UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of Commonwealth Edison Company (Zion Station, Units 1 and 2)	)	Docket Nos. 50-295 50-304

LICENSEE'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW

July 16, 1979

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I. Preliminary Statement

1. This proceeding is on the application of the Commonwealth Edison Company (Applicant) for amendments of the operating licenses for the Zion Nuclear Generating Station, Units 1 and 2. The proposed amendments would permit the Applicant to install new storage racks in the spent fuel pool thereby increasing the storage capacity of the pool from 868 to 2112 fuel assemblies.

2. On April 13, 1978, the Applicant formally requested the issuance of the license amendments. Notice of the proposed amendments was published in the Federal Register on July 18, 1978. 43 Fed. Reg. 30938. Pursuant thereto, the State of Illinois, through the Attorney General of Illinois (Intervenor), filed a timely petition for leave to intervene in the proceedings, and requested that a public hearing be held on the proposed amendments.

3. A Special Prehearing Conference was held on November 20 and 21, 1978, at Waukegan, Illinois for the purposes of ruling on Intervenor's standing to intervene as a party in the proceedings and determining whether certain of Intervenor's contentions met the legal requirements of the Nuclear Regulatory Commission's Rules of Practice. Limited Appearance statements were taken at that time.

4. On January 19, 1978, the Board admitted the State of Illinois as an intervening party and ruled upon the admissibility of certain of Intervenor's contentions. 1/

5. Subsequently, Motions for Summary Disposition were filed by Applicant and the Nuclear Regulatory Commission Staff (Staff). Certain of Intervenor's contentions were summarily dismissed on the grounds that no genuine issues of material fact existed as to these contentions. 2/

6. On June 5, 1979 Edward Luton, Esq. withdrew as chairman of the Atomic Safety and Licensing Board for this proceeding. He was replaced by John F. Wolf, Esq.

7. An evidentiary hearing was held in Zion, Illinois from June 11, 1979 through June 15, 1979 and from June 20, 1979 through June 22, 1979, at which time evidence was presented by the parties with respect to the remaining controverted contentions and Board questions. During these hearings all interested members of the public who wished to make limited appearance statements were heard.

1/ "Order Following Prehearing Conference' dated January 19, 1979.

2/ "Order", dated May 1, 1979; "Order, dated June 4, 1979.

II. Findings of Fact: Matters in Controversy

Contentions

8. Intervenor originally included twenty-three contentions in its original "Petition For Leave to Intervene", dated August 14, 1978. As a result of facts ascertained through discovery and negotiations between the parties, Intervenor withdrew these contentions and submitted sixteen amended contentions. Intervenor voluntarily withdrew one of these contentions during the course of the Prehearing Conference, which withdrawal was approved by the Board. 3/

9. In addition, the Board dismissed portions of Intervenor's amended contention 6 and amended contention 16 in its entirety for failing to conform to the Commission's legal requirements for a valid contention. 4/ The remaining amended contentions were admitted by the Board as issues in controversy. 5/

10. In January of 1979, Applicant and the Staff filed motions for summary disposition with respect to certain of Intervenor's contentions. The Board summarily dismissed Contention 2(n) which inquired about the occupational exposure resulting from the rack replacement program and

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3/ Tr. at 55.

4/ "Order Following Prehearing Conference", dated January 19, 1979.

5/ Id.

conformity to the principle that exposure would be maintained as low as is reasonably achievable (ALARA). 6/ However, the Board granted an opportunity to Intervenor to present argument at the evidentiary hearing in support of Intervenor's suggestion that an appropriate license condition be imposed upon Applicant to assure that occupational exposures be maintained ALARA. 7/

11. Attached to Applicant's January, 1979 motion for summary disposition was a letter from one of Applicant's attorneys to Intervenor's counsel, signed by both, in which Applicant and Intervenor agreed that certain portions of Contention 2(e) dealing with spent fuel pool area monitoring procedures and Zion Station ground water monitoring would be withdrawn. At the hearing on June, 1979, the Board did not approve this withdrawal and accordingly evidence was presented on these issues. 8/

12. By motion dated April 27, 1979, the Staff moved for summary disposition of Contentions 2(a), (b), (c) and (d). Subsequently, the Staff and Intervenor entered into a stipulated agreement that Contention 2(d) would be

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6/ "Order", dated May 1, 1979.

7/ Id.; At the evidentiary hearing, counsel for Licensee and Intervenor indicated that an agreement in principle had been reached with respect to this issue and that oral argument was therefore unnecessary. (Tr. 2063-4) The Licensee and Intervenor have reached a formal agreement, a copy of which is attached hereto as Appendix B.

8/ Tr. at 730.

withdrawn from the proceeding. The Board approved this stipulated withdrawal. [9/] Furthermore, the Board granted the Staff's motion with respect to contentions 2(b) and (c).[10/] During the evidentiary hearing, the Board reconsidered its June 6, 1979 decision, and denied the Staff motion for summary disposition of contentions 2(b) and (c).[11/]

13. In its "Motion In Regard To Scheduling of The Hearing To Be Held In Zion, Illinois June 11-23, 1979", Intervenor requested that contention 2(m) be withdrawn. This request was granted by the Board during the course of the evidentiary hearing. [12/]

14. Thus, the contentions as to which evidence was presented during the course of the evidentiary hearings were as follows: 2(a), 2(b), 2(c), 2(d), 2(e), 2(f), 2(g), 2(h), 2(i), 2(j), 2(k) and 2(l).

Board Questions

15. In its "Order Following Prehearing Conference", dated January 19, 1979, the Board propounded six questions and requested that evidentiary showings on each of the questions be made at the evidentiary hearings. These questions were identified as Board Questions 4(a), 4(b), 4(c), 4(d), 4(e) and 4(f).

9/ "Order", dated June 4, 1979.

10/ Id.

11/ Tr. at 551.

12/ Tr. at 730.

16. Subsequent to extensive limited appearance statements by members of the public during the evidentiary hearings, the Board posed four additional questions generated in part by limited appearance statements with respect to which an evidentiary showing was requested.[13] These questions were identified as Board Questions 4(g), 4(h), 4(i) and 4(j).

17. In addition, the Board conducted independent cross-examination of many of the witnesses who testified at the hearing. To the extent that these questions required further evidentiary presentations, they will be discussed in the findings of fact relating to the relevant Contentions or Board Questions identified above.

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[13] Tr. at 574-577.

A. Environmental Impact Appraisal

Contention 2(a) states:

> The State of Illinois contends that approval of the proposed license amendment would be a major action of the Commission significantly affecting the quality of the human environment in Illinois. The National Environmental Policy Act of 1969, as amended, requires the Commission to submit an environmental impact statement with respect to the proposed license amendment.

18. Mr. Tom Tramm, Commonwealth Edison's Project Engineer for Zion Station, and Mr. Gary Zech, NRC Staff Project Manager assigned to the Zion Station reracking, testified in regard of contention 2(a). The State of Illinois did not present any direct testimony regarding this contention.

19. Mr. Zech testified that the Staff performed an environmental evaluation of the proposed modification pursuant to the National Environmental Policy Act of 1969, as amended, ("NEPA"). (Zech, prepared testimony at 1, Tr. 595). An environmental impact appraisal pertaining to the Zion Station reracking ("EIA") was prepared by the Staff under Mr. Zech's direction and supervision, and was received in evidence as Staff Exhibit 1B (Tr. 608). Mr. Zech testified that based upon the review as documented in the EIA, the Staff concluded that the environmental impacts of the proposed reracking would be negligible.

20. The Staff's reasons for its conclusion that the proposed reracking will not significantly affect the

environment are detailed in §§5 and 6 of the EIA. The Staff is supported by Mr. Tramm's prepared testimony. (Tramm, prepared testimony at pp. 2-7, Tr. 564). First, there will be no alteration of the pool structure, and thus no change in the use of land. (Staff Exhibit 1B, §5.1; Tramm, prepared testimony at p. 3, Tr. 564).

21. Although there will be a slight increase of the heat load on the spent fuel pool cooling system due to the increase in the total number of fuel assemblies stored in the pool, the cooling system is designed to accommodate this increase. Therefore, there will be no need to increase Zion Station cooling water usage. (Staff Exhibit 1B, §5.2; Tramm, prepared testimony at pp. 4-5, Tr. 564).

22. The increase in the spent fuel inventory which will result from the reracking means that there is a higher potential for radioactive gas release due to leaking fuel elements. The primary volatile fission product nuclides which might be released are the noble gases, tritium and the iodine isotopes. (Staff Exhibit 1B, §5.3.1).

23. Experience with fuel stored at other fuel pools reveals that after spent fuel has decayed 4 to 6 months there is no significant release of fission products from defective fuel. (Staff Exhibit 1B, §5.3.2). Nonetheless, the Staff conservatively estimated that an additional 90 curies of krypton-85 could be released when the modified pool is completely filled. (Staff Exhibit 1B,

§5.3.2). Krypton-85 is the only significant noble gas isotope attributable to storing additional assemblies for a longer period of time. Exposures calculated based upon the Staff assumptions demonstrate that there would be an increase of less than 0.2 percent of the exposures from the plant evaluated in the Final Environmental Statement related to the operation of Zion Station, Units 1 and 2. (Staff Exhibit 1B, §5.3.2).

24. The Iodine-131 releases from the spent fuel assemblies will likewise not increase significantly since the total iodine-131 inventory in the fuel decay to negligible levels between refuelings due to the short half life (8.08 days) of iodine-131. (Staff Exhibit 1B, 5.3.2; Nestel, Tr. 885).

25. Most of the tritium in the spent fuel pool results from mixing with reactor coolant during refueling operations. The Licensee's expert witness, Dr. A. B. Johnson testified that the tritium levels observed in spent fuel pools which communicate directly with primary reactor coolant are about two orders of magnitude greater than those observed in pools in which direct communication is not present. Less than 1% of the tritium concentration in the fuel pool is attributable to storing additional fuel assemblies for a larger period of time. Thus, the modification will not cause a significant increase in the concentrations of tritium in the Zion spent fuel pool water.

(Johnson, Tr. 1060, 1065). Since the bulk water temperature during normal refuelings is not expected to increase above the 120°F used in the design analysis, gaseous emmissions of iodine and tritium due to evaporation will be small compared to the amount normally released from the plant and that which was previously evaluated in the Final Environmental Statement. (Staff Exhibit 1B, §5.3.2).

26. The concentration of solid radioactive nuclides in the spent fuel pool is controlled by filters and demineralizers and by decay of short-lived isotopes. (Staff Exhibit 1B, §5.3.3). Past refueling experience at Zion Station shows that within about two to three weeks of a refueling discharge, the activity level in the spent fuel pool returns to the level which existed prior to discharge. (Tramm, Tr. 592). There are two demineralizer trains at Zion Station capable of being run in parallel if the water conditions should require additional filtering. (Leider, Tr. 776). Thus, there will not be a significant increase of solid radioactive nuclides in the fuel pool as a result of the modification. (Staff Exhibit 1B, §5.3.3).

27. Mr. Tramm testified that since spent fuel pool filter changes and disposal are a function of the number of refuelings there should be no increase in solid radioactive waste from this source. (Tramm, prepared testimony at p. 5, Tr. 564). However, the Staff conservatively estimated that an additional 30 cubic feet of resin

per year from the demineralizers will be produced as a result of the modification.

28. The present racks will be crated intact and shipped to a licensed low-level waste burial site. (Staff Exhibit 1B, §5.5.5). The volume involved is about 17,000 cubic feet. (Tramm, prefiled testimony at p. 5). Averaged over the lifetime of Zion Units 1 and 2, the total waste shipped from the plant will be increased by about 2% of that shipped per year, on the average from two pressurized water reactors. (EIA §5.3.3). Consequently, there will not be any significant environmental impact.

29. The Staff and Licensee estimate the occupational exposure for the entire rack replacement operation will be about 2-5 man rem. (Staff Exhibit 1B, §5.3.5; Pliml, prepared testimony at p.5, Tr. 677). The incremental exposure from the modifications will thus add less than 1% to the total annual exposure at the Station. (Staff Exhibit 1B, §5.3.5). The Board has already ruled that the Licensee's proposed method of carrying out the rack replacement will ensure that occupational exposures are maintained as low as is reasonably achievable.

30. With respect to environmental impacts associated with nonradiological effluents, since no chemicals or biocides will be used in the modification or subsequent operation of the plant, there will be no change in the chemical or biocidal effluents from the plant as a result of

the proposed modification. (Staff Exhibit 1B, §5.3.8; Tramm, prepared testimony at p. 6, Tr. 564).

31. The maximum increase in total station thermal discharge to Lake Michigan will be 5.4×10^6 Btu per hour. (Staff Exhibit 1B, §5.3.8). This represents less than a .04 percent increase in the thermal discharge from the station and thus will not have a significant environmental impact. (Staff Exhibit 1B, §5.3.8; Tramm, prepared testimony at p. 4, Tr. 564).

32. All of the work relating to installation of the racks will be accomplished inside existing structures. Furthermore, no new work force will be mobilized to complete the task, and thus there should be no environmental or socioeconomic impacts as a result of the proposed modification. (Staff Exhibit 1B, §5.3.8; Tramm, prepared testimony at p. 6, Tr. 564).

33. As discussed in detail infra, there are no significant impacts associated with the occurance of postulated accidents, as a result of the proposed modification.

34. The Board requested that the Staff substantiate that the EIA was performed after specific examination of plant design and in consideration of conditions unique to Zion Station including its location and possible impact on the environment and the human health of the surrounding area. (Tr. 577). Mr. Zech explained that the Staff considered the full range of the potential site-specific en-

vironmental impacts for the operation and continued construction of Zion Station in the Staff's Final Environmental Statement ("FES") which was issued in December, 1972. In performing its environmental review pertaining to the proposed modification, the Staff evaluated whether the modification and subsequent operation would result in a potential for increasing the impacts previously evaluated in the FES. The Staff concluded that there would not be a significant increase in potential environmental impacts as a result of the modification. (Zech, Tr. 609-610).

