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)	)	

APPLICANT'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW IN THE FORM OF A PARTIAL INITIAL DECISION

SHAW, PITTMAN, POTTS & TROWBRIDGE

Thomas A. Baxter
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TABLE OF CONTENTS

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I. INTRODUCTION

1. On April 6, 1976, the Commission issued Construction Permits Nos. CPPR-139 and CPPR-140, which authorized Union Electric Company (hereinafter "Applicant" or "Union Electric") to construct the Callaway Plant, Units 1 and 2, two pressurized water nuclear reactors, at the Applicant's site in Callaway County, Missouri. Issuance of the permits was authorized by an Atomic Safety and Licensing Board which had conducted public hearings on both contested (by intervenors) and uncontested aspects of the application. See LBP-75-47, 2 N.R.C. 319 (1975) and LBP-76-15, 3 N.R.C. 445 (1976).

2. On August 19, 1980, the Commission issued "Notice of Receipt of Application for Facility Operating Licenses;

Notice of Consideration of Issuance of Facility Operating Licenses and Notice of Opportunity for Hearing." 45 Fed. Reg. 56956 (August 26, 1980). That Notice was clarified and superseded on November 14, 1980, by "Clarification of Notice of Receipt of Application for Facility Operating Licenses; Consideration of Issuance of Facility Operating License and Notice of Opportunity for Hearing." 45 Fed. Reg. 77208 (November 21, 1980).

3. The Notice announced that the Commission had received from Union Electric Company an application for a facility operating license to possess, use and operate the Callaway Plant, Unit 1.[1] The application filed with the Commission for its review on October 19, 1979, includes, along with other information, a Final Safety Analysis Report (which references the Standardized Nuclear Unit Power Plant System (SNUPPS) Final Safety Analysis Report), and an Environmental Report.

4. The Notice provided that any person whose interest may be affected by the proceeding may file a petition for leave to intervene and a request for hearing in accordance with the Commission's rules of practice, 10 C.F.R. Part 2.

5. On October 2, 1980, the Acting Chairman of the Atomic Safety and Licensing Board Panel established this Atomic Safety and Licensing Board to rule on petitions for leave to

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1 Applicant's counsel advised the Board and the parties by letter of October 9, 1981, that Union Electric Company had cancelled its plans to construct and operate Unit 2 of the Callaway Plant.

intervene and/or requests for hearing, and to preside over the proceeding in the event that a hearing is ordered. 45 Fed. Reg. 67178 (October 9, 1980).

6. A number of requests for hearing and petitions for leave to intervene were filed in response to the Commission's published notices. Responsive pleadings to these filings were submitted by Applicant and the NRC Staff. In a Memorandum and Order (Ruling on Requests for Hearing, Petitions for Intervention and Order of Special Prehearing Conference) issued on February 5, 1981, the Board ruled on the requests and petitions.

7. The Board granted the petition for leave to intervene under 10 C.F.R. § 2.714 by Mr. John G. Reed of Kingdom City, Missouri. The Board also granted the joint petition, pursuant to section 2.714, of: Coalition for the Environment, St. Louis Region; Missourians for Safe Energy; and Crawdad Alliance (hereinafter "Joint Intervenors").

8. In addition, the Board granted the petitions to participate, under 10 C.F.R. § 2.715(c), of the following representatives of an interested state, county, municipality, and/or agencies thereof: Mr. Howard Steffen; Mr. Harold Lottman; Mr. Earl Brown; Mr. Fred Lukey; Mr. Samuel J. Birk; Mr. Robert G. Wright; and the Public Service Commission of Missouri.

9. A special prehearing conference pursuant to 10 C.F.R. § 2.751a was held in Jefferson City, Missouri, on March

24, 1981. In a subsequent Special Prehearing Conference Order (Ruling on Intervention Petitions, Requests for Hearing and Contentions), dated April 21, 1981, the Board confirmed its earlier rulings on the requests for hearing, petitions for leave to intervene and other requests to participate in the proceeding. The Board also ruled on the admissibility for litigation, under the standards of 10 C.F.R. § 2.714(b), of the various contentions proposed by Mr. Reed and Joint Intervenors.

10. The Board established, in the Special Prehearing Conference Order, a schedule for further actions in the proceeding. A trifurcated hearing schedule was adopted to accommodate the three, distinct sets of contentions admitted: (a) Joint Intervenors' contentions grouped by them under the general heading "Failure of the Quality Assurance Program," or Joint Intervenors' Contention No. 1; (b) Joint Intervenors' contentions labeled "Inadequate Environmental Protection from Radioactive Releases," or Joint Intervenors' Contention No. 2; and (c) Mr. Reed's contentions on emergency planning.

11. On April 21, 1981, the Board also issued a Notice of Hearing, to announce that hearings would be held in this matter, and to advise members of the public of the opportunity to attend hearing sessions and prehearing conferences, and to make limited appearance statements pursuant to 10 C.F.R. § 2.715(a). 46 Fed. Reg. 23574 (April 27, 1981).

12. By letter to the Board dated December 4, 1981 (incorporated into the record following Tr. 2081), Joint

Intervenors withdrew their Contention No. 2, entitled "Inadequate Environmental Protection for Radioactive Releases." The Board approved this withdrawal in its Memorandum and Order dated December 7, 1981. Consequently, there will be only two sets of hearings and two partial initial decisions -- one on Joint Intervenors' Contention No. 1, and one on Mr. Reed's contentions. This Partial Initial Decision is limited to the contentions on quality assurance -- Joint Intervenors' Contention No. 1.[2]

13. Pursuant to a Memorandum and Order (Modification of Hearing Schedule) dated September 24, 1981,[3] a prehearing conference pursuant to 10 C.F.R. § 2.752 was held on October 26, 1981, in St. Louis, Missouri, to consider outstanding matters related to, and to plan for, the hearings on Joint Intervenors' Contention No. 1. The Board's Memorandum and Order on Prehearing Conference, dated October 29, 1981, recited the actions taken at the conference and confirmed the dates and location of the hearing.[4] 46 Fed. Reg. 54827 (November 4, 1981).

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2 No precise date has been selected for the commencement of the hearing on Mr. Reed's emergency planning contentions. We are told that the litigation of those issues awaits the finalization of off-site, local emergency response plans.

3 The Memorandum and Order also announced the schedule for the hearing sessions. 46 Fed. Reg. 48349 (October 1, 1981).

4 The hearing location was changed in the Board's Memorandum and Order on Prehearing Conference (Change of Hearing Place), dated November 2, 1981. 46 Fed. Reg. 55170 (November 6, 1981).

14. Pursuant to the Board's notices, the evidentiary hearing on Joint Intervenors' Contention No. 1 commenced on November 17, 1981, in St. Louis, Missouri,[5] with Applicant, Joint Intervenors and the NRC Staff appearing as parties, and the Public Service Commission of Missouri appearing as a representative of an interested state. Hearing sessions were held on November 17 through 24, and December 1 through 5, 1981. The hearing session of Saturday, December 5, 1981, was devoted to limited appearance statements presented by interested members of the public pursuant to 10 C.F.R. § 2.715(a). Limited appearance statements were also received at earlier hearing sessions when requested and as the schedule permitted.

15. The record of the hearing includes the written and oral testimony of witnesses presented by Applicant and the NRC Staff. No witnesses were offered by Joint Intervenors. In the findings of fact below, the location of the direct, written testimony of each witness will be identified fully the first time it is cited. For convenience, we have also compiled an alphabetical listing by witness, Appendix A to this decision, which identifies the location in the transcript of all of the written testimony.

16. The record also includes exhibits which were offered and received into evidence. Appendix B to this

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5 Locating the hearing in St. Louis was by agreement of the parties.

decision is a list of the exhibits which were marked for identification. It also identifies whether each exhibit, if offered into evidence, was admitted or rejected by the Board. The list does not attempt to codify any rulings made by the Board which limited the purposes for which a particular exhibit was received into evidence. Any such ruling, however, generally may be found at the transcript page or pages indicated on the list.

17. The Board's findings of fact have been organized by the subject matter divisions reflected in the various parts of Joint Intervenors' Contention No. 1. We have simply taken them in order, except that the summary introductory paragraph in the contention is addressed both before and after the Board's findings on the specific allegations in the contention. Each portion of the contention is quoted in full at the outset of our findinqs on that aspect of the contention. The language of the contentions is drawn from Joint Intervenors' "Amended and Supplemental Joint Petition to Intervene," March 6, 1981, as modified by interlineation in "Revised Contentions of Joint Intervenors," March 24, 1981.[6] While the Board did not, in its rulings, change the language of the contentions as proposed by Joint Intervenors, we specifically held that the only allegedly deficient activities placed in litigation are those specified

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6 The complete wording of the contentions, as modified, was placed in the record following Tr. 2081.

in the contentions proposed at the time of the special prehearing conference, unless additional contentions are proposed and admitted by the Board in the future. Special Prehearing Conference Order, April 21, 1981, at 7. No additional contentions were proposed.

II. FINDINGS OF FACT

A. Overview of the Quality Assurance/Quality Control Programs Involved in the Design and Construction of the Callaway Plant

Joint Intervenors' Contention No. 1 (Introductory Paragraph):

> 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 should not be licensed.

18. Joint Intervenors' Contention No. 1 alleges, in general, a failure in the Callaway Plant quality assurance/quality control programs applied during project design and construction. This general contention is followed by specific subcontentions of alleged defects in the construction of the Callaway Plant which purportedly evidence failures of the quality assurance/quality control programs. It is only these specific allegations of deficient activities which are at issue in this proceeding and which will be the subject of the Board's decision. See paragraph 17, supra. Nonetheless, the Board recognizes Joint Intervenors' argument that the findings on the specific contentions could well lead to a cumulative conclusion which differs from the findings on any one allegation. Consequently, in the concluding section of our findings of fact, the Board will return to and briefly address this general contention in light of our specific findings of fact on Joint Intervenors' substantive allegations. First, however, a general overview of the Callaway Plant quality assurance/quality control programs and the Callaway construction process will be provided in this section of the decision in order to present a framework of understanding for the Board's findings of fact on the specific subcontentions.

19. The evidence providing this general overview of the quality assurance/quality control programs was presented principally in the written testimony of Donald F. Schnell. Mr. Schnell is Applicant's Vice President, Nuclear. He has corporate responsibility for the design, construction and operation of the

Callaway Plant. He has been employed by Applicant since 1954 and has been involved with the Callaway project since 1971. Mr. Schnell's previous positions included Supervising Engineer, Nuclear Group; Manager, Nuclear Engineering; and finally, General Manager, Operations, before assuming his present position in October, 1981. Applicant's Testimony of Donald F. Schnell in Response to Joint Intervenors' Contention No. 1, following Tr. 216 (hereinafter "Schnell Testimony"), at 1-4.

20. The major relevant organizations involved in the design and construction of the Callaway Plant and responsible for the quality assurance and quality control programs[7] are Union Electric Company, SNUPPS (Standardized Nuclear Unit Power Plant System), Bechtel Power Corporation (hereinafter "Bechtel"), and Daniel International Corporation (hereinafter "Daniel"). Schnell Testimony at 4-8.

21. SNUPPS is an organization comprised of a group of utilities engaged in the design, purchase, construction and licensing of standardized nuclear power plants. The SNUPPS concept is designed to reduce the period required to build nuclear plants by reducing the time necessary for licensing,

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7 "Quality assurance", in broadest terms, includes all those planned and systematic actions which provide adequate confidence that an item, process or facility will perform satisfactorily in service. "Quality control" is one aspect of quality assurance. It is used to signify those actions which provide a means to measure the characteristics of an item, process or facility against established requirements. Schnell Testimony at 11, 12.

engineering, design and construction by means of standardization. Thus, each nuclear plant to be constructed and operated by the individual SNUPPS utilities, including the Callaway Plant, has a standardized Power Block consisting of the reactor building, turbine building, auxiliary building, fuel building, radwaste building, diesel generator building, control building, and all systems and equipment within these buildings. Schnell Testimony at 4, 5.

22. In furtherance of the SNUPPS concept, each of the SNUPPS utilities has entered into individual agreements with Bechtel to provide lead architect/engineer (A/E) services. Bechtel is responsible for designing all structures and systems, except the nuclear steam supply system (NSSS),[8] within the standard Power Block. This includes the preparation of design criteria, drawings and specifications. Bechtel is responsible for establishing design interfaces among the principal contractors and assuring that compatibility exists at these interfaces. As lead A/E, Bechtel is also responsible for procurement of equipment for systems within the standard Power Block, with the exception of the NSSS and the first core fuel fabrication. This includes providing inspection and the witnessing of tests of suppliers' equipment during manufacture, and conducting periodic audits on behalf of the SNUPPS utilities. Schnell Testimony at 6, 7; see also, Tr. 652 (Meyers).

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8 The NSSS is designed and provided by Westinghouse Electric Corporation. Schnell Testimony at 6.

23. Daniel has been engaged by Union Electric to construct the Callaway Plant utilizing design information prepared by the lead A/E, Union Electric, the NSSS supplier and the site A/E, and using manufactured items and materials procured by the lead A/E, the NSSS supplier and Union Electric. In addition, Daniel has responsibility for procurement of additional bulk materials and consumable items; procurement and/or administration of the services of various subcontractors; and planning and scheduling activities related to construction, testing and inspection activities in accordance with the design. Schnell Testimony at 7, 8.

24. Each of these organizations, Union Electric, SNUPPS, Bechtel and Daniel, has a quality assurance/quality control program which controls its activities. At the time of its application for a construction permit to build the Callaway Plant, Union Electric was required by federal regulation, 10 C.F.R. §50.34, to submit a Preliminary Safety Analysis Report (PSAR) to the NRC. The PSAR is a multi-volume report describing the design concepts to be embodied in the plant and includes a description of the quality assurance program which the Applicant has committed to apply to the design, fabrication, construction and testing of the safety-related structures, systems and components of the facility.[9] Schnell Testimony at 9, 10.

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9 Subsequent to the submission of the SNUPPS Final Safety Analysis Report to the NRC on October 2, 1979, the Union Electric Design and Construction Quality Assurance Program description was extracted from the PSAR and is now documented

(continued next page)

25. The Union Electric program was and is required to meet the quality assurance requirements of Appendix B to 10 C.F.R. Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants." Appendix B imposes the quality assurance program requirements directly on Union Electric and requires that Union Electric retain ultimate responsibility for quality assurance. Appendix B does recognize, however, that portions of the task of establishing and executing this program, or parts thereof, may be delegated to others. Accordingly, Union Electric contractually imposes quality assurance program requirements on each major contractor and supplier consistent with its scope of work. Schnell Testimony at 10.

26. The adequacy of the Union Electric Quality Assurance Program for design and construction was reviewed at the construction permit application stage. The Atomic Safety and Licensing Board which authorized issuance of a construction permit for the Callaway Plant specifically found "that the Callaway Plant QA Programs are in compliance with the requirements of Appendix B to 10 CFR 50 and further that they are adequate for the design, procurement, and construction of the Callaway Plant." The same Licensing Board also concurred in the following Staff finding: "The Staff has also evaluated the QA programs of Bechtel Power Corporation (architect/engineer for the

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(continued)
in a separate manual entitled Quality Assurance Program for Design and Construction Manual. Schnell Testimony at 10.

standard plant), Westinghouse Electric Corporation (supplier of the nuclear steam supply system), and Daniel International Corporation (construction contractor), and has found those programs to be in compliance with Appendix B to 10 CFR Part 50." Schnell Testimony at 10, 11; LBP-76-15, 3 N.R.C. 445, 454-457 (1976).

27. The quality assurance program is applied to all structures, systems and components necessary to assure plant safety, including those which involve the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, and the capability to prevent or mitigate the consequences of accidents which co ld result in potential off-site exposures comparable to those prescribed in 10 C.F.R. Part 100. This quality assurance program involves the proper functioning of many disciplines and activities, and is not the sole domain of any single entity or group. Each department, group, committee or other organizational subdivision controls its activities in order to maintain quality, through the use of written procedures and instructions. Elements of the quality assurance program associated with design and procurement activities related to the standard Power Block are implemented jointly by Applicant and the other involved utilities through the SNUPPS organization. Elements of the program which are site-related or non-standard are implemented by Applicant. Schnell Testimony at 16-18.

28. For those aspects of the quality assurance program related to the standardized Power Block, the SNUPPS utilities have adopted a standarized quality assurance program to be utilized by each of the utilities. The SNUPPS organization provides both administrative control and project direction through an Executive Director who is empowered to act for the SNUPPS utilities and who reports to the utilities' Management Committee. The SNUPPS Executive Director, assisted by his staff, provides project direction to Bechtel, the lead A/E. Bechtel, in turn, provides similar direction to the NSSS supplier and all suppliers of safety-related materials and services within Bechtel's scope of responsibility. Schnell Testimony at 18, 19 and Figure 1.

29. The SNUPPS Quality Assurance Committee established by the SNUPPS utilities consists of one quality assurance representative from each utility. The activities of the Committee are coordinated by the SNUPPS Quality Assurance Manager. The Committee is responsible for developing the standard quality assurance program for the common design and procurement activities within the SNUPPS project. Additionally, the Quality Assurance Committee is responsible for reviewing the quality assurance program of the principal SNUPPS contractors (Bechtel and Westinghouse) to verify that such programs are adequate in scope and degree, and are being effectively implemented. The SNUPPS Quality Assurance Committee also performs audits of the SNUPPS Staff and participates in audits of

principal contractors. Audit results are documented and selected items are submitted for review to the SNUPPS Management Committee and Executive Director. The SNUPPS Quality Assurance Committee is responsible for providing the SNUPPS Management Committee with an objective evaluation of the effectiveness of the quality assurance program and overall conformance with established procedures. Schnell Testimony at 19.

30. Each member of the SNUPPS Quality Assurance Committee is individually responsible to his utility for providing a lead role in implementation of quality assurance program policy. He is responsible for reporting audit results to his utility management and for providing his utility management with an evaluation of the effectiveness of the quality assurance program regarding activities within the SNUPPS concept. The Union Electric Quality Assurance Committee representative is the Manager, Quality Assurance, who reports directly to the Union Electric Vice President, Nuclear. Schnell Testimony at 20 and Figure 2.

31. The SNUPPS Quality Assurance Manager is responsible for verifying implementation of the quality assurance program within the SNUPPS concept and reports directly to the SNUPPS Executive Director. The SNUPPS Quality Assurance Manager attends SNUPPS Quality Assurance Committee meetings and is responsible for surveillance and audit of the SNUPPS organization, the first core fabricator and the lead A/E. He is the formal interface between the quality assurance organizations of the SNUPPS utilities. Schnell Testimony at 20.

32. The Union Electric quality assurance program interfaces with the SNUPPS quality assurance program and is also responsible for the site-related and non-standard aspects of the quality assurance program. Appendix B to 10 C.F.R. Part 50 requires that a utility establish an organization to assure the effective execution of the quality assurance program; that quality assurance personnel have sufficient authority and organizational freedom to identify quality problems and to initiate, recommend or provide solutions; and that these persons report to a management level which affords a sufficient independence from production (cost and schedule) considerations. Applicant's organizational structure satisfies these requirements. Schnell Testimony at 21 and Figure 2.

33. The Union Electric Manager, Quality Assurance is responsible for directing the quality assurance program for Union Electric. This includes program development, maintenance and verification of implementation. The Manager, Quality Assurance has access at all times and reports directly to the Union Electric Vice-President, Nuclear, who is the individual responsible for all aspects of the design, construction and operation of the Callaway Plant. This provides the quality assurance department with a direct path to management personnel with ultimate responsibility for the plant. The Manager, Quality Assurance is supported by three groups of engineers. Two groups are assigned to the Callaway Plant and are charged with monitoring and coordinating quality activities relating to construction and

operations. The third group is located at Applicant's headquarters in St. Louis, Missouri, and is involved principally in monitoring design and procurement activities within Applicant's home office organization and within SNUPPS. Schnell Testimony at 21, 22 and Figure 2.

34. Implementation of Applicant's Quality Assurance Department responsibilities results in an independent overview of design, procurement, fabrication, installation, testing and operating activities to assure compliance with Applicant's regulatory commitments. This overview is in addition to the quality assurance functions that are delegated to other organizations including Daniel, Bechtel, Westinghouse and individual material, equipment and service suppliers. Implementation of the total quality assurance commitment by these organizations results in multiple levels of review and surveillance which provide assurance that the design, procurement and construction effort produces a plant which will be safe to operate. Schnell Testimony at 22-25.

35. The day-to-day construction activities at the Callaway project are monitored principally by the Daniel and Union Electric quality assurance programs. As previously indicated, Daniel was engaged by Union Electric to construct the Callaway Plant, utilizing design information provided by the lead A/E and others, and manufactured items and materials procured under the SNUPPS concept. The day-to-day construction activities are performed by Daniel in accordance with the Daniel quality

assurance program. The task of establishing and executing such a program was imposed on Daniel by Union Electric. Daniel's responsibilities include constructing the physical plant, preparing procedures to support work activities, controlling documents and special processes, inspecting construction activities to verify compliance to the design, identifying nonconforming materials, parts or components, performing repairs and rework when necessary, and maintaining records of quality activities. Schnell Testimony at 26, 27.

36. A significant and relevant aspect of these responsibilities, particularly in terms of the specific allegations raised by the Joint Intervenors, is the responsibility of Daniel to identify, document, control, disposition and correct nonconforming items. Any material, part or component that does not conform to the requirements of applicable drawings, codes, standards, specifications or other documents is considered to be either a material deficiency, which under the Daniel quality assurance program is reported on a Deficiency Report (DR), or a material nonconformance, which is reported on a Nonconformance Report (NCR). DR's may be dispositioned either "rework" or "reject for this use". NCR's may be dispositioned either "repair" or "use-as-is" and require the approval of Bechtel or, if NSSS equipment is involved, approval by Westinghouse. Schnell Testimony at 13, 14; <u>see generally</u>, Tr. 1470-1472 (Starr, Holland), 1613, 1614 (Laux).

37. The distinction between "rework" of an item under a DR and "repair" of the item under an NCR relates to whether or not the item ultimately conforms to the original design requirements. The reworking of an item pursuant to a DR is the process by which it is made to conform to the prior specified design requirement by completion, remachining, reassembling or other corrective means. The process of repair pursuant to an NCR is the restoration of a nonconforming characteristic to a condition such that the capability of the item to function reliably and safely is unimpaired, although the item does not conform to the original design specification. Since such dispositioning of an NCR involves a departure from the design requirements, approval by the lead A/E, Bechtel, is required. Schnell Testimony at 14; Tr. 1613-1615, 1618, 1630, 1631, 1672 (Laux); Applicant Ex. 9.

38. Implementing procedures under this system for nonconformances make all project personnel responsible for identifying deficiencies or deficient activities and bringing them to the attention of Daniel Quality Control or Engineering personnel who originate the NCR or DR in accordance with project procedures. A project discipline engineer reviews the NCR or DR, recommends a disposition, and identifies the cause of the nonconformance and any appropriate corrective action. The construction engineering manager reviews and approves the recommended disposition and quality control personnel perform an inspection/verification of the implementation of the disposition. This process is supplemented by other reviews and approvals in

the case of nonconformances dispositioned "use-as-is" or "repair", American Society of Mechanical Engineers Boiler and Pressure Vessel (ASME) Code-related NCR's and DR's, and nonconformances significantly affecting power block installation, operation, and/or interchangeability. A technical review of material nonconformances which affect site installation or use is made by the same, or equivalent, organization that established the original design basis for the affected item. Based upon this review, recommendations for disposition of the nonconforming item and for necessary corrective action to prevent recurrence are prepared. As necessary, supporting calculations are also provided. Schnell Testimony at 14, 15; see also, Tr. 1620-1623 (Laux), 1922, 1923 (Meyers); Applicant Ex. 9.

39. Similarly, major contractors for the SNUPPS Project are required to incorporate into procurement documents appropriate provisions which require vendors and suppliers to control nonconforming items which are identified at their shops and factories. The vendors and suppliers are required to provide a description of material nonconformances and their disposition prior to installation or use of the item. The design organization that established the design basis or an equivalent organization, as applicable, is responsible for providing the engineering disposition of material nonconformances. The disposition of significant material nonconformances affecting power block installation, operation, and/or interchangeability involving principal contractor procured hardware is subject to review and

concurrence by the SNUPPS organization. Disposition of Site A/E designed items are subject to Union Electric's review and concurrence. This system for controlling nonconforming items satisfies the requirements of Appendix B to 10 C.F.R. Part 50, Criterion XV, Nonconforming Materials, Parts or Components, and the corresponding commitments in the Union Electric and Daniel quality assurance programs. Schnell Testimony at 15, 16; see also, Tr. 1922, 1923 (Meyers).

40. Another important aspect of the SNUPPS/Callaway quality assurance program is the control process imposed upon manufacturers and suppliers of equipment and materials used in safety-related applications. By way of example, the procurement control process utilized by Bechtel, the lead A/E responsible for the procurement of equipment for systems within the standard Power Block,[10] includes the following stages: (1) supplier evaluation and selection based upon past demonstrated performance or prior survey of capability and determination that the supplier is capable of meeting the technical requirements of the specification and that its quality assurance program can meet the specified requirements; (2) supplier inspection during the manufacturing process by Bechtel personnel based upon approved inspection plans and instructions, including witness and

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10 A review of the Bechtel process will be illustrative and representative of supplier-related controls utilized in the Callaway project by others, including Union Electric, Westinghouse and Daniel.

mandatory hold points and documentation of the results of such source surveillance and final release for shipment; (3) receiving inspection at the construction site, including appropriate documentary evidence that the item conforms to procurement documents required to be available at the construction site prior to installation or use; and (4) periodic audits of the supplier's quality assurance program. Schnell Testimony at 28-34; see, e.g., Tr. 537-540 (Schnell, Meyers); see also, 1557 (Laux); 1952-1954 (Porter, Meyers).

41. As stated above, this introductory overview of the Callaway quality assurance/quality control programs will be followed by the Board's findings of fact as to the Joint Intervenors' specific allegations of failures of this program. At the conclusion, the Board will return to the general allegation from the introductory paragraph of Contention No. 1, quoted above, and will consider it in light of our findings of fact on the various subcontentions.

