violated Criterion V. Criterion V states in part:

> [A]ctivities affecting quality shall be prescribed by documented instructions, procedures, or drawings, of a type appropriate to the circumstances.

The Youngstown welding procedure, with its wide range of parameters, was clearly not "appropriate to the circumstances" (T. 1811). In addition, Youngstown's procedure contained no documented instructions regarding alignment of the weld head on the seam, one of the factors that caused CLP.

126. Criterion V also states:

> [I]nstructions, procedures, or drawings shall include appropriate quantitive or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished.

That provision of Criterion V has also been violated because of the inability of the nondestructive examination method employed by Youngstown to detect significant amounts of CLP. The ineffectiveness of the nondestructive examination means that there were not appropriate acceptance criteria for determining that the "important activity" of welding was satisfactorily accomplished.

127. The testing program implemented by Bechtel to determine the extent and significance of CLP in SA-312 pipe violated Criterion IX. Criterion IX provides:

> IX. CONTROL OF SPECIAL PROCESSES
>
> Measures shall be established to assure that special processes, including welding, heat treating, and nondestructive testing, are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

The nondestructive testing employed to determine the extent of CLP — the etch test — was not done "in accordance with applicable codes," the ASME Code. Not only is the etch test not recognized in the Code for the purpose for which it was used, an applicable Code acceptance criterion — for the liquid penetrant examination — which would have required rejection of pipe with more than 15% CLP, was ignored.

Furthermore, one of the three Code-required mechanical tests, the flattening test, was not performed on pipe containing known amounts of CLP.

128. The philosophy behind Criterion X was ignored when Youngstown was assigned the task of performing burst tests on the pipe it manufactured. Criterion X states that, "inspection shall be performed by individuals other than those who performed the activity being inspected." When those burst tests were performed the suitability of approximately 25,000 feet of pipe produced by Youngstown was in question. That Bechtel engineers were present during the testing provides little, if any, assurance of objectivity. Bechtel was involved in several nuclear power plants where SA-312 welded pipe had been selected (T. 1773(20); Applicant's Ex. 11, p. 1).

129. Criterion X has also been ignored in the acceptance of material which is impossible to inspect for a known defect and which is known to have been manufactured without adequate controls. Criterion X states:

> If inspection of processed material or products is impossible or disadvantageous, indirect control by monitoring processing methods, equipment, and personnel shall be provided. Both inspection and process monitoring shall be provided when control is inadequate without both.

Here, inspection for CLP is impossible; and that fact was discovered too late to allow "monitoring [of] processing methods, equipment, and personnel." Had the inspection deficiency been known, at least monitoring of the manufacturing process could have been performed. With neither inspection nor monitoring of the manufacturing process, no one knows how defective the SA-312 pipe at Callaway really is. All that Applicant can base its assurance of safety on is the assertion that if seriously defective SA-312 is in the plant, Applicant will find it before a serious mishap occurs (T. 1891-94).

130. In conclusion, the evidence in connection with the manufacture, inspection, and testing of SA-312 pipe, demonstrates several instances where Applicant's quality assurance program fails to satisfy the requirements of 10 CFR Part 50, Appendix B. Moreover, the safety of the SA-312 pipe in the Callaway Plant has not been established.

IV. PREASSEMBLED PIPING FORMATIONS

A. SUMMARY AND OUTLINE

131. In 1979 welding deficiencies were discovered in preassembled piping formations intended for and in some cases already installed in several safety-related systems at the Callaway Plant. Despite the fact that the deficiencies were apparent on radiographs of the welds, and in some cases were visible, they were not discovered by Bechtel's surveillance activities at the manufacturer's facility. Bechtel's surveillance inspection at that facility was the highest level Bechtel performs. The deficiencies also were not discovered by Daniel personnel either upon receipt at the plant, or at the point of installation. The inital discovery of defects was reported as the result of a nonmandatory inspection by a craft worker at the Wolf Creek Plant — the other SNUPPS construction site — and then communicated to Applicant. These circumstances indicate the continued failure of Applicant's quality assurance program to identify nonconforming and defective materials.

The proposed findings and conclusions pertaining to the preassembled piping formations are organized as follows:

A. Summary and Outline

B. Gulf and Western Preassembled Piping Formations at the Callaway Plant

C. Failure of Applicant's Quality Assurance Program to Identify Deficiencies

D. Conclusions Regarding Preassembled Piping Formations

B. GULF AND WESTERN PREASSEMBLED PIPING FORMATIONS AT THE CALLAWAY PLANT

132. Preassembled piping formations are portions of piping systems that are assembled at a manufacturer's facility and contain lengths of pipe, fittings, valves, pumps, tanks and other equipment (T. 1920(8-9)).