35. Mr. Zech also addressed the issue relating to the apparent similarities in language of the Zion EIA and the EIA prepared by the Staff in the fuel pool modification proceedings for Public Service Company of New Jersey's Salem plant. Mr. Zech testified that the similarities are at least partially attributable to the fact that he was the Staff project manager responsible for both the Zion Station and Salem reracking. (Zech, Tr. 611). Other similarities are due to the fact that the relevant portions of both documents discuss generic issues applicable to all fuel pool modifications regardless of location. (Zech, Tr. 637).

36. Based upon the findings recited above, the Board finds that the proposed modification will not significantly affect the quality of the human environment. Further, the Board finds that the Staff's review adequately

addressed the site-specific aspects of the proposed modification. Accordingly, the Board finds that no environmental impact statement was necessary in this case and Intervenor's Contention 2(a) is without merit.

B. Nuclear Regulatory Commission's "Notice of Intent"

Intervenor's Contention 2(b) states:

> Approval of the amendment request would be contrary to the NRC policy position on spent fuel storage which prohibits non-emergency licensing of any existing storage facility prior to the adoption of an official long term policy regarding the permanent storage of spent fuel. See "Intent to Prepare Generic Environmental Impact Statement of Handling and Storage of Spent Light Water Power Reactor Fuel," 40 Fed. Reg. 42801, September 16, 1975.
>
> (1) There is no emergency need to rerack as the existing storage pool contains more space than is necessary to accommodate full core discharge.
>
> (2) The existing pool is able to accomodate normal refueling discharges until 1981; therefore, failure to grant the application at this time poses no threat of imminent shutdown of the facility.

37. Contention 2(b) invokes the Nuclear Regulatory Commission's "Notice of Intent to Prepare Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel," 40 Fed. Reg. 42801 (September 16, 1975) (hereinafter, "Notice of Intent"). The environmental impact statement to which the Notice of Intent refers has not yet been issued, although a draft version (NUREG 0404) was published in March, 1978. Pending the issuance of the final generic environmental impact statement, the Commission has directed that for any licensing action intended to ameliorate a possible shortage of spent fuel storage capacity

five factors will be applied, weighed and balanced within the context of environmental impact statements or environmental impact appraisals in reaching licensing determinations. The five factors are:

(1) Is it likely that each individual licensing action of this type would have a utility that is independent of the utility of other licensing actions of this type?

(2) Is it likely that the taking of any particular licensing action of this type during the time frame under consideration would constitute a commitment of resources that would tend to significantly foreclose the alternatives available with respect to any other individual licensing action of this type?

(3) Is it likely that any environmental impacts associated with any individual licensing action of this type would be such that they could be adequately addressed within the context of the individual license application without overlooking any cumulative environmental impacts?

(4) Is it likely that any technical issues that may arise in the course of a review of an individual

license application can be resolved within that context?

(5) Would a deferral or severe restriction on licensing actions of this type result in substantial harm to the public interest?

40 CFR 42801, 42802.

38. The Staff's environmental impact appraisal (Staff Exhibit 1B, Zech, Tr. 608) examines each of these five factors. With respect to the first factor, the Staff's testimony is that the proposed licensing action has independent utility in that it will allow Zion Station to continue operating beyond 1983, when lack of spent fuel storage space would otherwise force the station to shut down until the proposed federal storage facility for spent fuel is in operation. (Staff Ex. 1B, Section 8.4.1) Upon cross-examination, Mr. Zech indicated that the Staff estimates that a federal storage facility of some type will be available in 1985 or 1986; however, this anticipated date is not firm (Zech, Tr. 690, 692). The Administration has proposed legislation to authorize the government to contract for such facilities or to build them itself, but this legislation has not yet been approved (Zech, Tr. 693).

39. The Staff also states that the proposed modification will provide the licensee with additional flexibility which is desirable even if adequate off-site storage

facilities become available (Staff Ex. 1B, Section 8.4.2). On cross-examination, Mr. Zech explained the Staff's use of the term, "flexibility." Even if a federal storage facility becomes available before all of the additional storage spaces requested in the Licensee's application have been filled up, this additional storage capacity would be useful in allowing the Licensee to offload a full core, if that became desirable for operational reasons (Zech, Tr. 691). Further, Mr. Zech testified that just because a federal facility is available all licensees will not be able to instantaneously transport their spent fuel to the facility. The additional storage capacity at Zion would provide a useful function in allowing the efficient scheduling of spent fuel shipments from a variety of reactors to the spent fuel repository (Zech, Tr. 694-5).

40. Neither the Licensee nor Intervenor submitted any evidence in respect of the first factor. We are in agreement with the Staff that the proposed licensing action has a utility which is independent of any other licensing actions of this type which may be under consideration by the NRC.

41. The second factor which the Commission has stated must be addressed is whether the proposed action would constitute a commitment of resources which would tend to significantly foreclose other licensing actions designed to

ameliorate a possible shortage of spent fuel storage capacity. The Staff's testimony is that the proposed licensing action will not constitute a significant commitment of material resources such as steel, aluminum, boron, and carbide. (Staff Ex. 1B, Section 8.3.2). This is in accord with Applicant's testimony. (Tramm, prepared testimony at p. 7, Tr. 564). In addition, the Staff has determined the proposed expansion in storage capacity at Zion is only a measure for continued operation and to provide operational flexibility at Zion which will not foreclose similar licensing actions at other nuclear power plants. Nor will it commit the NRC to once again authorize additional expansion of storage capacity at Zion in 1992, when the proposed storage racks will be full if spent fuel is not shipped off-site in the interim (Staff Ex. 1B, Section 8.4.2).

42. Intervenor did not submit any evidence of its own in respect of this second factor, nor did it challenge the Staff's evidence on cross-examination. The Board believes the evidence supports a finding that this factor has been adequately evaluated.

43. The third factor is whether any cumulative impacts have been overlooked. The evidence from the Staff indicates that no such cumulative impacts exist (Staff Ex. 1B, Section 8.4.3). Intervenor has not submitted any evidence to the

contrary, nor has it suggested by way of cross-examination that the Staff has overlooked any cumulative impacts. We think the third factor has been adequately evaluated.

44. With regard to the fourth factor, the Staff believes that all technical issues which have arisen during their review of this appplication have satisfactorily been resolved in their Safety Evaluation and Environmental Impact Appraisal (Staff Ex. 1B, Section 8.4.4). Although Intervenor has offered no evidence specifically addressing this factor, it disagrees with the Staff's conclusion that its technical review has been adequate. Intervenor points to the technical issues such as corrosion, pool boiling, etc. it has raised in its other contentions (Tr. 695-6). The Board has on its own motion asked the parties to address certain technical issues which were not explicitly dealt with in the Staff's Safety Evaluation and Environment Impact Appraisal.[14/] However, as the Board interprets the Commission's Notice of Intent the real question raised by the fourth factor is whether any technical problems have arisen which the Board is unable to resolve in this individual licensing proceeding. We conclude that there are no technical problems here which are beyond our capacity to resolve.

14/ See Findings of Fact, infra ¶'s 152 through 212.

45. The fifth factor is whether a deferral or severe restriction on this licensing action would result in substantial harm to the public interest. The Staff's evidence is that while the Zion units will not face certain shutdown until 1983, the Station will lose full core discharge capability in 1982. After this point, Zion would face the possibility of shutdown at any time due to lack of a full core reserve in the spent fuel pool. Reactor shutdown would harm the public interest in that it could adversely affect the Licensee's ability to meet electrical energy needs, or force the operation of other plants which are less economical or which have greater environmental impacts (Staff Ex. 1B, Section 8.4.5).

46. The Licensee's evidence is to the same effect, except that it estimates that it will have to shutdown the two Zion units due to lack of refueling capacity in the fall of 1983 and the spring of 1984, and the Licensee also estimates that Zion will lose full core discharge capability in the fall of 1981, rather than 1982, as the Staff predicts (Pliml, prepared testimony at pp. 2-3, Tr. 677).

47. The Licensee's witness, Mr. George Pliml, admitted in his direct testimony that there is no emergency need to install absorber racks at Zion by the fall of 1979 (Pliml prepared testimony at p. 6, Tr. at 677). However, he stated

that the replacement of the spent fuel racks should proceed as soon as possible to minimize occupational exposure. For example, if the first four racks are placed in the pool before the Spetember 15, 1979 refueling outage a diver can be used to position the racks. This would reduce the amount of time and workers required to accomplish the job and thereby reduce occupational exposure. If the rack replacement does not take place until after the September 1979 refueling outage, the presence of additional spent fuel in the pool will probably preclude the use of a diver to align the racks. Alignment of these racks will then require more workers working for longer periods of time above the pool surface. Moreover, the rack replacement will require the transfer from the old racks to the new racks of all the spent fuel stored in the pool, including that discharged during the most recent refueling. Additional fuel movements due to additional fuel discharged during refueling will necessarily result in increased occupational exposures. The Licensee has estimated that the total occupational exposure if the first four racks are installed before the September 1979 refueling outage will be from 2-5 man-rem. Thereafter, this number will increase by .8 man-rem. After each subsequent refueling outage the occupational exposure will continue to increase due to the presence of more spent fuel

in the pool requiring additional spent fuel movements (Pliml, prepared testimony p. 4-6, Tr. at 677, 682).

48. Intervenor submitted no testimony in respect of the fifth factor. It did not shake Mr. Zech's testimony or that of Mr. Pliml on cross-examination. We find that the public interest is served by proceeding at this time, both to minimize occupational exposure and to reduce the possibility that Zion Station might be forced to undergo a prolonged shutdown due to the lack of full core discharge capability.

C. Need for Continued Operation of Zion Station

Contention 2(c) states:

> Should it be necessary to shut down the Zion facility, pending the development of an alternate, away from reactor facility, the Applicant has not shown that the community currently being served by Zion would be adversely affected economically or by experiencing loss of electricity.
>
> (1) The Applicant has not explored the possibility of meeting current demand by increased use of underutilized fossil-fueled plants serving the Edison system.
>
> (2) The Applicant has not considered curtailing the output from Zion in conjunction with a conservation program and coordianted rate structure which would reduce the demand for electricity in the area served by Zion.

49. The Board heard testimony in respect of this contention from the Licensee's witness, Roland Kraatz, a senior staff engineer in Commonwealth Edison Company's System Planning Department (Tr. 815), and from Mr. Argil L. Toalston, Chief of the Power Supply Analysis Section of the NRC's Antitrust and Indemnity Group, Office of Nuclear Reactor Regulation (Tr. 846). Intervenor offered no witness in support of its contention.

50. Mr. Kraatz testified if the Zion units were forced to shutdown in the early 1980's the cost of serving the electric energy needs of Licensee's customers would increase substantially. Replacement energy costs would average $441,000 per day while both Zion units were inoperable

(Kraatz, prepared testimony at p. 2, Tr. 815). If only one unit were allowed to operate, the replacement energy cost would be $178,000 per day.[15/] The Licensee's customers would bear the substantial burden of these additional costs (Kraatz, Tr. 814). Mr. Kraatz's calculations are based on a comparison of the cost of fuel used in generating electricity at Zion Station versus equivalent fuel-related costs for other nuclear, coal, and oil-fired generating units (primarily within the Commonwealth Edison System) which would be called upon to replace Zion's output (Kraatz, prepared testimony Attachment A, Tr. 815). The $441,000 per day figure is expressed in constant 1978 dollars and does not assume any inflation rate or escalation rate in replacement power costs (Kraatz, Tr. 836-7).

51. The Licensee has also estimated, using the same assumptions, that the portion of Zion's output which would be replaced by oil-fired generating units would require burning approximately 850,000 gallons of oil per day or approximately 300 million gallons of oil annually (Kraatz, prepared testimony at p. 4, Tr. 815, 837).

52. Further, Mr. Kraatz testified that reliability of electric supply to Licensee's customers would be

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15/ At the hearings, Mr. Kraatz testified that this cost would be $262,000 per day (Kraatz, Tr. 832). However, by affidavit dated July 9, 1979, he stated that his testimony was in error and supplied the lower estimate given above.

adversely affected if the Zion generating units are unavailable in the early 1980's. Without Zion in service, the Licensee's estimated peak load reserve levels would be 2.3% in 1982, 10.1% in 1983, 17.1% in 1984, and 12.1% in 1985 (Kraatz, Tr. 812; prepared testimony Attachment B, Tr. 815). Licensee's present reserve criterion is 14%. The purpose of maintaining such a reserve margin is to ensure reliable electric service to Licensee's customers allowing for forced outages of Licensee's generating units. Licensee's 14% reserve criterion is generally lower than what other utilities are using for planning purposes because it reflects the help the Licensee can receive through its interconnections to other neighboring utilities. The 14% reserve criterion corresponds to a loss of load probablity of one day in ten years (Kraatz, Tr. 813).

53. Mr. Kraatz's testimony concerning reliability of electric supply in the early 1980's is based on a projection of increased peak load demand for electricity at an annual rate of 4-1/2% (Kraatz, Tr. 820, 838). Licensee has used this demand forecast since January 1979, prior to which time, in 1978, Licensee used a rate of 5.1%. The actual peak load demand for electricity increased from 1976 to 1977 by 7.9%. From 1977 to 1978 it decreased by 1.5%, reflecting a very cold summer period (Kraatz, Tr. 820-821).

54. Mr. Kraatz testified that Licensee encourages energy conservation through both customer information programs

and time-of-day rates for its large industrial customers. Additionally, an experimental time-of-day rate program for residential customers has been started (Kraatz, prepared testimony at p. 4, Tr. 815). However, the Zion units are utilized in a base load manner because of their low operating cost. Thus, the present energy conservation programs and time-of-day rates have had an insignificant effect on the operation of the Zion units, and additional programs or rate changes would similarly not greatly affect Zion's operation (Kraatz, prepared testimony at pp. 4-5, Tr. 815).

55. On cross examination, Mr. Kraatz admitted that the Licensee has never sent out energy conservation information with customers' electric bills (Kraatz, Tr. 822). In addition, Mr. Kraatz authenticated a condensed summary of Licensee's rates, which was then submitted by Intervenor as Intervenor's Exhibit No. 4 (Kraatz, Tr. 826-9). Mr. Kraatz agreed that the rates charged to commercial, industrial, governmental, and school customers reflect a "declining block rate structure". This term means that the greater the amount of electricity that such customers use, the lower the cost per Kilowatt-hour they pay (Kraatz, Tr. 830-831).