B. Embedded Plates

> I.A. Embedded plates, or embeds, so called because they are embedded in concrete, are fixtures installed in concrete walls to support the ends of load-bearing steel beams, piping and other structures. The plates are made of steel with short steel studs welded to one face, like the bristles of a brush. They are mounted flush with the wall surface, with the studs extending into the concrete. The exposed surfaces of the plates serve as point of attachment for girders and other structural members. If an embedded plate tears loose from a wall, the result could be

the collapse of an entire floor, breakage of critical pipes in the primary and emergency core cooling systems, and even core melt-down (Class 9 accident).

When the Callaway Plant was approximately five and one-half to seven percent complete, a stop-work order was issued on June 9, 1977, when it was discovered that some of the studs were not properly welded to the embedded plates. (See NRC Report No. 50-483/77-10, p. 8). Prior to June 9, 1977, 480 plates had been installed in the plant. (See NRC Report No. 50-483/80-14, p. 4). The NRC and the Applicant do not know how many of those 480 plates contain faulty welds, they do not know where those plates are located in the plant, they do not know what loads each plate must bear, and they do not know what the consequences of plate failure would be to the safe operation of the plant and to the health safety of the public. (See, e.g., NRC Report No. 50-483/80-14, Attachment A - item 17, pp. 4-5 and Attachment B - item 17, pp. 5-6).

The Applicant and NRC staff do know that after the June 1977 stop-work order, many unused plates had to be repaired (See NRC Report No. 50-483/77-10, p. 8) or were returned to the manufacturer. There is evidence of multiple defects on some plates. (See NRC Report No. 50-483/80-14, Attachment B, p. 3). Although it is not known whether the manufacturer inspected the plates before shipping them to Callaway (See NRC Report No. 50-483/80-14, Attachment B, p. 2), none of the 480 installed plates were removed and reinspected, and, none were repaired or replaced.

During the process of evaluating the question whether the embedded plates presented a safety-significant problem, the Applicant improperly determined, with the NRC's apparent approval, that certain exceptions to structural welding code standards would be tolerated. (See, e.g., NRC Report No. 50-483/80-14, pp. 7-10).

> We contend that inadequate and incomplete inspection and testing were performed. Omissions include the failure to conduct live-load tests and the failure to consider whether defective plates could withstand the effects of an earthquake as per 10 CFP Part 100, Appendix A, Section VI.

42. The essence of Joint Intervenors' Contention No. 1, Part I.A. is that certain embedded plates installed in concrete structures at the Callaway Plant prior to June 9, 1977, may contain faulty welds, and that if such welds fail the consequence could be the collapse of an entire floor, breakage of critical piping or core melt-down.

43. This embed contention was the principal focus of Joint Intervenors' case, with all or part of seven of the twelve hearing days devoted to an extensive cross-examination of the Applicant, Staff and Board witnesses on this contention. Applicant presented a comprehensive, multi-discipline panel of six witnesses on this issue. Included was Applicant's Vice-President, Nuclear, who, in his former position as Manager, Nuclear Engineering, was personally involved in the resolution of the embedded plate problem. The three engineers on the panel from Bechtel Power Corporation, the project architect engineer, each had personal involvement in the investigation and resolution of this concern. Finally, Applicant's witness panel included two Professors of Civil Engineering at Lehigh University in Bethlehem, Pennsylvania, Dr. John W. Fisher and Dr. Roger G. Slutter, who had performed physical testing on the

embedded plates as part of the Applicant's investigation. Both Dr. Fisher and Dr. Slutter are highly qualified and widely recognized experts in areas directly relevant to the embedded plate contention -- including the design, manufacture and static and fatigue strength analyses of welded concrete anchors and shear connectors used in steel-concrete structures and components. See Applicant's Testimony of Donald F. Schnell, Bernard L. Meyers, Eugene W. Thomas, Kirit G. Parikh, John W. Fisher and Roger G. Slutter on Joint Intervenors' Contention No. 1, Part I.A. (Embedded Plates), following Tr. 501 (hereinafter "Applicant Embed Testimony"), at 5-8 and Attachments 4 and 5. In addition to the Applicant's witnesses, the Board called two witnesses from Daniel International Corporation, the constructor of the Callaway Plant. Included were the Daniel Project Manager, who has been with the project since 1976 (including the period of interest here), and the individual who had been the Daniel Quality Assurance Manager at Callaway during much of the investigation of the embedded plate issue. Finally, the NRC Staff presented the testimony of the NRC civil engineer who had been responsible for the investigation and final resolution of the embedded plate issue. As a result of the written testimony, the cross-examination by both the Joint Intervenors and the Board, and the redirect testimony of these witnesses, as well as the exhibits received into evidence, the Board is confident that the issues involved in this contention have been fully examined and finds there is substantial evidence in the record to support the findings of fact which follow. The Board's findings on this contention will include first a general description of the embedded plates at issue and will then separately consider the concerns raised pertaining to the two generic types of embedded plates: machine welded plates and manually welded plates.

44. An embedded plate (or "embed") is a structural steel plate which is embedded in and anchored to a concrete member, such as a wall, beam or column. The embed is installed so that one face of the plate is flush with the surface of the concrete member. After the plate is embedded in the concrete member, either steel brackets or a structural steel member may be attached to the exposed face of the embedded plate by welding. The embeds are used at the Callaway Plant to support structural steel framing, heating, ventilation and air conditioning duct supports, electrical cable tray supports, and pipe support steel. Applicant Embed Testimony at 10, 11, 28 and 34; NRC Staff Testimony of Eugene Gallagher, following Tr. 1261 (hereinafter "Gallagher Testimony"), at 2.

45. The embedded plates are flat rectangular steel plates with either headed steel studs or steel anchor rods welded to one face of the plates. Prior to concrete placement the plates are positioned in construction forms. After concrete placement, when the concrete hardens around the studs or anchors, the plates become permanently embedded in the concrete member. Applicant Embed Testimony at 11 and Figures 1 and 2; Gallagher Testimony at 2.

46. The headed studs are round steel bars with integrally formed anchor heads (similar to the heads on common nails). Headed studs are manufactured in many sizes up to one inch diameter. They are welded to the plates by an automatic welding process which produces a complete butt weld between the end of the stud and the plate. A nonstructural "flash" of weld metal is deposited around the shank of the stud during the welding process. Embedded plates with headed studs are referred to as "machine welded" embeds or plates. At Callaway, such plates range in size from 1 foot by 1 foot with 4 studs, to 1 foot by 4 feet with 16 studs. The studs themselves vary from 3/8 inch diameter by 4 inches in length, to 7/8 inch diameter by 8 inches in length. Applicant Embed Testimony at 11-13 and Figure 1; Gallagher Testimony at 3.

47. Anchor rods are fabricated anchors made from round steel bars, structural steel plates and structural nuts. One end of the rod (the end not attached to the plate) is threaded, a structural steel anchor plate is installed on the threaded end of the rod, and a structural nut is used to support the anchor plate.[11] Applicant Embed Testimony at 12 and Figure 2. Anchor rods are too large to be welded to the embedded plates using the automatic welding procedures employed

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11 Some anchor rods are not threaded and are welded to plates at both ends. Such double embeds are used to provide attachment points on both sides of a concrete wall. The steel plates themselves act as anchor devices. See Tr. 536 (Thomas, Meyers), 1273 (Gallagher).

with the headed studs. Therefore, they are welded to the plates by fillet welding around the perimeter of the rod at the juncture with the plate using manual structural welding procedures. Embedded plates with anchor rods are referred to as "manually welded" embeds or plates. At Callaway the manually welded embeds vary in size from 1 foot by 2 feet with 6 anchor rods, to 2 feet by 4 feet with 15 anchor rods. The anchor rods themselves vary from 1 inch diameter by 15 inches long, to 1 1/2 inch diameter by 18 1/2 inches long. Applicant Embed Testimony at 11-13 and Figures 2 and 4; Gallagher Testimony at 3.

48. Responsibility for the design of the embedded plates, including the specification of materials and fabrication requirements, establishing load capacities for the various plates, and the selection of a suitable embed plate for a specific load application, rests with Bechtel, the architect engineer. Bechtel also has responsibility for purchasing the embeds and for quality surveillance during fabrication. The plates were manufactured and inspected by Cives Steel Company ("Cives"), Gouverneur, New York. Jobsite receipt inspection, installation and final acceptance of the plates in place is the responsibility of the constructor, Daniel.[12] Applicant Embed Testimony at 13, 14.

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12 The nature of Daniel's jobsite receipt inspection responsibilities for embedded plates, as well as other vendor supplied materials, has been modified during the course of the Callaway project. Under the original SNUPPS procurement program, any such materials purchased by Bechtel were to be given their final quality inspection at the fabricator's

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49. The materials, fabricating methods and welding procedures used in the manufacture of both the machine welded plates and the manually welded plates for the Callaway Plant are used throughout the steel fabrication industry for commercial, nuclear and industrial construction. Applicant Embed Testimony at 13; <u>see generally</u>, Tr. 947-950, 954, 955 (Fisher). The American Welding Society (AWS) <u>Structural Welding Code</u>, D1.1-75, is the relevant industry code for the welding of the embedded plates. Applicant Embed Testimony at 13. Pertinent sections for the welding of headed studs by the automatic welding process are sections 4.29 and 4.30. One of the pertinent code sections for the manual welding of anchor rods is section 8.15 of AWS D1.1-75. <u>See</u> Tr. 537 (Thomas); Joint Intervenor Exs. 15 and 17.

50. It is important to note, and to bear in mind throughout these findings of fact, that the fabrication and inspection procedures for these two types of embedded plates -- machine welded and manually welded -- are substantially different and must not be confused. The engineering

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facility prior to shipment to Callaway. Upon receipt, Daniel was only to verify the quantity of items shipped and to inspect for shipping damage. However, in the early stages of construction, in July, 1977, an additional quality assurance responsibility was imposed by Applicant on Daniel, requiring Daniel to perform a quality control inspection of all Bechtel procured safety-related items received, including the Cives embedded plates. Tr. 663-666 (Schnell), 1348-1351, 1375, 1376 (Starr); <u>see also</u>, Tr. 1931-1933, 1936, 1937 (Powers).

considerations and analyses involved in the design of each type of embed are also different. Much of the confusion which became apparent during Joint Intervenors' questioning of the witnesses on this issue, and much of Joint Intervenors' apparent disagreement with the Applicant's and the NRC Staff's embed testimony, results from the failure to distinguish the inherent differences between the two types of plates and to separate the data and documentation concerning each. See, e.g., Tr. 738 (Meyers), 870, 871 (Parikh); see also, Gallagher Testimony at 7. It is for these reasons that the Joint Intervenors' allegations concerning machine welded embeds and manually welded embeds must and will be considered separately. See generally, Tr. 1236, 1237 (Thomas), 1241 (Meyers).

Machine Welded Embeds

51. On June 9, 1977, during a routine NRC inspection, a concern was raised by the NRC inspector regarding the compliance with the AWS Code inspection requirements of some stud welds on certain machine welded embeds.[13] This concern

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13 Earlier, during the first stages of performance of the Cives contract for supply of miscellaneous steel, including embeds, the SNUPPS quality assurance staff determined, based on Bechtel shop inspections and Daniel site inspections, that some nonconforming materials were being received at the Callaway site from the Cives shop. Accordingly, Daniel was requested to inspect a 10% sampling of the embeds received on site prior to November 15, 1976. Tr. 672, 673, 687 (Schnell); see also, Tr. 1377 (Holland); Joint Intervenor Ex. 19. The resulting inspection of 374 embeds found that three (3) embedded plates and one (1) embedded frame had deficient welds. Joint Intervenor Ex. 18. A review of these four purported deficiencies reveals, however, that they either are of a very minor nature or are acceptable imperfections and that none will

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was raised during a tour of the Callaway site storage area, when the inspector identified some studs on machine welded embeds with welds that did not have full 360° weld flashes around the base of the studs and which had not been bend tested in accordance with AWS D1.1-75, Section 4.30.1. This section of the AWS Code, which provides inspection criteria for certain machine welded studs classified as "shear connectors", requires that each stud on an embed be inspected to determine if it has a full 360° flash around the base. If it does not, it must be struck with a hammer and bent in the direction opposite the missing weld flash to an angle of 15 degrees from its original axis. Studs which after bending have not separated from the plate and do not show cracks in the flash, base metal or shank are acceptable to use as is. Studs which after bending do exhibit any of these deficiencies are to be rejected and repaired or replaced. Applicant Embed Testimony at 14, 15; Gallagher Testimony at 3; see Joint Intervenor Ex. 17.

52. On June 9, 1977, the only concern raised was whether the machine welded plates had been properly inspected in compliance with the requirements of AWS D1.1-75. Contrary to the allegation in Joint Intervenors' embed contention, it

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affect the intended function of the embeds. Tr. 1234, 1235 (Thomas). Accordingly, it was determined that Cives' performance was acceptable and that there was no need at the time for site inspection of the remaining Cives materials. Tr. 1235 (Thomas); see also, Tr. 683-685 (Meyers, Schnell), 831 (Schnell), 1451, 1452 (Starr).

was not "discovered" that the studs had been improperly welded. In fact, subsequent investigations and analyses confirmed that quality stud welds on the machine welded plates had been supplied to the Callaway Plant. Applicant Embed Testimony at 15; see paragraph 58, infra. Nonetheless, as a prudent and conservative action, Daniel issued two stop work orders precluding further use of both the machine welded and the manually welded embedded plates pending further investigation.[14] Applicant Embed Testimony at 14, 15; Gallagher Testimony at 3.

53. Contrary to the concern raised, it was determined that the machine welded studs had been properly inspected by Cives in accordance with the AWS Code requirements. The machine welded studs found to be without 360° weld flashes had not been bend tested in accordance with AWS D1.1-75, Section 4.30.1, because Cives had been inspecting the stud welds in accordance with AWS D1.1-75, Section 4.30.2. Both of these inspection standards are contained in AWS D1.1-75, Section 4, Part F (Joint Intervenor Ex. 17), which identifies two types of machine welded studs, characterized by their intended use:

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14 The issuance of the stop work orders did not halt all construction work, but merely precluded the further issuance of embeds to the field and the further placement of concrete with embedded plates. Moreover, within a short period of time (less than a week), as individual plates were reinspected and found to be in compliance with the required specifications, such plates were allowed to be used. Tr. 1363, 1364, 1397, 1398 (Starr).

(a) Shear connectors - used in composite steel-concrete construction (e.g. composite beams) and,

(b) Concrete anchors - for other than composite steel-concrete construction to attach members and connection devices to concrete.

Applicant Embed Testimony at 15; Tr. 835 (Meyers); see generally, Tr. 957-961 (Slutter). The inspection requirements for these two types of machine welded studs are different. The requirements for shear connectors are contained in AWS D1.1-75, Section 4.30.1, and those for concrete anchors are contained in AWS D1.1-75, Section 4.30.2. See Joint Intervenor Ex. 17. The original Bechtel purchase order required Cives to inspect the machine welded studs in accordance with AWS D1.1-75, but did not specify Section 4.30.1 or Section 4.30.2. Cives determined that the machine welded studs were concrete anchors and not shear connectors. Accordingly, it inspected the welds in accordance with Section 4.30.2, which requires that during final inspection, at least one stud in every 100 be bend tested.[15] The testimony confirms that Cives' interpretation and classification of the studs as concrete anchors is correct. Therefore, the stud welds had been properly inspected in accordance with Section 4.30.2. Applicant Embed Testimony at 16; Tr. 835 (Meyers), 969, 978, 994 (Fisher).

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15 In addition, although not part of the "inspection requirements", if during the fabrication process a stud is identified as not having a full 360° weld flash, it was either replaced or repaired in accordance with AWS D1.1-75, Section 4.29, for concrete anchors. Applicant Embed Testimony at 16.

54. Subsequently, the Bechtel Specification 10466-C-131 for the purchase of miscellaneous steel from Cives was revised to incorporate the more rigorous final inspection requirements of Section 4.30.1, which include bend testing of all studs with less than full 360° weld flashes. The specification revision, although not called for by the Code, was a conservative and prudent action designed to provide additional evidence of the quality and acceptability of stud welding being supplied to the Callaway Plant and to document the inspection program at the fabrication shop.[16] The revision to the specification only changed the welding inspection requirements. No revisions were made to the welding procedures being used by Cives. All Cives stud welding procedures were in accordance with the AWS D1.1-75 welding requirements. Bechtel quality assurance audits and inspections have verified that the requirements were being implemented. Further confirmation of the high quality of machine welding being performed by Cives is found in the results, discussed below, of the reinspection programs conducted for machine welded embeds. Applicant Embed Testimony at 17, 18; see paragraph 58, infra.

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16 The inspection criteria in AWS D1.1-75, Section 4.30.1, provide for testing of studs that are identified by a particular variable, i.e., the lack of a 360° weld flash, to assure that the presence of this variable is not an indication of any hidden weld defect, such as a lack of fusion at the end of the stud. The criteria in AWS D1.1-75, Section 4.30.2, provide for the random inspection of studs to assure that unidentified programmatic type problems which might affect weld quality are not present. Applicant Embed Testimony at 17.

55. At the time of the issuance of the stop work orders in June, 1977, 481 machine welded embeds had been installed in safety-related buildings at Callaway. These embeds support structural steel framing, heating, ventilation and air conditioning duct supports, electrical cable tray supports and pipe support steel. Of this number, 255 machine welded embeds were identified in July, 1977, as supporting safety-related loads in the auxiliary building, control building and reactor building.[17] Applicant Embed Testimony at 28; Gallagher Testimony at 3; Tr. 532, 533, 612, 613 (Thomas). The precise location within the Callaway Plant and the actual loads imposed on each of these embeds are known. The machine welded embeds at Callaway are not loaded to their full structural capacity. To the contrary, the design loads for these embeds provide a minimum safety factor of at least 2.0 against the applicable limit state of the plate or studs. In addition, the actual loads applied to an embed generally are considerably less than the allowable load capacity of the embed, further increasing the safety factor against failure. Applicant Embed Testimony at 29, see also, Tr. 772 (Meyers), 776 (Fisher), 915 (Parikh).

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17 Due primarily to system modifications and support revisions, the current number of these machine welded embeds installed prior to June 9, 1977, which support safety-related loads, is 204. Applicant Embed Testimony at 28, 29.

56. Although there was no indication that the Cives machine welding procedures or inspection procedures were deficient, a complete investigation of the machine welded studs was undertaken in order to confirm that those machine welded plates already installed would function as designed. The investigation included a 100 percent reinspection of the welds on all available machine welded plates at the Callaway jobsite and an engineering analysis of the machine welded plates using the data collected in the reinspection program. Confirmation of the results of these efforts was later provided through performance of load tests to the full design load on six (6) machine welded plates which had been embedded in concrete prior to June 9, 1977. Applicant Embed Testimony at 18; Gallagher Testimony at 4, 5.

57. In the reinspection program, Cives inspectors visually inspected each stud weld on all available machine welded plates to determine if it had a full 360° weld flash. If the full flash was observed the weld was deemed to be acceptable. If the weld did not have a full 360° flash it was subjected to a bend test in accordance with AWS D1.1-75, Section 4.30.1, in order to determine if it was acceptable. If after being struck by a hammer and bent to an angle of 15 degrees the weld flash did not exhibit any cracking, it was accepted. Studs exhibiting cracking or which fell off were counted as rejects.[18] In such a reinspection program it was

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18 It should be noted that the Code specified bend test imposes loads on the stud weld greater than any loads the weld

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not necessary to record or describe the nature or degree of any welding deficiencies observed. The significant information which was required was the number of studs with less than a 360° weld flash and the number of such studs which subsequently failed the bend test. Applicant Embed Testimony 18, 19; Tr. 1237, 1238 (Thomas).

58. The 100% reinspection of the machine welded plates performed by Cives produced the following results:

1. 81,673 studs, on 7,453 machine welded plates, were visually inspected.
2. 457 studs did not have a full 360° weld flash.
3. 66 of the 457 studs failed the bend test.

Thus, only 66 out of 81,673 studs (0.08%) were found to be rejectable under the inspection standards of AWS D1.1-75, Section 4.30.1. Applicant Embed Testimony at 19; Gallagher Testimony at 4; Applicant Ex. 4 at 1; see also, Tr. 1169-1171 (Schnell). These results of the Cives reinspection program of the machine welded plates were confirmed by a separate inspection conducted by Daniel. Daniel welding inspectors visually inspected 96,472 machine welded studs[19] and rejected only 106

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will encounter in operation. The test is merely an indication of whether there is a potential problem with the critical part of the weld on a machine welded stud. This critical portion is not the visible non-structural flashing around the base of the stud. Rather, it is the fused metal between the stud and the plate which cannot be visually inspected. If when the stud is bent 15 degrees, the weld flash exhibits cracking, it is conservatively assumed that this is an indication of a possible deficiency in the actual stud weld, and the weld is rejected. Applicant Embed Testimony at 19; Tr. 523 (Meyers).

19 The Daniel inspection was conducted over a longer period of time than was the Cives reinspection program. Since

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studs, a reject rate of 0.11%.[20] Tr. 1239, 1240 (Schnell), 1410, 1411 (Gallagher); Joint Intervenor Ex. 31; Staff Ex. 6, Attachment B at p. 4.

59. The results from the Cives and Daniel inspections of machine welded embedded plates compare very favorably with normal industry standards. Defect rates of 0.08% and 0.11% are exceedingly low and demonstrate that adequate quality controls were in effect during fabrication of the embedded plates. Applicant Embed Testimony at 20; Gallagher Testimony at 4; Tr. 1308 (Gallagher). This very low rate of stud weld rejection also provides evidence of the quality and acceptability of the stud welds on the machine welded plates embedded in concrete prior to June 9, 1977, since the reinspected plates were fabricated by the same company, in the same time period,

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embedded plates were still being received from Cives, the Daniel inspection included a larger number of machine welded studs. See Tr. 1412 (Gallagher); Staff Ex. 6, Attachment B at p. 4.

20 As will be discussed below, the data from the Daniel inspection program for manually welded embeds was found to be unusable for an engineering analysis of such plates, because the data lacked specificity in describing the weld deficiencies observed. The data compiled for the machine welded plates, however, was not rejected because, as stated above, a description of the weld deficiencies was not required for the evaluation of such welds. All that was required was the number of welds which failed the visual inspection and bend test. This data was provided in the Daniel records (see Joint Intervenor Exs. 13 and 31) and was available for review. As indicated above this review confirmed the results of the Cives reinspection program. Tr. 1239, 1240 (Schnell); see also, Tr. 878 (Parikh), 1029, 1032-1034, 1133, 1134 (Fisher), 1306, 1307 (Gallagher).

using the same procedures as those installed before June 9, 1977.[21] Applicant Embed Testimony at 20, 21.

60. Applicant considered these results alone to be sufficient to confirm the safety and structural integrity of the machine welded plates. Tr. 505, 831 (Thomas); see also, Tr. 1302, 1328 (Gallagher). Nonetheless, in an effort to quantify and communicate better the extremely small possibility of there being any adverse impact on safety, Bechtel used the data from the Cives reinspection program and performed an engineering analysis to determine the probability of a failure in any of the machine welded plates installed prior to June 9, 1977. Tr. 505 (Thomas); see Applicant Ex. 4 at 2. In order to establish this probability, the analysis accounted for several factors: the probability of a stud being ineffective; the probability of a plate (which is assumed to have an ineffective stud) supporting a safety-related attachment; the probability of a load on a plate being of sufficient magnitude and at a location relative to an assumed failed stud to exceed the failure capacity of the plate; and the probability of the plate ever experiencing the attachment design load. None of the

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21 Further confirmation of this high quality of Cives stud welding was provided by the results of an inspection of machine welded embeds supplied by Cives in the same time frame to the SNUPPS project at the Wolf Creek plant in Kansas. Of 9,946 stud welds inspected at Wolf Creek, five did not have a full 360° weld flash (0.05%) and three studs were found to be rejectable (0.03%). Applicant Ex. 4 at Appendix A; see Tr. 757-759 (Schnell).

factors in itself is representative of plate failure. Rather, the resultant probability against a single plate failure is the product of these factors. Imposing substantial conservatisms in the analysis, Bechtel calculated that the probability of a plate failure resulting from a machine welded stud separating from its plate is less than one in one billion (10^{-9}). Applicant Embed Testimony at 21-27; Applicant Ex. 4 at 3-5; Tr. 505 (Thomas), 910-918 (Parikh). Dr. Fisher and Dr. Slutter of Lehigh University confirmed that this Bechtel analysis represents a very conservative approach and provides additional assurance of the structural integrity of the machine welded embeds installed in concrete prior to June 9, 1977. Applicant Embed Testimony at 26, 27.

61. Further confirmation of the safety of these machine welded embeds was provided by physical tests performed on six machine welded plates which had been embedded in concrete prior to June 9, 1977. These tests were performed at the Callaway site under the direction and supervision of Dr. Fisher and Dr. Slutter. The tests were witnessed by a representative of the NRC Staff. The six selected plates were chosen based upon accessibility at the time of testing and the feasibility of mounting a test rig for the plates. The selection of these plates was concurred in by the NRC Staff prior to testing. Applicant Embed Testimony at 27; Gallagher Testimony at 4, 5; Applicant Ex. 5 at 2; Tr. 1418 (Gallagher). By means of a hydraulic jack, each of the six plates was

subjected to a tension load in excess of its design capacity load and each exhibited no indications of yielding of the plate or studs, no audible or visual signs of cracking or failure, no sudden changes in deflection during the application of the load and no excessive overall deflection. These results confirm that the machine welded embeds installed prior to June 9, 1977 are capable of safely supporting their design loads.[22] Applicant Embed Testimony at 27, 28 (Fisher, Slutter); Gallagher Testimony at 4, 5, 8; Applicant Ex. 5 at 4, 5.