133. The deficiencies involved herein are in piping formations manufactured by Gulf and Western (G & W). Thirty-two such formations are to be used in the following safety-related systems at the Callaway Plant: auxiliary feedwater, chemical and volume control, component cooling water, and high pressure coolant injection. In its Final Report on Gulf and Western Preassembled Formations, Bechtel states with respect to those systems:

> Each system relies upon at least one of these preassemblies to effect a safe shutdown of the plant concurrent with either a safe shutdown earthquake or a design basis accident. Failure of the welds in certain of these preassemblies could significantly degrade the functionability of critical systems to the extent that safe shutdown capability is compromised. (J.I. Ex. 69, Final Report p. 2, ¶ 4.0).

134. The auxiliary feedwater system provides cooling water to the steam generators, removing heat from the primary system in the event of failure of the main feedwater system (T. 1927-28).

135. The chemical and volume control system "provides a method for controlling the chemistry of the reactor coolant system," and "a mechanism for controlling the volume of the reactor coolant system by making up and letting down as required." It at times contains primary coolant (T. 1792-93, 1928).

136. The component cooling water system removes heat from various safety-related heat exchangers during the normal operation of the plant (T. 1928).

137. The high pressure coolant injection system is a part of the emergency core cooling system and provides the initial injection of water into the primary cooling system in a loss-of-coolant accident (T. 1928).

C. FAILURE OF APPLICANT'S QUALITY ASSURANCE PROGRAM TO IDENTIFY DEFICIENCIES

138. The initial report of welding deficiencies in a Gulf and Western preassembled piping formation was made by a craft worker at the Wolf Creek Plant, the other SNUPPS construction site. The worker discovered the deficiencies merely by looking

at the welds during the installation of the formation. Quality assurance procedures, however, did not require craft workers to inspect such welds at the point of installation. The report was made as the result of a nonrequired inspection. Craft workers who had installed similar formations with similar welding deficiencies at the Callaway Plant did not report any deficiencies. (J.I. Ex. 69, Final Report, p. 1; T. 1920 (11-12), 1929-31).

139. After further inspection and examination it was determined that the following five weld deficiencies existed in Gulf and Western piping formations: incomplete penetration, slag inclusion, incomplete fusion, surface porosity, and improper weld profiles. The latter three conditions are visible weld discrepencies. Some or all of those five conditions were evident on radiographs taken by the manufacturer. (J.I. Ex. 69, Final Report p. 1; T. 1928-29). Over half of the radiographs taken by Gulf and Western were themselves defective in several respects (T. 1920 (12-13)). The defective weld conditions were identified on at least half of the preassemblies at Callaway (T. 1920 (17)).

140. A total of 32 Gulf and Western piping formations were intended for use at the Callaway Plant.[48] At the time of the discovery of the defects 31 of the 32 formations already had been received at the Callaway Plant site, approximately 20 had been released from the site warehouse and taken to the point of installation, and approximately half of that number (10) had been completely installed (T. 1935-36). Nevertheless, no deficiencies were reported at Callaway (T. 1931).

141. Daniel's receipt inspection procedures in effect when the piping formations were received on site were limited to the review of documentation that the materials conformed to specifications, and a review of the equipment to check for shipping damage and proper component configuration (T. 1920 (11)). The receipt inspection did not require inspection of welds and on the inspection checklist there was no requirement

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[48] Design changes during construction reduced that number to 30 (T. 1938).

that the inspector was to look for a vendor's nonconformance to specifications (T. 1932-33). Despite the lack of specific requirements Applicant contends there was a general requirement that the receipt inspectors document and report indications of nonconformances if they happen to see them (T. 1931-32). That general requirement obviously was not sufficient to cause the Daniel receipt inspectors to discover, or report the discovery of, the visible welding deficiencies on the Gulf and Western pipe. The NRC Senior Resident Inspector at the Callaway Plant from October 1979 to July 1981 understood the Daniel receipt inspection procedures to include only review of documents and inspection for shipping damage (T. 1979(1), 1981-82).

142. The surveillance and inspection procedures that were in effect with respect to piping formations included regular inspections by Bechtel at Gulf and Western's facility under "the highest level of surveillance inspection that [Bechtel] place[s] at [a] vendor's facility." (T. 1954). The procedure involved both "in-process inspection and final inspection." (Id.). The inspections performed by Bechtel at Gulf and Western were deficient both in the area of in-process inspections and the area of final inspections. The welding defects in the piping should have been discovered by the inspector in his review of radiographs, and in his final visual inspection of the assemblies (T. 1955-57).

143. Although its quality assurance procedures failed to identify the defective welds at the manufacturer's facility, upon receipt at Callaway, and during the installation process, Applicant contends that the defects would have been discovered later (T. 1920 (20-22), 1936-50). That contention is based entirely on speculation. There is no more assurance that the welding defects would have been discovered and reported during later inspections and tests, than there was that the defects would have been found before the piping left the vendor, when it was received on site and when it was being installed.