56. The Staff's witness, Mr. Argil Toalston, testified, in general agreement with the Licensee's position, that a shutdown of Zion Station could adversely affect the Licensee's ability to meet electrical energy needs or force the operation of other plants which are less economical to operate.

However, Mr. Toalston estimated the differential costs of not operating Zion Station at $240,000 per day, in comparison with the Licensee's estimate of $441,000 per day. (Toalston, prepared testimony at p. 2, Tr. 846).

57. The Staff also estimated the replacement energy costs if Zion were operated at half load, assuming that such a reduced loading would also reduce the rate of generation of spent fuel by a factor of two. This would in turn extend the capacity of the Zion pool until late 1986. The increased costs would be $3.6 million per month. If such reduced load operation began after the 1979 fall refueling at Zion, the differential fuel costs from this mode of operation could reach $300 million by late 1986 (Staff Ex. 1B, Section 7.6, Toalston Tr. 843, 847-8).

58. Mr. Toalston attributed the difference between the Staff's estimate of replacement costs and the Licensee's estimate to two factors. First, the Staff assumed a much greater amount of replacement power for the Zion units would come from cheaper high sulfur coal burning units (60 percent versus the Licensee's 8%) while the Licensee assumed a larger use of more expensive low sulfur coal (50 percent for the Licensee versus 1.7 percent in the Staff's estimate) (Toalston Tr. 849, 871). Second, the Staff used a 58% capacity factor for both Zion units in normal operation, as opposed to the Licensee's estimate of

67% (Toalston, Tr. 849-50). This is equivalent to an assumption that less energy would have to be replaced, on annual basis, if the Zion units were shut down.

59. With respect to capacity factors, Mr. Toalston stated that his estimate of 58% was a reasonable number for nuclear power plants on a national basis, although he was not familiar with the actual capacity factors experienced by Zion Station in the last two years (Toalston, Tr. 850). He also stated that it was his interpretation of a response provided by the Licensee to a Staff question that the Licensee's 67 percent capacity figure did not take into account normal refueling outages, so that on an annual basis his 58 percent figure would be more accurate. However, he had not confirmed this interpretation with any representative of the Licensee (Toalston, Tr. 850-3).

60. Mr. Toalston stated that his assumptions about the relative use of cheaper high sulfur coal versus more expensive low sulfur coal were a more important factor than the capacity factor issue in accounting for the Staff's lower estimate of replacement power costs (Toalston Tr. 853). Mr. Toalston also stated that the Staff chose to take a "conservative" method of calculating replacement power costs by assuming that much of the replacement power would come from high sulfur fossil generating units, even though it was "quite likely" that either this would not be allowed to happen because of the environmental impacts, or if it did

happen the Licensee could be fined for violating pollution laws. Therefore, Mr. Toalston believed that actual replacement costs would be higher than his estimate (Toalston, Tr. 864-5).

61. On cross-examination by Intervenor, Mr. Toalston admitted that he had not investigated the conservation measures that Licensee could put into effect or which its customers could use to reduce power demand (Toalston, Tr. 861-2). He testified that he did not consider energy conservation important because neither the peak demand nor the total energy demand on a nuclear unit is affected by conservation measures. This is because nuclear power plants are used to serve the base load portion of the load cycle rather than the peaks. Thus if conservation measures tend to shift load from the peaks to the base, that makes the nuclear units even more important. If conservation measures reduce the base load demand, new generating capacity is delayed or reduced, so that the power demand on an existing nuclear unit is not affected (Toalston, Tr. 862-3).

62. The Board finds that replacement power costs for both Zion units will quite likely be greater than $240,000 per day (the Staff's estimate) and may be as high as $441,000 per day (the Licensee's estimate). Even using the lower estimate, it is clear that Licensee's customers derive substantial economic benefits from the continued operation of Zion Station.

63. In subsection (2) of Contention 2(c) Intervenor suggests that the Licensee has not done all that it could to encourage energy conservation, and further that a reduction in demand for power caused by conservation would allow curtailing the output from Zion Station. However, the evidence before us falls far short of establishing that additional energy conservation measures would substantially reduce the need for continued operation of Zion Station. The record shows that the Licensee does encourage energy conservation (Kraatz, prepared testimony at p. 4, Tr. 815). The fact, adduced on cross-examination, that Licensee does not mail energy conservation literature to its customers with their bills (Kraatz, Tr. 822) proves nothing without some estimate of the incremental effect such a measure would have on reducing demand. Similarly, it is impossible to assess the importance of the fact that Licensee's rates for industrial and commercial customers show a declining block rate structure (Intervenor's Exhibit 4) without having at least some evidence before us on the degree to which demand for electricity by such customers is influenced by rate structure; i.e., whether such demand is price elastic. Further, even if it were assumed that further energy conservation measures might reduce Licensee's system load demand, Intervenor has not shown that this would reduce the need for Zion Station's output. According to Licensee's testimony, the Illinois Commerce Commission is presently holding public

hearings to consider, among other things, the possibility of selling portions of excess generating capacity and the economic reasonableness of delaying the construction schedule of the Licensee's Byron and Braidwood nuclear generating stations (Kraatz, prepared testimony at p. 3, Tr. 815). On this record there is nothing to indicate the Illinois Commerce Commission will not take into account the effect of energy conservation on Licensee's system load demand in considering whether to delay construction schedules for Byron and Braidwood. And there certainly is no evidence in this proceeding which would allow this Board to determine whether it would be preferable to curtail or shut down the operation of an existing nuclear station such as Zion, rather than delaying the operation of new nuclear units at Byron and Braidwood.

64. Therefore, although this Board concludes as a matter of law elsewhere that the need for continued operation of Zion Station is not at issue in this proceeding[16/], if we were called upon to decide the matter, we would find as a matter of fact that the Zion Station units are needed to supply reliable electric service to Licensee's customers and to avoid the substantial economic costs associated with replacing the electric power generated by such units. Moreover, because nuclear units such as Zion are operated to

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16/ See Conclusions of Law, infra, paragraph 3.

meet base load demand and because new generating capacity can be delayed if system load demand does not increase in accordance with Licensee's predictions, it is unlikely that the additional energy conservation measures Intervenor suggests would substantially affect the need for continued operation of Zion Station.

D. Accidents

(i) Drops of Heavy Objects.

Contention 2(f) states:

> There has been insufficient development of credible accident scenarios. For example:
>
> (1) there is insufficient documentation to establish the methods by which the Applicant will positively prevent the movement of heavy objects, such as shipping casks or empty fuel racks over the pool during modification; thus accidental droppings of such heavy objects, which could lead to unacceptable damage to spent fuel or the pool liner and consequent release of radionuclides, has not precluded.
>
> (2) there is insufficient information regarding the methods by which accidental damage to stored spent fuel assemblies will be prevented during the installation of the new poisoned spent fuel storage racks.

65. The Licensee's witness, Mr. John P. Leider described how the proposed rack replacement will be carried out. To prevent damage to spent fuel assemblies stored in the pool, neither the old racks being removed nor the new absorber racks which are being placed in the pool will at any time be carried over the spent fuel (Leider, prepared testimony at p. 3, Tr. 758).

66. The installation will involve the following steps. Initially, the spent fuel will be stored in the southern end of the pool. The eight northernmost racks in the spent fuel pool will be removed, one by one, from the north end of the pool. These racks will be empty and will

be removed one at a time, northernmost first. Where these racks are adjacent to racks which contain fuel they will be raised slightly and translated at least the width of the rack away from the rack containing fuel before they are lifted out of the pool. After these eight old racks are removed, eight new absorber racks will be placed in the north end of the pool, northernmost first, one by one. Using normal fuel handling procedures, the stored fuel assemblies will be transferred to the new absorber racks in the north end of the pool. The remaining twelve old racks will be removed one by one over the west side of the pool, and the remaining sixteen new absorber racks will be installed, one by one, northernmost first, from the west side of the pool (Leider, prepared testimony at pp. 3-4, Tr. 758). This is the same procedure described in the Staff's testimony (Zudans, prepared testimony at p.2, Tr. 1960).

67. The rack replacement operations will be supervised by Licensee's two fuel handling foremen, who each have a limited senior reactor operator's license (Leider, Tr. 1888). Both fuel handling foremen participated in a similar reracking at Zion Station in 1976 (Leider, Tr. 1892-3). At least one of these fuel handling foremen will be present at all times. They will direct the activities of Licensee's fuel handlers, who have extensive experience in

working with the crane and in moving fuel. Four of these fuel handlers worked on the 1976 reracking (Leider, prepared testimony at p. 5, Tr. 758). The fuel handlers receive intensive refresher training before each semi-annual refueling outage. In addition, prior to the proposed rack replacement job, they will review the procedures, the lifting rig, and the technigues to be used, and they will conduct a test lift using the main crane and the lifting frame attached to a new rack (Leider, Tr. 1896-7).

68. Assurance that racks will not be lifted over stored spent fuel during the proposed rack replacement operation is provided during much of the rack movement by crane interlocks which prevent loads moving over the pool. During those portions of the rack replacement which must involve movement over the pool with the interlocks bypassed, written procedures will be in effect during the reracking to prevent movement of the racks over the stored spent fuel (Leider, prepared testimony at p. 3, Tr. 758). The interlock is bypassed through use of a key which is in the possession of the senior licensed fuel handling foreman (Leider, Tr. 1890, 1913). Reliance is placed on administrative controls during those portions of the rack replacement which require movement of the racks over the pool since crane movement in many directions to many coordinates is required,

and it would be almost impossible to devise a scheme of mechanical interlocks to handle all circumstances. The administrative controls on rack movement will be set forth in written procedures and enforced by the crane operator, under the direct supervision of a licensed fuel handling foreman (Leider, Tr. 1891). The written procedures for rack installation are being developed at Zion Station and have not yet been finalized (Leider Tr. 1890).

69. The Licensee has testified that there is no possibility that a spent fuel shipping cask will be carried over the pool during the proposed rack replacement operation. Such casks will not be involved at all in the proposed modification. In addition, there are no casks in the plant, and there are no plans to bring any casks in the plant (Leider, prepared testimoney at p. 2, Tr. 758; Tramm, Tr. 1903). This is consistent with the Staff's testimony (Zech, prepared testimony at p. 2, Tr. 1958, 1980-1).

70. The Staff's testimony generally supports and parallels that of the Licensee in its description of the rack replacement operation. Additionally, the Staff testified at some length as to how it intends to enforce the requirement mentioned in the Licensee's testimony that heavy objects not be carried over stored spent fuel. At the time the rack replacement is carried out, this requirement will

be embodied in two documents. By letter dated April 8, 1976 the Licensee has made a commitment to notify the NRC in advance should it become necessary to handle heavy loads in the vicinity of the spent fuel storage pool (Staff, Ex. 1A, Section 2.3). Such commitments are enforceable (Kohler, Tr. 1972). In addition, the Staff intends to issue a technical specification which will preclude the handling of any loads of greater weight than a single fuel assembly plus the spent fuel handling tool over stored spent fuel (Staff Ex. 1A, Section 3.2). This will preclude among other things the movement of a shipping cask or an empty fuel rack over the stored spent fuel during the proposed rack replacement (Zech Tr. 1963, 1965). This technical specification has been drafted but not finalized, and it will be included in the license amendment should the proposed rack replacement be approved by the Board (Zech, Tr. 1971).

71. The NRC resident inspector for Zion Station, who appeared as a staff witness, testified that he or another NRC inspector from the NRC's Office of Inspection and Enforcement will be present to observe the proposed installation of the absorber racks to the extent deemed necessary by him or by his management. Additional NRC inspectors are available on a phone call basis if that is thought necessary (Kohler, Tr. 792). If the NRC inspector determines that the racks are being installed in an improper way, he will first

notify Licensee and ask for an immediate response. If a satisfactory response is not made by the Licensee, the inspector after checking with his supervisor by telephone could very quickly generate an immediate action letter or stop-work order which will force Licensee's compliance (Kohler, Tr. 798-9). The resident inspector testified that if he detects a heavy load lifted over the stored fuel he will stop the job (Kohler, Tr. 1974-5).

72. The Licensee and the Staff have considered the consequences of a number of hypothetical drop accidents related to the proposed rack replacement. These include the drop of a rack onto the pool floor, the drop of a fuel assembly onto a storage rack during the transfer of the stored fuel from the old racks to the new racks, and the drop of one fuel assembly being transferred onto another stored fuel assembly.

73. The Licensee and the Staff agree that the drop of a rack onto the pool floor would not result in major damage to the pool structure allowing gross leakage (Tramm, prepared testimony at p. 9-10, Tr. 564; Zech and Zudans, Tr. 1980-1982). This drop accident was not specifically analyzed (Zudans, Tr. 1966-7). However, during the original plant design and safety review it was determined that the drop of a shipping cask into the pool would not result in through-the-slab cracking and gross leakage (Tramm, prepared testimony at p.7, Tr. 564; Zech, Tr. 1980). A fuel rack is

much lighter than a shipping cask; moreover, because it is wider the impact would be spread out more over the pool floor. Therefore the effects of the drop of a fuel storage rack upon the pool structure would be less than the effects of a cask drop and gross leakage would not be expected (Tramm, prepared testimony at p. 9-10, Tr. 564; Zech and Zudans, Tr. 1981-2). It is credible that such a drop could tear the stainless steel pool liner (Tramm, Tr. 1903; Zudans, Tr. 1970). Beneath the liner a network of channels is embedded in the surface of the concrete pool structure which would collect the water draining through such a tear. The water collected in this manner is piped through six 1-1/2" pipes through the concrete walls of the pool to a collection tank for processing a liquid radwaste and recycle in the plant. No pool water would escape through the concrete structure of the pool to the outside environment. The maximum drainage rate through these pipes would be 288 gallons per minute. At this rate, a minimum of 23 hours would be available either to repair the liner or to add makeup water (Tramm, prepared testimony at p. 10-11, Tr.564). During that time a number of effective temporary measures could be taken to significantly reduce the leak rate. Depending on the severity of the liner break, these measures would include plugging the torn liner with metal plates or

plastic sheets, reducing the driving head by lowering the pool level, closing valves to partially isolate the drain collection tank, or crimping the breakoff piping (Tramm, prepared testimony at p. 11, Tr. 564, Tr. 1911-12). The Staff agrees that the minor damage to the liner which might result from the drop of a fuel rack would be within the makeup capability of the various water sources that exist at the plant (Zech and Zudans, Tr. 1980-1982). 17/

74. The Licensee's architect-engineer, Nuclear Services Corporation, a division of Quadrex ("NSC") has analyzed the consequences of a drop of a single fuel assembly onto one of the new storage racks (Hossain, prepared testimony, Tr. 1700; Licensee Exhibit 4, Sections 3.4.3.5 and 3.4.4). The assembly is hypothesized to drop from a height of 24 inches, which is the maximum height at which such an assembly can be transported over storage fuel (Hossain, prepared testimony, Attachment B, Tr. 1700). There is no NRC acceptance criteria for this fuel assembly drop analysis; the criteria used by NSC and the Licensee is that no structural part of the rack which is required to maintain the criticality coefficient K-effective less than .95 is stressed beyond the elastic limit. In fact, the part of the rack which can be locally damaged is not [illegible] here neutron absorber material is located or required. Accordingly, there is no increase in

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17/ The sources of makeup water at Zion Station are discussed infra, in Findings of Fact paragraph 179.