62. Contrary to Joint Intervenors' allegation, in the extremely unlikely event that a machine welded embed failed to perform its design function, the result would not be the collapse of an entire floor or the failure of an entire system needed for safe shutdown of the reactor. Machine welded embeds are not used to support main floor framing beams. Therefore, the failure of an entire floor or even portions of a floor would not and indeed could not result from such a hypothetical occurrence. Machine welded embeds do support piping systems needed for safe shutdown. Such systems, however, are designed

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22 During construction at Callaway, a cooling water pipe being installed in the radwaste tunnel accidentally rolled off all but one of its supports which in turn was attached to a single machine welded embed. This imposed on the embed and its stud welds a load far in excess of the maximum design load. The embed failed and pulled partially away from the wall leaving some of the studs in the wall. The stud welds, however, did not fail. Rather, the failure occurred in the base metal of the steel plate, indicating that the welds performed as designed and were actually of a greater strength than the base metal. Tr. 626, 627, 669, 670 (Schnell, Meyers).

with certain conservatisms which result in a minimum safety factor of 1.64 against yielding and a much greater factor against exceeding the limit state. Furthermore, the relevant systems are each comprised of two completely independent, 100% capacity subsystems which are designated as train A and train B. Any failure in one subsystem as the result of a failed embed (or for any other reason) will have no effect on the redundant counterpart. Therefore a single failure of any machine welded embed will not lead to the failure of an entire system. Applicant Embed Testimony at 30, 31 (Meyers, Thomas).

63. The NRC Staff reviewed and evaluated the results of Applicant's inspection program and the Lehigh University physical tests on machine welded embeds. Based on these results, the Staff agreed with Applicant's conclusion and found that the machine welded embedded plates installed prior to June 9, 1977, will provide adequate structural support for piping and component supports, and that the use of such embeds does not threaten the safe operation of the Callaway Plant. Gallagher Testimony at 4, 5; Staff Ex. 6 at 5-7.

64. The Board finds, therefore, that the machine welded plates embedded in concrete prior to June 9, 1977, are capable of providing the intended support for which they were designed, and will have no adverse effect on the safe operation of the Callaway Plant. In summary, our conclusion is based on the favorable results of the Cives reinspection of 81,673 machine welded studs and the Daniel inspection of 96,472

machine welded studs, on the engineering analysis which concluded that the probability of a plate failure resulting from a defective stud weld is extremely remote, and on the results of the Lehigh University tests on six machine welded plates embedded prior to June 9, 1977, which demonstrated that the plates are capable of supporting their design loads.

Manually Welded Embeds

65. Anchor rods are too large to be welded by the automatic welding process used on the machine welded embeds. Therefore, fillet welds are used to join the plates and anchor rods. The fillet welds are made by depositing weld metal around the perimeter of the anchor rod shank at the intersection with the surface of the plate. The weld metal fuses to the anchor rod and the plate, and provides a positive mechanism for load transfer between the two items. The pertinent parameters associated with fillet welds are the horizontal and vertical weld leg size, the weld throat size and the weld profile (i.e., concavity or convexity of the exposed weld surface). Applicant Embed Testimony at 33 and Figure 4.

66. There were 225 manually welded plates embedded in safety-related buildings at Callaway prior to June 9, 1977. They are used for attachment of structural steel framing members to the concrete. All support safety-related loads. Their precise location and the actual loads imposed are known. The manually welded embeds at Callaway are not loaded to their full structural capacity. To the contrary, the design loads

for the manually welded plates provide a minimum safety factor of at least 2.0 against the yield limit state of the plate and tensile capacity of the anchor rods. Furthermore, in general, the actual loads imposed on the plates are considerably less than the allowable design load capacity, thereby providing an additional margin of safety. Applicant Embed Testimony at 34, 35; Gallagher Testimony at 3; see Tr. 772 (Meyers), 776 (Fisher), 915 (Parikh).

67. Although the concern with the embeds as originally raised during the NRC inspection on June 9, 1977, related only to machine welded embeds, Applicant initiated an investigation of all embeds, manually welded as well as machine welded. Tr. 642, 661, 663, 827, 1227 (Meyers, Schnell). Therefore, in addition to the reinspection of the machine welded embeds, Cives was requested to conduct a 100% reinspection of the anchor rod welds on all manually welded embeds on site but not yet installed. The initial reinspections indicated that there were certain deficiencies in the manual welding of the anchor rods, and Cives was directed to identify the nature and maximum extent of such deficiencies. Applicant Embed Testimony at 33; Gallagher Testimony at 4; see Tr. 796, 828, 1241 (Meyers).

68. In the SNUPPS Preliminary Safety Analysis Report, Applicant committed to compliance with the requirements of American Welding Society (AWS) Structural Welding Code, D1.1-75, for the welding of manually welded embeds. This

requirement was imposed on Cives in the pertinent Bechtel purchase order, 10466-C-131. In its reinspection effort, Cives inspected to the requirements of D1.1-75. See Tr. 795, 1225 (Meyers). In this reinspection program, the significant factor was not the number of welding deficiencies identified, as was the case in the reinspection of the machine welded plates. Rather, the critical factor which had to be identified was the nature and maximum extent of the deficiencies. Such information was necessary in order to make an engineering determination as to whether the deficiencies identified would have an unacceptable effect on the structural integrity of the manually welded embeds. Tr. 1241 (Meyers); see also, Tr. 695 (Parikh), 796, 871 (Meyers).

69. Cives reinspected over 400 manually welded embeds at the Callaway site. Eighty (80) plates were found to have weld deficiencies not in compliance with the AWS D1.1-75 requirements committed to in the Preliminary Safety Analysis Report. The nature and maximum extent of the welding deficiencies identified by Cives during its reinspection program were:

(1) Insufficient weld (leg) size. The required weld sizes on the various manually welded embeds varied from 3/8 inch to 5/8 inch. 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 (i.e., the weld leg measured parallel

to the anchor rod). The undersize rarely extended around the entire circumference of the weld.

(2) Unequal leg size. The two legs of the weld were not of equal length. The vertical leg of the weld was usually shorter than the horizontal leg of the weld.

(3) Unacceptable profile. The weld exhibited excessive convexity when compared with the requirements of AWS D1.1-75.

(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 Embed Testimony at 35; Tr. 1241 (Meyers); Applicant Ex. 4 at 1-3; Board Ex. 1 (Enclosure 2 to ULNRC-238); Staff Ex. 6 at 7 and Attachment B, item 9.

70. The identified deficiencies were not in strict compliance with the requirements of AWS D1.1-75, Section 8. However, the requirements of the AWS Code are not mandatory and are intended only to be engineering guidelines for the architect engineer. The Code is intended to cover a wide range of applications and in specific instances the architect engineer is permitted by the Code itself to take exceptions if technically justified. Tr. 773, 1135, 1136 (Fisher); <u>see also</u>, Applicant's Testimony of Bernard L. Meyers, Thomas H. McFarland and Donald W. Pfeifer in Response to Joint Intervenors' Contention No. 1, Part I.C.1 (Honeycombing, Reactor Building

Base Mat), following Tr. 227, at 7-9; Joint Intervenor Ex. 15. In the case of the manually welded anchor rods, the AWS D1.1-75 required weld detail is almost impossible to produce using normal production materials and techniques. These requirements, however, were developed for linear welds and not for the type of weld of interest here. As such, the AWS requirements include controls on all the various weld parameters which are important in a variety of welding applications, but not all such weld parameters are significant in the specific application of welding anchor rods to plates. Applicant Embed Testimony at 35, 36.

71. In order to determine if the deviations from the required weld detail which were identified on the manually welded embeds would adversely affect the load carrying capacity of such embeds, Bechtel undertook an engineering analysis. Certain very conservative assumptions were made in this analysis. Based upon the information from the Cives reinspection, the "worst case" deviations were identified and these deviations were assumed, for purposes of the analysis, to exist on every weld on every plate. Tr. 724, 792 (Meyers), 1242 (Thomas). The analyses of the individual deficiencies were as follows:

(1) Weld Undersize. An engineering evaluation was performed to determine the load carrying capacity of each manually welded plate, assuming it contained undersized welds. The evaluation was made using certain conservative "worst case"

assumptions, principally, that all anchor rods on the plate were considered to have 1/8 inch undersized welds (even though most of the undersized welds which had been observed were only 1/16 inch undersized) and all welds were considered to be undersized for the total 360° perimeter of the anchor rod (even though such extensive undersize was rarely observed). Accordingly the average weld undersize assumed for this analysis was a full 1/8 inch undersize for each weld on the plate. Using these conservative assumptions, a reduced load carrying capacity was calculated for each plate. 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.[23] The smallest minimum safety factor against exceeding the plastic limit state of the plate is 1.91. Applicant Embed Testimony at 37, 38; Applicant Ex. 4; Staff Ex. 6 at 7-9; Tr. 724, 740, 792 (Meyers), 1242 (Thomas).

(2) Unequal Weld Legs. Unequal weld legs are not generally permitted for linear structural welding since this condition can result in thermal stress in one of the pieces being welded. These stresses occur in steel weldments with a restrained member. The anchor rods, however, are not

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23 For many of the manually welded plates, there was no reduction in the load carrying capacity resulting from the assumed undersize. See Applicant Ex. 4 at Appendix B, Sheet No. 3.

restrained. The rod is free to move under differential thermal strains during the welding process, thereby eliminating these stresses and the requirement for the anchor rod welds to meet this criterion. The movement that does occur is very small and does not affect anchor rod performance. Applicant Embed Testimony at 38; see also, Applicant Ex. 4 at Appendix C; Joint Intervenor Ex. 16.

(3) Unacceptable Weld Profile. Weld profile and convexity are also indicative of the amount of heat transmitted to the elements being welded and are therefore not critical in anchor rod welding for the same reasons stated above in item (2). Applicant Embed Testimony at 38; see also, Applicant Ex. 4 at Appendix C; Joint Intervenor Ex. 16.

(4) Undercut. Undercutting the base metal of the threaded anchor rod reduces the cross-sectional area of the rod which governs the load carrying capacity of a rod. The maximum undercut observed during the Cives reinspection was 1/16 inch. The net area of a rod with a 1/16 inch undercut around the entire circumference of the rod, however, is still greater than the net area of the rod at the root of its threads. Since in the design process it was the net area at the root of the threads which governed the capacity of the anchor rod, the 1/16 inch undercut has no effect on the load carrying capacity of the rod. Applicant Embed Testimony at 38, 39; Applicant Ex. 4 at 2, 5 and Appendix B.

72. Dr. Fisher and Dr. Slutter have reviewed the Bechtel analyses of these worst case welding deviations and concur in Bechtel's conclusion as to the acceptability of the manually welded embeds. Applicant Embed Testimony at 39; see also, Tr. 742-745, 1136 (Fisher). The NRC Staff also reviewed and evaluated the Bechtel analysis and concluded that the manual welds provide adequate strength for the design loads. Staff Ex. 6 at 7-10.

73. Based upon the results of the Bechtel engineering analyses, and the Staff review and evaluation of such analyses, the Board concludes that even with the welding deficiencies observed in the Cives reinspection of the manually welded embeds, such embeds are structurally sound and will have no adverse effect on the safe operation of the Callaway Plant.

74. As a result of the identification of the welding deficiencies, the recognition that the strict requirements of AWS D1.1-75 could not be met for the welding of anchor rods to embedded plates, and the determination that the worst case deficiencies observed would not adversely affect the load carrying capacity of tbe manually welded embeds, Applicant determined that certain minor exceptions to the structural welding code could safely be adopted. Accordingly, the following exceptions to AWS D1.1-75, as identified in the SNUPPS FSAR Section 3.8.3.6.4.3 and Bechtel Specification 10466-C-131 Sections 8.4 and 8.6, were determined to be permissible for welding between manually welded anchor rods and plates:

(1) Vertical leg of the weld may be up to 1/16 inch smaller than that specified on the drawings.

(2) Unequal legs are permitted.

(3) Weld profile and convexity requirements need not be imposed.

(4) An undercut of up to 1/16 inch for 10% of the weld length is permissible.

Applicant Embed Testimony at 39, 40; Applicant Ex. 4 at Appendix C, Gallagher Testimony at 5; Staff Ex. 6 at 7-9 and Attachment B, item 2; Tr. 1292 (Gallagher).

75. The determination that these exceptions are acceptable is based on the same engineering analyses used to evaluate the effect of the worst case welding deficiencies observed on the manually welded embeds. Furthermore, the allowable deviations from the AWS Code adopted by these exceptions for weld undersize and weld undercut are substantially less than those deficiencies which were found to be not significant in the analyses. Applicant Embed Testimony at 39, 40; see also, Applicant Ex. 4 at Appendix C. The exceptions to the code and the changes to the FSAR and the Bechtel specification were reviewed and approved by the SNUPPS Technical Committee and the SNUPPS utilities (Tr. 656, 657, 1046 (Meyers, Schnell)), as well as the NRC Staff. Gallagher Testimony at 5; Staff Ex. 6 at 7-9; Tr. 1292 (Gallagher).

76. The Bechtel analyses of the structural integrity of the manually welded embeds with certain welding deficiencies

was premised upon certain "worst case" assumptions derived from the Cives reinspection program. The principal assumptions were that average weld undersize did not exceed 1/8 inch and average weld undercut did not exceed 1/16 inch for the entire 360° perimeter of the weld. Subsequent to the issuance of Bechtel's "Final Report-Investigation of Welded Studs" (Applicant Ex. 4) in August, 1977, these "worst case" assumptions were called into question by certain inspection records prepared by Daniel welding inspectors. Applicant Embed Testimony at 40, 41.

77. After the issuance of the June 9, 1977 stop work order, Daniel had been directed by Union Electric to perform inspections on all embed items supplied by Cives, including both machine welded and manually welded embeds. Daniel's inspection was separate from the Cives reinspection program and was an ongoing process which included receipt inspections of incoming embeds. Applicant Embed Testimony at 40, 41. Because of the nature of the reporting process at the time, the deficiencies identified in this Daniel reinspection were not brought to the attention of the appropriate Union Electric or Bechtel personnel.[24] It was not until November, 1977,

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24 The surveillance reports from the Daniel inspections were accumulated in Daniel's general file category N11.02 for several months and were dispositioned under the Category B nonconformance procedure for on-site rework of the indicated deficiencies. Nonconformance Report NCR-2-0831-C-B was generated to cover this work. As a Category B nonconformance, approval of the architect engineer, Bechtel, was not required. Furthermore, since this was a generic NCR for all the rework of these plates, it remained "open" throughout this period. Because this NCR was repeatedly supplemented and only the initial

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therefore, that it came to the attention of Union Electric and Bechtel that a large number of manually welded embeds had been rejected by Daniel during its reinspection and that in some cases the reported weld undersize appeared to exceed 1/8 inch, the "worst case" assumed in the Bechtel analysis. An investigation was undertaken of the apparent differences in the Cives and Daniel reinspections to determine whether the actual conditions of the manually welded anchor rods justified the conclusions in the Bechtel Final Report. Applicant Embed Testimony at 41; Applicant Ex. 6; Tr. 720-726 (Meyers, Schnell); see also, Tr. 1243 (Meyers), 1294-1296 (Gallagher).

78. At the time this apparent contradiction arose, it was determined that a group of manually welded embeds rejected by Daniel during its inspection program, but not yet repaired, were available for further inspection. The inspection reports for these plates did not fully describe the extent of the weld deficiencies.[25] In November, 1977, 45 of these plates were reinspected by Daniel inspectors. These reinspections indicated that average weld undersize did not exceed 1/8

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report was distributed outside of the Daniel organization, Union Electric and Bechtel were not notified of the extent of the potential problem indicated by this NCR. Applicant Embed Testimony at 41; Tr. 798 (Meyers), 799 (Schnell), 1383, 1384 (Holland), 1386, 1386A (Starr).

25 As indicated above, for purposes of an engineering evaluation of the significance of welding deficiencies on manually welded embeds, the critical element is the maximum average extent (or "worst case") of the deviation. Tr. 1241 (Meyers).

inch for any embed, and that the Daniel inspection reports in NCR-2-0831-C-B often did not accurately represent the condition of the welds. Applicant Embed Testimony at 42; Applicant Ex. 6, attached report at p. 2; Applicant Ex. 7 at p. 1; Board Ex. 1, enclosure 4; Staff Ex. 6 at 8. Meanwhile, initial review of NCR-2-0831-C-B and its associated surveillance reports revealed numerous inconsistencies, erroneous data and errors. For example, some inspectors reported weld remaining rather than weld undersize, and some reports indicated a 3/4-inch undersize for a 3/8-inch weld. Daniel itself recognized and acknowledged these problems and attempted to clarify the data. Applicant Ex. 6, attached report at p. 2; Applicant Ex. 7 at p. 1; Board Ex. 1, enclosures 3 and 4; Tr. 543 (Meyers), 727 (Parikh). Despite persistent efforts, Daniel was unable to reformulate the data from its inspection reports so that it could be used for an engineering analysis similar to that performed using the data from the Cives reinspection. Applicant Embed Testimony at 42; Applicant Exs. 6 and 7; Joint Intervenor Ex. 14; Board Ex. 1, enclosure 3; Tr. 1244 (Schnell), 1357, 1358 (Starr).

79. 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.[26]

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26 A review of the Daniel data package cannot be conducted by looking at a handful of pages in isolation as Joint Intervenors attempted during this hearing. Tr. 1243 (Meyers).

Tr. 893 (Parikh). The results of this review are contained in Bechtel's "Final Report-Investigation of Documentation Supporting NCR-2-0831-C-B", dated January 16, 1978 (Applicant Ex. 7). Bechtel concluded that it was inappropriate and impossible to base an engineering analysis on the Daniel data because of its poor documentation, inconsistencies and apparent errors. The data was considered inaccurate and suspect in the sense that Daniel's inspectors had been inconsistent in their manner of recording data,[27] had not recorded sufficient information regarding the extent of weld deficiencies to permit engineering analysis,[28] and had recorded weld undersizes that were excessively high[29] and not technically feasible.[30]

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27 Some inspectors reported weld remaining rather than weld undersize. Board Ex. 1, enclosure 4 at p. 2 and attachment I; see also, Tr. 1380, 1381 (Holland).

28 Most Daniel inspection reports did not record the extent of weld undersize or weld undercut around the anchor rod. Daniel acknowledged that in most cases the inspectors' entries record the greatest amount of undersize and that the extent of undersize varies around the circumference of the rod. Joint Intervenor Ex. 14. Accordingly, an accurate calculation of the average weld undersize or undercut for all the rods on an embed was precluded. It is important to emphasize that "worst case" deviations, in terms of undersize and undercut, refer to the average undersize or undercut for the entire 360° circumference of the weld fillet. If the extent of the deficiency is not recorded, no assessment of average undersize or undercut can be made and therefore, an accurate calculation of reduced load capacity cannot be performed. Applicant Exs. 6 and 7; Tr. 728 (Parikh), 732 (Schnell), 896, 897, 900 (Parikh).

29 Inspectors indicated weld undersizes greater than the required weld. Board Ex. 1, enclosure 4 at p. 2; Tr. 727 (Parikh).

30 Weld undersizes of 5/16 inch to 1/4 inch for a 3/8 inch required weld were reported. This indicated a 1/16 to 1/8 inch

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Applicant Embed Testimony at 42, 43; see Applicant Exs. 6 and 7; Tr. 871 (Meyers), 892-897 (Parikh).

80. It is important to note that Daniel agrees with Bechtel's conclusion tbat Daniel's inspection data in NCR-2-0831-C-B and its related surveillance reports cannot be used for an engineering analysis of the manually welded embeds. Tr. 1357, 1358 (Starr), 1380-1384 (Holland); see also, Tr. 1244 (Schnell); Joint Intervenor Ex. 14. Because of the purpose and scope of the Daniel embed inspection program, there is good reason why the results of the inspection program had limited use. Daniel inspection reports were not prepared in order to provide an absolute picture of the amount and extent of the weld deviations such as would be required for an engineering evaluation. Rather, the Daniel inspection reports were intended only to provide a basis for accepting an embed, or for rejecting it and setting it aside for rework. It was not necessary, therefore, to make specific entries as to amount or percentage of the total weld which was rejectable. Applicant Embed Testimony at 43; Tr. 722, 730, 1244, 1245 (Schnell), 1357, 1358 (Starr), 1380-1384 (Holland); Joint Intervenor Ex. 14 at 2. In submitting its final effort at clarifying its data package, Daniel acknowledged tbat its inspectors had

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weld deposit. In general, it is not technically possible to deposit such a small weld with the size electrode used by Cives. Applicant Ex. 7 at p. 3; Tr. 727 (Parikh).

recorded greatest undersize and not average undersize, and concluded

> Because of the manner in which weld deficiencies were reported, an engineering evaluation which assumes the maximum undersized condition around the complete weld circumference will not represent a true image of the actual conditions.

Joint Intervenor Ex. 14 at 2.

81. A final reinspection of Daniel rejected, but unrepaired, manually welded embeds was conducted jointly by representatives of Daniel, Bechtel and Union Electric. These embeds were considered to be typical of Cives workmanship and had been retained in their as-received condition during the embed investigation. The joint team of inspectors confirmed that the perceived weld deficiencies were less than originally reported by Daniel, and most importantly, confirmed that none of the welds exceeded the 1/8 inch undersize or 1/16 inch undercut assumed in the Bechtel engineering analysis.[31] Applicant Embed Testimony at 44; Applicant Ex. 6, attached report at p. 5; Staff Ex. 6 at 8, 9; Tr. 1245, 1246 (Schnell).

82. It is Joint Intervenors' apparent theory that Applicant together with its architect engineer, Bechtel, improperly concluded that the results of the Daniel embed inspection program could not be used for an engineering

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31 In June, 1980, NRC inspectors visually inspected the same group of manually welded embeds and determined that the Union Electric, Bechtel and Daniel team inspection was valid. Staff Ex. 6 at 9.

analysis of the manually welded plates. As has been established in the record and set forth above, there is ample evidence to support the conclusion of Applicant, Bechtel and Daniel, itself, that the Daniel inspection results cannot be used in such an analysis and that such results do not contradict the "worst case" findings of the Cives reinspection program which formed the basis for the Bechtel analysis. It is also important to note that Joint Invervenors have come forward with no evidence to the contrary. But even if Joint Intervenors were able to establish that the results of the Daniel inspection were reliable, accurate and usable for an engineering analysis, Dr. Fisher of Lehigh University has testified that the conclusion as to acceptability of the manually welded embeds would be unchanged. Dr. Fisher reported that as a result of recent experimentation leading to proposed revisions in the code requirements for manual welding of anchor rods, it has been demonstrated that if the Daniel data were taken at face value (with the exception of readily obvious errors such as where the data is not technically feasible) and it was assumed that the worst weld deviations indicated therein extended 100 percent around the circumference of the anchor rods, there still would have been no adverse effect on the load carrying capacity of these embeds or upon their required margins of safety. Indeed, Dr. Fisher testified that there could have been a further 25 percent reduction in the size of welds assumed by Bechtel in its engineering analysis without affecting the structural integrity of the anchor rod welds. Tr. 742-745, 1136 (Fisher).

83. Final confirmation that the manually welded embeds, even if they contain "worst case" welding deficiencies, are structurally sound and will adequately perform their intended design function, was provided by physical tests performed by Dr. Fisher and Dr. Slutter at Lehigh University. From the group of plates previously rejected by Daniel inspectors, but not repaired, twelve plates were selected for testing. Specific anchor rods selected for testing were those that exhibited the most severe welding deficiencies. Both bend tests and tension tests were performed. All tests were witnessed by a representative of the NRC Staff. Six anchor rods on six separate plates were selected for bend tests. The specific rods were designated and their direction of bend specified by the NRC Staff. The bend testing was similar to that required for machine welded studs, except that because of the size of the anchor rods the loads were applied by a hydraulic ram rather than a hammer. In the bend tests each specimen was bent to an angle of 30 degrees and the welds were inspected for cracking. No cracks were identified in the six specimens tested. Applicant Embed Testimony at 45, 46; Applicant Ex. 5; Gallagher Testimony at 4, 8; Tr. 1052-1059, 1062 (Fisher); 1418, 1419 (Gallagher).

84. Six other specimens were tension tested to failure. Three specimens failed in the weld; the other three

specimens developed the tensile strength of the anchor rod and failure occurred not in the weld but in the anchor rod itself. The design load for manual welds is 13,650 pounds. The minimum ultimate weld strength observed in the six "worst case" specimens was 46,200 pounds, over 3 times the design load. The results of this testing verified the Bechtel analysis that the nonconforming anchor rod welds on manually welded plates embedded in concrete are more than sufficient to support the design loads, and that the identified minor exceptions to the AWS welding code are acceptable without impairing the function or safe operation of the Callaway Plant. Applicant Embed Testimony at 45, 46 (Fisher, Slutter); Applicant Ex. 5.

85. Joint Intervenors' contention that a failure of a manually welded embed could cause catastrophic results is without merit. Although the manually welded embeds installed prior to June 9, 1977, are used to support floor framing beams, the reinspection program, engineering evaluation and testing detailed above demonstrate conclusively that all the anchor rod welds are capable of supporting the required loads and that the collapse of an entire floor or breakage of critical pipes as a result of a plate failure is not a credible event. Even assuming such a failure, this would not result in the collapse of a floor slab. The slabs are designed to span in one direction between beams. They are constructed, however, with reinforcing in two orthogonal directions and supports on four sides of the slab panel, provided by other beams and interior

and exterior concrete walls, all of which provide sufficient capability for the slab to span one failed beam and prevent collapse. Also, the beam is connected to the slab by shear studs which will prevent the beam from falling. Applicant Embed Testimony at 46, 47.

86. The Board finds, therefore, that the manually welded plates embedded in concrete prior to June 9, 1977 are capable of supporting the required design loads imposed on them. In summary, our conclusion is based on the results of the Cives reinspection and the joint reinspection of Union Electric, Bechtel and Daniel which accurately identified the limits of the welding deficiencies; on the Bechtel engineering evaluation of the deficient welds which concluded that such "worst case" welds are capable of supporting the required design loads as well as Dr. Fisher's assessment that even greater reductions in weld size would have had no adverse effect; and on the results of the Lehigh University physical testing of actual anchor rods with welding deficiencies which demonstrated that such "worst case" welds had ultimate load capacities far in excess of the design requirements.