D. CONCLUSIONS REGARDING PREASSEMBLED PIPING FORMATIONS

144. The failure of Applicant's quality assurance program to identify and report visible weld deficiencies and weld deficiencies that appeared on radiographs violates the requirements of 10 C.F.R. Part 50, Appendix B, Criterion VII; which provides in part:

> Measures shall be established to assure that purchased material, [and] equipment . . . conform to the procurement documents. These measures shall include provisions, as appropriate, for source evaluation and selection, objective evidence of quality furnished by the contractor or subcontractor, inspection at the contractor or subcontractor, and examination of products upon delivery.

In this instance it is significant that Bechtel's "highest level" of vendor inspection failed to identify significant and obvious welding defects in half or more of the materials manufactured. It is also significant that Applicant's on site receipt inspection program, which had been undergoing "extensive revision" since the discovery of the embed problem in 1977, had not yet been modified to the point that these defects would be discovered upon delivery (T. 1936-37).

145. The evidence regarding the Gulf and Western piping formations establishes the continuing failure of Applicant's quality assurance program to prevent the manufacture, shipment, receipt and installation of nonconforming materials at the Callaway Plant.

V. HONEYCOMBING IN THE REACTOR BUILDING BASE MAT

A. SUMMARY AND OUTLINE

146. In the concrete slab of the reactor building base mat, areas of honeycombing, or voids, were discovered at the bottom of the slab in the only area available for inspection. The extent of honeycombing in other areas, not accessible for visual inspection, is not known. The honeycombing was caused by improper quality control procedures including lack of documented instructions and inadequate training of personnel. The evidence does not establish the absence of honeycombing in other areas and, therefore, does not establish the safety of the base mat. In addition, the documentation of the performance of the concrete pour failed to comply with quality assurance requirements.

The proposed findings and conclusions with respect to the issue of honeycombing in the reactor building base mat are organized as follows:

A. Summary and Outline

B. Description of the Reactor Building Base Mat and Honeycombing

C. Applicant's Failure to Demonstrate the Safety of the Base Mat

D. Failure of Applicant's Quality Assurance Program to Provide Proper Documentation

E. Conclusions Regarding Honeycombing in the Reactor Building Base Mat

B. DESCRIPTION OF THE REACTOR BUILDING BASE MAT AND HONEYCOMBING

147. The reactor building base mat of the Callaway Plant is a circular reinforced concrete slab with a diameter of 154 feet and a depth of 10 feet (T. 396(2)). At the center of the base mat is the reactor cavity, an opening of approximately 19 feet in diameter. Two additional openings to the north of the reactor cavity provide access to it and to an instrumentation passage. One of the functions of the base mat is to serve as a primary radiological shield (T. 227(9-11)).

148. The tendon access gallery is an area below the slab extending the entire circumference immediately beneath the trumplates. The gallery roof is the underside of the base mat (T. 396(2)). The gallery is 8 feet wide and 10 feet high and provides access for the installation and anchorage of the vertical tendons and allows their surveillance during the life of the plant (Applicant's Ex. 2, p. 4; T. 227(9-11)).

149. Over a period of approximately 62 hours between April 6 and 9, 1977 the concrete for the reactor building base mat was poured (T. 227(11), 396(6)). The placement began on the western portion and proceeded to the east. In an effort to achieve a monolithic slab, the placement was performed using a step method of five lifts, each about 2 feet thick (T. 446). Curing began after about 24 hours as the volume was filled, and followed the placement across the area (Staff's Ex. 2A, p. 11).

150. Honeycombing is a loose structure in concrete that leaves air or voids around the aggregate and prevents the aggregate, or solid material, from settling into a more dense state. Consolidation is exercised to avoid honeycombing and ensure proper bonding of layers. Consolidation is a process of vibration of concrete performed in order to liquify the cement to ensure that it completely fills the space required and surrounds the aggregate. Inadequate consolidation, depending on the nature of the placement, could create voids that are not visible, but nevertheless concrete that is less dense than what was designed for the structure (T. 401-02).

151. The cause of the honeycombing above the tendon access gallery at Callaway is credited to a number of different factors. One significant factor is the congestion of that area due to the presence of trumplates, wall dowels, main steel, rebar supports and form ties (T. 364). In addition, lack of supervision and inadequate training of crews were cited by Daniel as a cause of the honeycombing. NCR 2-0653-C-A initiated 5/11/77 states clearly that closer supervision over vibration crews needs to be maintained in order to prevent recurrence, and that a "[t]raining session will be held" (J.I. Ex. 4). Third, the slump of the concrete may have been another contributing factor (J.I. Ex. 8;

T. 363, 369). Union Electric acknowledged that the low slump mix contributed to the problem and Daniel subsequently requested and received permission to use a higher slump concrete in other highly congested areas (J.I. Ex. 8, T. 369). Fourth, the distance from the point of the pour to the bottom of the 10 foot thick slab was cited by Union Electric as a factor contributing to the honeycombing (J.I. Ex. 8). Applicant has indicated that special care had been taken and special preparations had been made in the concrete placement in the area where the honeycombing has been discovered (T. 227(13), 338-39). In spite of the extra care taken in this area, the mobility of the crews was hampered and there was insufficient vibration.