K-effective as a result of this accident (Hossain and Olson, Tr. 1713-14, 1717). The deformation at the top of the fuel rack resulting from such an accident might temporarily preclude the withdrawal of a fuel assembly stored in the tube at the time, but the tubes are made of light material, 105 mil stainless steel, which could be pulled back so that the assembly could be removed (Mollerus, Tr. 1717-1718).

75. The NRC Staff informed the Board that they have analyzed the consequences of a fuel assembly dropping directly on top of another fuel assembly from a height of 2-1/2 feet. The results of this analysis show that no damage to any of the fuel rods in either assembly will occur as a result of such a drop (Zudans, Tr. 1964-5, 1982-3).

76. Both the Licensee and the Staff testified that during the operating license review the design basis fuel handling accident considered was the drop of a spent fuel assembly onto the spent fuel pool floor and the breaking of all the fuel rods in the assembly. The analysis of the postulated accident is documented in Section 14.2.1 of the Zion Final Safety Analysis Report, where it is shown that the plant's safety and clean-up systems are adequate to keep the consequences of this occurence to within 10 CFR Part 100 limits (Tramm, prepared testimony at p. 25-27, Tr. 564; Hossain, prepared testimony at p. 3, Tr. 1700; Zudans, prepared testimony at p. 3, Tr. 1960; Staff Exhibit 1A at Section 2.3).

77. The Licensee and the Staff concede that the additional handling required to shift stored fuel assemblies from the old racks to the new racks will increase the probability of a fuel assembly drop (Tramm, prepared testimony at p. 27, Tr. 564; Zudans, prepared testimony at p. 3, Tr. 1960). According to the Licensee, the reracking will necessitate only about 400 extra fuel moves, which adds less than 1 percent to the total number of fuel moves which will be accomplished during the plant's lifetime. The Licensee states that the consequences of a fuel assembly drop will not be increased by the proposed reracking (Leider, prepared testimony at p. 8, Tr. 758; Tramm, prepared testimony at p. 27, Tr. 564). The Staff testified that the consequences of a fuel assembly drop during the proposed rack replacement would actually be less than the consequences of dropping a fuel assembly freshly removed from the reactor during refueling, which was the assumption used for the design basis fuel handling accident (Zudans, prepared testimony at p. 3, Tr. 1960).

78. There are four loads lighter than a fuel assembly which are handled over stored fuel. These are the spent fuel handling tool, the burnable poison tool, the rod cluster control changing fixture; and the thimble plug. Although lighter than a single fuel assembly, these four loads could develop greater kinetic energy because of greater potential drop heights. Accordingly, the Staff intends to

issue a Technical Specification change which will require that none of these loads be transported at a height greater than 2 feet over the storage racks (Staff Ex. 1A, Section 2.3).

79. On cross examaination of Licensee's witnesses, Intervenor suggested that a number of other hypothetical accidents should have been analyzed. First, Intervenor suggested that the maximum credible accident would be the drop of a rack onto stored fuel, which would be more dangerous than the drop of a single fuel assembly. Licensee's witness responded that he did not consider the dropping of a rack on stored fuel credible, because the rack is a light load carried by a heavy duty crane, operated by a qualified operator, and the rack is not carried over spent fuel (Leider, Tr. 1900-1901). Intervenor also suggested that the Licensee should have analyzed the drop of a rack onto the steel gate which separates the spent fuel pool from the spent fuel transfer canal, which is not filled with water except during refueling. However, the gate is located at the middle of the east wall of the spent fuel pool, and the racks will not be carried over this gate during the proposed reracking. Moreover, the bottom of the gate is above the stored spent fuel assemblies, so there is no possibility that damage to the gate could allow enough water to drain from the pool into the canal to uncover the fuel stored in the pool (Leider, Tr. 1907-1910).

80. In its Order dated May 1, 1979 the Board directed the parties to address three issues in connection with contention 2(f). The first issue was the possible increased probability and potential consequences of accidental damage to spent fuel assemblies as a result of increased handling of the fuel assemblies. The Licensee and the Staff introduced testimony on this subject which is summarized in paragraphs 74 through 77, above. The second issue identified in the Board's order was the possible swelling of the fuel storage racks. This Licensee and the Staff agree that the vented design of the proposed racks precludes the possiblity that the racks will swell during rack installation (Leider, prepared testimony at p. 8, Tr. 758; Draley, prepared testimony at p 13, tr. 1290, Tr. 1315-6; Zudans, prepared testimony at p. 3, Tr. 1960). (See Findings of Fact, infra, at paragraphs 118 to 121). Third, the Board inquired about possible sliding or tipping of the fuel storage racks during installation and fuel assembly transfer. The Licensee's and Staff's testimony is that the use of the fuel building overhead crane, a lifting frame, and hand-held guide wires will preclude tipping during installation (Leider, prepared testimony at p. 9; Tr. 758; Kohler, prepared testimony, p. 2 Tr. 1962). Sliding during installation is precluded by the levelness of the floor footings, and the weight of the racks. (Leider, prepared testimony at p. 10, Tr. 758). Sliding

or tipping of the racks during fuel assembly transfers is precluded by the fact that the racks far outweigh a fuel assembly (Leider, prepared testimony at p. 10, Tr. 758, Kohler, prepared testimony,, Tr. 1962, 1986).

81. Although Intervenor filed prepared testimony by its witness, Mr. Minor, in respect of Contention 2(f), at the hearing Intervenor chose not to offer this testimony into evidence (Tr. 2034).

82. Based on the foregoing, the Board finds that all credible drop accidents associated with the proposed rack replacement have received sufficient attention to assure the public health and safety. The major concern would appear to be the drop of a rack onto stored fuel. We find that the administrative controls and Technical Specification described by the Licensee and the Staff, if followed, will be adequate to ensure that such an accident does not happen. We expect the Licensee's management and the NRC's Office of Inspection and Enforcement to devote sufficient attention to the rack replacement operation to confirm that the administrative controls and Technical Specification are followed during the rack replacement.

(ii) Pool Boiling

Contention 2(g) states:

> The Applicant's discussion of spent fuel boiling is inadequate in that (1) there is no consideration given to the possibility that the pool might boil, and (2) there is no discussion of possible damage to fuel cladding or of the consequent release of radionuclides under such conditions; therefore, there is no assurance that public health and safety will not be endangered.
>
> In addition, the heat removal capacity of the spent fuel pool cooling system has not been shown to be adequate to support the expanded pool capacity.

83. The Licensee and the Staff have analyzed the heat removal capability of the cooling systems pertaining to the spent fuel pool and found such systems to be adequate to support the expanded pool storage capacity (Licensee Exhibit 4, Section 3.6; Tramm, prepared testimony at pp. 11-23, Tr. 564; Staff Ex. 1A, Section 2.2.2; Lobel, Donohew and Lanz, prepared testimony at pp. 7-9, Tr. 1632). Intervenor's witness, Dr. Marvin Resnikoff, disagrees. (Resnikoff, prepared testimony at pp.1-2, 19-20, Tr. 1528).

84. The Zion spent fuel pool cooling system has two cooling trains, each of which consists of a pump, a heat exchanger, piping, and associated valves and instrumentation. The spent fuel pool cooling system is itself cooled by the Zion Station component cooling system, which includes five pumps, three heat exchangers and associated piping and valves. The component cooling system transfers the heat load from the spent fuel pool and other station heat sources

(primarily the residual heat removal systems, which cool the reactor cores after shutdown) to the service water system, which discharges the heat into Lake Michigan (Tramm, prepared testimony at pp. 12-13, Tr. 564). The details of these cooling systems are set forth in Sections 9.3, 9.4, and 9.5 of the Zion Station Final Safety Analysis Report (Licensee Exhibit 3) and the accompanying FSAR charts (Licensee Exhibit 7).

85. The heat load in the spent fuel pool comes from the decay heat generated by the stored spent fuel. The heat generation rate in the pool reaches a peak when spent fuel is discharged from the reactor into the pool. Thereafter, until the next fuel transfer the heat generated decreases as the discharged fuel cools exponentially. (Tramm, prepared testimony at p. 14, Tr. 564; Licensee Exhibit No. 4 at pp. 3-49).

86. The Licensee has analyzed the spent fuel pool cooling system and concluded that either of the two spent fuel pool cooling system trains is sufficient by itself to prevent the spent fuel from boiling, even with 2112 spent fuel assemblies stored in the pool, which is the maximum capacity covered by the application (Tramm, prepared testimony at p. 12, Tr. 564). This conclusion is based on thermo-hydraulic analyses performed by Licensee's architect-engineer, NSC, which use a proprietary computer code named POOLHT

to calculate bulk fuel pool temperature as a function of heat input from spent fuel, heat rejection through the pool cooling systems, pool water mass and time (Tramm, prepared testimony Appendices F and G, Tr. 564; Licensee Exhibit 4, Section 3.6). Application of this code shows that for the worst case considered by the Licensee the maximum temperature reached is only 180°F (Tramm, prepared testimony at p. 18, Figure 3-22 Appendix G, Tr. 564).

87. The worst case considered by the Licensee was a situation in which an entire core of spent fuel (193 assemblies) is discharged, filling the pool, following completion of a normal one-third core refueling discharge by 10 days, at a time when only one heat exchanger is operating (Tramm, prepared testimony at p. 18, Tr. 564; Licensee Ex. No. 4 at p.3-2). In its Order dated May 1, 1979, the Board inquired whether the fuel pool will reach boiling temperature under such circumstances where the full core discharge from one Zion unit follows the core refueling discharge from the other Zion unit by 10 days or less. The Licensee testified that considering an existing Zion Technical Specification requiring that fuel transfers not begin until 150 hours following reactor shutdown, it is not likely that a full core discharge could be accomplished in less than 10 days following completion of a refueling discharge. Nevertheless the Licensee expressed willingness to accept a further Technical Specification restricting fuel movements during core unloading to impose a 10 day minimum on completion of

full core discharge (Tramm, prepared testimony at p. 19, Tr. 564). Both Staff and Licensee agree that there is no safety reason which would compel the Licensee to move fuel more quickly from the reactor into the spent fuel pool (Lanz, Tr. 1674; Donohew, Tr. 1676; Tramm, prepared testimony at pp. 17-28, Tr. 564, 1508-10). There may be an economic penalty associated with such a delay, but the Licensee has indicated that it is willing to accept that penalty (Donohew, Tr. 1676, Tramm, Tr. 1510).

88. In addition to its POOLHT analysis of maximum bulk pool temperatures, NSC performed a calculation of natural circulation flow rates within the pool to determine thermal loads on the proposed absorber racks and the potential for localized boiling. The maximum change in water temperature from the bottom of spent fuel assembly in a storage tube to the top of the tube as the natural circulation of water up through the tube pulls heat from the peak power spent fuel assembly in the pool is 32.38°F (Licensee Exhibit 4, pp. 3-50 to 3-51; Mollerus, Tr. 1753-4). These calculations employ an NSC proprietary code named CIRCUS in which the peak power spent fuel assembly is assumed to be stored in the middle of the pool at the end of an east-west row of average power spent fuel assemblies. Water flow in this row of fuel assemblies is assumed to follow a path from the top of the pool, down the side of the pool (in the 9-inch gaps between the new absorber racks and the east and west sides of the pool), through the 7-inch area underneath the racks, through the 5-inch hole in the bottom of the fuel storage tubes, and up past the stored spent fuel assemblies to the top of

the pool (Licensee Exhibit 4 at p. 3-51; Mollerus, Tr. 1749, 1754, 1771). This model gives an upper bound for increase in water temperature within the storage tubes, since it ignores flow from the north and south sides of the pool and flow between the racks (Mollerus, Tr. 1749-50; Licensee Exhibit 4 at p. 3-51). Moreover, the major restriction to flow of cooling water occurs within the stored fuel assemblies themselves, and for purposes of its calculations NSC maximized this restriction by assuming that the fuel assemblies are stored with control rods present, which is not usually done at Zion except in the case of a full core discharge (Mollerus and Clark, Tr. 1754-7, 1475; Leider, Tr. 1931).

89. According to Licensee's witness, Mr. Tramm, the performance of the spent fuel pool cooling system is related somewhat to the other heat loads which are transferred by the component cooling system in that such performance is a function of the temperature of the component cooling system water. Postulated plant upset conditions such as a loss of coolant accident ("LOCA") could increase the temperatures in the component cooling system and therefore possibly cause a temporary reduction in spent fuel pool cooling (Tramm, prepared testimony at p. 29, Tr. 564, Tr. 1460-1). Neither POOLHT nor CIRCUS calculates the temperature of the component cooling system during a LOCA. Instead the Licensee made allowance for such conditions in its choice of component cooling water temperature, which Licensee believes is conservative enough to confirm the conclusion that no boiling will

occur in the spent fuel pool even during LOCA conditions in other portions of the plant (Tramm, Tr. 1464, 1466).