C. Concrete Cracks

> I.B. There exist several cracks in concrete structures at the Callaway Plant that affect its safe operation. Examples include, but are not necessarily limited to, the following:
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> 1. A crack up to 1/4 inch wide was discovered in the Reactor Building in the reactor cavity moat area in May 1977, a month after the concrete mat was

poured. The crack extended approximately 270 degrees around the circumference. Upon visiting the site in June 1977, an NRC inspector was unable to view repairs performed on this crack because work had progressed to an extent that made physical inspection of the repair impossible. (See, NRC Report No. 58-483/77-06, pp. 20-21).

2. The NRC was notified by a Callaway Plant iron worker in January 1978 that a lift of the north wall of the Control Building had been poured above a part of the wall which contained a crack approximately 12 feet long and 8 inches deep, and which extended from the inside to the outside of the wall and which apparently had been overlooked by the Applicant's quality assurance personnel. (See, NRC Report No. 50-483/78-01, p. 20).

87. The allegations above in Part I.B of Joint Intervenors' Contention No. 1 were ruled upon by the Board in granting motions for summary disposition, pursuant to 10 C.F.R. § 2.749, filed by both Applicant and the NRC Staff. See Memorandum and Order (Motions for Summary Disposition), November 13, 1981.

88. In its ruling, the Board made the following findings of fact with respect to the concrete crack in the reactor cavity moat area (I.B.1):

1. The concrete crack which occurred in the reactor cavity moat area of the Callaway Unit 1 plant did not create a significant safety concern since it was of only localized extent in a noncritical structure.

2. The crack was caused by thermal stress due to welding and not by faulty concrete placement in the moat area.

3. The crack was promptly discovered by the Applicant and promptly reported to NRC Staff.

> 4. The crack was properly repaired with materials of at least equal strength to the original design.
>
> 5. The Applicant's quality assurance procedures functioned adequately to detect, analyze and repair the crack.
>
> 6. Joint Intervenors have not controverted any statement by either Staff or Applicant.

Memorandum and Order, _supra_, at 8.

89. The Board made the following findings of fact with respect to concrete cracks in the north wall of the control building (I.B.2):

> 1. None of the concrete cracks in the north wall of the control building were severe enough to affect the safe operation of the plant or structural integrity of the wall.
>
> 2. The pouring of an additional lift of concrete over a portion of a wall containing cracks where such cracks could be repaired if necessary was not improper.
>
> 3. The occurrence of the cracks was due to normal shrinkage of concrete and not due to faulty construction practice.
>
> 4. None of the cracks exceeded the reporting criterion of 1/16 inch width and no nonconformance report was necessary under that criterion.
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> 5. No deficiency of the Applicant's quality assurance program was demonstrated by the investigation of the cracks.
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> 6. Joint Intervenors have submitted no facts to the contrary.

Memorandum and Order, _supra_, at 10.

D. Honeycombing, Reactor Building Base Mat

I.C. Instances of air pockets or voids, known as honeycombing, have been found in concrete structures at the Callaway Plant. As described in NRC Regulatory Guide 1.55, "Concrete Placement in Category I Structures":

> [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 instances of honeycombing at Callaway include but are not limited to:

1. Reactor Building Base Mat

On May 31, 1977, voids described by the NRC as up to six inches, but described by a worker as big enough for a man to crawl into, were found in the tendon access gallery of the reactor base mat. (See, NRC Report No. 50-483/77-06, pp. 21-22). Repairs were undertaken at this time, but during the NRC inspection of August 31 - September 2, a stop-work order was issued because of a discrepancy in work specifications concerning the testing of dry-pack group. (See NRC Report No. 50-483/77-07, p. 13). The stop-work order was lifted on December 7, 1977, after the necessary changes in specifications were made (See, NRC Report No. 50-483/78-01, pp. 2-3), but no information is available on whether any testing was performed on repairs done prior to the stop-work order. A report dated August 1, 1977, by Wiss, Janey, Estner and Associates, Inc., described a soniscope study performed by this firm to determine the possibility of additional honeycombing within the 10 foot thick base slab. The study states that, "Based upon a 25 per cent sample. . .internal honeycomb probably does not occur in the base slab, except at those 19 areas where honeycomb was visible." (See, NRC Report No. 50-483/77-07, pp. 12-13, emphasis added). This assessment of probability is the only assurance given that no additional honeycombing exists. According to a letter from

James Keppler, Director, Region III, NRC, to Kay Drey dated January 3, 1979, the tendon access gallery represents nineteen percent of the base mat area. In the same letter Mr. Keppler described the twenty-four large holes which were repaired, as follows:

> Large voids are defined as those that require approval prior to repair. The largest void in this category was approximately 22 square feet in surface area, and it was irregular in shape. Its maximum depth was 17 inches, and its average depth was 8 inches. The smallest void in this category was approximately 0.25 square feet in surface area, and its maximum depth was 5 1/2 inches. The size of the remainder of the voids in this category varied between those previously described.

90. In response to these allegations by Joint Intervenors, Applicant presented a three-witness panel: Dr. Meyers of Bechtel, who had the responsibility to review the issue of honeycombing in the reactor building base mat; Mr. McFarland of Union Electric, who, as Construction Supervisor in the Nuclear Construction Department at the time of the base mat concrete placement and repairs, was assigned to the reactor building; and, Mr. Pfeifer of Wiss, Janney, Elstner and Associates, who was project manager for the soniscope investigation of the reactor building base mat at the Callaway Plant. Applicant's Testimony of Bernard L. Meyers, Thomas H. McFarland and Donald W. Pfeifer in Response to Joint Intervenors' Contention No. 1, Part I.C.1 (Honeycombing, Reactor Building Base Mat), following Tr. 227 (hereinafter "Applicant Base Mat Testimony"), at 1-5. The evidence presented by Applicant also includes the nonconformance report prepared by Daniel, which

documents the condition of each honeycombed area and the repair procedure, and the report prepared by Wiss, Janney, Elstner and Associates to document the soniscope investigation. Applicant Exs. 1 and 2.

91. The NRC Staff, in response to this contention by Joint Intervenors, presented the testimony of a civil engineer, from the Office of Inspection and Enforcement, who had conducted inspections at the Callaway site during the base mat construction and repairs. Testimony of Anthony A. Varela, following Tr. 396 (hereinafter "Varela Testimony"), at 1, 2. The Staff also presented the reports which document Mr. Varela's inspections. Staff Exs. 2A, 3 and 4.

92. The Board's findings on part I.C.1 of Joint Intervenors' Contention No. 1 will address first the design and function of the reactor building base mat, and the process of placing concrete for that structure. The phenomenon of honeycombing will then be explored, along with the discovery and repair of this condition in the tendon access gallery of the reactor building base mat at the Callaway Plant. The soniscope investigation of the base mat will be addressed next, followed by our assessment of the safety significance of the honeycombing and any implications its occurrence have for the quality assurance and quality control programs employed during the design and construction of the Callaway Plant.

93. The reactor building base mat is a flat, circular slab 154 feet in diameter and 10 feet thick. The base

mat serves as a foundation and base for the reactor building. The tendon gallery, which is located directly below and along the outside edge of the base mat and continues around the circumference, provides access for installation and surveillance of the vertical tendons. Each of these vertical tendons, which are anchored to the trumplates in the base mat directly above the tendon gallery, consists of 170 high strength, 1/4-inch diameter steel wires bundled together. They are inserted in tendon sheaths embedded in the walls and dome, and extend over the top of the reactor building. Each of these vertical tendons is anchored to another trumplate on the opposite side of the base mat. The tendons are placed under tension prior to plant operation, forcing the shell and dome into a permanent state of compression. Applicant Base Mat Testimony at 9-11 and Figure 1; Varela Testimony at 2, 3.

94. The placement of concrete for the reactor building base mat at the Callaway Plant took place over a 62-hour period from April 6 to 9, 1977, and involved 6,720 cubic yards of concrete. The concrete was placed monolithically, using the step method, in five lifts, each approximately two feet in thickness. Two shifts of personnel were used throughout the pour, in alternating fashion. Each shift involved approximately 190 construction craft, engineering, quality control and supervisory personnel. In addition, three NRC Staff inspectors were present during the concrete placement operation, and one or more of these inspectors observed most of

the operation. Applicant Base Mat Testimony at 11, 12; Varela Testimony at 3, 6-7.

95. Applicant recognized in advance that the placement of concrete for the reactor building base mat would be difficult because of congestion, especially in the top and bottom lifts, from a greater concentration of reinforcing steel, embedded plates and tendon trumpets. In addition to the normal reinforcing steel which occurs throughout the slab,[32] this area (i.e., the portion of the bottom of the base mat which forms the roof of the tendon gallery) has 172 trumplates embedded in the roof, spaced around the circumference of the slab. The area also contains additional reinforcing steel (dowels) which extend vertically down from both faces of the reactor building exterior walls (above the base mat) on either side of the tendon sheathing, and which terminate with a hook adjacent to the bottom layer of slab reinforcing in the area of the trumplates. Applicant Base Mat Testimony at 13, 14, and Figures 2 and 3; Varela Testimony at 6; Tr. 355-357 (McFarland).

96. Each phase of the placement was pre-planned and discussed to assure that the participants were well aware of their responsibilities, the placement method, and areas of

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32 The normal complement of reinforcing steel runs along the bottom and top of the slab, with shear ties (reinforcing bars) running vertically through the thickness of the slab. Applicant Base Mat Testimony at 14.

congestion. A scaled model of the reinforcing steel was used during the planning sessions. Applicant Base Mat Testimony at 11; Tr. 371 (McFarland). Difficulty from the standpoint of concrete workability in areas of congestion had been anticipated in the planning for the pour. In areas known to have a greater concentration of embedments, such as the first lift,[33] engineering personnel, Quality Control inspectors and laborers involved in concrete placement and consolidation were positioned down within the steel assembly on the first layer of reinforcement in an effort to more accurately maintain control of placing requirements and vibration of the concrete. In areas of reduced workability, care was taken to assure that vibrators penetrated the preceding lift more frequently to provide for adequate bonding of the two lifts. In addition, throughout the placement vibrator frequencies were monitored by Daniel Quality Control inspectors at the point of discharge every 12 hours. Applicant Base Mat Testimony at 11-13; Varela Testimony at 7; Tr. 334-339, 353-358 (McFarland).

97. Governing Daniel quality control and work procedures were adequately administered and satisfactorily documented for each phase of the base mat construction effort: pre-placement, placement, and post-placement.[34] Applicant Base

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33 The greatest congestion was in the area above the tendon gallery. Applicant Base Mat Testimony at 13; Tr. 363 (McFarland), 364 (Meyers).

34 The Staff did determine, on inspection, that only the civil QC inspector present at the termination of the pour

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Mat Testimony at 12. During the pour, Staff witness Varela observed the efforts of the quality control personnel to maintain the quality of the pour consistent with the design requirements. In particular, Mr. Varela observed the quality control personnel with regard to their responsibility for assuring the timely coordination of relocating vibratory equipment craft personnel with placement equipment changes, and found their performance to be satisfactory. Varela Testimony at 7, 8.

98. Honeycombing[35] in the tendon access gallery portion of the reactor building base mat at the Callaway Plant was discovered by Daniel construction personnel subsequent to form and shoring removal.[36] At the completion of form removal,

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signed a Concrete Placing Report verifying work performance and activities, whereas the Staff determined that each of the QC inspectors should have signed such a report. Staff Ex. 3 at 22, 23. This item was closed in a subsequent inspection, however, where all the reports were observed to be completed and the Staff inspector's interviews confirmed the statements relative to verification of the placement activities. Staff Ex. 4 at 4. The Board finds no basis upon which to question the reliability of this documentation, and cannot view the original documentation to represent any serious QC deficiency. Applicant had followed its QC procedures. Tr. 325 (McFarland).

35 "Honeycombing" is a condition of small air pockets in hardened concrete, giving a "popcorn" appearance, resulting from the absence of complete consolidation, usually in very difficult to reach areas. Applicant Base Mat Testimony at 16, 17; Tr. 401, 402 (Varela).

36 Pursuant to the requirements of 10 C.F.R. § 50.55(e), Union Electric notified the NRC's Region III Office by telephone on June 17, 1977, of the deficiency in base mat concrete at the trumplates. Varela Testimony at 4.

detailed quality control inspection of the exposed concrete and concrete imperfections was performed as required by engineering specifications and quality control procedures. The nonconformance was documented on NCR 2-0653-C-A, dated May 11, 1977. That report was later superceded by NCR 2-0856-C-A, dated June 27, 1977 (Applicant Ex. 1).[37] Applicant Base Mat Testimony at 15; Varela Testimony at 3.

99. All honeycombed areas were chipped to sound concrete to determine the extent of the nonconformance. The chipping operation was performed in accordance with a repair procedure which defined the extent of chipping needed to achieve satisfactory surface preparation prior to repair. Localized honeycombing was identified at 19 areas, resulting in 24 separate excavations that may have affected the performance of 14 out of 172 trumplates in the base mat. Scaled sketches, drawn to document the condition of each honeycombed area, show the extent and maximum depth of the concrete removed in preparation for replacement materials. See Applicant Ex. 1. These areas range from less than one square foot to a maximum of approximately 22 square feet, with most of the excavations being less than 4 square feet in area. While the depth of the

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37 This NCR includes the number, location and extent of the nonconformance in concrete at each trumplate; describes the nonconformance; identifies the cause of the nonconformance; and suggests corrective action to prevent recurrence. The NCR also contains detailed maps and dimensional sketches of trumplates where unsound concrete was removed behind rebars and bearing plates. Varela Testimony at 3, 4; see Applicant Ex. 1.

excavations varied within each excavated area, the average depth of the individual excavation was approximately 10 inches, with a very localized maximum of 17 inches.[38] Applicant Base Mat Testimony at 15, 16; Varela Testimony at 3, 4; Staff Ex. 3 at 21, 22.

100. To place the extent of the honeycombing in perspective, we note that approximately 150 cubic feet of repair material was used to fill in the excavated volumes, whereas the reactor building base mat has a volume of roughly 181,000 cubic feet of concrete. Tr. 240 (Meyers), 245, 246 (Pfeifer); Applicant Base Mat Testimony at 21. This amount of honeycombing is quite small compared to the volume of the base mat and considering the difficulty of the pour. Tr. 365 (Meyers).

101. Applicant's conclusion is that the honeycombing identified adjacent to the trumplates was due to incomplete consolidation of the concrete. Consolidation of concrete is accomplished by internal-type mechanical vibrators. While the design provided for adequate clearances between embedded items to allow necessary flow and consolidation of concrete, the presence of the hooked reinforcing bars from the wall above, trumplates and sheathing, in conjunction with the shear ties

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38 The sketches show the condition of the defects after all unsound concrete had been removed. Since it is quite possible that quantities of sound concrete were also removed during the chipping process, the excavations shown may over-estimate the area of unsound concrete. Applicant Base Mat Testimony at 16.

and necessary supports for the reinforcing above, hampered the access and visibility of the construction personnel in this area. Applicant Base Mat Testimony at 18. Noting that the congestion in the base mat area presents unique problems, the NRC Staff also concluded that the honeycombing around the trumplates was caused by insufficient vibration of the concrete or inadequate full depth of penetration of the vibratory tools manually applied by craft personnel. Varela Testimony at 6, 7.

102. The Board concurs in these assessments of the cause of the honeycombing in the reactor building base mat at the Callaway Plant. We also note that this is not a surprising occurrence for a difficult concrete placement. Structural engineers have recognized that at free surfaces there is a possibility that, even with all diligent care being exercised, honeycombing will take place. The phenomenon is addressed in structural documents[39] and repair procedures are prescribed so that the structure will be completely adequate to serve its function. Honeycombing, in short, has been experienced at other structures ever since reinforced concrete has been used as a structural material.[40] Tr. 358, 359 (Meyers).

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39 If the honeycombing is relatively minor, no adverse effect will result in the load carrying capability of the structure, since provisions exist in the design codes which are used to account for such anomalies. Applicant Base Mat Testimony at 18. The occurrence of honeycombing here was sporadic within the tendon gallery and, with a few exceptions, was limited to relatively small, shallow areas. Id. at 19. Even if the honeycombing extended to the entire volumes excavated (see n.38, supra), it would not be considered significant. Tr. 240, 241 (Meyers).

40 Corrective actions were taken by Applicant, however, to minimize the recurrence of honeycombing such as occurred in the

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103. A procedure to repair the base mat honeycombing was developed by Daniel, commented on and approved by Bechtel, and is documented in Applicant Exhibit No. 1. The procedure required that the repairs were to be made using pressurized grout,[41] and included, in summary, the following elements:

> 1. Requirement that all honeycombed concrete be removed.
>
> 2. A procedure to assure good bond between the existing and replacement material and to provide keying action between the existing and replacement material.
>
> 3. Requirement for proper form work, including time limitations regarding their installation and removal.
>
> 4. Identified specific grouts which may be used for the repair.
>
> 5. Requirement for pre-pour and post-pour inspection and preparation of documentation for permanent records.

Applicant Base Mat Testimony at 19, 20; Varela Testimony at 8. Dry pack was used in those areas between trumplates that were shallower than a projected 45-degree line from the top edge of any trumplate base plate, and in those areas where one surface dimension was less than the hole depth.[42] Applicant Base Mat Testimony at 20, 21.

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reactor building base mat. Additional training was provided to concrete placing crews, and Daniel was permitted to use a higher slump concrete in other highly congested areas. Applicant Base Mat Testimony at 21, 22; Varela Testimony at 8; Tr. 370 (McFarland).

41 The material used for the repairs was a fluid non-shrink grout, which must be capable of being pumped under pressure. Applicant Base Mat Testimony at 20.

42 "Dry pack" is a mixture of cement and sand with only sufficient water added to produce a material, with the

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104. The repairs were made in accordance with the instructions provided in the disposition of the nonconformance report and in applicable Daniel quality control and work procedures. Daniel did issue a "stop work" order, however, when it was discovered during repair activities that no section had been included in the appropriate Specification C-191 to describe compressive testing of dry pack mortar. Consequently, the dry pack was not being tested. Applicant Base Mat Testimony at 21; Staff Ex. 4 at 12, 13. A nonconformance report was written by Daniel to identify the nonconformance, and Bechtel revised Specification C-191. Bechtel dispositioned the NCR "use as is" since all the repairs made with the dry pack were structurally insignificant. Furthermore, test results obtained on dry pack prepared from the same materials using the same construction techniques resulted in compressive strengths substantially above the minimum strength required. Applicant Base Mat Testimony at 21. The Board does not find this to have been a serious oversight. It should be noted that the estimated amount of grout used in the total repairs was 150 cubic feet, and it is estimated that only 3 cubic feet of dry pack was used. Id. The dry pack repairs were essentially cosmetic, i.e., done for visual effect. Tr. 375 (Meyers).

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consistence of putty, that can be molded in one's hands. It is used primarily for small repairs where concrete replacement is not practical. Rather than being pumped into the void, the dry pack is tamped in layers. Applicant Base Mat Testimony at 20; Tr. 471 (Varela).

105. Although any defects would become apparent during the post-tensioning operations and before plant operation,[43] Union Electric asked Bechtel to confirm that the repair of the honeycombing would not jeopardize the integrity of the structure. While it is above and beyond the normal industry practice of visual inspection, Bechtel requested that an ultrasonic volumetric examination be conducted. Consequently, Wiss, Janney, Elstner and Associates ("WJE") were retained to undertake a soniscope study to determine if internal voids or honeycombing existed within the base slab. Applicant Base Mat Testimony at 22, 23.

106. A soniscope evaluation employs a nondestructive testing technique that measures the velocity of a generated sound pulse which travels through the concrete. A number of material properties and physical characteristics of concrete structures can be determined by measuring sonic pulse velocity -- including the uniformity of the concrete and the location of voids, honeycombing or cracks in the concrete. In this study, the soniscope was used to detect the disturbance of the signal passed through to the concrete base slab near the selected plates. Applicant Base Mat Testimony at 23, 24; Varela Testimony at 5. The soniscope is a long-used, well accepted and established tool for determining concrete quality, concrete soundness, and amount of deterioration. Applicant Base Mat

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43 _See_ paragraph 112, _infra_.

Testimony at 24; Tr. 385 (Pfeifer). The Staff reported that non-destructive methods employing the soniscope tests are used throughout the industry to determine if internal voids or honeycombs have occurred within thick concrete slabs. Varela Testimony at 5.

107. For the soniscope investigation, WJE selected at random for testing 44 of the 172 trumplates, covering the entire 360-degree circumference of the base mat. The soniscope investigation was directed at examining sound concrete near the plate, with the specific intention of determining if unseen honeycombing exists behind or near the trumplates.[44] The soniscope testing was conducted from July 12 to 19, 1977, by WJE personnel. Twelve vertical soniscope readings were made at each of the 44 plate locations: four through the plate regions and eight through concrete in the vicinity of the plate. In addition, angled shots were planned[45] and made in 15 of the plate areas to supplement the vertical shots through plate regions which might prove to be partially unsuccessful. These

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44 The investigation focused upon the trumplates because the concrete behind them is exposed to higher local bearing stresses than any other concrete in the Callaway Plant project. Applicant Base Mat Testimony at 22; Tr. 314 (Meyers).

45 It was recognized in the preliminary planning stages that a minute separation between the trumplate and the concrete (which is due to normal shrinkage and has no effect on structural integrity) or a poor contact between the transducer and the relatively rough surface on the top of the slab could cause a disturbance in the signal which would invalidate the vertical readings through plate regions. Applicant Base Mat Testimony at 25; Tr. 312, 313 (Pfeifer).

angled shots were made such that the signal would have to pass directly behind the steel bearing plate. In total, 760 soniscope shots were performed. Applicant Base Mat Testimony at 23, 25, 26, 28, and Figures 4 to 7; Varela Testimony at 5.

108. The data resulting from the soniscope readings is presented in detail and discussed in the WJE report, Applicant Exhibit No. 2. The received data was subjected to a statistical analysis, which shows it to be extremely uniform and reliable. In addition, the velocities obtained in the readings are unusually high, indicative of very high-strength concrete. Applicant Base Mat Testimony at 27. WJE reached the following conclusions from its investigation:

1. The concrete directly above the gallery and the tested trumplates is very uniform in composition and strength.
2. The concrete tested has a high compressive strength.
3. The soniscope testing of these 44 trumplate areas found no evidence of internal honeycombing in the concrete.
4. Based upon a 25 percent sample, the results of this soniscope investigation indicate that internal honeycombing probably does not occur in the base slab.

Id. at 28; Applicant Ex. 2 at 21.

109. The NRC Staff reviewed the WJE report findings and also compared the report with similar studies at another nuclear site. The Staff witness testified that, in his opinion, based upon the 25 percent sample (44 of 172 trumplates) used for the test,[46] the results of the soniscope

46 In the Staff's view, use of a 25 percent sample was both appropriate and conservative. Varela Testimony at 5.

investigation indicate that internal honeycombing probably does not occur in the base slab except in those areas where honeycombing was visually detected when the forms in the tendon gallery access roof were removed. Varela Testimony at 5; Staff Ex. 4 at 12, 13.

110. Joint Intervenors, in their contention, appear to find some weakness in the use of the word "probably" in the fourth conclusion, quoted above, reached by WJE. Since the study was done on a sampling basis, however, it follows that the conclusion could not be expressed as a certainty. Applicant Base Mat Testimony at 28. Mr. Pfeifer of WJE testified, however, that -- based upon the random selection of the locations representing the entire circumference of the tunnel, the large number of readings taken at these locations, the fact that three different types of soniscope shots were made yielding quite uniform results, the high velocities recorded and the low statistical variation in the data -- he is confident the results of the soniscope study provide assurance that internal honeycombing does not occur in the Callaway Plant reactor building base mat. Id. at 29. Dr. Meyers of Bechtel agreed, observing in addition that the repaired areas represent less than 13 percent of the total bottom exposed surface, the area most susceptible to honeycombing, and that a small aggregate concrete was used which mitigates the consequences of honeycombing. Id. at 29, 30; Tr. 371, 372 (Meyers). Further, Dr. Meyers testified that even if minor honeycombing were

present at other areas of the base mat, the impact that it would have in altering the concrete stress over the entire base mat section would be incidental. Likewise, its impact on reinforcing bond would be very much limited due to the design requirement to use mechanical anchorages on all anchored reinforcing steel. Applicant Base Mat Testimony at 30.

111. Bechtel reported to Union Electric in September, 1977, that with the proper repair of the defects originally identified, the structural integrity of the concrete above the base mat is not impaired and the safety margins included in the original design are maintained. Applicant Base Mat Testimony at 30. Dr. Meyers of Bechtel testified here that the repair of the voids in the tendon access gallery results in a condition at the repaired areas which is at least as good as the original design requirement. This is the result of (1) using material for repair which equaled or exceeded the quality and strength requirements of the original design; and, (2) utilizing procedures that provide for proper placement and bonding. Id. at 31. In IE Inspection Report No. 50-483/80-16, dated June 24, 1980, the NRC Staff closed out its review of the matter of honeycombing in the reactor building base mat. Staff Ex. 5.

112. These assessments by the witnesses for Applicant and the Staff have been supported by very strong evidence in the form of the post-tensioning operation at the Callaway Plant, which imposed the most severe loads which will

ever occur on the concrete in the area of the repairs and on the trumplates. By the time of the hearing, all of the tendons anchored in the base mat had been tensioned, with no evidence of distress in the concrete. This indicates that the concrete behind the trumplates, both in the repaired and the unrepaired areas, is acceptable. Applicant Base Mat Testimony at 31.

113. The Board finds that the evidence indicates overwhelmingly that there is no significant additional honeycombing in the reactor building base mat beyond that which was originally identified and repaired by Daniel, and that there are no adverse safety implications from the current, repaired condition of the structure. Furthei, the Board finds that Joint Intervenors have selected here an experience which proves the opposite of their point -- it indicates that the quality assurance and quality control programs worked as they were designed. The problem was identified, thoroughly investigated, controlled and repaired in accordance with site procedures and in a manner satisfactory to assure the integrity of the structure.