C. APPLICANT'S FAILURE TO DEMONSTRATE THE SAFETY OF THE BASE MAT

152. Applicant has failed to demonstrate the safety of the basemat in the area over the tendon access gallery where the honeycombing was discovered. There was a total of 44 areas of honeycombing identified above the tendon gallery. Some of the areas extended above two or three trumplates and from one wall of the gallery to and beyond the opposite wall of the gallery. According to the NRC inspector, the worst area seemed to be at azimuth 210 degrees to 213 degrees. "It covers an irregular area affecting two tendon bearing plates and exposes four layers of horizontal rebar at the bottom of the base mat to a maximum depth of 17". (Staff's Ex. 3, pp. 21, 22; Applicant's Ex. 1; T. 484). It is questionable whether workers who chipped out unsound concrete were able to see and reach the full extent of the unsound concrete, particularly above the tendon bearing plates. A worker using a chipping tool would not be able to reach much farther than 18 inches into the concrete (T. 457). On the drawing of the largest area of honeycombing, involving three trumplates, while it appears the void extends behind all three plates, it is indicated that concrete was chipped only behind two of the plates (Applicant's Ex. 1, continuation sheet 17).

153. "The concrete directly behind the trumplates is exposed to higher local bearing stresses than any other concrete on the Callaway Plant project." (T. 227 (22)). The trumplates act as anchors for vertical tendons that extend from below the basemat, through the walls and over the dome of the reactor building. The two ends of each tendon are anchored at the bottom of the base mat to the trumplates in the roof of the tendon gallery. Prior to plant operation, the tendons are placed under a high degree of tension. The concrete was designed to have full contact with the bearing surface of the trumplates in order to complete the load path between the concrete and the steel plate. Concrete that has voids would fail to provide the requisite strength and the proper bond to the steel. Because of the extreme loadings and the importance of full contact to provide the intended transfer of stress, it is extremely important that whatever honeycombing exists above the trumplates be carefully repaired (T. 227 (9-11), 239-43, 265, 365, 369 (2, 3), 403-07; J.I. ex. 1, p. 1).

154. The NRC Staff does not know, and the record does not reflect, the loadings on the trumplates under normal structural load conditions. Nor does the record reflect the increased loads that could be imposed under accident conditions when the internal pressure in the containment structure would be increased (See T. 406-08). Applicant has failed to demonstrate that the concrete above the trumplates that was not repaired, and the areas above the trumplates that were repaired, are adequate to resist the extreme loading forces that would be imposed on them, especially in the event of an accident. Concrete with voids would not be able to resist the force of the tendons pulling up on the plates and of the plates pushing up on the concrete. If the concrete is inadequate, the plate will move. Without evidence of the amount of pressure that would be on the plates under various conditions and the capacity of the concrete to resist that pressure, the Board is not able to determine that there would not be, in accident situations, enough pressure to lift the entire structure off the base.

155. Applicant places great reliance on the investigation by Wiss, Janney, Elstner & Associates, Inc. (W.J.E.) as the basis for two claims: first, that there is no internal honeycombing above the ceiling of the tendon gallery other than that initially discovered; and second, that there is no honeycombing elsewhere in the base mat. For the reasons outlined below, the investigation cannot be relied on to prove either of those claims.

156. The W.J.E. report does not support a conclusion that the base mat above the tendon gallery is free of internal cavities for three reasons. First, the report does not establish that the sound traveled along a straight path between the sending and receiving transducers. No information is provided concerning the wave length of sound in concrete. The relation of this wave length to the size of possible cavities would seem to determine the degree to which the sound may bend around, and thereby fail to detect, the cavities. While the pulse was characterized as a straight line measurement in W.J.E. sketches (Applicant's Ex. 2, pp. 11-12) it is clear from the testimony of Mr. Pfeifer that the pulse is rather like that which would result from dropping a stone in the middle of a pond (T. 314). Such a pulse could easily travel around an area of considerable size without appreciable interference. The defraction of the wave or devious routing is not discussed in the report. Second, if the sound path through the structure is partly in concrete and partly in reinforcing steel the effect of the steel would be to increase the velocity of the wave. The W.J.E. report indicates that the velocity of sound in good concrete is at least 12,000 ft/sec and that velocities above 15,000 ft/sec indicate excellent concrete. The velocities reportedly measured at Callaway were almost always above 15,000 ft/sec and often above 16,000 ft/sec (Applicant's Ex. 2, p. 19). The velocity of sound in steel, however, is 16,600 to 19,200 ft/sec.[49] Thus, the measured velocities reported by W.J.E. may not be