90. For the purposes of its POOLHT calculations, the Licensee's assumption was that the temperature of the component cooling system water at the inlet to the spent fuel pool heat exchangers is 80°F. On cross examination, Licensee's witness admitted that the corresponding temperature in the Zion Final Safety Analysis Report is 95°F (Tramm, Tr. 1454-5). Mr. Tramm defended this choice by observing that the 95°F temperature assumed in the Final Safety Analysis Report is derived from a water temperature in Lake Michigan of 80°F which is very conservative in the high direction. The Licensee's use of 80°F component cooling water assumed a more realistic lakewater temperature of 70°F. The records of lakewater temperature in the Zion Final Environmental Statement, Appendix D indicate that this lower temperature is still conservative, in that the maximum recorded average monthly lakewater temperatures at Waukegan is only 63°F, in August. In contrast refuelings normally take place in the spring and fall of the year when lakewater temperatures are less (Tramm, Tr. 1496-1500). If the Licensee had used a value of 90°F, for the component cooling water temperature Mr. Tramm testified that the pool temperatures would have been about 15°F higher (Tramm, Tr. 1459-60).

91. Using its own analytical methods, the NRC Staff performed its own calculation of spent fuel pool cooling capacity. Their calculations involved a hypothetical situation similar to the worst case assumed by the Licensee in which a full core with a full inventory of fission

products is offloaded, filling the last of the 2112 spaces in the pool ten days after the thirtieth refueling. The maximum possible heat load in the spent fuel pool under such circumstances would be 51 X 10^6 Btu/m. If one of the cooling loops is not operative, the outlet water temperature would rise to about 170°F (Lobel, Donohew and Lanz, prepared testimony at pp. 8-9, Tr. 1632). Based on these calculations the Staff concluded that the present cooling capacity for the Zion spent fuel pool is adequate for the proposed modification (Lobel, Donohew and Lanz, prepared testimony at p. 9, Tr. 1632; Staff Exhibit 1A, Section 2.2.2).

92. Intervenor's witness, Dr. Marvin Resnikoff, submitted prepared testimony to the effect that boiling could occur in the spent fuel pool under two circumstances. The first circumstance would be if there were no cooling of the water in the spent fuel pool. According to Dr. Resnikoff, this could occur if the component cooling system became overloaded under reactor accident conditions (Resnikoff, prepared testimony at pp. 6-8, Tr. 1528). The second way boiling could occur would be under heat load conditions similar to those analyzed by the Licensee and the Staff, in which a full core discharge follows completion of a normal refueling discharge by 10 days or less and only one spent fuel heat exchanger is operative. In this case Dr. Resnikoff predicted localized boiling could take place (Resnikoff, prepared testimony at pp. 1, 9-10, Tr. 1528).

93. The accident conditions Dr. Resnikoff referred to in his prepared testimony involve a hypothetical situation in which it becomes necessary to cool down both Zion reactors simultaneously using the residual heat removal system (Resnikoff, prepared testimony at p. 7, Tr. 1528). Under such circumstances, Dr. Resnikoff calculated that the total heat load on the component cooling system taking into account the maximum heat load produced by the spent fuel pool during the 33rd refueling discharge, would exceed the design heat transfer capability of the component cooling system heat exchangers given in the Zion Final Safety Analysis Report ("FSAR") (Resnikoff, prepared testimony at p.6-8, Tr. 1528). However on cross examination Dr. Resnikoff admitted that he had overestimated the total heat load on the component cooling system (Resnikoff, Tr. 1543-4); and that in using the design heat transfer capability given in the FSAR he had underestimated the maximum heat removal capability of the component cooling system, which could be very much greater (Resnikoff, Tr. 1546-7, 1575-6). Further, Dr. Resnikoff could not hypothesize any circumstances under which the Licensee would not be able to maintain cooling on one reactor unit through the steam and power conversion system. Therefore he conceded that the heat load from at least one reactor unit would not have to be put on the component cooling

system under such circumstances (Resnikoff, Tr. 1539-41). 18/ Dr. Resnikoff also conceded that even if the component cooling system were subjected to the extreme heat loads described in his testimony, this would not cause a malfunction of the component cooling system. He agreed that it would require more than a single failure to cause the component cooling system to cease to function (Resnikoff, Tr. 1548-9).

94. In his prepared testimony Dr. Resnikoff estimated that the bulk spent fuel temperature would rise to only 142.5°F in the event of a full core discharge following a normal refueling discharge by 10 days with one heat exchanger operative. However, Dr. Resnikoff further postulated that the 5-inch hole at the bottom of a storage tube which normally allows entrance of cooling water, could become blocked. Under such circumstances, Dr. Resnikoff predicted that localized boiling could occur (Resnikoff prepared testimony at pp. 9-10, Tr. 1528). On cross examination, Dr. Resnikoff explained that the hole at the bottom of a tube could become blocked if a shoe fell in the pool. However, even if this occurred the resulting localized boiling would not boil off enough water to expose the top of the stored fuel assemblies,

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18/ Dr. Resnikoff observed however that this answer requires an assumption that given a design basis LOCA at one unit at Zion, personnel could operate the second unit. See General Design Criteria 5 and 19, 10 CFR Part 50 Appendix A.

nor would Dr. Resnikoff be concerned about damage to the particular fuel assembly caused by such localized boiling (Resnikoff, Tr. 1553).

95. In its May 1, 1979 Order the Board directed the parties to address whether the Zion spent fuel pool cooling system and the component cooling system meet the single failure criterion as defined in 10 CFR Part 50, Appendix A. The Staff and the Licensee testified that the Component Cooling System does meet the single failure criterion (Lantz, Tr. 1676, Tramm, prepared testimony at p. 20, Tr. 564, 1496, 1510-13, 1955-6). They also testified that the spent fuel pool cooling system does not meet the single failure criterion. A single failure of the pipe which returns water to the pool from the spent fuel pool cooling system could result in a loss of spent fuel pool cooling ability (Lantz, Tr. 1676, Tramm, Tr. 1514). The Staff testified that the single failure criterion is not applicable to the spent fuel pool cooling system (Lantz, Tr. 1654). The Licensee's witness testified that the Zion spent fuel pool meets the applicable general design criterion in

10 CFR Part 50 Appendix A, which does not incorporate the single failure criterion (Tramm, Tr. 1495). 19/

96. Nevertheless, both the Staff and the Licensee concede that a single failure of the inlet pipe which returns water from the spent fuel pool cooling system to the pool is a credible event (Lantz, Tr. 1677, Tramm, Tr. 1514). Accordingly, the Board investigated the consequences of such an event.

97. Once cooling capability is lost, the Licensee estimates that it would take at least 8.2 hours to boil, assuming the pool were initially at 150°F, which is far in excess of the normal pool temperature (Tramm, prepared testimony at pp. 20-21, Tr. 564). The Staff's estimate is about 8 hours, starting from 125°F (11°F per hour). Dr.

19/ Mr. Tramm identified the applicable criterion as General Design Criterion 61, "Fuel Storage and Handling and Radioactivity Control", which states"

> "The fuel storage and handling, radioactive waste, and other systems which may contain radioactivity shall be designed to assure adequate safety under normal and postulated accident conditions. These systems shall be designed (1) with a capability to permit appropriate periodic inspection and testing of components important to safety, (2) with suitable shielding for radiation protection, (3) with appropriate containment, confinement, and filtering systems, (4) with a residual heat removal capability having reliability and testability that reflects the importance to safety of decay heat and other residual heat removal, and (5) to prevent significant reduction in fuel storage coolant inventory under accidnet conditions."

Resnikoff's estimate, 6.3 to 12.9 hours starting from 150°F, is in the same range (Resnikoff, prepared testimony at p. 2, Tr. 1528).

98. Mr. Tramm testified that before boiling would occur the Licensee would have sufficient time to fix a broken cooling system or to add make-up cooling water which would drive down the temperature of the spent fuel pool (Tramm, prepared testimony at pp. 21-23, Tr. 564). 20/ The Staff testified that there would be sufficient time before boiling commenced to establish a flow of makeup water to the pool equal to the maximum possible boiloff rate (Lantz, prepared testimony at pp. 8-9, Tr. 1632). Intervenor's witness, Dr. Resnikoff agreed that the question of boiling is negated if a continuing source of readily available makeup water for the Zion spent fuel pool is guaranteed. He also agreed that the sources of makeup water at Zion Station would be adequate, but only if it would be possible to deliver the water to the pool under all circumstances (Resnikoff, Tr. 1556-60). For this reason, he suggested that the makeup water systems be fully automated so that human intervention is unnecessary (Resnikoff, Tr. 1570).

20/ The sources of makeup water at Zion Station are described in more detail in Findings of Fact, paragraph 179 below.

99. The Licensee and the Staff have testified that the pumps and heat exchangers of the spent fuel pool cooling system and the controls to the makeup water supply are located in a room in the fuel building which has walls and ceiling of concrete. They agree that such equipment and controls are accessible under any circumstances, even if one of the reactors thould experience a LOCA through a railroad trackway entrance to the fuel building, and this could be done without going past the spent fuel pool (Tramm, Tr. 1485-6, 1500-1, Zech and Lantz, Tr. 1688-9, 1859-1863). Intervenor's witness did not contradict this testimony (Resnikoff, Tr. 1559-60).

100. In its May 1, 1979 Order the Board asked the parties to address if boiling will occur, the possible effect on the integrity of the cladding on fuel which has been stored for a long period of time. Licensee's expert witness, Dr. A.B. Johnson, Jr. testified that there currently is no basis to expect that aged fuel will be jeopardized by boiling conditions in the spent fuel pool (Johnson, prepared testimony at p. 10, Tr. 1057). The Staff agrees (Lobel, Donohew and Lanz, prepared testimony at p. 4, Tr. 1632). Further, the Staff testified that leakage of radioactivity from a stored spent fuel assembly during spent fuel pool boiling would not be significantly different from that observed during normal pool operations (Lobel, Donohew and Lanz, prepared testimony at pp. 4-7; Tr. 1632). Intervenor

submitted no testimony dealing with the effect of boiling on stored spent fuel in conditions where the stored fuel is not exposed to the air (Resnikoff, Tr. 1526).

101. The Staff testified that if boiling were to occur some non-volatile radioactivity normally present in the pool water could be entrained in water droplets in the air above the pool. These droplets would condense out on surfaces in fuel building or ventilation ducts or be removed by the building filtration system (Lobel, Donohew and Latz, prepared testimony at p. 6, Tr. 1632). The Staff's judgment is that after boiling commenced access to the pool area would have to be controlled to maintain exposures as low as reasonably achievable, but people could still enter the pool area (Donohew, Tr. 1651-2). The Licensee's witness also testified that the pool area would remain accessible (Tramm, Tr. 1485-6).

102. In response to Board questioning, the Staff admitted that conditions of high humidity caused by pool boiling, if continued for very long periods, could disable the prefilters and HEPA filters in the building filtration system. However, the Staff stated that it did not believe that boiling would be allowed to continue for such a length of time. Further, the Licensee could replace the filters even during conditions of high radioactivity within the fuel building. Accordingly, the Staff does not believe any

changes to the fuel building filtration system are required to account for the possibility that the pool might boil (Donohew, Tr. 1678-82).

103. In response to a question from the Board the Licensee presented an expert witness, Brian Erler, who confirmed that boiling in the spent fuel pool would have a negligible effect on the pool liner. Further, a rise in pool temperatures to boiling and continued boiling for a period of up to 5 to 7 days would not affect the design behavior or structural integrity of the concrete in the spent fuel pool (Erler, Tr. 1881-2, 1885).

104. Finally, in response to a question from the Board the Staff testified that boiling would have no effect whatever on the neutron absorbing material Boral present in the proposed storage racks (Lantz, Tr. 1683-4). Boiling would tend to increase the concentration of boron present in solution in the pool water, since the water would boil away but the boron would remain (Lantz, Tr. 1664). Licensee's expert witness, Dr. Draley testified that these higher concentrations of Boric acid could be continued for periods of at least two weeks before they could have any possible effect on corrosion of the metals within the storage tubes (Draley, Tr. 1324-1327). Accordingly, boiling will not increase the risk of criticality in the spent fuel pool.

105. In his prepared testimony Dr. Resnikoff discussed an accident which might follow if the water in the spent fuel pool were allowed to boil away, uncovering the stored spent fuel assemblies. According to Dr. Resnikoff's calculations, if no makeup water were added the tops of the spent fuel racks would be uncovered in a period of 2.9 to 5.9 days following initiation of boiling. Dr. Resnikoff testified that after being uncovered the spent fuel assemblies would heat up rapidly, and above 920°C an exothermic metal water reaction would take place producing large amounts of heat and hydrogen gas. The hydrogen liberated by this reaction could subsequently explode, which might lead to a major release of radioactivity from the spent fuel building. Because of the large inventory of radioactive materials in the spent fuel pool, Dr. Resnikoff stated that such an accident would be much more severe than a reactor melt-down accident (Resnikoff, prepared testimony at pp. 3, 11-19, Tr. 1528). In support of his thesis that exposure to air of stored spent fuel could lead to a serious accident, Dr. Resnikoff cited a report by Sandia Laboratories, NUREG/CR-0649, "Spent Fuel Heatup Following Loss of Water During Storage," A.S. Benjamin, et al., March 1979. The Sandia report, however does not include any analysis of events which could lead to such an accident.

106. Neither the Licensee nor the Staff has performed calculations relating to the possible heat up of spent fuel

following exposure to air or the radiological consequences of such an event. Both take the position that such a loss of water accident at Zion Station is not credible (Tramm, Tr. 1486-7; Lantz and Donohew, Tr. 1654-5).

107. The Board does not believe Intervenor has presented a credible sequence of events by which boiling in the spent fuel pool could lead to a loss of water accident of the kind described in the Sandia Report or in Dr. Resnikoff's testimony. Even according to Dr. Resnikoff there would be a minimum of three to six days to add water to the pool to prevent this occurence, and Dr. Resnikoff concedes the supplies of makeup water at the Station are adequate for this purpose. Although he has raised a question whether human intervention to add makeup water would be possible under all circumstances, the Licensee and the Staff have testified, without contradiction on this record, that such intervention would always be possible. There is no reasonable basis for Dr. Resnikoff's speculation that such an accident might be allowed to occur through neglect. Further his concern that during a war or other period of social disruption the Licensee might "simply turn off the cooling system and walk away" from the generating station (Resnikoff, Tr. 1561) seems unreasonable.