E. <u>Reactor Building Dome Concrete Imperfections</u>

> I.C. Instances of air pockets or voids, known as honeycombing, have been found in concrete structures at the Callaway Plant. As described in NRC Regulatory Guide 1.55, "Concrete Placement in Category I Structures":
>
> > [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 instances of honeycombing at Callaway include but are not limited to:
>
> * * *
>
> 2. Reactor Building Dome
>
> Four areas of concrete imperfection in the Reactor Building dome were identified by Union Electric personnel during an inspection on August 22 and 27, 1980. These imperfections were attributed to "the complex nature of those portions of the dome slab where the imperfections occurred." However, on December 12, 1980, NRC personnel noticed that blockouts for the tendon grease vents had not been removed to facilitate inspection, and after the removal of the blockouts on December 13, three additional honeycomb areas were found. After conducting interviews with UE personnel concerning the three new void areas, the NRC concluded that, "There appeared no plausible explanation for their occurrence," and that "...there was not adequate assurance that the imperfections' existence were limited to only those areas identified." (See, NRC Report No. 50-483/80-30, pp. 3-4).

114. At the hearing session of November 21, 1981, Joint Intervenors indicated that they would not conduct any cross examination on the testimony filed by Applicant and the Staff on this contention, stating that Joint Intervenors had "never spoken with anyone who has ... first hand knowledge of the honeycombing", other than media representatives. Tr. 940 (Drey); see also, Tr. 1524 (Chackes). On December 2, 1981, the Board announced that we would require the appearance of the

Staff and Applicant witnesses on this issue. Tr. 1698 (Gleason). Subsequently, Applicant and Staff witnesses were made available for examination by the Board on December 4, 1981, with the exception of Applicant witness Muenow, whose appearance was not required by the Board.[47] See Tr. 1988 (Gleason).

115. The dome of the reactor building serves as the roof of the reactor building and is constructed in the shape of a hemisphere. The interior surface of the dome consists of a one-quarter inch carbon steel liner plate, which assures the leak-tightness of the reactor building and which also served as the inside form for the dome concrete placement. The thickness of the dome concrete is nominally three feet. Between the inner and outer concrete surfaces are two layers of reinforcing steel, tension tie bars and corrugated metal tubes (through which steel wire tendons were inserted for post-tensioning of the reactor building). Applicant's Testimony of Eugene W. Thomas, Guy H. Goddard, Jr., B. Christopher Tye and Richard A. Muenow in Response to Joint Intervenors' Contention No. 1, Part I.C.2 (Reactor Building Dome Concrete Imperfections), following Tr. 2010 (hereinafter "Applicant Dome Testimony"), at 7, 8 and Figure 1; Tr. 2011-2012, 2033-2035 (Tye); see also, "Partial Dome Section" sketch, following Tr. 2037.

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47 The affidavit of Mr. Muenow attesting to those portions of the prefiled testimony which he sponsored is incorporated into the record following Tr. 2010.

116. The final, or top, pour of concrete for the reactor building dome was begun at a vertical azimuth of approximately 45° from horizontal, with the concrete placed in two feet lifts to the top of the dome. This sloping surface, combined with the lack of an outside face form, resulted in an unusual and difficult placement. When vibrating (consolidating) the concrete near the outside surface, the concrete tended to subside or "boil" over the lift immediately below. In an effort to mitigate this boil over action, construction personnel replaced the concrete which had subsided to the top of the lift and continued the vibration process until the concrete was consolidated. Applicant Dome Testimony at 9, 10; Tr. 2012, 2036 (Tye).

117. Approximately one month following the completion of the final dome pour, in conjunction with the normal post-pour inspection, four areas of concrete imperfections were discovered during the removal of construction supports. In accordance with site procedures, Daniel Quality Control reported the existence of these imperfections on inspection reports dated August 20, August 25 and August 27, 1980. Applicant Dome Testimony at 10; Tr. 2012, 2013 (Tye).

118. Daniel procedures require that any concrete imperfections be removed by chipping away the affected areas until sound concrete is reached. The dimensions of the chipped out areas determine whether the concrete may be left as is (no repair required), whether Daniel may repair the concrete

without Bechtel's concurrence, or whether Bechtel must review the areas of imperfections and approve the disposition. Tr. 2025, 2039-2040 (Tye). Following these procedures, Daniel personnel began chipping out the four areas of imperfections; this operation proceeded as allowed by the construction schedule, and was completed on November 6, 1980. Applicant Dome Testimony at 12. The size of the chipped out areas was such that Daniel was required to report these imperfections to Bechtel; therefore, NCR 2SN-2790-C (Board Exhibit 6), which documented the extent of the imperfections, was initiated by Daniel on November 10, 1980, and transmitted to Bechtel.[48] Applicant Dome Testimony at 12; Tr. 2039, 2040 (Tye).

119. The four areas of imperfections were initially identified as slight honeycombing located at the surface of the concrete where the construction supports were removed. However, as chipping progressed, it was discovered that the defects being removed were air gaps of approximately one-quarter to one-half inch in diameter between the horizontal reinforcing steel and the concrete in which the bars were embedded. The gaps were usually found on the under and down-hill side of the reinforcing bar, with the remaining portion of the bar circumference firmly bonded to the concrete. The

48 As with the base mat, sound concrete in the dome undoubtedly was removed during the chipping process. Consequently, the excavations described in the documentation over-estimate the area of unsound concrete. See paragraph 99, n.38, supra.

imperfections were limited to areas adjacent to or immediately below the upper layer of reinforcing steel, at a depth of four to six inches from the outer surface. Applicant Dome Testimony at 11; Tr. 2027 (Tye).

120. The four areas of imperfections were not reported to the Staff as a potential significant deficiency at either the time of the original discovery or at the time that NCR 2SN-2790-C was initiated. Applicant's witness Tye, then the Project Civil Engineer for Daniel, made the determination that these imperfections were not reportable to the Staff under the provisions of 10 C.F.R. § 50.55(e), in that it was believed that the imperfections were limited to areas of interference and were not generic to the entire dome. However, upon review of NCR 2SN-2790-C and additional information, Applicant determined that the possible existence of additional areas of imperfections could not be excluded and therefore notified the Staff of these imperfections on December 5, 1980. Applicant Dome Testimony at 12, 13. The Staff has reviewed Applicant's actions in reporting these imperfections and has concluded that Applicant acted responsibly and in accordance with applicable requirements governing the reporting of significant construction deficiencies. NRC Staff Testimony of Frank C. Hawkins, following Tr. 2067 (hereinafter "Hawkins Testimony"), at 2, 3; Staff Ex. 8 at 4.

121. Subsequent to reporting the four areas of imperfections to the Staff, Applicant discovered three

additional areas of concrete imperfections similar to those described earlier. These additional imperfections were identified following the removal of grease vent blockouts, at the Staff's request, on December 13, 1980. Applicant Dome Testimony at 13, 14. Joint Intervenors' contention implies that these additional imperfections would not have been identified had the Staff not recommended that these blockouts be removed. The Board finds no support in the record for this implication. Rather, the testimony shows that the removal of the blockouts, which eventually would have been necessary, was proceeding in accordance with the construction schedule and that the additional imperfections would have been identified in the normal course of construction. In accordance with the governing procedures and specifications, the existence of these additional imperfections was documented in a Quality Control Inspection Report and was reported to Bechtel on NCR 2SN-3155-C. Id. at 14; see also, Staff Ex. 8 at 4.

122. In an effort to determine the nature, cause and extent of the imperfections, Bechtel reviewed the data contained in the nonconformance reports, interviewed construction and engineering personnel involved in the pour, and conducted visual observations of several of the excavated areas. Based upon this information, it was concluded that the imperfections were due to intermittent subsidence of the concrete during placement along with minor localized unconsolidation, which would not degrade the structural integrity of the dome. The

cause of the subsidence was due to the downward movement of the concrete during consolidation. _See_ paragraph 116, _supra_. Bechtel further concluded that the imperfections are limited to the concrete adjacent to the outer layer of reinforcing steel, as the phenomena of subsidence cannot occur at depth. Applicant Dome Testimony at 15-17; Applicant Ex. 19 at 5-9; Tr. 2013-2015 (Thomas).

123. A program of destructive and non-destructive testing was undertaken and an engineering analysis of the dome was performed in order to confirm Bechtel's conclusions regarding the extent and significance of the imperfections. A combination of nuclear densometer testing and boroscopic examination was initially used to evaluate the dome concrete. The density readings obtained showed no evidence of honeycombing in the first three inches of concrete,[49] while the boroscopic examination revealed no significant evidence of the existence of unsound concrete. Applicant Dome Testimony at 18, 19; Applicant Ex. 19 at 11-15.

124. In addition to the nuclear densometer and boroscopic examinations, an extensive microseismic examination of the dome was performed utilizing the "pulse-echo" technique. This method of examination utilizes the theory of reflection

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49 The nuclear densometer has a published depth limitation of three inches; however, field investigations indicated that it appeared capable of identifying areas of unsound concrete at depths of four to six inches. Applicant Ex. 19 at 13.

and refraction of energy waves to identify imperfections in concrete. A material of lower density, such as an air gap in a mass of concrete, will reflect back a specific amount of the energy wave introduced, which will, in turn, cause an additional wave reflection image to appear on the visual display used by the examiner. See Applicant Dome Testimony, Figure 4. This pulse-echo method has been demonstrated to be accurate in identifying concrete imperfections such as air gaps, including those at the inner (or bottom) surface of a concrete mass (i.e., in this case, the pulse-echo method would have been capable of identifying gaps next to the liner plate). Applicant Dome Testimony at 19, 20; Applicant Ex. 19 at 15-18 and 26-27; Tr. 2056-2059 (Thomas, Goddard), 2075-2076, 2078-2079 (Hawkins).

125. The visual displays of the reflected pulse images were interpreted using one of five descriptive categories, "A" being solid or excellent concrete, "E" signifying a lack of mechanical bond. Only consecutive E readings were determined to be of structural significance. Of the initial 1,671 pulse-echo readings, only 92 (5.5%) were category E; of these, 28 (1.68%) were consecutive E readings. In view of the limited number of category E readings, no structural significance was attributed to these imperfections. The sporadic occurrence of category E readings confirmed the earlier conclusion regarding the intermittent nature of the imperfections. Further, the microseismic examination found no

significant indications of imperfections below the outer layer of reinforcing steel. Applicant Dome Testimony at 21, 22; Applicant Ex. 19 at 22-24.

126. Following the completion of the microseismic examination, two of the test areas which contained consecutive E readings were excavated. Of the six E test points excavated, imperfections were found at four, with no imperfections identified at two of the E test points. Thus, the excavations demonstrated that a positive correlation exists between the E readings and the actual imperfections. Applicant Dome Testimony at 22, 23; Applicant Ex. 19 at 24-26.

127. The results of the testing performed of the dome, as well as Bechtel's engineering analysis (see paragraph 130, infra), were documented in the "Final Report of Containment Dome Concrete Imperfections at Callaway Unit 1", dated March 26, 1981, and submitted to the Staff for review. The Staff's review concluded that additional effort was necessary in order to resolve several Staff questions, including the need for further testing to fully identify the extent to which E readings, which occurred at the boundary of the test grid, extended beyond the original test boundaries. Hawkins Testimony at 3, 4; Applicant Ex. 19 at 35.

128. In response to the Staff's recommendations, additional microseismic examination of the dome was undertaken. A total of 76 cases were investigated to determine if the original E reading at the test grid boundary extended beyond

the original boundary. The results of the testing were as follows: in 42 cases no additional E readings were obtained; 13 cases resulted in one or two additional E readings; and, in 21 cases, more than two additional E readings were obtained. In view of the fact that over one-half of the E readings did not continue past the grid boundaries, combined with the cases for which only one or two additional E readings were obtained, Applicant concluded that the additional testing adequately demonstrates the sporadic, intermittent nature of the imperfections. Applicant Dome Testimony at 24, 25; Applicant Ex. 19 at 35-41. The Staff has reviewed the testing performed of the dome, as set forth in Applicant Exhibit No. 19, and has concluded that the test results clearly identify the extent of the imperfections. Hawkins Testimony at 4.

129. As noted above, the destructive and non-destructive examinations of the reactor building dome have shown that the imperfections consist, for the most part, of sporadic air gaps located on the outer and down-hill side of the outer layer of reinforcing steel. The result of these imperfections is a reduction in the bond capability between the reinforcement and the concrete. Testimony of John S. Ma, Ph.D, P.E. following Tr. 2067 (hereinafter "Ma Testimony"), at 3; Applicant Dome Testimony at 25; Applicant Ex. 19 at 27. Therefore, in order to demonstrate that the structural integrity of the dome has not been degraded, engineering analyses of the dome were performed by both the Staff and Applicant.

130. The design intent for the dome is that the concrete be adequately bonded to the reinforcing steel to permit transfer of loads between the concrete and the reinforcing steel. Applicant Dome Testimony at 26; Applicant Ex. 19 at 30. The purpose, then, of the engineering analyses was to demonstrate that the imperfections would not preclude such load transfers. The analyses performed by the Staff and Applicant considered the types and amount of reinforcing provided, the loads which would be imposed on the structure, the strength of the concrete, and the effect of the imperfections upon the load-carrying capability of the structure. In summary, the analyses demonstrated that: (1) the compressive strength of the concrete (7,290 psi) exceeds the design strength (6,000 psi) and is more than adequate, assuming the existence of air gaps; (2) the lap splice length provided for the hoop reinforcing provides an ample margin of safety to permit the transfer of applied loads; and, (3) the anchorage (embedment) length provided for the radial tie bars is sufficient to develop the tensile force required for the prestressing force effect. Both the Staff and Applicant have concluded that the imperfections do not jeopardize the structural integrity of the reactor building dome and that, as-built, the dome has an ample and acceptable margin of safety. Ma Testimony at 3, 8; Applicant Dome Testimony at 25-27; Applicant Ex. 19 at 27-30. Indeed, Applicant has determined that sufficient margin has been provided in the design to allow for a fifty percent loss of

mechanical bond around the entire perimeter of the outside layer of reinforcing steel without jeopardizing the structural integrity of the dome. Applicant Dome Testimony at 26.

131. Joint Intervenors' Contention No. 1 alleges generally that Applicant has failed to provide an adequate quality assurance program and, more specifically, would have the Board find that "[s]urveillance and inspection functions of Applicant ... failed to ensure the quality of safety-related material, structures, systems and components ..." and that "deficiencies and nonconformances were accepted against code requirements." With respect to the issue of the containment dome concrete imperfections, the Board finds no basis in the record for finding any failure in the QA program. Rather, based upon the record as described above, the Board agrees with the Staff finding that Applicant's quality assurance and quality control programs functioned as planned to identify the imperfections, control related work activities and aid in the resolution of the matter. Hawkins Testimony at 5.

132. Upon review of the evidence presented, the Board concludes that the concrete imperfections will not adversely affect the structural integrity of the dome and that sufficient margin exists to assure that the dome will be capable of performing its design function. Further assurance as to the integrity of the dome will be provided by the pre-operational tests (a structural integrity test combined with an integrated leak rate test) to be performed by Applicant, which

will detect any significant defect. Tr. 2061-2063 (Thomas), 2079 (Hawkins, Ma).

F. Concrete Cover

> I.D. There exist many areas where concrete coverage of reinforcing bars in concrete walls and floors at the Callaway Plant does not adhere to requirements. Bechtel Power Corporation's interpretation of the cover requirements was that minimum cover requirements could be reduced by one-third, but the NRC stated in a meeting between NRC, UE, Bechtel, and Daniel International personnel on January 23, 1978, that no reduction of the two-inch cover minimum is acceptable. However, the NRC indicated that it would be acceptable "if the cover requirements were fully met in the area of the sixth lift, utilizing the fifth lift as a transition area." (See, NRC Report No. 50-483/77-11, pp. 10-11).
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> Some examples of nonadherence to concrete cover requirements are as follows:
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> 1. At 340 degrees azimuth, vertical reinforcement bars and supporting bars for the horizontal tendon sheathing in the 3rd lift of the reactor containment wall had concrete cover "less than that specified by NRC requirements, but within the concrete cover requirements as interpreted by licenses and contractors." (See, NRC Report No. 50-483/77-11, pp. 4 and 9-11).
>
> 2. NRC inspectors observed the preplacement preparation of the fourth lift of the exterior wall of the Reactor Containment Building, finding 14 unacceptable items, in half of which concrete cover was less than the 2 inch minimum required or more than the 9.6 inch maximum required. These items include instances where the concrete cover is as small as 5/8 of an inch (at azimuth 210 degrees) and as great as 12 inches (at azimuth 200 degrees). Some items were corrected, and the rest were within the range judged to be acceptable below the sixth lift because of the one-third placement tolerance. (See, NRC Report No. 50-483/78-01, pp. 9-11).

133. The allegations above in Part I.D of Joint Intervenors' Contention No. 1 were ruled upon by the Board in granting motions for summary disposition, pursuant to 10 C.F.R. § 2.749, filed by both Applicant and the NRC Staff. See Memorandum and Order (Motions for Summary Disposition), November 13, 1981.

134. In its ruling, the Board made the following findings of fact with respect to the adequacy of concrete cover for the reactor building wall:

> 1. The reduction of the cover requirements, where used, and the exceptions granted by the Staff in the two cases cited for excessive thickness of the cover, do not jeopardize the safe operation of the Callaway Plant.
>
> 2. The Board also finds that the instances of reduction of the concrete cover resulted from Applicants' interpretation of the appropriate ACI code, and not from any construction defects.
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> 3. This set of circumstances, therefore, does not present an issue with respect to the Quality Assurance Program.
>
> 4. No contrary information has been furnished by any party.

Memorandum and Order, supra, at 12.

G. SA-358 Piping

> II.A. Safety-related pipe installed at Callaway was manufactured by a company or companies which did not have adequate control of welding parameters. This resulted in known cases of defects which did not comply with the requirements of the American Society of Mechanical Engineers (ASME) Code. The evaluation and acceptance

of those defects and deficiencies were not done in accordance with the ASME Code. The safety of pipe installed at Callaway remains in question and demands further investigation before an operating license should be issued. For example:

1. In May 1979 a pipefitter discovered and reported a substandard piece of ASME Class II SA-358 piping which had been installed in the emergency core cooling system. The pipe was substantially out-of-round, was machined below the minimum wall. and had rejectable weld defects on the inside of a longitudinal seam weld. (See, NRC Report No. 50-483/80-10). The piping was approved for shipment at the vendor's, was accepted on site, and was installed despite these deficiencies.

135. SA-358 is an ASME material specification for welded stainless steel pipe, which is widely used in pipe sized greater than eight inches in diameter.[50] The pipe is made from plate by forming and rolling the plate into a continuous tubular shape. The longitudinal seam is then welded, usually by the submerged arc process,[51] with the weld made from both the inside and outside surfaces. Applicant's Testimony of Michael F. Stuchfield and Joseph V. Laux in Response to Joint

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50 The ASME Code and its uses are explained in Applicant's Testimony of Bernard L. Meyers, Michael F. Stuchfield, John D. Hurd and Geoffrey R. Egan in Response to Joint Intervenors' Contention No. 1, Part II.A.2 (Centerline Lack of Penetration in SA-312 Piping), following Tr. 1773 (hereinafter "Applicant SA-312 Piping Testimony"), at 7-10.

51 This welding process will be addressed further when we discuss Joint Intervenors' apparent thesis that "melt through" occurred with respect to the pipe at issue. See paragraph 145, infra.

Intervenors' Contention No. 1, Part II.A.1 (SA-358 Piping), following Tr. 1537 (hereinafter "Applicant SA-358 Piping Testimony"), at 4; Tr. 1545, 1546 (Stuchfield). This material specification provides a series of limits and permissible variations for several dimensional requirements for the finished pipe. Applicant SA-358 Piping Testimony at 5.

136. The internal weld surface irregularity in the SA-358 pipe which is the subject of part II.A.1 of Joint Intervenors' Contention No. 1 was first brought to the attention of the Daniel Quality Control staff on April 26, 1979, by a Daniel pipefitter.[52] The pipefitter was in the process of preliminary work on the spool piece, prior to fit-up for welding, when he observed the internal weld surface and notified a Daniel inspector. The Daniel inspector observed the irregularity and a pipe ovality/possible thin wall condition. The inspector requested that an ultrasonic test (UT) be performed to determine if the oval appearance was emblematic of a thin wall condition.[53] The UT results did confirm the

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52 The allegations focus upon a section of pipe in an accumulator discharge line. Testimony of James Foster, following Tr. 1681 (hereinafter "Foster Testimony"), at 1.

53 An ultrasonic test is a volumetric, nondestructive examination method in which beams of high frequency sound waves are introduced into the material being examined. Utrasonic examination is a widely used method of non-destructive examination. Its primary application in the examination of metals is the detection and characterization of internal flaws; however, it is also used as a means of measuring thickness. <u>See</u> Applicant SA-312 Piping Testimony at 14, 15.

suspected thin wall area and a nonconformance report (NCR) describing the weld surface irregularities was issued by the inspector on April 27, 1979. Applicant SA-358 Piping Testimony at 5, 6.

137. The actions described above followed the normal procedure prescribed for the identification and documentation of a nonconformance. Daniel administrative procedure AP-VII-02 requires project personnel, including craft personnel, to report nonconformances or nonconforming activities and bring them to the attention of Quality Control or Engineering personnel. The Quality Control or Engineering personnel are required to document the condition on a nonconformance report. Applicant SA-358 Piping Testimony at 6.

138. Joint Intervenors claim that some of the documentation is not in accordance with procedures.[54] First, it is asserted that a nonconformance report was dispositioned erroneously by an inspector and not the project discipline engineer. The evidence shows, however, that the NCR was dispositioned properly by Daniel in that the cause of the nonconformance was identified by the Piping Engineer (not the inspector as Joint Intervenors contend), who under Daniel procedures is authorized to disposition NCRs for the Project Piping Engineer. Applicant SA-358 Piping Testimony at 6, 7.

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54 These arguments were asserted in answer to motions for summary disposition filed by Applicant and the NRC Staff.

Second, Joint Intervenors claim that a deficiency report does not indicate the cause of the nonconformance. Again, the evidence shows to the contrary. The report indicates that the cause of the deficiency resulted from off-site conditions beyond Daniel's control, and constitutes an effective identification of the cause as vendor error. Id. at 7. The Board finds that these allegations of procedural error are without merit.

139. We turn, then, to the actual nature and extent of the irregularities in the pipe in question. A weld reinforcement height of 3/16 inch was measured.[55] The length of weld involved was approximately 6 inches, and the area of interest (i.e., affected by the grinding and blending operation) was approximately 2 inches wide. Measurements from the original radiograph[56] indicate a width of 1 and 1/4 inch at the widest point, with 5/8 to 3/4 inch being the average width. The worst

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55 The term "reinforcement," as it applies to welding, is defined in ANSI/AWS A3.0-1978, as "weld metal in excess of the quantity required to fill a joint." In the case of SA-358 pipe, the reinforcement normally would appear as a uniform ridge of excess metal on both the inside and outside surfaces. SA-358 permits a maximum of 1/8 inch reinforcement. Applicant SA-358 Piping Testimony at 9.

56 A radiograph is a film record with a permanent image produced from a radiographic examination. Radiography is a method used for nondestructive examination of materials and welds that is based on differential absorption of penetrating radiation by the part or test piece being examined. Radiography is used to detect features of a material or weld that exhibit a difference in thickness or physical density as compared to surrounding material. Applicant SA-312 Piping Testimony at 13.

case minimum wall thickness was measured to be 0.060 inch less than allowed by the Bechtel specification (0.874 inch). The thin area covered approximately 15 square inches of the pipe. The 27 square-inch area of the spool piece that was affected by these irregularities represents 0.28 percent of the total spool piece surface area. Applicant SA-358 Piping Testimony at 7, 8.

140. The first irregularity asserted in Joint Intervenors' contention is that the pipe is substantially out of round. NRC Staff and Applicant personnel conducted several measurements of the ovality of the pipe, and determined that the actual maximum ovality is 0.86 percent. This is well within the one percent difference between major and minor outside diameters which is permitted by material specification SA-358. Applicant SA-358 Piping Testimony at 5, 8; Foster Testimony at 2; Testimony of Gordon Beeman, following Tr. 1681 (hereinafter "Beeman Testimony"), at 2, 3. Consequently, this piping is not substantially out of round. See id.

141. Joint Intervenors also allege, in their contention, that the pipe in question "was machined below the minimum wall" thickness. SA-358 pipe invariably is used in pipe wall thickness which requires machining on the inside surface of the pipe (called "counterboring") for purposes of weld joint fit-up and as a means of improving in-service inspectability. In this case, while the Bechtel specification was written to require 0.874 inc thickness (see paragraph 139, supra), the actual minimum design wall thickness was

conservatively calculated to be 0.795 inch. The measured minimum wall thickness of the pipe in question was 0.814 inch. Applicant S: 358 Piping Testimony at 8, 9; Foster Testimony at 2, 3. The NRC Staff performed independent calculations to determine the acceptable minimum wall thickness for this pipe, and concluded from its calculations that a minimum wall thickness of 0.814 inch is acceptable. Beeman Testimony at 3. In the Staff's view, the disposition of this nonconformance was both acceptable and conservative. Staff Ex. 7 at 8. The Board agrees.

142. The third irregularity raised in the contention is that the pipe "had rejectable weld defects on the inside of a longitudinal seam weld." The hearing on this claim addressed irregularities, and their potential causes, of several names -- including excess reinforcement, overlap, and fissures.

143. As we have already found (paragraph 139, supra), Daniel measured an area of weld reinforcement on the inside of the SA-358 pipe with a reinforcement height of 3/16 inch and documented it in a nonconformance report dated April 30, 1979. While Bechtel initially erroneously dispositioned this NCR,[57] it is clear that there was a nonconformance as to

57 Bechtel, in its review of the NCR, incorrectly referenced a paragraph of the ASME code used for circumferential welds in piping, and not for longitudinal welds. Bechtel concluded, based on the inapplicable paragraph of the ASME code, that a nonconformance did not exist since the code permits a maximum reinforcement height of 3/16 inch on circumferential welds. Applicant SA-358 Piping Testimony at 9, 10.

the reinforcement height, since 1/8 inch is the maximum permitted by SA-358. Applicant SA-358 Piping Testimony at 9, 10. Apparently recognizing the error, Daniel elected to rework the item, in accordance with its approved procedures, to bring the weld into compliance with the ASME code. The excess weld reinforcement was reworked by simple removal of the excess material by localized grinding.[58] Id. at 16; Tr. 1706, 1707 (Foster, Key). Joint Intervenors have alleged that this nonconformance was not repaired or reworked in accordance with documented procedures. The Board fails to understand the point of this criticism. Daniel could have first initiated a deficiency report for rework (rather than an NCR), and simply reworked the item. Instead, a more conservative approach was taken by seeking the designer's review of the matter.[59] Applicant SA-358 Piping Testimony at 16, 17; Tr. 1625-1627 (Laux). The Board finds that Daniel acted properly in assuming the responsibility to correct the nonconformance.