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[49]The Board can take official notice of this scientific fact pursuant to 10 C.F.R. §2.744(i). See also, Rule 201(b), (d), and (f), F.R.Evid. The source for the fact is CRC Handbook of Chemistry and Physics, 61st Ed., velocity of sound in solids, p. E-47).

indicative of the quality of concrete, as there is no indication of how much steel was transversed by each shot. Third, the velocity of the pulse through the base mat is measured by the alignment of cross hairs on an oscilloscope (T. 301). A cross hair moved to the leading edge of the received signal wave form determines the time the pulse traveled (T. 302). Precise readings of the transit time for the pulse depend on the accuracy of the placement of the crosshair. If there is an area of uncertainty in the definition of the leading edge of the wave form it would be difficult to achieve a reading precise to four figures. The report does not discuss the margin of error, or with what bias such factors might have been resolved. It is interesting to note that different inspection techniques were employed to determine the extent of honeycombing in the dome (T. 270, 2010 (19, 20), 2016, 2057).

157. Applicant has failed to demonstrate that the honeycombing was confined to the area above the tendon access gallery. Many of the factors said to contribute to the honeycombing over the gallery are present in other areas of the base mat, particularly the area near the reactor cavity. The problem of congestion is certainly not unique to the gallery (T. 363). While trumplates are not located elsewhere in the base mat, wall dowels may be present elsewhere, and form ties, rebar supports and main steel are generally present throughout the mat. The most congested level of rebar, the fifth (lowest) layer of steel is more concentrated near the reactor cavity than over the tendon gallery (T. 368-69). The fact that there was a substantial distance between the point of the pour and the bottom of the 10 foot thick mat would certainly be true throughout the base mat. If special care was taken over the tendon gallery it follows that something less than special care was taken on the rest of the placement (T. 339). Finally, inadequate supervision of crews and lack of training are factors that would have existed throughout the pour (Applicant's Ex. 1).

158. The area investigated by W.J.E. was confined to the area and volume above the tendon gallery, since the rest of the slab is cast on the ground and was impossible

for W.J.E. to examine with the soniscope (T. 245-247). The tendon gallery represents about 19% of the base mat. Test shots were taken in the vicinity of only one-fourth (44) of 172 trumplates, which amounts to less than 5% of the total base mat (T. 232; 396(5)). Mr. Pfeifer related the 150 cu.ft. of pressurized grouting repair to the 181,000 cu.ft. of the total volume of the mat. However, 81% of the base mat remains unexplored by W.J.E. (T. 245-47). The volume of repairs is more than 1 1/2% of the volume actually tested, and of the area accessible it represents more than .4%. The surface area of the repairs covered nearly 13% of the exposed surface of the mat. If the same extent of honeycombing repaired exists throughout the base mat, .4% of the rest of the concrete by volume and 13% of the bottom surface would be unsound.

D. FAILURE OF APPLICANT'S QUALITY ASSURANCE PROGRAM TO PROVIDE PROPER DOCUMENTATION

159. The reactor building base mat was a difficult placement problem. Similar problems have been encountered at other nuclear plants (T. 358, 365, 2010 Attachment 4)). The best assurance that honeycombing does not exist in other areas would be adequate records of the concrete placement. NRC Regulatory Guide 1.55, "Concrete Placement in Category I Structures" states:

> [T]he presence of numerous concrete voids which have been detected at or near the surfaces of nuclear containment buildings raises concern about the density of portions of these and other concrete structures that cannot readily be inspected. For such unaccessible areas, the only method of assuring a quality concrete structure is through good planning and control of the placement of concrete and all items embedded in it.

The documentation that exists demonstrates weaknesses in work procedures and quality control procedures that were governing at the time of the placement.

160. Subsequent to the placement of the concrete, the NRC Staff cited Daniel Work Procedure WP-109 for its failure to comply with 10 C.F.R. Part 50, Appendix B, Criterion V (Staff's Ex. 3, Notice of Violation ¶2; T. 401). Criterion V provides in part: "Activities affecting quality shall be prescribed by documented instructions,

procedures, or drawings of a type appropriate to the circumstances." WP-109, however, did not contain any instructions, procedures, or drawings or provide for implementation of the specification requirements on consolidation of concrete (Staff's Ex. 3, p. 23; see also T. 401).