108. The Board finds that the heat removal capacity of the Zion spent fuel pool cooling system and related cooling systems is adequate to support the expanded pool capacity. The Board also finds that if boiling should occur

in the spent fuel pool, there would be no damage to fuel cladding and no significant increase in the release of radionuclides. We find that there are sufficient sources of makeup water and adequate access to such sources to ensure that the public health and safety is not endangered by boiling in the spent fuel pool. Accordingly, Intervenor's Contention 2(g) is without merit. 21/

21/ The Board realizes that although Contention 2(g) and Intervenor's testimony only dealt with loss of water accidents in the spent fuel pool caused by boiling (Resnikoff, Tr. 1527), such accidents could be hypothesized to occur through other means. Accordingly, the Board on its own motion directed the Licensee and the Staff to summarize the design and/or engineered safeguards at the Zion spent fuel pool which decrease the likelihood of severe pool drainage accidents. The Board's findings with respect to these safeguards are found in Findings of Fact, paragraphs 175 through 180 below.

E. Corrosion

Intervenor's contention 2(e)(3) and (4) state:

The amendment request and supporting documentation do not adequately discuss monitoring procedures. In the light of the proposed modification and long term storage of nuclear spent fuel the Applicant should clarify the following:

(3) Methods for detecting the loss of neutron absorber material and/or swelling of stainless steel tubes in storage racks.

(4) Details of a corrosion test program to monitor performance of materials used in the construction of racks.

Intervenor's contention 2(h) states:

The amendment request and supporting documentation have not analyzed the long term (including storage during the operating lifetime of the reactor) electrolytic corrosion effects of using dissimilar alloys for the pool liners, pipes, storage racks and storage rack bases, such as the galvanic corrosion between unanodized aluminum as is used in Brooks and Perkins storage racks, and the stainless steel pool liner.

Intervenor's contention 2(i) states:

The Applicant has not discussed whether the proposed modification and long term storage may cause the following effects on the stored fuel: accelerated corrosion, micro-structural changes, alterations in mechanical properties, stress corrosion, cracking, intergranular corrosion, and hydrogen absorption and precipitation by the zirconium alloys.

Intervenor's contention 2(j) states:

The amendment request and supporting documentation do not give sufficient data to fully assess the durability and performance of the Boral-stainless steel tubes which form the spent fuel storage racks:

(1) there is inadequate analysis of the corrosion rate of the tubes.

(2) there is no calculation of the effect of water chemistry on the Boral within the stainless steel.

(3) there is no mention of the possible swelling of Boral within the stainless steel tubes, a condition which could effect, among other things, removal of fuel assemblies from the racks.

Intervenor's contention 2(k) states:

The amendment request and supporting documentation do not consider possible degeneration of the Boral density due either to generic defects or to mechanical failure which would diminish the effectiveness of Boral as neutron absorber, thus leading to criticality in the spent fuel pool.

109. The Licensee and the NRC Staff presented expert testimony on the subject of corrosion in the spent fuel pool. Licensee's witnesses were Dr. A.B. Johnson, Jr. of Battelle Pacific Northwest Laboratories, a recognized authority on the integrity of spent fuel and spent fuel pool equipment in water storage, and Dr. Joseph E. Draley, a leading expert on the corrosion of aluminum alloys. The NRC Staff's expert witness was Frank M. Almeter, a Senior Materials Engineer in the Engineering Branch, Division of Operating Reactors. In support of its contentions, Intervenor offered the testimony of Gregory C. Minor, a partner in MHB Associates, San Jose, California. However, on voir dire examination Mr. Minor admitted that he is not an expert in the fields of corrosion or metallurgy (Minor, Tr. 1378-9). Accordingly, the Board struck those portions of Mr. Minor's testimony which purported to express an expert opinion on those subjects

(Tr. 1402-3). Thereupon Intervenor made an offer of proof (Tr. 1406-1414).

110. The proposed storage racks consist of a welded array of rectangular stainless steel tubes into which the spent fuel assemblies will be inserted. Within each stainless steel tube are four neutron-absorbing Boral sheets, one on each side. On each side of each tube, near the top, is a 1/4 inch vent hole which penetrates the inside stainless steel wall and which will allow spent fuel pool water to enter the tube and come in contact with the Boral material (Licensee Proprietary Exhibit No. 6). Boral is a product manufactured by Brooks and Perkins, Inc. which consists of boron carbide (B_4C) particles embedded in a matrix of commercially pure (1100) aluminum formed into a plate and clad with 1100 aluminum on both sides (Draley, prepared testimony at p. 3, Tr. 1290; Almeter, Tr. 1261-3).

111. With respect to contention 2(h), the Staff's witness, Dr. Almeter testified that the only materials exposed to water in the spent fuel pool are stainless steel in the pool liner, in the spent fuel assemblies and in the storage racks, Zircaloy and Inconel in the spent fuel assemblies, and Boral in the storage racks. Of these the stainless steel, Inconel and Zircaloy do not have dissimilar electrolytic potential and therefore can be coupled without significant electrolytic or galvanic effects. Dr. Almeter stated that there is a major difference in electric potential between

aluminum and stainless steel and therefore galvanic corrosion will occur between the aluminum cladding in the Boral and the stainless steel tubes which encapsulate the Boral. (Almeter and Lantz, prepared testimony at pp. 3-9, Tr. 1141). However, Dr. Almeter stated that the stainless steel pool liner will not be affected by interaction with the Boral (Almeter, prepared testimony at p. 8, Tr. 1141, 1149). Licensee's expert witnesses both agree that there is no basis to expect that the Boral contained in the stainless steel tubes will contribute to degradation of the fuel assembly materials or the pool liner (Johnson, prepared testimony at p. 6, Tr. 1057; Draley, prepared testimony at p. 9, Tr. 1290). This conclusion is true whether or not the racks are vented (Johnson, Tr. 1099, 1118). This is becuase under the conditions and conductivities in the Zion spent fuel pool, galvanic corrosion requires direct contact (Johnson, Tr. 1129-30).

112. Dr. Draley and Dr. Almeter agree that some galvanic corrosion between the Boral sheets and the stainless steel tubes within which they are enclosed will take place (Draley, prepared testimony at p. 5-7, 9, Tr. 1290; Almeter and Lantz, prepared testimony at pp. 6-9, Tr. 1141, 1142-5). Because stainless steel is electrochemically more noble than the Boral such galvanic corrosion will not affect the stainless steel tubes, nor does it threaten the structural integrity of the racks (Draley, prepared testimony at pp. 5, 10, Tr. 1290; Johnson, prepared testimony at p. 6, Tr. 1057; Almeter, prepared testimony at p. 8, Tr. 1141, 1142-3;

Minor, Tr. 1421). Dr. Draley states that one can expect some pitting of the edges of the Boral plate and perhaps the 1100 aluminum cladding which forms the outside layer of the Boral where the electrical contact with the stainless steel tube is good. In neither of these two locations is the attack expected to be great enough to lead to serious loss of the neutron absorbing boron in the Boral or to cause corrosion product swelling of the Boral which would interfere with free movement of the spent fuel stored in the racks. The reason for this is that the corrosion will be self-limiting due to the formation of an insulating oxide film over the growing pit (Draley, prepared testimony at p. 5-6, 10, Tr. 1290).

113. During an in camera session Intervenor questioned Dr. Draley about several proprietary reports describing galvanic corrosion experiments conducted by Brooks and Perkins, Inc., the manufacturer of Boral, and by Battelle, Columbus laboratories for Brooks and Perkins (Intervenor's In Camera Exhibits 1 and 2). These reports were provided by Licensee to Intervenor during discovery. The Brooks and Perkins report (Intervenor's In Camera Exhibit 1) contains a conclusion that maintaining a significant oxygen concentration in the water surrounding the Boral could lead to unacceptable corrosion behavior. Probably on the basis of this research the Licensee changed its rack design so that the vent holes through the stainless steel tubes are located only at the

top of the tubes, rather than at the top and the bottom. This limits the access of fresh oxygen-bearing pool water to the inside of the tubes (Draley, In Camera Tr. 1342-3). Dr. Draley testified that he did not agree with the Brooks and Perkins report that maintaining oxygen saturation would lead to results that would be unacceptable. However, he had no objection to the closing of the vents at the bottom of the tubes (Draley, In Camera Tr. 1342-3). The Battelle, Columbus report (Intervenor's In Camera 2) reflects experiments in which a high rate of galvanic attack of Boral in a concentrated boric acid solution was observed. Dr. Draley testified that this experiment did not influence his testimony very strongly because the boric acid solution involved in the experiment was quite a bit more aggressive than the conditions in the Zion spent fuel pool. Therefore Dr. Draley testified that the results in the Battelle Columbus report do not apply to the Zion spent fuel pool (Draley, In Camera Tr. 1345-49).

114. Under cross examination by Intervenor, Dr. Draley stated that in his judgment, anodizing the aluminum cladding of the Boral would not reduce the amount of corrosion over the 40 year lifetime of the racks (Draley, Tr. 1319). Dr. Almeter testified that use of unanodized, rather than anodized, aluminum means that there will be accelerated corrosion of the Boral during the first five days after the racks are first immersed in the pool water until a protective

aluminum oxide layer is built up. At that point the accelerated corrosion will be over and thereafter there will be no significant corrosion (Almeter, Tr. 1202-3, 1239-40, 1250).

115. Dr. Draley and Dr. Almeter agree that significant amounts of neutron-absorbing boron will not be lost from the Boral by corrosion. This is because the boron carbide (B_4C) particles are inert to pool water environment and galvanic corrosion and remain embedded in any aluminum corrosion product. The amount of this corrosion product which flakes away will be very small (Draley, prepared testimony at pp. 7, 9, Tr. 1290, 1358; Almeter, prepared testimony at pp. 7-8, Tr. 1141, 1250-2).

116. Based on the testimony described above, the Board finds that Intervenor's contention 2(h) is without merit. However, the Board finds that the continued integrity of the Boral within the tubes is of sufficient concern to merit a corrosion surveillance program, described below in paragraphs 125 through 128.

117. In response to contention 2(i) Dr. Johnson testified that there has been no evidence of pool-stored commercial water reactor fuel degradation to date from visual inspections, radiation monitoring of spent fuel pools, and detailed examinations of selected fuel rods (Johnson, prepared testimony at p. 10, Tr. 1057). Further, theoretical assessments by Dr. Johnson and five other independent researchers have failed to identify any mechanism

which is regarded as a substantial threat to fuel cladding integrity in pool storage (Johnson, prepared testimony, Attachment B at p. 171, Tr. 1057, 1076-7, 1113-4). Dr. Johnson concludes that there is sufficient basis at this time to proceed with long term storage of spent fuel. He notes however that surveillance should continue to be provided for the spent fuel over whatever time period the spent fuel will be stored (Johnson, Tr. 1113, 1117). The NRC Staff is in agreement with Dr. Johnson (Almeter and Lantz, prepared testimony at pp. 9-11, Tr. 1141, 1149). The Board finds that Intervenor's contention 2(i) has been answered satisfactorily.

118. With respect to Intervenor's contention 2(j)(1) Dr. Draley and Dr. Almeter testified that the corrosion rate of the stainless steel tubes will be negligible (Draley, prepared testimony at pp. 2-3, 10, Tr. 1290; Almeter and Lantz, prepared testimony at pp. 8, 12, Tr. 1141). The issues raised by Intervenor's contention 2(j)(2) have already been addressed above in connection with contention 2(h). The third subsection of Intervenor's contention 2(j) raises the possibility of swelling of the Boral within the stainless steel tubes.

119. Dr. Draley testified that swelling of unvented storage rack tubes, not involving the swelling of Boral, apparently occurred at Monticello last year. This swelling is believed to have been caused by the accumulation of entrapped gas between the Boral and the stainless steel tube. The gas was a mixture of the air originally in the

tube and hydrogen which may have been produced as a corrosion product when water leaked into the unvented Monticello tubes. This kind of swelling should not occur at Zion due to the use of vented racks which will allow gas to escape (Draley, prepared testimony at p. 13, Tr. 1290). The NRC Staff's testimony is to the same effect (Almeter and Lantz, prepared testimony at pp. 12-13, Tr. 1141).

120. Dr. Draley testified that there were two processes which could lead to swelling of the Boral within the stainless steel tubes. In the first, if the quality of the Boral is so poor that there is porsity, water could permeate into the core material. It would then be possible for reaction of this water with the aluminum at some internal place to produce hydrogen gas in quantities sufficient to expand the Boral as by the formation of an internal blister. Dr. Draley testified however that this kind of swelling should be self-limiting, since expansion of the blister should deform the piece enough to allow release of hydrogen pressure (Draley, prepared testimony at p. 11, Tr. 1290). Some swelling of this type has occurred in tests run by Exxon Nuclear Company, but the Boral samples used were not representative of the commercial grade Boral which will be used in the Zion racks. The Exxon samples differed in that they contained quantities of finer mesh boron carbide particles and areas of imperfect bonding within the Boral between the aluminum cladding and the B_4C/Aluminum matrix. Dr. Draley does not expect this kind of swelling to occur in

the Zion racks (Draley, prepared testimony at p. 12, Tr. 1290). Dr. Almeter is of the same opinion, observing that the Exxon Nuclear tests indicate that any small bulges would be rare, random, and self limiting. Further, such bulging should not occur where there is good quality control (Almeter and Lantz, prepared testimony at p. 13, Tr. 1141, 1221-1226).

121. Dr. Draley testified that the second kind of Boral swelling which might occur would be related to local corrosion or pitting which might be induced by galvanic interaction between the aluminum in the Boral and the stainless steel tubes where the two plates are pressed together. The solid corrosion product has a greater volume than that of the corroded metal, and local swelling could result. Using the density of the predominant aluminum corrosion product, Bayerite, Dr. Draley calculated that the corrosion product will occupy a volume some 3.2 times that of the aluminum from which it is formed. Even if a Boral plate in a Zion storage tube corroded all the way through (cladding and core material) the maximum swelling produced by the corrosion product would be .234 inch, an amount which would not interfere with the movement of fuel within storage tubes (Draley, prepared testimony at pp. 12-13, Tr. 1290, 1316-1318). Dr. Draley stated that a more realistic estimate of maximum possible swelling in the Zion racks would be a tenth of an inch (Draley, Tr. 1316-17).