144. The Daniel NCR also identified a condition described as overlap in the same area as the excess weld reinforcement.[60] The overlap apparently was excess weld

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58 Bechtel acknowledges that the original disposition is in error. Applicant SA-358 Piping Testimony at 9, 10 (Stuchfield). It appears, however, that there would have been no effect on the safe use of the pipe if the excess reinforcement material had not been removed. Id. at 11; Tr. 1654 (Stuchfield). See also, Tr. 1707, 1708 (Key, Beeman).

59 See paragraphs 36 and 37, supra, for the Board's discussion of the differences in dispositioning nonconformance and deficiency reports.

60 The pipe manufacturer, ARMCO, had identified this condition. ARMCO performed radiography of the entire

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material which had rolled over onto the surface of the pipe material. Bechtel advised, in its disposition of the NCR, that overlap is not listed in the ASME code as a rejectable condition for radiography.[61] This is because overlap does not affect the volumetric quality of the weld. It is a condition that occurs at the intersection of the weld with the pipe material surface, but could not propagate through the thickness of the weld because it is in the wrong plane for propagation. Applicant SA-358 Piping Testimony at 11, 12. Nevertheless, the overlap was reworked by the grinding process discussed above with respect to excess reinforcement. Id. at 16; paragraph 143, supra.

145. Joint Intervenors assert that the overlap condition could have been caused by a "melt through" -- i.e., the first weld pass from the outside of the pipe melting through the pass made from the inside.[62] The welding process

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longitudinal weld seam, and on the radiograph report described this area as a "washout" -- another way of describing an overlap condition. The ARMCO radiograph report further indicates that the washout was within the radiographic acceptance standards. Applicant SA-358 Piping Testimony at 14.

61 Bechtel's response to the NCR cited an inapplicable section of the ASME code, but the applicable code section has identical requirements. Applicant SA-358 Piping Testimony at 12.

62 If a melt through had occurred, the volumetric quality of the weld would have been affected. For instance, exposure of the molten metal would have caused porosity of the weld which in turn would affect the tensile strength of the weld. Applicant SA-358 Piping Testimony at 14.

used to make the longitudinal weld in this pipe is called the submerged arc process. This is a machine welding process, where general weld quality depends on a series of parameter settings, such as arc voltage, current, travel speed and wire feed speed. A slight momentary variation in any of these parameters would cause the overlap condition. Applicant SA-358 Piping Testimony at 12; Testimony of William Key, following Tr. 1681 (hereinafter "Key SA-358 Testimony"), at 2. A weld pass was first made along the seam on the inside surface of the pipe. The weld was then completed by weld passes from outside of the pipe. Any melt through of the outside pass through the inside pass would have resulted in a surface condition on the inside of the pipe which would be totally unacceptable and readily detected. With the high heat input and the continuous wire feed mechanism associated with the submerged arc welding process, total passage of molten material through the weld would have resulted. This would have caused slag and weld metal to adhere to a large area of the inside surface of the pipe, resulting in a totally unacceptable visual condition. Applicant SA-358 Piping Testimony at 13; Tr. 1564, 1642-1643 (Stuchfield).

146. There have been no reports or indications that a melt through occurred here. In addition, if melt through had occurred even to a limited degree there would have been other physical evidence on the quality of the weld. Since molten weld metal would have interfaced with the atmosphere, surface

porosity would have quickly occurred. However, there was no report on the presence of such porosity either visually or on the radiographs. Applicant SA-358 Piping Testimony at 13, 14. A number of reviews of the ARMCO radiograph of the questionable area have been performed by Union Electric and Daniel personnel. None of the reviews has resulted in this weld being declared unacceptable, or not within the acceptance criteria. Id. at 15.

147. In addition, during the course of the Staff's review of this matter it was determined that a new radiograph of the weld in its present condition would aid in assessing the adequacy of the weld. The radiography was performed on March 20, 1981, and Staff witness Foster was present during each step of the radiographic process. Foster Testimony at 3; Applicant SA-358 Piping Testimony at 17. Staff witness Key visually inspected the identified SA-358 pipe, reviewed the pipe's documentation, and inspected the radiographs of the weld seam taken after the rework. His inspection revealed the weld to be free of defects and within ASME code acceptance criteria.[63] Key SA-358 Testimony at 1, 2. It is Mr. Key's opinion that the excess weld material deposited on the inside could not have been caused by weld material from the outside pass melting

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63 Radiography is widely used throughout the industry to detect defects of this kind (i.e., on the inside of a of a longitudinal seam weld). It will reveal any significant weld defects with a reasonable degree of certainty. Beeman Testimony at 3, 4.

through the seam. _Id_. at 2; Tr. 1751 (Key). _See also_, Tr. 1751, 1752 (Beeman).

148. The Board finds that there is virtually no evidence which would tend to support Joint Intervenors' hypothesis that the overlap condition was caused by melt through. We conclude that melt through during the process of welding this pipe from the outside in fact could not have caused this overlap condition.

149. There has also been reference to the possible presence of two fissures on the surface of the questionable weld area. The fissures were reported in NRC IE Inspection Report No. 50-483/81-04 (Staff Ex. 7), where it is stated that their presence was indicated on a number of photographs of the questionable weld area (Joint Intervenors' Physical Ex. C). Applicant's witnesses reviewed the photographs, and in their opinion there is no evidence of fissures. Applicant SA-358 Piping Testimony at 15, 16. During his appearance, Staff witness Key testified that the fissures referred to in the report were in the excess material and not in the weld. Tr. 1710, 1750 (Key). Staff witness Beeman, from his examination of the photographs, explained that the dark indications are not really cracks (in that there are no fracture surfaces), but areas where the excess material rolled over (_i.e._, _overlap_). Tr. 1712-1714 (Beeman). In any case, if there had indeed been fissures present, they would have shown on the radiograph. Any fissures which would be visible to the naked eye or on

photographs would show on a radiograph. Applicant SA-358 Piping Testimony at 16; Tr. 1648 (Stuchfield).

150. It is clear that the only nonconformance to the ASME code in connection with this piece of ASME pipe has been identified and repaired. The following examinations or tests were performed after the repair was made:

A. Visual and liquid penetrant examinations to determine proper fusion and the soundness of the weld metal, along with an ultrasonic test to assess wall thickness, were performed immediately following the removal of the excess material.

B. A liquid penetrant examination was performed in the presence of the NRC Resident Inspector on May 2, 1980.

C. Radiography was performed on March 20, 1981, and evaluated by a Daniel inspector and a NRC Radiographic Interpretor.

All of the above examinations and tests identified no apparent defects present in the reworked subject weld. Applicant SA-358 Piping Testimony at 17. In addition, during hydrotesting of the emergency core cooling system prior to plant operation this pipe will be hydrostatically tested to a pressure 1.25 times its design pressure to confirm the structural integrity of the weld. Id. at 18.

151. In addition to the testimony heard in this proceeding in response to Joint Intervenors' contention, this 27 square-inch area of a single piece of pipe has been the subject of two separate NRC Staff investigations in response to anonymous allegations received from one individual. These inspections are documented in the record as Staff Exhibit No. 7. The first investigation, conducted in March and May, 1980, concluded that the allegation was not substantiated and found no items of noncompliance. NRC IE Inspection Report No. 50-483/80-10, Staff Ex. 7, page 3 of 21 of Exhibit I. The second investigation, conducted in February and March, 1981, and involving 88 on-site inspection hours by three NRC Staff personnel, reviewed the previous investigation and expanded upon the matters previously investigated. One item of noncompliance was observed relative to radiographic examination. Otherwise, the investigation concluded that the nonconformances in the pipe piece in question had been identified and corrected as required, and that examinations showed the pipe to be acceptable. NRC IE Inspection Report No. 50-483/81-04, Staff Ex. 7 at 2, 3.

152. The Board finds no basis, from this incident, upon which to question the effectiveness of the Callaway site QA/QC inspection programs.[64] The defect condition would not

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64 Neither does the failure of the manufacturer to identify the area of excess reinforcement represent a breakdown in its QA/QC program. Within the limits of practicability, it is not feasible to examine or inspect every single inch of weld

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normally have been detected at receiving inspection. The pipe spool piece assembly is received with end caps fitted in place in order to maintain the established cleanliness condition for the internal surfaces of the pipe up to the point of preparation for installation in the plant. The QA/QC program/procedures for identification and control of nonconformances were correctly followed. The system worked as intended, including the questioning and evaluation of parts/components previously accepted whenever their condition appears questionable. <u>See</u> Applicant SA-358 Piping Testimony at 18.

H. <u>Centerline Lack of Penetration in SA-312 Piping</u>

> II.A. Safety-related pipe installed at Callaway was manufactured by a company or companies which did not have adequate control of welding parameters. This resulted in known cases of defects which did not comply with the requirements of the American Society of Mechanical Engineers (ASME) Code. The evaluation and acceptance of those defects and deficiencies were not done in accordance with the ASME Code. The safety of pipe installed at Callaway remains in question and demands further investigation before an operating license should be issued. For example:
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surface on the inside of welded pipes. The program requires that QC inspectors examine as much of the welds as is visible, and it is normally only possible to examine most of the inside weld from a distance, due to the length of the pipe. Under such circumstances, one isolated area with slighter higher reinforcement would not be visible. Applicant SA-358 Piping Testimony at 11.

2. Substandard fusion welded SA-312 pipe manufactured by Youngstown Welding and Engineering Company and fabricated into safety-related pipe spools by Dravo Corporation has been installed at the Callaway Plant. (See, NRC/IE Bulletin 79-03 and 79-03A, and Union Electric letter ULNRC-314 dated May 11, 1979, to NRC - Region III). The evaluation and acceptance of this substandard SA-312 piping were not performed according to the requirements of Section III of the ASME Code.

153. Joint Intervenors contend that the integrity and safety of certain SA-312 stainless steel piping installed in the Callaway Plant and which may contain a weld imperfection known as centerline lack-of-penetration (CLP) have not been satisfactorily established and remain in question, and that the evaluation and acceptance of such piping by Applicant and the NRC Staff were not done in conformance with the applicable requirements of the American Society of Mechanical Engineers (ASME) Code.[65]

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65 The ASME Code provides standardized rules for the materials, design, fabrication, examination, testing and inspection of boilers, pressure vessels and nuclear power plant components. The ASME Code is contained in eleven sections, some of which are subdivided into parts, divisions and/or subsections. The relevant portions for purposes of these findings of fact are Subsections NB, NC and ND of Section III, Division 1 - Nuclear Power Plant Components. The three subsections provide rules for Class 1, Class 2 and Class 3 components, respectively. These Code classes are intended to be applied to the classification of the components in a nuclear power system. Within these systems, the Code recognizes the different levels of importance associated with the function of each component as related to the safe operation and shutdown of the plant. The Code classes allow a choice of rules that provide assurance of structural integrity and quality commensurate with the relative importance assigned to the individual components of the plant. Applicant SA-312 Piping

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154. SA-312 is an ASME material specification for both seamless and welded stainless steel pipe. The piping at issue in this contention is limited to double-welded SA-312 pipe. This piping is made from stainless steel plate which is formed and rolled into a tubular shape. The edges of the plate are square butt edges. The longitudinal seam where these edges are pressed tightly together is autogenously welded (without filler metal) by the gas tungsten arc method. The weld is made simultaneously from both the inside and outside surfaces of the pipe.[66] Applicant's Testimony of Bernard L. Meyers, Michael F. Stuchfield, John D. Hurd and Geoffrey R. Egan in Response to Joint Intervenors' Contention No. 1, Part II.A.2 (Centerline Lack of Penetration in SA-312 Piping), following Tr. 1773 (hereinafter "Applicant SA-312 Piping Testimony"), at 19; Tr. 1794, 1795, 1809, 1810 (Stuchfield); <u>see also</u>, Applicant SA-312 Piping Testimony at Figure 1.

155. Centerline lack-of-penetration (CLP) occurs in double-welded without filler metal SA-312 pipe when complete through-wall fusion does not occur between the inside and outside welds during welding of the longitudinal seam. A plane

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Testimony at 7-9. (<u>See</u> paragraph 154, <u>infra</u>, for complete citation to testimony).

66 The inside and outside arc heads of the welding machine are offset by several inches so that the weld from the leading arc solidifies before the trailing arc passes over and welds at the same point of the weld seam. Tr. 1809, 1810 (Stuchfield); <u>see also</u>, Tr. 1877A, 1878 (Stuchfield).

then exists in the center of the pipe wall between the two weld passes where the original plate edges are tightly abutted but not fused. Applicant SA-312 Piping Testimony at 17 and Figure 1. See Staff Testimony of William R. Rutherford, following Tr. 1898 (hereinafter "Rutherford Testimony"), at 3.

156. Those safety-related systems at the Callaway Plant which contain double-welded SA-312 pipe (the residual heat removal, high pressure coolant injection, the refueling water storage tank, fuel pool and clean-up systems) are designated as ASME Class 2 or Class 3. Seamless pipe only was used for systems designated as ASME Class 1.[67] Under the rules of the ASME Code, welded piping is required to meet all the tests and examinations prescribed by Section III of the Code. The material specifications for SA-312 piping[68] require chemical analysis, tension tests and flattening tests to be performed on each lot of pipe. The material specification also

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67 10 C.F.R. § 50.55a requires that vessels, piping, valves and pumps which are part of the reactor coolant pressure boundary shall be classified as Class 1 and constructed in accordance with the requirements of subsection NB of ASME Section III. NRC Regulatory Guide 1.26 requires, in part, that components in systems important to safety be classified as Class 2 and be constructed to the requirements of subsection NC of ASME Section III. This Regulatory Guide also requires that components in systems providing cooling water to components in Class 1 or Class 2 systems be classified as Class 3 and be constructed to the requirements of subsection ND of ASME Section III. Applicant SA-312 Piping Testimony at 9, 10.

68 The material specifications for SA-312 piping are contained in ASME Section II. Applicant SA-312 Piping Testimony at 10; see also, Applicant Ex. 17; Joint Intervenor Ex. 67.

requires each length of pipe to be hydrostatically tested. In addition, for use in Class 2 systems, ASME Section III requires that welded pipe be nondestructively examined by one of the following methods: ultrasonic, eddy current, magnetic particle, liquid penetrant or radiographic. It is customary for pipe manufacturers to select the ultrasonic method for SA-312 pipe.[69] The other methods are not suitable for detecting internal imperfections in large diameter austenitic stainless steel pipe. ASME Section III does not require nondestructive examination for double-welded SA-312 pipe used in Class 3 systems. Applicant SA-312 Piping Testimony at 16, 17; see Tr. 1782-1788 (Hurd), 1824, 1825 (Stuchfield).

157. The CLP problem in SA-312 piping was first identified in the fall of 1978. Imperfections were found in the longitudinal welds of double-welded SA-312 pipe being fabricated into piping subassemblies for the Palo Verde Nuclear Generating Station. The imperfections were discovered during the radiographic examination of circumferential shop assembly welds made by Pullman Power Products (PPP). The pipe had originally been manufactured by Youngstown Welding and

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69 In simplest terms, ultrasonic examination involves the sending of a sound wave from a transducer through the test item. If an internal flaw is encountered, the sound wave is reflected back to the transducer and is displayed as an indication. The reflected energy and other parameters are measured and interpreted in accordance with ASME Code specifications in order to determine the significance of the indication. See generally, Applicant SA-312 Piping Testimony at 14, 15; Tr. 1825, 1826 (Stuchfield).

Engineering Company (YWEC) and had been ultrasonically examined and accepted in accordance with ASME Section III requirements by a subcontractor of YWEC, Ultralabs, Inc. Ultrasonic examination by PPP and Ultralabs, Inc., purportedly performed in accordance with ASME Section III, resulted in the rejection of approximately 44% of the completed and partly fabricated piping subassemblies. The majority of the rejectable indications were felt to be centerline lack-of-penetration in the longitudinal seam welds of the SA-312 piping manufactured by YWEC. A similar percentage of rejection was reported by PPP on pipe purchased from YWEC for the San Onofre 2 & 3 Nuclear Generating Stations. The Palo Verde and San Onofre owners reported these findings to the NRC.[70] Applicant SA-312 Piping Testimony at 17, 18; Rutherford Testimony at 1, 2; see Applicant Ex. 11 at 1.

158. In response to these developments, the NRC Office of Inspection and Enforcement issued I&E Bulletin 79-03 in March, 1979, requiring all operating licensees and construction permit holders to: (i) determine whether double-welded SA-312 pipe manufactured by YWEC had been incorporated or would

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70 It should be noted that piping of this type has been fabricated over the past twenty years and used in both nuclear and non-nuclear applications. A computer search of the NRC's data bank indicates that there have been no known failures of SA-312 pipe in nuclear facilities. There is no negative history of the pipe relative to the ASME Code applications which includes non-nuclear uses of the product. Rutherford Testimony at 3.

be incorporated into safety-related piping systems, (ii) identify the system, location, pipe size and pressure/temperature parameters where the double-welded SA-312 pipe was or would be, and (iii) develop a program for the volumetric examination of the longitudinal welds and provide suitable corrective action for non-conforming material. Applicant SA-312 Piping Testimony at 19; see generally, Rutherford Testimony at 2. In response to this Bulletin, Applicant determined that pipe manufactured by YWEC had been used in piping subassemblies fabricated for the Callaway Plant. A complete schedule of the location of all YWEC-supplied pipe was provided to the NRC and a program for ultrasonic examination of longitudinal welds was established as required by the Bulletin. This information was provided to the NRC in Applicant's letter ULNRC-314 dated May 11, 1979 (Applicant Ex. 10). Applicant SA-312 Piping Testimony at 19.

159. A generic investigation into the CLP problem was undertaken by Bechtel. A detailed test program was designed (1) to assess the ability of the ASME Code-specified ultrasonic examination to detect CLP and (2) to assess the effects of CLP on various mechanical properties of double-welded SA-312. The results of this investigation are reported in Bechtel's "Report on Investigation of Weld Imperfections in ASME SA-312 Double Welded Austenitic Stainless Steel Pipe for Compliance with NRC I&E Bulleting 79-03," issued August 9, 1979 (Applicant Ex. 11). Applicant SA-312 Piping Testimony at 20.

160. During this investigation it was determined that the principal cause of CLP was the wide range of allowable welding parameters permitted by the YWEC qualified welding procedure. Tr. 1799 (Stuchfield); see Applicant SA-312 Piping Testimony at 20, 21; Joint Intervenor Ex. 61. The significant welding parameters include arc voltage, amperage, travel speed, and weld head oscillation. Differences in the allowable settings for thes parameters affect the depth of penetration of the upper and lower weld passes. Thus, as amperage is decreased to the minimum allowable setting under the YWEC qualified welding procedure less heat is transmitted to the weld surface and the weld is relatively shallower. Similarly, an increase in arc travel speed will result in a shallower weld as will an increase in the weld head oscillation rate. The effect of any combination of settings depends on the thickness of pipe being welded. The range of parameters in the YWEC qualified welding procedure was approved for a thickness range of 1/16 inch to 3/8 inch. Therefore, settings which would produce acceptable penetration for a 1/16 inch pipe might result in some CLP if used for a thicker walled pipe. Tr. 1799-1803 (Stuchfield). An additional factor which can contribute to CLP is arc misalignment in which the upper and lower weld arcs are not aligned with the longitudinal seam and with each other. As a result, the weld penetrations may be sufficient, but the upper and lower weld beads will not meet in the center of the pipe thickness because the point of deepest penetration in the top

weld is not aligned with the deepest penetration point in the lower weld.[71] Tr. 1804 (Stuchfield), 1807 (Egan).

161. The Bechtel investigation concluded that the ASME Code-required ultrasonic examination cannot reliably detect CLP in double-welded SA-312 pipe. Bechtel's investigation included review of the ultrasonic testing techniques used by PPP and Ultralabs, and testing of four special test weldments fabricated by Bechtel with intentionally produced CLP, varying in amount from 35% to 60%.[72] The Code-mandated ultrasonic examination was not able to detect the CLP in the four samples. Bechtel concluded that the two unfused base metal edges of the rolled plate are in such intimate contact that the ultrasonic sound waves are transmitted without interruption across the unfused area and are not reflected back to the ultrasonic transducer and displayed as an indication. Furthermore, the geometry of the CLP is such that even if the ultrasonic sound wave is reflected from a CLP condition, the majority of the energy would not be returned to the transducer and displayed as an indication. Accordingly, Bechtel concluded that the Code-specified ultrasonic examination will not

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71 An example of the effect of arc misalignment is shown in the top photograph in Figure 1 of Applicant Ex. 11 at 6 and in Figure 1.1 of Applicant Ex. 12 at p. 1-2.

72 It is important to note that welding parameters outside the range of parameters shown on the original YWEC welding procedure had to be used to produce CLP at these high levels. Applicant SA-312 Piping Testimony at 22, 23; Tr. 1839, 1840 (Stuchfield).

reliably detect the presence of CLP in SA-312 piping. Applicant SA-312 Piping Testimony at 23; Tr. 1797, 1827, 1828 (Stuchfield); see also, Applicant Ex. 11 at 2, 3, 7, 8.

162. As part of its investigation, Bechtel determined the maximum amount of CLP in the SA-312 piping produced by YWEC. Bechtel examined 71 cross-sections of longitudinal welds in over 500 feet of double-welded SA-312 pipe supplied by YWEC to PPP. Of the specimens, 25 showed some degree of CLP. The greatest amount of CLP was 26% of the wall thickness of the pipe. There is ample evidence that the extent of CLP that may exist in Callaway SA-312 piping will be no greater than that examined in the Bechtel generic investigation. The Callaway pipe was fabricated by the same process, same machines, same personnel and within the same time period as the pipe supplied to PPP and examined by Bechtel. Furthermore, in intentionally producing test samples with greater than 26% CLP, Bechtel was required to use welding parameters outside the range of parameters used by YWEC.[73] Applicant SA-312 Piping Testimony

73 Joint Intervenors attempted to establish during cross-examination of Applicant's witnesses that due consid- eration was not given to the effect of arc misalignment when coupled with other worst case welding parameters, and that this could hypothetically result in greater amounts of CLP than 26%. Applicant's witnesses, however, established that this concern is without substance. The amount of misalignment is limited by the welding equipment used by YWEC and it was demonstrated that as the settings for the welding parameters are moved towards their worst case settings (i.e. amperage is decreased and travel speed is increased), the shape of the weld bead changes and becomes flatter. See Applicant Ex. 12, Figure 9.1 (bottom photograph) at p. 9-2. As a result, there is no "point" of deepest penetration in the weld beads and the significance of arc misalignment is nil. Tr. 1810-1816 (Egan, Stuchfield).

at 24, 25; Tr. 1811-1814 (Stuchfield, Egan); see also, Rutherford Testimony at 4; Applicant Ex. 11 at 2, 3.

163. The final aspect of the Bechtel generic investigation was to assess the effect of CLP on various mechanical properties of double-welded SA-312 pipe and to determine whether the possible presence of CLP will affect the ability of the piping to perform safely its design function. Tensile tests and hydrostatic (burst) tests were performed.[74] The evidence developed in the Bechtel test program established that even with 26% CLP, SA-312 piping will meet all of the ASME mechanical property requirements (yield strength, ultimate tensile strength and elongation) and that even with 47% CLP, yield strength requirements are met.[75] Applicant SA-312 Piping Testimony at 25, 26; Applicant Ex. 11 at 2, 3, 7. In terms of the CLP problem in SA-312 piping, the only significant stress component is the "hoop stress" or the outward force exerted on the pipe due to the internal pressure of the fluid in the pipe. Rutherford Testimony at 3; Tr. 1830 (Hurd); see also, Applicant

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74 The test program did not include flattening tests. The YWEC production pipe had already undergone flattening tests by YWEC to the Code requirements. Furthermore, the flattening test is not an effective means for screening for defects in the center of the weld such as CLP. It is designed for surface-connected defects. Applicant SA-312 Piping Testimony at 26; Tr. 1845, 1846 (Stuchfield), 1848, 1849 (Egan).

75 Yield strength is the stress at which a metallic material ceases to return to its original size when the stress is removed. Stresses in excess of yield strength will cause a permanent deformation of the material. Applicant SA-312 Piping Testimony at 25.

Ex. 12 at p. 4-1. Therefore, the most significant results from the Bechtel test program came from the burst tests[76] performed on three SA-312 pipe sections with known CLP of 15%, 40% and 55%.[77] Plugs were welded into the ends of the pipe and each was hydrostatically pressurized until fracture occurred. The lowest burst pressure recorded was for the pipe with 55% CLP which burst at 3000 psi.[78] This value is far in excess of the ASME Code-required hydrostatic test pressure of 882 psi for the same size and schedule pipe, and is correspondingly again higher than design pressure and actual operating pressure for SA-312 piping applications. Applicant SA-312 Piping Testimony at 27, 28; Rutherford Testimony at 6; Applicant Ex. 11 at 2, 3, 14-19; see also, Tr. 1906 (Rutherford).

164. In addition to the Bechtel test program, two engineering analyses of SA-312 pipe with CLP were performed by

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76 During a burst test, the predominant stress is the hoop stress. Tr. 1880 (Stuchfield).

77 The latter two sections were specially welded pipes using welding parameters outside the range specified in the YWEC procedure in order to produce such large amounts of CLP. See Applicant SA-312 Piping Testimony at 24, 25, 27.