161. Applicant was also cited for two infractions relating to quality control concrete placing reports (CPRs) (Staff's Ex. 3, Notice of Violation). Thirteen quality control inspectors, on alternating twelve hour shifts, monitored the concrete placement. However, the documentary records produced for the NRC inspector's review contained only one CPR. This report was reportedly signed by the inspector present at the termination of the pour. It "contained no information regarding verification of work performed on shifts when this one inspector was not present." (Staff's Ex. 3, pp. 22-23). In addition, QCP 109 identified thirteen significant attributes for verification by the QC inspector. The one CPR produced for the NRC had only one of those specified attributes: the signature of the inspector (Staff's Ex. 3, p. 23; T. 447-48). The CPR and its instructions failed to identify acceptance criteria for the pour, in violation of 10 C.F.R. 50, Appendix B, Criterion V (Staff's Ex. 3, p. 23).

162. The CPRs are nearly identical and contain practically no information from which a judgment can be made as to whether the pour was satisfactorily accomplished. All but one of the CPRs appear to have been filled out by the same person. All the CPRs contain the same information regarding the weather, the slump, the amount of concrete wasted, the number of vibrators used and available, and the placement rate. (J.I. Ex. 5). Shift numbers are entered but neither Mr. McFarland nor Mr. Varela could identify from the reports what activities the signature of each inspector was verifying that he had witnessed (T. 326-27, 489). The information which they do all contain is a summary of the pour. The occurrence of the stopping of the concrete placement for approximately one hour is not mentioned. Nor is it reflected that the change in the batch plant procedure from part ice to all water or from all water to part ice,

which caused the halt in the continuous pour, was brought about by a change in the ambient temperature.

163. In addition to inadequate documentation of the pour activity, there was a failure to document in a timely manner the existence of honeycombing and the need for extensive repair. More than a month after the completion of the pour, after 12-14 areas of honeycombing had been removed, and the discoveries that three or four of those areas extended beyond the lower layer of reinforcing steel, and that two areas were at tendon bearing plates, no NCR had been written. The initial NCR on the honeycombing in the base mat was not written until after Mr. Miller of Bechtel observed the ongoing repair activities during his visit to the site on May 10-11, 1977. Further, Bechtel had determined the honeycombing was not a potentially significant reportable occurrence under 10 C.F.R. §50.55(e) (J.I. Exs. 1 and 4; T. 257). By contrast, the areas of honeycombing initially recognized as potentially significant in the dome were only 1/4 to 3/4 inch in diameter (T. 2010(11), 2015).

164. The honeycombing in the base mat was clearly a condition that should have been reported to Bechtel. According to Bechtel's specification, any void which exposes a reinforcing bar around its full circumference for a length of 6 or 9 inches, depending on the size of the bar, would require Bechtel's approval prior to repair (J.I. Ex. 2, p. 1).

E. CONCLUSIONS REGARDING HONEYCOMBING IN THE REACTOR BUILDING BASE MAT

165. The evidence in connection with honeycombing in the reactor containment building base mat fails to establish the structural integrity of the mat and therefore the safety of the reactor building. First, Applicant has not demonstrated that the concrete above the tendon gallery is now free of voids and of sufficient strength to withstand the tremendous pressures imposed by the tendons and trumplates. In addition, the extent of honeycombing in other areas of the base mat remains unknown. The

logical conclusion that if extensive honeycombing was found in the only place accessible to inspection it is likely to be elsewhere has not been dispelled. No efforts were undertaken tc try to find honeycombing in any location other than the area over the tendon gallery.

166. The evidence demonstrates several important deficiencies in Applicant's quality assurance pcgram. Of the issues under consideration that are addressed by Joint Intervenors, this is the only contention issue involving activities performed exclusively at the Callaway Plant site. The failure of Applicant to assure proper documentation of the procedures that were to be followed in the pour, proper documentation of the activities of the pour itself, and proper reporting and documentation of critical repair activies, are all significant departures from good quality assurance. The fact that honeycombing was found within the reinforced concrete of the reactor building done, completed over three years after the base mat, demonstrates a continuing failure of the Applicant's quality assurance program to assure that significant activities affecting quality are accomplished in a satisfactory manner (T. 2010 (12)).

GENERAL CONCLUSIONS OF LAW

167. The evidence adduced at the hearing on Joint Intervenors' Contention One demonstrates a pervasive failure of Applicant's quality assurance program to perform its intended functions in conformity with the regulations of the NRC, 10 C.F.R. Part 50, Appendix B. Of equal or perhaps even greater importance is the failure of Applicant to prove in this proceeding that certain safety-related structures, systems and components in the plant are adequate to assure that it can be operated without endangering the health and safety of the public.[50] The evidence also suggests that because of the firing of ironworker foreman Bill Smart, following widespread publicity about his allegations of construction deficiencies at the plant, other construction workers have been unwilling to come forward with evidence of nonconformances. Finally, Applicant and Bechtel appear to have made material misrepresentations of fact both to the NRC Staff during the course of its investigations, and to the Board in connection with this proceeding. For those four reasons, the Board should recommend that Union Electric Company's application for an operating license be denied.