122. The Board finds that the Licensee and the Staff have adequately explored the possible corrosion rates of the storage tubes, the effect of water chemistry on the

Boral, and the possibility of swelling within the storage tubes.

123. To the extent Intervenor's contention 2(k) raises quality assurance issues, it is discussed below in Subsection F of these Findings. With respect to the remaining issues, Dr. Draley testified that mechanical failure which might cause the Boral to fragment or break is highly unlikely in view of the good record of Boral products and in view of the excellent record of the Boral cladding allow, 1100 aluminum. Further, if mechanical defects should occur, the stainless steel tubing would keep the Boral largely in position. Therefore, Dr. Draley believes the risk of developing criticality in the pool on the basis cited is negligible (Draley, prepared testimony at p. 13-14, Tr. 1290). The Staff also believes the Boral would be held in place by the stainless steel. In addition they point out that the Boral plates are not load-bearing elements of the racks. Only the mechanical strength of the stainless steel is relied on in the design of the racks, and the strength of this material will not significantly deteriorate over the life of the racks (Almeter and Lantz, prepared testimony at pp. 15-16, Tr. 1141). The Staff states that the only other effect which could possibly diminish Boral density in the spent fuel pool is radiation. The low levels of neutron flux in the pool will have no significant effect on the Boral in 40 years of full time use (Almeter and Lantz, prepared testimony at p. 16, Tr. 1141). On examination by the Board, Mr. Lantz admitted that some helium gas is gener-

ated as a result of neutron absorption by the boron in the Boral. However, at the neutron fluxes expected in the Zion pool there is no possibility of sufficient helium gas generation to cause swelling in the Boral (Lantz, Tr. 1269-70).

124. The Board finds that adequate consideration has been given to possible degeneration of Boral density due to generic defects or mechanical failure and accordingly we find that the risk of criticality in the spent fuel pool from these sources is negligible.

125. In response to Intervenor's contentions 2(e)(3) and 2(e)(4) Dr. Draley outlined the surveillance program the Licensee will use to ensure that unexpected damage to the Boral is not occurring. Eighteen small vented stainless steel coupons containing Boral specimens will be stored in the pool. These coupons will be removed periodically, opened, and examined for corrosion damage. In addition two full-size storage tubes will be exposed in the pool near stored fuel so as to reproduce the radiation condition as well as exposure to the pool water. These tubes will be examined periodically for visual signs of swelling and will be opened and examined for loss of boron if examination of the small coupons indicates ^{10}boron content in the enclosed Boral specimen below .02gm/cm^2 (Draley, prepared testimony at p. 8 and Attachment 5, Tr. 1290).

126. It is Dr. Draley's belief that this surveillance program will detect indications of corrosion damage involving possible loss of neutron absorber or swelling or other damage to the tubes in time to take any necessary remedial action for the storage tubes in the pool. He believes that any corrosion reactions will be sufficiently slow that any damage that occurs will not endanger the safe and effective operation of the pool (Draley, prepared testimony at pp. 8-9, Tr. 1290, 1302). This opinion is shared by the Staff (Almeter and Lantz, prepared testimony at pp. 2-3, Tr. 1141).

127. On cross examination by Intervenor, Dr. Draley testified that if ^{10}boron content in the coupons fell below .02 gm/cm^2 and the full length tube specimens also showed some damage, it would be possible, as a general matter, to remove spent fuel from the storage racks and inspect the tubes in the racks (Draley, Tr. 1307-8). Dr. Draley stated that there presently are no plans to monitor the generation of gas or corrosion products within the tubes being used to store fuel (Draley, Tr. 1308-9). He testified that in view of the Licensee's proposed surveillance program, this is not necessary (Draley, Tr. 1358-9). Similarly there are no plans to measure the size of any corrosion products that might flake off within the tubes, or to monitor any accumulation of crud or corrosion products

around the vent holes in the tubes (Draley, Tr. 1309-10). Dr. Draley stated that since the density of the corrosion product is greater than that of pool water, there is no force he knows of which make them rise to go to the hole (Draley, Tr. 1358).

128. In response to further questioning by Intervenor, Dr. Draley reaffirmed that the small coupons and full length tubes used as samples in the surveillance program will simulate the behavior of the tubes in the racks adequately to be safe in the identification of any unexpected swelling or problem that occurs (Draley, Tr. 1312). Further, Dr. Draley testified that it is unnecessary to conduct more frequent examination of these samples than the present plan calls for; however the present schedule could of course be changed if the Licensee elected to do so (Draley, Tr. 1320-1). Dr. Draley affirmed that the Licensee has made a commitment to institute the surveillance program at the time it places the racks in the pool, although a delay of a few weeks would not be an undue risk of any kind (Draley, Tr. 1321-2).

129. Intervenor's witness, Mr. Minor questioned the Licensee's surveillance program because there are a small number of the coupons to be used and they may not be truly representative of the tubes to be used in the storage racks due to the difference in size (Minor, prepared testimony at p. 3, Tr. 1405, 1426-7). However, Mr. Minor admitted that his testimony did not address the full length tube samples which Licensee plans to use (Minor, Tr. 1420). Mr.

Minor argued that specific acceptance criteria should be established in advance for judging the results of any tests performed on the samples (Minor, Tr. 1421-2). Nevertheless, Mr. Minor admitted that by observing corrosion, Licensee would be a long way toward determining whether or not the ultimate criterion, that is, the neutron absorbing capability of the Boral, is being maintained (Minor, Tr. 1422-3).

130. In response to a Board question, Dr. Draley and Dr. Almeter testified that electrically grounding the test coupons would make no difference to the rate of the galvanic corrosion between the Boral and stainless steel within the coupons (Draley, Tr. 1291; Almeter Tr. 1263-4). Dr. Johnson agreed with this assessment, although he stated that it would be fairly simple to confirm this by measuring whether coupling to the pool liner made a difference in the electric potentials between stainless steel and Boral in the coupons (Johnson, Tr. 1281-3).

131. The Board also questioned whether the ionic content of the Zion spent fuel pool water might influence the rate of corrosion of fuel pool materials. Dr. Johnson testified that the presence of some ions could influence the corrosion behavior of aluminum. He also agreed that a periodic analysis of the ionic content of the water in the spent fuel pool, once every five years would not be unreasonable (Johnson, Tr. 1126-28).

132. Finally, the Board questioned whether the Licensee's commitment to conduct a corrosion surveillance program should be formalized in a Technical Specification in view of its long term ongoing nature. The NRC Staff testified that it has no plans to impose a Technical Specification on this subject, but that it will record the Licensee's commitment to follow this surveillance program in the cover letter which will accompany the issuance of any license amendment issued in this case. Further, the NRC's Office of Inspection and Enforcement does keep track of licensee commitments so listed and can and does enforce them (Zech, Tr. 1983-4; Kohler, Tr. 1972-3).

133. The Board finds that the surveillance program described by the Licensee is adequate to protect the public health and safety, and accordingly it finds that the concerns expressed in Contentions 2(e)(3) and 2(e)(4) have been answered satisfactorily.

F. Quality Assurance

Contention 2(k) states:

> The amendment request and supporting documentation do not consider possible degeneration of the Boral density due either to generic defects or to mechanical failure which would diminsh the effectiveness of Boral as neutron absorber, thus leading to criticality in the spent fuel pool.

Contention 2(l) states:

> The Applicant has not described the procedures it intends to employ to prevent the installation and use of damaged and defective racks.

134. Mr. Walter Shewski, Corporate Manager of Quality Assurance for Commonwealth Edison Company, Mr. John P. Leider, former assistant Superintendent of Zion Station, and Mr. Tom Tramm, Project Manager for Zion Station testified on behalf of the Licensee with respect to these contentions. The Staff witnesses were Mr. Joel E. Kohler, NRC resident inspector at Zion Station, and Messrs. Frank M. Almeter and Edward Lantz, of the NRC technical staff. Mr. Greg Minor, testified on behalf of Intervenor.

135. The Licensee and the Staff have detailed the Quality Assurance and Quality Control procedures of Commonwealth Edison, Brooks and Perkins and Leckenby, which are designed to prevent the installation of racks with insufficient boral density or other defects into the spent fuel pool. (Shewski, prepared testimony, at pp. 1-10 Tr. 707; Leider, prepared testimony, at pp. 10-12 Tr. 758; Kohler,

prepared testimony regarding contention 2(1) at pp. 1-4; Almeter and Lantz, prepared testimony at pp. 13-16, Tr. 1141). These witnesses all agree that these procedures will prevent the installation of nonconforming racks into the pool.

136. Mr. Shewski testified that the boron carbide and other materials used by Brooks and Perkins to manufacture the Boral plates are certified by the supplier to meet applicable ASTM standards. The certification documents are traceable to specific lot numbers of the boron carbide and reviewed by Brooks and Perkins quality assurance personnel. (Shewski, prepared testimony at pp. 5-6, Tr. 707).

137. As an additional check, a sample of each lot is sent to Isotopic Analysis, Inc. to verify the boron-ten content of the boron carbide powder by means of isotopic analysis. (Shewski, prepared testimony at p. 6, Tr. 707).

138. These steps are documented by Brooks and Perkins, and reviewed by Nuclear Services Corporation (NSC). Only upon a finding of adequate compliance with these procedures will NSC authorize use of the boron carbide powder for fabrication. (Id.)

139. The boron carbide is then used in the fabrication of Boral plates. A sample is taken from each end of the Boral plates and 10% of these samples are chemically analyzed for boron-ten loading by Brooks and Perkins. (Shewski, prepared testimony at p. 7, Tr. 707). Mr. Tramm

testified that the Boral sample is dissolved, the boron carbide filtered out and then dried and weighed. Since the isotopic content of the boron carbide is known through previous isotopic analysis of each batch of boron carbide, the boron-ten loading of the sample can be calculated by measuring the weight of the boron carbide which was separated from the Boral plate. (Tramm, Tr. 1040). Mr. Tramm further testified that the precision of the test is .0003 grams per square centimeter of ^{10}boron. (Tramm, Tr. 1941).

130. Brooks and Perkins then forwards the test results to NSC for review, and upon a finding by NSC that these procedures have been adequately complied with, the tubes are released to Leckenby for rack fabrication. (Shewski, prepared testimony at p. 6-8, Tr. 707).

141. In addition to review by Brooks and Perkins and NSC Quality Assurance personnel, Commonwealth Edison performs independent reviews, inspections and audits of the tube manufacturing process to ensure that there is adequate density of ^{10}boron in the Boral plates. Mr. Shewski explained that as of the date of the hearings, there had been three audits of Brooks and Perkins conducted by Commonwealth Edison Quality Assurance personnel. (Shewski, Tr. pp. 720-721).

142. During the course of cross-examination, Intervenor introduced two letters pertaining to shipments of tubes from Brooks and Perkins to Leckenby which contained

insufficient ^{10}boron content. (Intervenor Exhibits 2 and 3). Mr. Shewski confirmed that five nonconforming tubes had in fact been shipped to Leckenby, and that the boron content of those tubes was .0189, .0189, .0186, .0196 and .0182 grams per centimeter squared. (Shewski, Tr. 747-748). The minimum required ^{10}boron concentration is specified as .0200 gms/cm^2. Mr. Shewski testified that this deficiency was discovered in the June audit of Brooks and Perkins by the Licensee, that none of these defective tubes had been used in the fabrication of the racks and that each tube had been tagged as defective and isolated to insure they would not be used. This fact was personally verified by the Licensee's Quality Assurance personnel. (Shewski, Tr.736,740,755).

143. Prior to releasing the completed racks for shipment to Zion Station, NSC is required to review and accept Leckenby's Quality Assurance inspection and review. (Shewski, prepared testimony at p. 8, Tr. 707). Upon receipt of the racks at Zion, the Licensee's on-site Quality Control and Quality Assurance personnel are required to perform a receipt inspection for shipment damage and other possible defects. (Shewski, prepared testimony at pp. 8-9, Tr. 707). Furthermore, Quality Assurance personnel will be required to review the documentation to assure compliance of the materials and fabrication requirements. (Shewski, prepared testimony, pp. 8-9, Tr. 707). Written procedures detailing these inspections were received in evidence as Licensee Exhibit Number 1. (Tr. 1939).

144. Mr. Leider testified that as part of the receipt inspection, a dummy fuel assembly built to exactly the same dimensions and tolerances as the fuel stored at Zion will be lowered into and raised out of each tube in the absorber rack. The Licensee will use a 20 pound drag criterion for determining the existance of a defect in the physical contours of any tube. (Leider, prepared testimony at pp. 11-12, Tr. 758). On cross-examination, Mr. Leider explained that past experience shows that the 20 pound drag is the friction force that the dummy assembly will exhibit in being lifted and lowered into a rack. (Leider, Tr. 762).

145. After the racks are installed into the pool, but prior to placing spent fuel therein, neutron attenuation tests will be performed by National Nuclear Corporation to confirm that there is a Boral plate in each of the four walls of the individual tubes. (Shewski, prepared testimony at p. 9, Tr. 707; Tramm, Tr. 1942). Mr. Tramm testified that these tests will prove within a 95% confidence level that the four plates are present in each tube. (Tramm, Tr. 1942). He further explained that the test is capable of establishing within 20% accuracy the boron-ten loading of each plate with 100% confidence. (Id.; Tramm, Tr. 1492; Tr. 1947). Mr. Zech explained that the Staff will require a commitment on the part of the Licensee to conduct neutron attenuation tests which could assure that the Boral plates are present such that a k effective .95 would not be exceeded

with a 95% confidence level. (Zech, Tr. 1984). On cross-examination by Intervenor, Mr. Tramm testified that the fact that the tests will be conducted while the tubes are immersed in a boric acid aqueous solution will not mask any deficiency in the Boral (Tramm, Tr. 1944). This is because the test will be calibrated to take into account the boric acid concentration in the fuel pool water. (Tramm, Tr. 1950).