78 The test specimen with 40% CLP burst at an internal pressure of 3700 psi. The specimen with 15% CLP was pressurized to 5300 psi and did not fail. Applicant SA-312 Piping Testimony at 27, 28; Applicant Ex. 11 at 2, 3, 14. In testing the specimen with 15% CLP, shortcomings in the test equipment precluded accurate readings beyond 5300 psi and therefore the burst pressure was assumed by Bechtel to be 5300 psi. In the Aptech Engineering Services, Inc. analysis discussed infra, it was conservatively assumed to be 5000 psi. Tr. 1872-1875 (Egan); Applicant Ex. 12 at pp. 9-1, 9-2.

Aptech Engineering Services, Inc. (Aptech). These included a fracture analysis study and a subsequent fatigue analysis. The results of these studies are contained in two Aptech reports introduced into evidence as Applicant Exhibits 12 and 13.[79] The fracture analysis demonstrated that because of the very ductile nature of the stainless steel material used in SA-312 piping, the failure mode of the pipe would not be brittle fracture, but rather, a "leak-before-break" and ductile fracture mode.[80] Applicant SA-312 Piping Testimony at 28-30(Egan); Rutherford Testimony at 5; Applicant Ex. 12 at p. iii. A limit load analysis was therefore used to calculate critical flaw sizes for a range of pipe stress conditions, pipe diameters and wall thicknesses. These calculations were conservatively confirmed by the actual results of the Bechtel burst tests. Using these results from the Aptech fracture analysis and assuming the highest hoop stress values in piping systems at Callaway containing double-welded SA-312 pipe, it was concluded that the CLP condition of the magnitude identified will not result in the initiation of a leak in such piping and that the possible presence of CLP is not a concern.

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79 The fracture analysis (Applicant Ex. 12) was included in the Bechtel report (Applicant Ex. 11) issued in August, 1979. The fatigue analysis (Applicant Ex. 13) was issued subsequently, in May, 1980.

80 The high level of ductility (the ability of the material to stretch or plastically deform before failure) was demonstrated by the Bechtel burst tests. Applicant SA-312 Piping Testimony at 28; Applicant Ex. 11 at 16, 17.

Applicant SA-312 Piping Testimony at 30-32; Rutherford Testimony at 5, 6; see Applicant Ex. 12 at pp. 7-5 to 7-7, 10-1, 10-2. Testimony at the hearing established that under the design conditions at Callaway, CLP on the order of 85% of wall thickness would have to exist before a pipe would leak. Tr. 1881 (Egan). Even assuming initiation of a leak, the fracture analysis demonstrated that the critical CLP size (amount of CLP above which catastrophic failure will occur) is greater than the wall thickness of the pipe and thus catastrophic failure cannot occur. Applicant SA-312 Piping Testimony at 32.

165. The subsequent Aptech fatigue analysis considered the effect of CLP in SA-312 piping under cyclic loading. The thrust of the analysis was to establish acceptance criteria based on "worst-case" assumptions. The analysis produced a series of flaw size versus life curves for a range of cyclic stresses so that the effect of any amount of CLP in any piping system can be assessed. Assuming worst case conditions, Aptech determined that the ASME Code safety factors were not reduced as a result of the presence of CLP until a cyclic life of approximately 45,000 cycles was exceeded. Using the highest hoop stress values and the highest expected number of stress cycles for the Callaway systems with SA-312 double-welded piping, it was determined that the ASME Code safety factors would not be reduced in these systems and that fatigue failure as a result of the possible presence of CLP was not a concern.

Applicant SA-312 Piping Testimony at 33, 34 (Egan); see Applicant Ex. 13 at p. 9-1.

166. In summary, the testing and analyses performed during this generic investigation of the CLP problem established that double-welded SA-312 piping even with amounts of CLP substantially in excess of that found in production pipe will function as intended with an adequate margin of safety. However, since it was also established that the ASME Code-required ultrasonic examination was ineffective in detecting the presence of CLP, Bechtel, in its report (Applicant Ex. 11), recommended a two-tiered response to the CLP problem in which the level of further examination for SA-312 piping would depend upon the hoop stresses in the system in which such piping was to be used. Applicant SA-312 Piping Testimony at 34, 35; Applicant Ex. 11 at 4.

167. The NRC adopted this recommendation. In April, 1980, it issued I&E Bulletin 79-03A which made several changes to the directives originally contained in I&E Bulletin 79-03. It deleted the requirement for the ultrasonic examination program, and instead required that a determination be made whether any welded SA-312 piping was in use, or planned for use, in safety-related systems subject to design hoop stresses greater than 85% of the allowable stress set forth in ASME Section III. Any piping systems falling in this category were to be identified, and where feasible, the ends of the piping were to be etched and the amount of CLP (if any) reported. No

further action was required for piping systems with design hoop stresses <u>less</u> than 85% of the ASME Code allowable stresses. Applicant SA-312 Piping Testimony at 35, 36; Rutherford Testimony at 2. Applicant's response to this revised Bulletin indicates that all piping systems containing double-welded SA-312 pipe at Callaway are subject to maximum hoop stresses <u>less</u> than 85% of the ASME Code allowable stresses. Accordingly, no further action was required by Applicant. Applicant SA-312 Piping Testimony at 38; Rutherford Testimony at 2; Applicant Ex. 14.

168. The recommendation by Bechtel and the decision of the NRC to adopt the 85% stress level is based upon the concern that the ASME Code-specified nondestructive examination methods are unable to detect CLP reliably. The Code does provide, however, for the use of "efficiency factors" for those circumstances where nondestructive examination is not performed. It was the use of the appropriate efficiency factor which lead to the recommendation and the adoption of the 85% stress level. Applicant SA-312 Piping Testimony at 36.

169. Efficiency factors provide design engineers with a mechanism for utilizing reduced or lower design stresses for various materials depending on the type and quantity of nondestructive examination performed on the material. Table I-7.2 of ASME Section III provides allowable design stress values for material permitted for ASME Class 2 and Class 3 construction, including double-welded SA-312 pipe. Footnote 3

to this table sets forth the relevant efficiency factors for such materials. Thus, Footnote 3 states that for materials welded without filler metal (such as double-welded SA-312 piping), which have been examined by the ultrasonic or eddy current methods, an efficiency factor of 1.00 may be used. This means that the full allowable stress for welded pipe shown on Table I-7.2 may be utilized for design purposes.[81] The footnote goes on to provide efficiency factors less than 1.00 for welded pipe of various configurations which have not undergone the nondestructive examination. For instance, for materials, such as welded SA-312 pipe, with a longitudinal butt weld made without filler metal, an efficiency factor of 0.85 is provided. This means that only 85% of the allowable stress shown in Table I-7.2 may be utilized for design purposes. In other words, a penalty on the design stress is taken when nondestructive testing is not performed. Applicant SA-312 Piping Testimony at 36, 37 (Stuchfield, Egan); see also, Tr. 1830-1839 (Hurd, Stuchfield), 1879, 1880 (Hurd); Applicant Ex. 15; Joint Intervenor Ex. 63.

170. The Code-required ultrasonic examination does not reliably detect the presence of CLP in SA-312 double-welded pipe. If it is assumed, therefore, that the ultrasonic

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81 The 100% Code allowable hoop stress has a very significant margin of safety incorporated into it so that the 100% level can and is used for design purposes. Tr. 1864 (Meyers), 1879, 1880 (Hurd).

examination required by ASME Section III had not been performed, Footnote 3 to Table I-7.2 of ASME Section III would then permit the use of the pipe if the 0.85 efficiency factor on the allowable stress is imposed. Accordingly, it was appropriate to treat the SA-312 piping as if it had not been nondestructively examined and to impose the efficiency factor penalty on the allowable design stress.[82] Applicant SA-312 Piping Testimony at 37; see also, Tr. 1830-1839 (Stuchfield). Therefore, the Board concurs with the determination by Bechtel and the NRC Staff that with this design penalty imposed, the Callaway piping systems with double-welded SA-312 pipe are acceptable to meet safely their intended design functions.

171. Joint Intervenors have also questioned the use in Callaway piping systems of SA-403 fittings which may contain CLP. SA-403 is a specification for wrought stainless steel pipe fittings, such as elbows, tees and reducers. SA-312 pipe, both welded and seamless, is frequently used as the raw material for SA-403 fittings. The double-welded SA-312 pipe used to manufacture fittings is no different than the

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82 It should be emphasized that all double-welded SA-312 piping in the Callaway Plant was ultrasonically examined as required by the ASME Code. The shortcoming was in the examination method, not in the manufacturer's compliance with the Code requirements. Furthermore, all other Code-required tests were performed on the piping, including hydrostatic testing of each piece of pipe, tension tests, flattening tests and chemical analyses, and all SA-312 piping installed at Callaway has been certified as meeting the acceptance standards of these tests. Tr. 1838, 1839, 1845 (Stuchfield).

double-welded SA-312 pipe used for straight-run pipe, and could contain CLP to the same extent as straight-run pipe. Applicant SA-312 Piping Testimony at 38, 39; see also, Applicant Ex. 16; Joint Intervenor Ex. 64

172. Applicant has determined that SA-403 fittings made from double-welded SA-312 pipe are used in certain Class 2 and Class 3 piping systems at Callaway.[83] No such fittings, however, are used in piping systems which have hoop stresses greater than 85% of the ASME Code allowable stresses. Applicant SA-312 Piping Testimony at 39; Tr. 1777 (Stuchfield), 1790-1793 (Hurd). Although the Aptech generic fracture analysis report suggests that certain fittings will require a separate evaluation because of additional stress conditions (see Applicant Ex. 12 at p. 4-1), Dr. Egan of Aptech demonstrated at the hearing that this caveat did not apply to the Callaway Plant because of the nature of the piping and piping systems in use at Callaway.[84] Tr. 1856-1860 (Egan); see also, Tr. 1913, 1914 (Rutherford).

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83 The three piping systems containing SA-403 fittings made from double-welded SA-312 pipe with the highest hoop stresses are the residual heat removal system, the accumulator injection system and the chemical and volume control system. Tr. 1790-1793 (Hurd); see also, Joint Intervenor Exs. 59 and 60.

84 Among the factors which could affect the stress on fittings are through-wall thermal gradients, steam hammer and water hammer loading, and the positioning of the seam weld on the fitting. Dr. Egan's testimony established, however, that none of these factors is relevant to the use of SA-403 fittings at the Callaway Plant. Through-wall thermal grad- ients would not affect the Callaway SA-403 fittings because they are all in thin-wall systems. Steam hammer loading is irrelevant because the affected Callaway systems are filled with water not steam. Water hammer loading is of no consequence because the

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173. The NRC Staff has also concluded, based on the analytical and experimental effort described above, that failure of double-welded SA-312 piping due to the possible presence of CLP is highly improbable. Rutherford Testimony at 4-7. The Board, therefore, finds substantial evidence in the record and concludes that the double-welded SA-312 piping installed at Callaway is structurally sound and can safely perform its design function.[85] Nonetheless, even if it is hypothetically postulated that a system containing this piping became overpressurized to the point that failure occurred in the longitudinal seam weld, the failure would occur in the "leak-before-break" mode. Under no circumstances would a brittle fracture resulting in a catastrophic failure occur. Rather, a small leak would form in the longitudinal weld and stable propagation would occur only if the internal pressure

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predominant loading resulting from water hammer is parallel to the longitudinal seam weld of the pipe or fitting and would have no effect on any CLP in that weld. Tr. 1857-1859 (Egan). In addition, any increased internal pressure on fittings, such as tees and elbows, resulting from their geometry, would have no effect on the longitudinal seam weld, because in manufacturing the fittings the welds are always placed in the neutral axis. Therefore, the seam welds in these fittings are subject to the same hoop stresses as in the straight-run lengths of pipe. See Tr. 1778-1780 (Stuchfield), 1854-1856 (Egan); see also, Rutherford Testi- mony at 3, 4; Tr. 1913, 1914 (Rutherford).

85 Further assurance of the structural integrity of these systems will be provided by the ASME Code-required hydrostatic testing of all piping systems to a pressure not less than 1.25 times the system design pressure. Applicant SA-312 Piping Testimony at 41.

were maintained or increased. This is unlikely to occur because of the instrumentation and control systems which would provide plant operators with appropriate information whenever conditions in a safety-related system exceed design conditions, so that appropriate action can be taken. Applicant SA-312 Piping Testimony at 40, 41; see also, Rutherford Testimony at 6.

174. Contrary to the general allegation of Joint Intervenors, the incorporation into the safety-related systems at Callaway of SA-312 piping which may contain CLP cannot be considered a breakdown in the quality assurance/quality control programs in effect at Callaway. The CLP problem was generic in nature. While its cause may have been inadequate process control by the piping vendor, the means prescribed by the ASME Code to detect this imperfection were later determined to be inadequate.

175. Furthermore, the Joint Intervenors' contention that the evaluation and acceptance of SA-312 piping with CLP were not performed according to the requirements of the ASME Code has also been shown to be without merit. Apart from the required destructive testing (hydrostatic, tension and flattening) which was performed, all welded pipe which may contain CLP underwent ultrasonic examination and met the ASME criteria for this examination. It was the examination procedure itself which was found to be deficient. It has been established that the use of the efficiency factors in the ASME Code provides a

conservative and satisfactory alternative to the ultrasonic examination. Accordingly, all SA-312 piping at Callaway complies with the ASME Code requirements. More significantly, however, the exhaustive investigation of the nature and extent of CLP in double-welded SA-312 pipe, including tensile tests and hydrostatic tests, along with the Aptech fracture and fatigue analyses that were performed, demonstrates that this type of pipe meets the design and service conditions specified in the ASME Code, and will safely and properly perform its intended function throughout the life of the Callaway Plant.

I. Preassembled Piping

> I.B. Additional evidence of deficiencies in surveillance and inspection functions include the following: In 1979 it was discovered that pre-assembly piping formations with defective welds from Gulf & Western were accepted and were installed at Callaway. After installation it was also discovered that the vendor had used improper radiographic techniques. (See, SNUPPS letter SLNRC-79-20 of November 29, 1979, to NRC - Region I, and Bechtel Final Report of November 28, 1979).

176. In March, 1979, a Daniel construction worker at the Wolf Creek[86] site detected potential deficiencies in a preassembled piping formation[87] supplied by Gulf & Western

86 Wolf Creek, like Callaway, is one of the SNUPPS units. Applicant's Testimony of Robert L. Powers, Joseph V. Laux, Bernard L. Meyers, Michael F. Stuchfield and Harry J. Porter in Response to Joint Intervenors' Contention No. 1, Part II.B. (Preassembled Piping), following Tr. 1920 (hereinafter "Applicant Preassembled Piping Testimony"), at 11.

87 Preassembled pipe formations are pre-designed, manufacturer- fabricated formations containing piping, valves,

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("G&W") during installation of the formation. These potential deficiencies were brought to the attention of a Daniel Welding Inspector, who subsequently visually examined the formation in question and identified possible concerns with respect to both the quality of the welds and the quality of the radiographic examination techniques employed by G&W. Applicant Preassembled Piping Testimony at 11; Tr. 1929, 1930 (Powers, Laux); <u>see also</u>, Joint Intervenor Ex. 69.

177. Recognizing that the potential deficiencies identified at Wolf Creek might constitute a problem generic to the SNUPPS units, a series of telephone conferences between the quality assurance groups at the two sites was initiated in an effort to determine the applicability of the concerns to formations at the Callaway site. Following the initial notification from Wolf Creek personnel, Applicant's Construction QA group conducted an extensive audit of the G&W formations at the Callaway site, which included a review of the G&W radiographs and a physical inspection of the hardware itself. The audit determined that the G&W formations exhibited noncompliances to the Bechtel Specification and to ASME Code requirements in the areas of both radiographic technique and visible weld discrepancies. This site audit was followed by a

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fittings, pumps and other similar equipment which are completely assembled at the manufacturer's plant. Applicant Preassembled Piping Testimony at 8.

SNUPPS QA Committee audit of the G&W manufacturing facility during which G&W's manufacturing and inspection activities were reviewed. At the close of the audit, G&W agreed to conduct a 100 percent review of the weld radiographs. When completed, this review indicated radiographic technique deficiencies in 35 to 50 percent of all radiographs. Applicant Preassembled Piping Testimony at 12, 13; Testimony of William A. Hansen, following Tr. 1979 (hereinafter "Hansen Testimony"), at 2.

178. The radiographic technique deficiencies identified by Applicant and confirmed by G&W's review precluded a definite determination as to the extent and significance of weld defects. In view of this, an agreement was reached between the SNUPPS members and G&W which required G&W to rework all safety-related formations.[88] This rework effort included: (1) preparing the weld surface for additional examination by surface grinding the weld area; (2) visually inspecting for weld acceptability and suitable surface preparation; and, (3) performing radiographic and/or liquid penetrant testing of the welds pursuant to ASME Code requirements. The on-site rework being performed by G&W was monitored by Union Electric, Daniel and Bechtel. This monitoring effort, combined with an inspection of three formations which had been reworked and accepted

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88 Those formations which had already been installed were to be reworked by G&W at the Callaway site, while those which had not yet been installed were returned for rework to G&W's manufacturing facility. Applicant Preassembled Piping Testimony at 14, 15.

by G&W, indicated that radiographic technique deficiencies and weld deficiencies were continuing to be encountered.[89] G&W was thereafter directed to cease its on-site rework efforts. Applicant Preassembled Piping Testimony at 13-16; Hansen Testimony at 3; Joint Intervenor Ex. 69, Final Report at 1-2.

179. In view of G&W's inability to properly perform the required rework, Daniel assumed the responsibility for the on-site rework of the G&W formations.[90] Each formation was subjected to a visual weld inspection; when necessary, the welds were surface ground in preparation for nondestructive examination. The required testing (radiography or liquid penetrant examination) was then performed for each formation. Of the 27 formations reworked by Daniel, 15 required some amount of weld repair in order to meet ASME Code and Bechtel Specification requirements. All rejectable safety-related formations were repaired and were re-examined by the

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89 Based upon these findings, Applicant reported the potential deficiencies to the Staff on November 2, 1979, pursuant to the provisions of 10 C.F.R. §50.55(e). At this time, the extent and significance of the deficiencies had not been determined. However, in that failure of the welds in certain formations could degrade the plant's safe shutdown capability, the Board believes Applicant acted prudently in reporting this condition. See Applicant Preassembled Piping Testimony at 15, 16. A final report regarding the formations was submitted to the Staff by SNUPPS on November 29, 1979. See generally, Joint Intervenor Ex. 69 .

90 Two formations which were located at the G&W facility were subsequently returned for use at Callaway and were subjected to weld inspection and radiographic review by Daniel. Applicant Preassembled Piping Testimony at 17; Tr. 1938 (Laux).

appropriate nondestructive examination technique. All repairs have been completed and all welds now meet the applicable criteria. Applicant Preassembled Piping Testimony at 16, 17; Hansen Testimony at 3; Testimony of William Key, following Tr. 1979 (hereinafter "Key Formation Testimony"), at 2.

180. The Board concurs with the Staff and Applicant testimony that, as repaired, the G&W safety-related formations are adequate for use at Callaway and that they are capable of performing their intended design functions. See Applicant Preassembled Piping Testimony at 18; Key Formation Testimony at 2. However, a parallel concern with this issue goes to the quality assurance/quality control implications, i.e., why these deficiencies were not detected and remedied prior to the release of the formations from the G&W facility, and whether the site QA programs are effective in identifying such deficiencies. The Board considers each of these subjects below.

181. As we described above (see paragraph 40, supra), Applicant's QA program includes an evaluation by Bechtel of a potential supplier's past performance and capabilities to perform quality work and continues during the manufacturing process by conducting in-process and final inspections by Supplier Quality Representatives. Applicant Preassembled Piping Testimony at 8, 10; Tr. 1952-1955 (Meyers, Porter). Since the Bechtel inspections at the G&W facility should have detected the discrepancies observed, Bechtel conducted an evaluation of the inspections performed at the G&W

plant. This evaluation uncovered a number of deficiencies in the inspections performed by the Bechtel representative, including less than required in-process and final inspections and radiographic reviews. Following the evaluation, Bechtel increased the level of inspection at the G&W plant to include a qualified resident inspector who performed a 100% inspection of the remaining fabrication and tests. Further, G&W was downgraded to a problem supplier in Bechtel's internal supplier evaluation system. Applicant Preassembled Piping Testimony at 18, 19; Tr. 1954-1958 (Porter).

182. In order to assure that the weaknesses found in the inspection program at G&W were not generic in nature,[91] radiographic and weldment techniques at all spool supplier facilities were reviewed to assure their compliance with applicable codes and standards. Additionally, Bechtel Supplier Quality Representatives throughout the country were informed of the problems encountered at G&W, and ten of Bechtel's nondestructive examination field specialists have been provided with additional, extensive metallurgical training and received upgraded certification. Applicant Preassembled Piping Testimony at 19; Tr. 1958, 1959 (Porter).

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91 In this regard, it should be noted that the Bechtel representative at G&W was not involved in any other nuclear work in the area and had been employed by Bechtel for only a short period. Tr. 1958 (Porter).

183. In a separate effort, project management at the Wolf Creek site has undertaken a sampling review of radiographs supplied by SNUPPS vendors. The satisfactory results of the Wolf Creek review provide a good confidence level as to the quality of materials received on site. A similar sampling review has been initiated at the Callaway site and will further assure the quality of materials on site. Applicant Preassembled Piping Testimony at 19, 20.

184. Based upon the foregoing, the Board finds that while weaknesses did exist in the Bechtel shop inspection program at the G&W facility, Applicant and its contractors have taken appropriate steps to assure that the problems encountered with the G&W formations are not applicable to other materials and, further, that such weaknesses do not recur in the future.

185. Joint Intervenors attempted to imply, during cross examination, that the manner in which the deficiencies in the G&W formations were discovered (and, by extension, the fact that the deficiencies were not initially identified at Callaway) constituted a failure in the QA program. At the time of the initial discovery of the potential deficiencies in the G&W formations, the Daniel QC receipt inspection program did not explicitly include a review for vendor nonconformances to Code and Specification requirements.[92] However, under the

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92 A program of receipt inspection including vendor nonconformances has since been initiated and has been 'retrofit' to cover material received on-site prior to the initiation of the program. Applicant Preassembled Piping

(continued next page)

terms of the Daniel site procedures, all personnel are required to report any nonconformances identified in order that they may be evaluated and appropriately dispositioned. Tr. 1929-1933 (Powers, Laux); see also, Tr. 1643-1644 (Laux), and paragraph 38, supra. The Board, therefore, does not attach any negative weight to the fact that the deficiencies were identified by a construction worker during installation, rather than during a required quality control inspection.

186. Another aspect of this issue which must be considered during our review of the Callaway quality programs is the importance of the fact that the deficiencies were not discovered at the Callaway site, but rather were identified at Wolf Creek. Testimony presented by Applicant throughout the hearing on construction issues has emphasized the importance of the SNUPPS concept and the added degree of confidence and quality provided by the standardized design employed by SNUPPS. With respect to the G&W formations, Applicant has testified that the SNUPPS site QA/QC programs functioned as designed, as the deficiencies were identified and reported during the installation process and, further, that the SNUPPS concept assured that fellow SNUPPS members were timely notified of the potential deficiencies. Applicant Preassembled Piping Testimony at 12, 22; Tr. 1930, 1931 (Powers). The Board agrees

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(continued)
Testimony at 23; Tr. 1936, 1937 (Powers); see also, paragraph 187, infra.

that the discovery of the deficiencies at Wolf Creek does not detract from the effectiveness of Applicant's quality programs. Indeed, we believe that this subject demonstrates the viability of the SNUPPS standardization concept.

187. The final area of concern which the Board will briefly address is the question of whether these deficiencies would have been discovered by Applicant prior to full power operation had they not been initially identified at Wolf Creek. Applicant has identified a number of opportunities during which the deficiencies could have been identified. These actions include the upgraded receipt inspection program which has been retrofit to include all safety-related material on-site, as well as a series of system preoperational tests which will be conducted. Applicant Preassembled Piping Testimony at 20-22; see generally, Tr. 1931-1950 (Powers, Meyers, Stuchfield). The Board concurs with Applicant's position that one or more of these actions would have identified the deficiencies and allowed their proper resolution.

188. In summary, the Board finds that Applicant's QA/QC programs functioned properly to allow for the identification and proper disposition of the deficiencies identified in the G&W formations, that the weaknesses identified in the Bechtel shop inspection program were appropriately resolved, and that the formations are now capable of performing their intended design functions.

J. Concluding Findings of Fact

189. In the initial section of this decision, the Board reviewed the general quality assurance/quality control program for the design and construction of the Callaway Plant and set forth the Joint Intervenors' general contention that there has been a failure of this program which precludes the safe operation of the plant.

190. The specific allegations which Joint Intervenors believe support their position have been addressed individually in the preceding sections of our findings of fact. As indicated therein, the Board has concluded that in none of the eight specific issues raised by Joint Intervenors has there been a failure in the quality assurance program nor evidence that the structural integrity or the safe operation of the Callaway Plant has been jeopardized.

191. Joint Intervenors assert, however, that while the specific allegations considered individually may not evidence quality assurance or safety problems, their cumulative effect is to raise serious questions as to the adequacy of the overall program of quality assurance. In the vernacular, Joint Intervenors' argument appears to be that these allegations are "just the tip of the iceberg."

192. This argument, however, falls of its own weight. Joint Intervenors have had access to voluminous documentation dealing with the construction of the Callaway

Plant, both in the discovery process and from documents available to the public. These sources of information include materials generated by Applicant, its contractors and the NRC. Indeed, Joint Intervenors' designated representative, Mrs. Kay Drey, made reference in her unsuccessful petition to intervene as a party in this proceeding, prior to the beginning of discovery, to her significant knowledge of the Callaway project and her significant library of documentation dealing with the Callaway construction effort. As such, Joint Intervenors have been able to pick and choose from the documentation generated by Applicant's own quality assurance and construction programs and by the NRC Staff's inspection and enforcement efforts, those issues which Joint Intervenors felt best supported their contention that such programs and efforts were deficient. Indeed, were it not for the proper functioning of the Callaway quality assurance program, Joint Intervenors would never have learned of most of the purported deficiencies which form the basis for their attack on that program.