168. While the safety of all of the plant's structures, systems, and components is in question because of the failure of the quality assurance program, the issues raised by Joint Intervenors — the embedded plates, the piping and the honeycombing in the reactor containment structure — cause the gravest concern. For example, many of the over two hundred safety-related manually welded embedded plates installed prior to the stop work orders in June 1977 and supporting main structural flooring beams in

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[50] The magnitude of the burden on an Applicant for an operating license is not established by statute or regulation. Whether the burden is to be "beyond a reasonable doubt," or "by clear and convincing evidence," or "by a preponderance of the evidence," is to be determined with due regard to the gravity of the issue in controversy. In the Matter of Virginia Electric and Power Co. (N. Anna Power Station), ALAB-256, 1 N.R.C. 10, 17, n. 18 (1975).

the auxiliary building and control building may be loaded to or beyond their full structural capacities.

169. In a second example, the case of SA-312 piping, a welding defect — centerline lack-of-penetration — is known to exist, but impossible to detect. The piping was manufactured without adequate controls and under an appropriate procedure. That situation is rendered intolerble by the fact that there are no effective nondestructive examination methods that can detect the existence of the defect or determine its extent.

170. A third example, honeycombing in the reactor containment structure, involves the ability of the reactor building to contain radiation during the normal operation of the plant and in the event of the accident.

171. Under NRC regulations Applicant is responsible for the implementation of a quality assurance program relating to all activities affecting the safety-related functions of all structures, systems and components of the plant. The activities for which Applicant is responsible include "designing, purchasing, fabricating, . . . erecting, installing, inspecting, testing, operating, maintaining, [and] repairing." While Applicant may delegate some of the work involved in establishing and executing the quality assurance program, Applicant remains responsible for every aspect of it. 10 C.F.R. Part 50, Appendix B, Introduction, and Criterion I.

172. The evidence in this case establishes several instances where Applicant's quality assurance program has failed to assure that structures, systems and components have been (1) properly designed and/or selected; (2) manufactured or constructed in conformity with applicable requirements; (3) properly inspected for deficiencies; (4) appropriately evaluated, corrected or otherwise dispositioned after nonconformances have been identified; and (5) properly controlled to prevent inadvertent use or installation of nonconforming items.

173. Among the failures of concern is the performance of inspection and reporting activities with respect to deficiencies in purchased materials manufactured by other companies at their own facilities. In July 1977, after discovery of welding deficiencies in embeds and the citation of Applicant by the NRC staff for Bechtel's failure to follow documented quality assurance procedures requiring inspection of welds at vendors' facilities, and for Daniel's failure to follow documented procedures requiring weld inspection upon receipt of items, Applicant directed Daniel to receipt-inspect all safety-related items for conformance to procurement document specifications. Nevertheless, as late as 1979 a piece of SA-358 piping and several piping assemblies from Gulf and Western with visible welding defects were accepted on site, released for installation, and in some cases installed. Bechtel's "highest level" of vendor surveillance at Gulf and Western's facility failed to identify numerous welding defects by visual inspection and on radiographs. In light of the obvious failure to improve inspection and surveillance activities after the discovery of the embed deficiencies, there can be little assurance in Applicant's assertion that its receipt inspection program has been improved after its investigation of the Gulf and Western problem (Applicant's Proposed Findings of Fact, p. 137 n. 92). Applicant's inspection and surveillance activities are responsible for safety-related materials provided by approximately 200 suppliers and contractors (Schnell, T. 216 (9)).

174. Applicant argues that the deficiencies and nonconformances identified by Joint Intervenors are those that they were able to "pick and choose" from the enormous amount of information available to them, and are, therefore, merely a few isolated occurrences that in no way suggest the existence of a larger problem (Applicant's Proposed Findings of Fact, pp. 141-42). One of the difficulties with that argument is that Joint Intervenors have indicated their inability to actively pursue issues because of limited resources (<u>see</u>, <u>e.g.</u>, Joint Intervenors' Answer to Applicant's and Staff's

Motions for Summary Disposition—concrete cracks and concrete cover), and because of lack of information (honeycombing in reactor building dome).

175. More important, however, is the question of the willingness of construction workers at the Callaway Plant to report deficiencies and nonconformances to their superiors and the NRC staff, especially after the firing of Bill Smart. The history of Bill Smart's reporting of construction defects to the NRC, and his firing and reinstatement, are a part of this record and relevant to Joint Intervenors' Contention One. Clearly, if the environment at the Callaway construction site has been such that workers have been unwilling to report defects for fear of reprisals, a valuable source of information regarding the quality of construction has been lost. Bill Smart's initial allegations to the NRC were made in October, 1977.[51] Investigations by the NRC were performed as a result of those allegations in October and November 1977. In December 1977 Mr. Smart visited the plant site with NRC inspectors to point out certain deficiencies to them. If Mr. Smart's identity as a whistle-blower was unknown prior to that visit, it was clearly established at that time. Further investigations into Mr. Smart's allegations ocurred in December 1977 and January 1978. In February 1978 the findings from those investigations were released by the NRC at a news conference. In the following month, March 1978, Bill Smart was fired by Daniel allegedly for disobeying an order of a superior. As a result of his union's arbitration of his discharge Mr. Smart was ordered reinstated with back pay, as the alleged grounds for the discharge could not be substantiated. The arbitrator's opinion, according to the NRC, noted that Daniel requested that reinstatement be denied even if the discharge were not for good cause. The NRC Staff's investigation made no determination one way or the other on

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[51]His allegations regarding embedded plates led to the NRC's on site investigation in November 1977 when the NRC obtained a copy of the Daniel inspection data (J.I. Ex. 12) which resulted in questions being raised regarding the validity of Bechtel's engineering analysis of the adequacy of the manually welded plates (J.I. Ex. 34, NRC Report No. 77-10).

the question whether Mr. Smart's discharge was in retaliation for his whistle-blowing activities, and made no definitive finding regarding the possible chilling effect of Mr. Smart's case on other workers. (J.I. Ex. 74, NRC Report No. 50-483/78-12; 50-486/78-02). An example of Applicant's attitude toward Mr. Smart's activities is contained in an excerpt from the transcript of a meeting regarding his allegations attended by Mr. Smart, NRC inspectors, and Union Electric and Daniel personnel. At that meeting Mr. Smart reported some negative information regarding an individual, who had made a conflicting statement to Mr. Foster of the NRC Staff. Mr. Smart asked Mr. Foster: "Well, would you expect him to tell you that he told us to move those tags?" In response, Morgan Doyne, the second highest on site management official of Union Electric responsible for plant construction, stated to Mr. Smart, "We would expect him to be more honest and forthright than we would expect from you, Bill." (J.I. Exs. 55 and 56, transcript pp. 22A-23; T. 1755-57). Such a comment indicates an attitude on the part of Applicant's management to discourage, rather than encourage, reporting of concerns regarding plant construction. Moreover, in light of the publicity surrounding Mr. Smart's discharge and the fact that the alleged grounds for his discharge were not substantiated in the arbitration proceeding, it had to have been clear to workers that whistle-blowing at the Callaway Plant meant risking one's job.

176. Material mistatements of fact made by Applicant and Bechtel to the NRC Staff investigators and in the course of this proceeding cast serious doubts concerning the safety of the plant and Applicant's ability to operate it. The apparent misrepresentations are discussed above in connection with the issues involving embedded plates and will not be repeated here (see ¶¶ 2, 36, 37, 39, 44).

177. The Commissioners of the NRC have indicated that strict scrutiny must be given in an operating license proceeding where, as here, there are numerous instances of the failure of the Applicant's quality assurance program to perform in accordance with 10 C.F.R. Part 50, Appendix B Criteria; where, as here, there is evidence of an

atmosphere where workers would be reluctant to come forward with information regarding construction defects; and where, as here, there is evidence of apparent misrepresentations and misleading statements to the NRC. In the Matter of Houston Lighting and Power Co. (South Texas Project, Units 1 and 2), CLI-80-32, 12 N.R.C. 281 (1980). The Commissioners indicated that the Atomic Safety and Licensing Board, in dealing with quality assurance issues, must look at "the broader ramifications" in order to determine whether the operating license application should be denied. Id. at 291-92. The Commissioners also indicated that "material false statements" made to the NRC may themselves be grounds for the denial of an operating license, "certainly if the falsehoods were intentional, . . . and perhaps even if they were made only with disregard for the truth." Id. at 291, n. 4. In addition to the similarities to the South Texas case, this case presents an additional ground for denial of the operating license, the failure of Applicant to meet its burden of proving that structures and components with known defects, such as the embeds, SA-312 piping, and the reactor containment building, are adequate to perform their intended functions. To the contrary, there are substantial questions whether the embedded plates can support the loads imposed on them, whether SA-312 piping will fail because of its centerline lack-of-penetration defect, and whether the base mat and dome of the reactor building are adequate to contain the radioactivity released during the routine operation of the plant in the event of an accident.

178. For all the foregoing reasons this Board should recommend the denial of Union Electric Company's application for an operating license for the Callaway Plant.

Respectfully submitted,

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March 1, 1982

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
UNION ELECTRIC COMPANY	)	Docket No. STN 50-483-OL
	)	
(Callaway Plant, Unit 1)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of Joint Intervenors' Proposed Findings of Fact and Conclusions of Law have been served this 1st day of March, 1982 by hand delivery to Francis Duda for Joseph E. Birk, Esq., Assistant to the General Counsel for Applicant, who will make express mail delivery to those persons indicated by an asterisk; and by deposit in the United States mail on all others indicated below.

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