193. It must be remembered that at this stage of the licensing process, the parties are litigating, and the Board is deciding, only those matters which the Joint Intervenors have chosen to place in controversy. Therefore, rather than being the tip of an iceberg, the issues that have been considered in this hearing present an isolated and one-sided view of the Callaway project, designed by Joint Intervenors to present the best case from their standpoint. This is not to suggest that

Joint Intervenors have proceeded improperly, but rather that these issues must be viewed in the perspective of the scope of this hearing.

194. The Board has found no basis for extrapolating from these isolated examples of alleged quality assurance shortcomings, a finding that the entire quality assurance program or safe operation of the Callaway Plant is suspect. Indeed, what the substantive record in this case demonstrates is that the quality assurance program functioned properly. A quality assurance program is not designed nor intended to prevent <u>all</u> construction or material deficiencies. Rather, by its very nature, it assumes that such deficiencies will occur, and it is designed to identify the deficiencies, see that they are corrected, and insure that they do not recur. In that regard, the Callaway program has performed satisfactorily. Upon identification of the construction deficiencies and nonconformances considered in this hearing, whether by formal, planned inspection, by casual observation, or by notification from the NRC of a generic, industry-wide concern, Applicant's quality assurance organization responded quickly and thoroughly to determine both the extent of the problem and its impact on the structural integrity and safe operation of the Plant. Our conclusion in this regard comports with the views of the Staff's former Senior Resident Inspector at the Callaway site. Now a specialist with the Performance Appraisal Branch, he testified that Applicant has, in his assessment, a good solid quality control program. Hansen Testimony at 4.

195. Accordingly, the Board concludes that there is no factual basis for Joint Intervenors' contention that the alleged failures of Applicant's quality assurance program which Joint Intervenors have chosen to present for the Board's consideration are indicative of any generic failure of the quality assurance program. To the contrary, the record amply reflects that this program has functioned satisfactorily and that it provides adequate assurance that the Callaway Plant can be operated without undue risk to the health and safety of the public.

III. CONCLUSIONS OF LAW

196. The Board has considered all documentary and oral evidence presented by the parties on all of the matters in controversy raised by the Joint Intervenors. The Board has not yet heard evidence with respect to, and this Partial Initial Decision does not address, the emergency planning contentions raised by intervenor Reed. Based upon a review of the entire record in this proceeding and the foregoing findings of fact, the Board enters the following conclusions of law.

197. This is a contested proceeding on an application for an operating license for a utilization facility, and the Board has made findings of fact and conclusions of law on the matters put into controversy by the parties to the proceeding, except for the matters put into controversy by intervenor Reed. The Board has not determined that a serious

safety, environmental, or common defense and security matter exists. See 10 C.F.R. § 2.760a. Other findings required to be made prior to the issuance of an operating license, except for the remaining matters in controversy, are to be made by the Director of Nuclear Reactor Regulation. See id. and 10 C.F.R. § 50.57.

198. Having decided all matters in controversy, raised by Joint Intervenors, in favor of authorizing operation of the facility, the Board concludes that as to the matters decided herein, the Director of Nuclear Reactor Regulation would be authorized, upon making the requisite findings with respect to matters not resolved in this Partial Initial Decision, and subject to the Board's resolution of outstanding matters in controversy, to issue to Applicant a license to operate Callaway Plant, Unit 1. Such authorization is not now granted by the Board, however, and will not be granted until the Board resolves the outstanding matters in controversy or issues a further order to the contrary.

IV. ORDER

199. WHEREFORE, IT IS ORDERED, in accordance with 10 C.F.R. §§ 2.760(a) and 2.762, that this Partial Initial Decision shall constitute the final action of the Commission thirty (30) days after the date of issuance hereof, unless exceptions are taken in accordance with section 2.762 or the Commission directs that the record be certified to it for final

decision. Any exceptions to this Partial Initial Decision or designated portions thereof must be filed within ten (10) days after service of the decision. A brief in support of the exceptions must be filed within thirty (30) days thereafter (forty (40) days in the case of the NRC Staff). Within thirty (30) days of the filing and service of the brief of the appellant (forty (40) days in the case of the NRC Staff), any other party may file a brief in support of, or in opposition to, the exceptions.

IT IS SO ORDERED.

Respectfully submitted,

SHAW, PITTMAN, POTTS & TROWBRIDGE

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APPENDIX A

DIRECT TESTIMONY RECEIVED INTO EVIDENCE

Witness	Following Transcript Page
BEEMAN, Gordon "Testimony of Gordon Beeman" (SA-358 Piping)	1681
EGAN, Geoffrey R. "Applicant's Testimony of Bernard L. Meyers, Michael F. Stuchfield, John D. Hurd and Geoffrey R. Egan in Response to Joint Intervenors' Contention No. 1, Part II.A.2 (Centerline Lack of Penetration in SA-312 Piping)"	1773
FISHER, John W. "Applicant's Testimony of Donald F. Schnell, Bernard L. Meyers, Eugene W. Thomas, Kirit G. Parikh, John W. Fisher and Roger G. Slutter on Joint Intervenors' Contention No. 1, Part I.A. (Embedded Plates)"	501
FOSTER, James "Testimony of James Foster" (SA-358 Piping)	1681
GALLAGHER, Eugene J. "NRC Staff Testimony of Eugene J. Gallagher" (Embedded Plates)	1261
GODDARD, Guy H., Jr. "Applicant's Testimony of Eugene W. Thomas, Guy H. Goddard, Jr., B. Christopher Tye and Richard A. Muenow in Response to Joint Intervenors' Contention No. 1, Part I.C.2 (Reactor Building Dome Concrete Imperfections)"	2010

HANSEN, William A.
"Testimony of William A. Hansen" (Preassembled Piping) 1977

HAWKINS, Frank C.
"NRC Staff Testimony of Frank C. Hawkins" (Reactor Building Dome Concrete Imperfections) 2067

HOLLAND, John A.
Resume, J.A. Holland 1344

HURD, John D.
"Applicant's Testimony of Bernard L. Meyers, Michael F. Stuchfield, John D. Hurd and Geoffrey R. Egan in Response to Joint Intervenors' Contention No. 1, Part II.A.2 (Centerline Lack of Penetration in SA-312 Piping)" 1773

KEY, William
"Testimony of William Key" (SA-358 Piping) 1681

"Testimony of William Key" (Preassembled Piping) 1977

LAUX, Joseph V.
"Applicant's Testimony of Michael F. Stuchfield and Joseph V. Laux in Response to Joint Intervenors' Contention No. 1, Part II.A.1 (SA-358 Piping)" 1537

"Applicant's Testimony of Robert L. Powers, Joseph V. Laux, Bernard L. Meyers, Michael F. Stuchfield and Harry J. Porter in Response to Joint Intervenors' Contention No. 1, Part II.B (Preassembled Piping)" 1920

MA, John S.
"Testimony of John S. Ma, Ph.D, P.E." (Reactor Building Dome Concrete Imperfections) 2067

McFARLAND, Thomas H.
"Applicant's Testimony of Bernard L. Meyers, Thomas H. McFarland and Donald W. Pfeifer in Response to Joint Intervenors' Contention No. 1, Part I.C.1 (Honeycombing, Reactor Building Base Mat)" 227

DOCUMENTS INCORPORATED INTO THE RECORD

Description	Following Transcript Page
NRC letter, September 17, 1980 with attached IE Inspection Report No. 80-14 (Staff Exhibit 6)	1261
Affidavit of Richard A. Muenow	2010
Drawing, "Partial Dome Section"	2037
Letter from K. Chackes to Licensing Board, dated December 4, 1981, withdrawing Joint Intervenors' Contention No. 2	2081
Final version of Joint Intervenors' Contention No. 1, as admitted by Licensing Board	2081

APPENDIX B

EXHIBITS

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
App. Ex. 1	Nonconformance Report No. 2-0856-C-A	226	228
App. Ex. 2	"Investigation of Concrete Base Slab at Callaway Nuclear Plant for Union Electric Company", WJE No. 77401, Wiss, Janney, Elstner & Associates, Inc.	227	228
App. Ex. 3	Sketch, "Example of Oscilloscope Display with ASTM C597 Soniscope Testing Procedure"	300	302
App. Ex. 4	"Final Report - Investigation of Welded Studs", Bechtel Power Corporation, August 10, 1977	497	501
App. Ex. 5	"Report on Testing to Evaluate Welds of Anchor Rods and Studs to Embedded Plates", Bechtel Power Corporation, September 15, 1980	498	501
App. Ex. 6	Union Electric letter ULNRC-238, March 10, 1978, with attached report, "Acceptability of Manually Welded Embedded Plates, Callaway Unit 1"	499	501
App. Ex. 7	"Final Report - Investigation of Documentation Supporting NCR 2-0831-C-B", Bechtel Power Corporation, January 16, 1978	497	501

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
App. Ex. 8	(1) ASME Material Specification SA-358 (Summer 1974 Edition); (2) ASME Code Section I, Article PW-51 (1974 Edition with Winter 1974 Addenda); (3) ASME Code Section V, Article 2 (1974 Edition); and (4) ASME Code Section V, Article 3 (1974 Edition)	1702	1702
App. Ex. 9	(1) Daniel Construction Procedure AP-VII-02, "Nonconformance Control and Reporting", Rev. 6; (2) Daniel Construction Procedure AP-VII-02, "Nonconformance Control and Reporting", Rev. 8	1704	1704
App. Ex. 10	Union Electric letter ULNRC-314 dated May 11, 1979	1769	1773
App. Ex. 11	"Report on Investigation of Weld Imperfections in ASME SA-312 Double Welded Austenitic Stainless Steel Pipe for Compliance with IE Bulletin 79-03", Bechtel National Corp., August 9, 1979	1770	1773
App. Ex. 12	"Significance of Centerline Lack-of-Penetration Defects in Double Welded, Stainless Steel Pipe-Fracture Analysis", Aptech Engineering Services, August, 1979	1771	1773
App. Ex. 13	"Significance of Centerline Lack of Penetration Defects in Double-Seam Welded SA-312 Stainless Steel Pipe", Aptech Engineering Services, May, 1980	1771	1773

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCPIPT PAGE
App. Ex. 14	SNUPPS letter SLNRC 80-38, dated August 20, 1980	1772	1773
App. Ex. 15	ASME Code Section III, Article NC-2000 (1974 Edition with Winter 1974 Addenda)	1821	1821
App. Ex. 16	ASME Material Specification SA-403 (1974 Edition)	1851	1851
App. Ex. 17	ASME Material Specification SA-312 (1974 Edition)	1886	1887
App. Ex. 18	ASME Material Specification SA-530 (1974 Edition)	1887	1887
App. Ex. 19	"Revised Final Report of Containment Dome Concrete Imperfections at Callaway Unit 1", Bechtel Power Corp., September 1980	2009	2011

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
Board Ex. 1	Enclosures 1-6, 8 and 9 to ULNRC-238 (App. Ex. 6), as follows: (1) Bechtel letter BLSM-5977 to N. A. Petrick from R. H. Stone; (2) Bechtel letter BLSM-6837 to N. A. Petrick from B. K. Kanga; (3) Daniel Inter-Office Communication PQWP-178 to File A29.04 from P. E. Johnson; (4) Bechtel letter BLSM-6589 to N. A. Petrick from B. K. Kanga; (5) Bechtel letter BLSM-6703 to N. A. Petrick from B. K. Kanga; (6) Bechtel letter BLSM-6708 to N. A. Petrick from B. K. Kanga; (7) Memorandum dated February 10, 1978 to W. H. Zvanut from Don Stecko enclosing UE Survey of DIC Data Package Transmitted with DLUC-2399; and, (8) Data Sheets for certain Cives embedded plates (47 pages)	1513	1513
Board Ex. 2	Daniel Inter-Office Communication SAE-321 dated May 21, 1980, minutes of meeting regarding Callaway dome pour	2050	2050
Board Ex. 3	Daniel Inter-Office Communication SAE-338 dated July 16, 1980, minutes of meeting regarding Callaway dome pour	2050	2050
Board Ex. 4	Union Electric letter ULNRC-406 dated January 2, 1981 to G. Fiorelli from J. K. Bryan	2052	2052
Board Ex. 5	NRC letter dated January 7, 1981 to J. K. Bryan from G. Fiorelli, enclosing IE Report 50-483/80-14	2052	2052
Board Ex. 6	NCR 2SN-2790-C	2052	2052

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
Staff Ex. 1	NRC letter, February 16, 1977, with attached IE Inspection Report No. 77-01	393	396
Staff Ex. 2	NRC letter, April 5, 1977, with attached IE Inspection Report No. 77-03	394	396
Staff Ex. 2A	NRC letter, May 12, 1977, with attached IE Inspection Report No. 77-04	461	461
Staff Ex. 3	NRC letter, August 1, 1977, with attached IE Inspection Report No. 77-06	395	396
Staff Ex. 4	NRC letter, October 17, 1977, with attached IE Inspection Report No. 77-07	395	396
Staff Ex. 5	NRC letter, June 24, 1980, with attached IE Inspection Report No. 80-16	396	396
Staff Ex. 6	NRC letter, September 17, 1980 with attached IE Inspection Report No. 80-14	1261	(Incorporated into record ff. Tr. 1261)
Staff Ex. 7	NRC letter, June 25, 1981, with attached IE Inspection Report No. 81-04	1682	1682
Staff Ex. 8	NRC letter, January 19, 1981, with attached IE Inspection Report No. 80-30	2068	2068

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
Jt. Int. Ex. 1	Bechtel Trip Report, Callaway Jobsite - Investigation of Concrete Crack at the Reactor Pit Moat Area, June 2, 1977	238	238
Jt. Int. Ex. 2	NRC Region III letter to Mrs. Leo A. Drey from James G. Keppler, April 4, 1980	247	250
Jt. Int. Ex. 3	NRC Region III letter to Union Electric, John K. Bryan, from R. F. Heishman, August 1, 1977 enclosing IE Inspection Report No. 77-06 (excerpts of IE Report attached)	319	
Jt. Int. Ex. 4	Daniel Inter-Office Communication PSE-029, March 20, 1978, with attached Daniel Inter-Office Communication PCE-535, June 27, 1977 and NCR 2-0653-C-A, May 11, 1977	341	341
Jt. Int. Ex. 5	Daniel International Concrete Placing Reports (18) for Pour No. 2C221S07, Reactor Base Mat	343	343
Jt. Int. Ex. 6	Daniel International Daily Civil QC Inspection Report, April 7, 1977, Pour No. 2C221S07	348-9	348-9
Jt. Int. Ex. 7	NRC 2-1176-C-A	373	373
Jt. Int. Ex. 8	Union Electric letter to J. G. Keppler, NRC Region III, from John K. Bryan, September 29, 1977	380	380
Jt. Int. Ex. 9	Stop Work Order No. 09, June 9, 1977	514	
Jt. Int. Ex. 10	Daniel Inter-Office Communication SM-446, re Stop Work Order pertaining to Cives material	514	

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
Jt. Int. Ex. 11	Union Electric letter ULNRC-349, April 24, 1980	527	
Jt. Int. Ex. 12	610 page document regarding Daniel investigation of embedded plate welds (Attachment C to DLUC-2399)	555	594
Jt. Int. Ex. 13	NRC 2-0831-C-B, June 17, 1977, with Attachments A, B, C and D	599	599
Jt. Int. Ex. 14	Daniel letter DLUC-2399, January 19, 1978, to W. H. Weber, Union Electric, from H. J. Starr, with Attachments A and B	601	601
Jt. Int. Ex. 15	Excerpt (pages 86-92) of AWS Structural Welding Code D1.1-75	632	632
Jt. Int. Ex. 16	Bechtel letter BLSE-4662, July 20, 1977, to Nicholas A. Petrick, SNUPPS, from J. L. Turdera with attached SAR Change Notice 21-77	634	634
Jt. Int. Ex. 17	Excerpt (pages 39-44) of AWS Structural Welding Code D1.1-75 (1977 revision)	639	668
Jt. Int. Ex. 18	Daniel letter DLUC-990, December 3, 1976 to W. H. Weber, Union Electric, from M.R. Hambry, with attached Daniel QC Inspection Report, July 18, 1977	672	672
Jt. Int. Ex. 19	SNUPPS letter SLU: 6-41, November 1, 1976 to D. F. Schnell, Union Electric, from S. J. Seiken	686	686
Jt. Int. Ex. 20	"Cives - Misc. Structural Steel Problem, Summary of Problem with welding of studs to embedment plates", July 1, 1977	691	691, 753

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
Jt. Int. Ex. 21	Bechtel letter BLSM-3806, February 4, 1977 to Nicholas A. Petrick, SNUPPS, from R. H. Stone, with attached response to SNUPPS QA Committee Audit	693	693
Jt. Int. Ex. 22	Cives' inspection reports for manually welded embeds	715	
Jt. Int. Ex. 23	Daniel Engineered Materials and Equipment Return Report, June 27, 1977 to Cives	819	819
Jt. Int. Ex. 24	Cives inspection data for machine welded studs (consisting of five data reports)	1007	1007
Jt. Int. Ex. 25	Correspondence regarding 10 CFR §50.55(e) report on bending of studs: ULNRC-256 to J. Keppler from J. K. Bryan, May 1, 1978; letter from R. Heischman to J. K. Bryan, June 16, 1978; letter from R. Heischman to J. K. Bryan, February 2, 1979	1120	1120
Jt. Int. Ex. 26	NRC Licensee Event Report printout, excerpt (cover sheet and page 24) of report for period 9/7/81 through 9/20/81	1146	1146 REJECTED
Jt. Int. Ex. 27	Newspaper articles regarding Kansas City Hyatt Regency accident	1147	1148
Jt. Int. Ex. 28	IE Inspection Report No. 77-05	1193	1193
Jt. Int. Ex. 29	St. Louis Post-Dispatch articles regarding Callaway construction	1196	1196 REJECTED
Jt. Int. Ex. 30	Collection of ten letters from K. Drey, dated December 6, 1977 through March 26, 1979, to various persons	1201	1201 REJECTED

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
Jt. Int. Ex. 31	Daniel letter, DLUC-2142, November 14, 1977	1247	1247
Jt. Int. Ex. 32	Chart prepared by Joint Intervenors, embedded plate numbers, types and weld sizes	1252	1252 REJECTED
Jt. Int. Ex. 33	Preliminary Notification of Event or Unusual Occurrence, PNO-III-81-12, January 22, 1981	1318	1318 REJECTED
Jt. Int. Ex. 34	IE Inspection Report No. 77-10	1431	1431
Jt. Int. Ex. 35	IE Inspection Report No. 77-11	1431	1431
Jt. Int. Ex. 36	IE Inspection Report No. 78-01	1431	1431
Jt. Int. Ex. 37	IE Inspection Report No. 78-04	1431	1431
Jt. Int. Ex. 38	IE Inspection Report No. 78-09	1431	1431
Jt. Int. Ex. 39	Daniel Letter, DLUC-1788, August 18, 1977	1434	1434
Jt. Int. Ex. 40	(1) Second Anniversary Embed Party Invitation; (2) June 9, 1980 letter from K. Drey to V. Stello; (3) list of recipients of June 9, 1980 letter	1517	1517
Jt. Int. Ex. 41	Letter dated September 21, 1978 from K. Drey to J. Keppler	1518	1518
Jt. Int. Ex. 42	Excerpt from ASME Material Specification SA-358 (page 413, 1977 Edition)	1544	1545
Jt. Int. Ex. 43	Excerpt from ASME Material Specification SA-358 (page 414, 1977 Edition)	1578	1702
Jt. Int. Ex. 44	Excerpt from ASME Code, Section I (page 96, 1977 Edition)	1578	1702

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
Jt. Int. Ex. 45	Excerpt from ASME Code, Section V, Article 2 (page 4, 1977 Edition)	1578	1702
Jt. Int. Ex. 46	Excerpts from AWS Code A3.0-76, Welding Terms and Definitions (20 pages)	1581	1702
Jt. Int. Ex. 47	Excerpt from Daniel Administrative Procedure AP-VII-02 (Exhibit A, page 3), Instructions for Completing Nonconformance Report (NCR)	1602	
Jt. Int. Ex. 48	Excerpt from Daniel Administrative Procedure AP-VII-02 (Exhibit A, page 1), NCR form	1615	1617
Jt. Int. Ex. 49	Excerpt from Daniel Administrative Procedure AP-VII-02 (Appendix I, page 1), Glossary of Terms and Definitions	1616	
Jt. Int. Ex. 50	Excerpt from Daniel Administrative Procedure AP-VII-02, Rev. 8, page 2 of 15	1616	
Jt. Int. Ex. 51	Excerpt from Daniel Administrative Procedure AP-VII-02, Rev. 8, page 12 of 15	1666	
Jt. Int. Ex. 52	Figure 6.3-1 from SNUPPS FSAR, Accumulator Safety Injection	1666	1666
Jt. Int. Ex. 53	Correspondence to and from Kay Drey, as follows: (1) July 11, 1980 letter to Jan Strasma, NRC Region III, from K. Drey; (2) August 29, 1980 letter to K. Drey from J. Strasma; (3) October 6, 1980 letter to G. Hayden and J. Charlip from K. Drey; and, (4) October 15, 1980 letter to K. Drey from J. Charlip	1689	1689

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
Jt. Int. Ex. 54	October 16, 1980 unsigned letter to J. Charlip	1694	1694 REJECTED
Jt. Int. Ex. 55	141 page transcript of interview conducted December 20, 1977 with Bill Smart	1747	1747
Jt. Int. Ex. 56	NRC Region III News Announcement 78-12, dated February 15, 1978, with attached correction to December 20, 1977 interview transcript (page 22a)	1748	1748
Jt. Int. Ex. 57	Letter dated March 1, 1978 to W. Smart from J. Keppler, with two attached transcripts	1748	1868 REJECTED
Jt. Int. Ex. 58	Newspaper article regarding Diablo Canyon nuclear facility	1785	1785 REJECTED
Jt. Int. Ex. 59	3 page list of pipe spools which contain SA-403 fittings made from SA-312 fusion welded material	1789	1789
Jt. Int. Ex. 60	2 page list of pipe spools which contain SA-403 fittings made from SA-312 fusion welded material	1789	1789
Jt. Int. Ex. 61	Youngstown Welding and Engineering Co., Welding Procedure Specification QW-482 for Specification No. 750 and Procedure Qualification Record No. SD 458-3	1800	1800
Jt. Int. Ex. 62	Cover sheet and page I-1 of Aptech Engineering Services Draft Report, "Significance of Centerline Lack of Penetration in Double Welded Stainless Steel Pipe - Fracture Analysis"	1806	1806
Jt. Int. Ex. 63	Excerpts from ASME Code Section III, Article NC-2000 (1977 Edition)	1820	1821

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
Jt. Int. Ex. 64	ASME Material Specification SA-403 (1977 Edition)	1851	1851
Jt. Int. Ex. 65	NRC Office of Inspection and Enforcement, Region IV, Report No. 99900029/79-01 (Youngstown Welding and Engineering Co.)	1885	1887
Jt. Int. Ex. 66	SNUPPS letter SLNRC 79-16 dated October 5, 1979 to Boyce Grier from S. J. Seiken for N. A. Petrick	1885	1837
Jt. Int. Ex. 67	ASME Material Specification SA-312 (1977 Edition)	1885	1887
Jt. Int. Ex. 68	ASME Material Specification SA-530 (1977 Edition)	1885	1887
Jt. Int. Ex. 69	(1) NRC Region I letter dated January 4, 1980 to N. A. Petrick from R. T. Carlson; (2) SNUPPS letter SLNRC 79-20 dated November 29, 1979, to Boyce Grier from N. A. Petrick with attached Final Report on Gulf & Western Preassembled Formations	1926	1926
Jt. Int. Ex. 70	Bechtel Technical Specification No. 10466-C131 (Q), Rev. 8	1972	1999
Jt. Int. Ex. 71	Bechtel Technical Specification No. 10466-C131 (Q), Rev. 9	1972	1999
Jt. Int. Ex. 72	Cover sheet and page 27 of NUREG-0040, Vol. 2, No. 5, "Licensee Contractor and Vendor Inspection Status Report", September 30, 1978	1973	1999 REJECTED
Jt. Int. Ex. 73	Arbitrator's Opinion and Award, FMCS Case No. 78K/17143	1973	2002 REJECTED

EXHIBIT NUMBER	DESCRIPTION	IDENTIFIED AT TRANSCRIPT PAGE	ADMITTED AT TRANSCRIPT PAGE
Jt. Int. Ex. 74	NRC Region III letter (date illegible) to J. K. Bryan with attached IE Investigation Report Nos. 50-483/78-12 and 50-486/78-02	1974	2002
Jt. Int. Ex. 75	Exhibits to IE Investigation Report Nos. 50-483/78-12 and 50-486/78-02	1974	2002
Jt. Int. Ex. 76	(1) NRC Region III letter dated July 14, 1980 to K. Drey from J. Keppler; (2) June 13, 1980 unsigned letter to J. Keppler	1974	2003 REJECTED
Jt. Int. Ex. 77	NUREG-0040, Vol. 2, No. 5, "Licensee Contractor and Vendor Inspection Status Report", September 30, 1978	1992	1992 REJECTED
Jt. Int. Physical Ex. A	Specimen, welded plate	1003	1005
Jt. Int. Physical Ex. B	Steel angle with two headed studs	1273	1273
Jt. Int. Physical Ex. C	Three photographs of pipe weld, prints of copies attached to IE Report 81-04	1650	1650
Jt. Int. Physical Ex. D	Piece of pipe, approximately 6 inches long, having a longitudinal single-welded seam.	1665	1665
Jt. Int. Physical Ex. E	Piping "elbow" fitting	1780	1781
Jt. Int. Physical Ex. F	Piping "tee" fitting	1780	1781
Jt. Int. Physical Ex. G	Piping "reducer" fitting	1780	1781

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

DOCKETED USNRC

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD '82 FEB -2 A11:28

OFFICE OF SECRETARY DOCKETING & SERVICE BRANCH

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 "Applicant's Proposed Findings of Fact and Conclusions of Law in the Form of a Partial Initial Decision" were served this 1st day of February, 1982 by hand delivery upon the parties identified by one asterisk, Express Mail to the parties identified by two asterisks, and deposit in the U.S. mail, first class, postage prepaid, to the other parties on the attached Service List.

Thomas A. Baxter

Thomas A. Baxter

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)	)	

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