146. In response to questioning by the Board, Mr. Tramm stated that in the unlikely event it is discovered that a Boral plate is missing any tube, the Licensee's commitment is to physically plug that tube to prevent the inadvertent insertion of a fuel assembly therein. Moreover, that the Licensee will require that 100% of the remaining tubes be examined by means of neutron attenuation testing. (Tramm, Tr. 1947, 1948, 1950).

147. Mr. Kohler testified that throughout the Station receipt inspection, installation of the racks and subsequent neutron attenuation testing, the NRC will conduct inspections and reviews to assure that only conforming racks are installed in the pool. (Kohler, Tr. 798, 803, 804). The NRC Region III Office of Inspection and Enforcement plans to utilize additional construction inspections during the proposed rack installation. (Kohler, Tr. 802). Furthermore, Mr. Kohler indicated that if it was determined that the Licensee is improperly installing or handling the racks, stop-work orders will be issued expeditiously. (Kohler, Tr. 798, 799).

148. During the course of cross-examination of Dr. Olson, the Licensee's expert on criticality, the Board inquired as to how much boron in the Boral could be lost before k effective, the criticality coefficient, would reach a level of .95. In response, Dr. Olson stated that roughly 75% of the boron in each plate could be lost, without reaching .95. (Olson, Tr. 1730). Further, Dr. Olson explained that .95 is an arbitrary number specified by the NRC's Standard Review Plan to assure that a criticality event cannot take place. Any criticality coefficient less than 1 would ensure maintaining sub-criticality. (Olson, Tr. 1726).

149. Intervenor pointed out during Mr. Shewski's cross-examination that when the Licensee originally sent its purchase order to Brooks and Perkins for the tubes in July of 1978, the order indicated that the fabrication of these tubes was not a safety-related item. (Shewski, Tr. 737). In response, Mr. Shewski explained that on November 22, 1978 the purchase order was changed to require that the fabrication of the tubes be safety-related, and that no Boral sheets or tubes had been fabricated prior to this date. (Shewski, Tr. 738).

150. Intervenor also pointed out that in Intervenor's Exhibit Number 2, one of the Brooks and Perkins Final Inspection Verification forms appeared to have been filled out and reviewed by Mr. Pulvirenti, Quality Assurance

Coordinator for Brooks and Perkins. (Tr. 718). On redirect examination, Mr. Shewski indicated that from time to time Quality Assurance personnel perform the overall inspection and acceptance of materials and work and that because they are independant of the actual fabrication process such a procedure is not objectionable. (Shewski, Tr. 751).

151. The Board believes that the Licensee has adequately documented the procedures which will be implemented to prevent the installation and use of nonconforming racks. The fabrication, receipt, installation and post-installation testing of the racks will be subject to intensive review by the Licensee, the fabricators of the racks and the NRC Staff. Of particular concern to the Board is the issue of whether the racks will be manufactured and installed in such a way that their neutron absorbing characteristics will not be impaired. We find that the Quality Assurance and Quality Control procedures described by the Licensee and the Staff will ensure that the racks will contain sufficient boron-ten loading. There is no reasonable basis for believing that the criticality coefficient will exceed .95 as a result of insufficient boron content in the neutron absorbing storage racks. This is particularly true in view of Dr. Olson's testimony that the racks could lose up to 75% of the boron without causing k effective to rise above .95. The Board finds that the issues raised by Intervenor's Contention 2(k) and 2(l) have been satisfactorily addressed.

G. Board Questions

1. Risk of Theft and Sabotage

Board Question 4(a) states:

> Will the proposed modification of the spent fuel pool and/or the operation of the Zion Station with increased spent fuel pool storage capacity:
>
> (1) increase the potential risk of threats to special nuclear material or to Station facilities?
>
> (2) increase the potential risk of theft of special nuclear material from the Station?
>
> (3) increase the potential risk of industrial sabotage to the Station or to the special nuclear material?
>
> (4) decrease the level of physical protection of the facilities or special nuclear material at the Station?

To the extent Board Question 4(b) is relevant to security planning it states:

> As a result of the proposed modification of the spent fuel pool and the proposed operation of the Station with increased spent fuel storage capacity, will it be necessary to modify the Physical Security Plan, Safeguard, Contingency Plan. . . for the Station?

152. Mr. Larry Bean, Commonwealth Edison Company's Nuclear Security Administrator, and Mr. Dean M. Kunihiro, Reactor Safeguards Analyst in the NRC Division of Operating Reactors, testified with respect to this question. No testimony was submitted on behalf of Intervenor regarding Question 4(a).

153. During the course of Mr. Bean's cross-examination by Intervenor, a question arose concerning the interpretation of Question 4(a)(3). The Board stated that it had meant the parties to address only the likelihood of industrial sabotage. The Board explained that it had not directed the parties to explore the possible consequences of a successful act of sabotage. (Bean, Tr. 2023, 2024).

154. Mr. Bean described the Licensee's Security Plan and Safeguards Contingency Plan in detail in his prepared testimony. (Bean, prepared testimony at pp. 1-10, Tr. 2019). In response to the Board Question whether the proposed modification or operation of the Station with increased spent fuel pool storage capacity would increase the potential risk of threats to special nuclear material or to Station facilities, Mr. Bean testified that since the Zion security program is already designed to meet the general performance requirements of 10 CFR §73.55 while construction activities take place on-site, there would be no increased risk to special nuclear material or to the Station as a result of on-site construction activities. Furthermore, Mr. Bean testified that because the same high degree of protection applies to the Zion Spent fuel pool regardless of the number of spent fuel assemblies stored therein, there would be no increased risk as a result of the operation of the Station with increased spent fuel storage capacity. (Bean, prepared testimony at p. 10, Tr. 2019). Mr. Kunihiro agreed with Mr. Bean's opinion in this regard. (Kunihiro, prepared testimony at p. 1, Tr. 2036).

155. In response to question 4(a)(2) which inquires about the increase of the potential risk of theft of special nuclear material from the Station, Mr. Bean stated that the Commission's regulations pertaining to security do not require that licensees design their security programs to prevent theft of spent fuel. This is because the nature of spent fuel makes it an unattractive target theft. However, Mr. Bean stated that the features of the Station Security Plan designed to prevent sabatoge would be adequate to protect against the risk of theft. (Bean, prepared testimony at p. 11, Tr. 2019). Mr. Kunihiro supported Mr. Bean's testimony stating that spent fuel does not lend itself to being desirable enough to steal. (Kunihiro, prepared testimony, p. 2, Tr. 2036).

156. Mr. Bean further testified that the modification and/or subsequent operation of Zion Station would not, in his opinion, increase the potential risk of industrial sabatoge to the Station or special nuclear material. This is because the level of risk which the Licensee must protect against is defined in 10 CFR §73.55(a), and this defined risk is not changed by the proposed modification and/or subsequent operation. (Bean, prepared testimony, p. 11, Tr. 2019). The risk defined in §73.55(a) is not dependant upon the amount of special nuclear material stored at the facility, or the number of workers present at the plant.

157. In response to Question 4(a)(4) which inquires as to whether the modification and/or subsequent operation will decrease the level of physical protection of the facility or special nuclear material at the Station, Mr. Bean testified that there will be no such decrease because the security program is designed to handle construction activities such as the proposed modification, and because the degree of physical protection relating to the spent fuel pool is independent of the number of fuel assemblies stored therein. (Bean, prepared testimony at p. 12, Tr. 2019). Mr. Kunihiro concurred in this opinion. (Kunihiro, prepared testimony at p. 2, Tr. 2036).

158. In response to the relevant portion of Question 4(b), both Mr. Bean and Mr. Kunihiro agreed that it would not be necessary to modify the Security Plan or Safeguards Contingency Plan because of the proposed modification and/or subsequent operation. This is due to the fact that the modification would not permit the Licensee to store material different from that presently stored in the pool and because the level of security protection required is independent of the quantity of irradiated fuel contained in the pool. (Bean, prepared testimony at p. 12, Tr. 2019; Kunihiro, prepared testimony at p. 3, Tr. 2036).

159. During the course of cross-examination by the Board, Mr. Bean was asked whether all company employees and contractors are subject to physical searches prior to

entering a protected area. Mr. Bean testified that each individual entering a protected area is screened by means of metal and explosive detection equipment. In addition, the Licensee's non-site assigned employees and contractors' employees are physically searched on a random basis. Licensee's regular Station employees are not physically searched. (Bean, prepared testimony at p. 7, Tr. 2019; Tr. 2027, , 2028).

160. The Board also inquired as to whether Mr. Bean or Mr. Kunihiro had considered special nuclear material other than spent fuel in preparing their written testimony. Both witnesses responded that they had not previously considered material other than spent fuel, but that the conclusions stated in their prepared testimony were equally applicable to such material. (Bean, Tr. 2030; Kunihiro, Tr. 2039).

161. In view of the testimony recited above, we are of the opinion that the modification and subsequent operation of Zion Station with increased spent fuel storage capacity will not increase the potential risk of threats to special nuclear material or to Station facilities by theft, sabotage or other means; that there will not be a decrease in the level of physical protection of the facilities or special nuclear material at the Station and that there is no reason to modify the Safeguard Contingency Plan or Security

Plan for Zion Station. This finding is based, in large measure, upon our belief that the degree and type of physical protection afforded to the Station's protected areas is independent of the amount of spent fuel stored at the Station.

2. Need for Changes in the Emergency Plans.

To the extent that Board Question 4(b) is relevant to Emergency Planning, it states:

> As a result of the proposed modification of the spent fuel pool and the proposed operation of the Station with increased spent fuel storage capacity, will it be necessary to modify the. . . Emergency Plan for the Station?

162. Mr. Denton Louis Peoples, Command Center Director under the Licensee's Generating Stations Emergency Plan, testified on behalf of the Licensee in regard to this Question. Mr. John R. Sears, Nuclear Engineer in the Environmental Evaluation Branch of the NRC Division of Operating Reactors, appeared on behalf of the Staff. These witnesses answered the Board Question in the negative. (Peoples, prepared testimony at pp. 1-15, Tr. 2044; Sears, prepared testimony at pp. 1-3, Tr. 2053). Before the hearing, Intervenor filed prepared testimony of Mr. Peter G. Cleary regarding emergency planning issues. The Board ruled, however, that Mr. Cleary's prepared testimony was not responsive to Question 4(b) and thus refused to accept it into evidence. (Tr. 1610-1611). Intervenor did make an offer of proof explaining the nature of Mr. Cleary's testimony had he been permitted to testify. (Cleary, Tr. 1612-1616).

163. Mr. Peoples submitted a detailed explanation of the Licensee's Generating Stations Emergency Plan ("GSEP") which included a description of the different emergency

response classifications, the corporate emergency response structure and facilities, and a description of the Licensee's training and practice drills. (Peoples, prepared testimony at pp. 1-15, Tr. 2044). Mr. Peoples concluded that the proposed modification or subsequent operation of the Station will not require a change to the GSEP since the GSEP is designed to provide an appropriate response to a continuum of possible accidents and is not predicated upon a particular amount of nuclear fuel in use or in storage at the facility, or tied to specific accidents or equipment malfunctions. (Peoples, prepared testimony at p. 15, Tr. 2044). No facts were ellicited during the course of cross-examination of Mr. Peoples which challenged or contradicted the basis for this conclusion. Mr. Sears concurred with Mr. Peoples' opinion that no change was required to the Emergency Plan as a result of the proposed modification. (Sears, prepared testimony at p. 3, Tr. 2053).

164. The Board is of the opinion that the Licensee and Staff have adequately established that the emergency plan is designed to respond to a continuum of possible incidents and is not dependent upon the amount of nuclear fuel stored at the station. Therefore, we find that there is no need to change the Licensee's emergency response plans due to the proposed modification and subsequent operation of Zion Station with increased quantities of spent fuel.

3. Changes in Accidents Postulated in Previous Licensing Reviews

Board Questions 4(c), 4(d), 4(e) and 4(f) state:

(c) What postulated accidents, which might affect the safety of plant operating personnel in the spent fuel storage building or which might result in the release of radiation or radioactive materials from the spent fuel storage building, were specifically analyzed in the FSAR, SER, ER and FES utilized in the CP and OL licensing reviews of Zion Units 1 and 2?

(d) Which, if any, of the postulated accidents in (c), above, will be increased in probability, magnitude or consequence (to personnel, to the general public or to the environment) if the proposed spent fuel pool modification are carried out?

(e) What provisions have been made or procedures developed to protect the workmen and/or plant personnel from the consequences of such postulated accidents during the period when the proposed spent fuel pool modifications are being performed?

(f) Which, if any, of the postulated accidents in (c), above, will be increased in probability, magnitude or consequence (to personnel, to the general public or to the environment) as a result of the completion of the proposed spent fuel pool modifications and the proposed subsequent usage of the increased spent fuel storage capacity.

165. Mr. Tom Tramm testified with respect to Board Questions 4(c), 4(d) and 4(f) on behalf of the Licensee. The Staff witnesses regarding these Questions were Messrs. Jack Donahew, Service Nuclear Engineer, Environmental Evaluation Branch of the NRC Division of Operating Reactors, and John J.

Zudans, Senior Mechanical Engineer, Engineering Branch, Division of Operating Reactors of the NRC Office of Nuclear Reactor Regulation. Mr. Jack Leider and Mr. Joel Kohler testified in regard of Question 4(e) on behalf of the Licensee and the Staff, respectively.

166. In response to Question 4(c), Mr. Tramm identified nine postulated accidents which were specifically analyzed in the FSAR, SER, ER and FES utilized in the CP and OL licensing reviews of Zion Station Units 1 and 2 which might affect the safety of plant operating personnel in the spent fuel storage building or which might result in the release of radiation or radioactive materials from he spent fuel storage building. These are: (1) the fuel handling accident; (2) accidents resulting from earthquakes; (3) tornado related accidents; (4) spent fuel cask drop accidents; (5) spent fuel pool cooling system malfunction; (6) malfunctions in other parts of the plant; (7) loss of AC power; (8) leakage of radioactive fluids; and (9) drop of a heavy object onto a fuel rack. (Tramm, prepared testimony at pp. 25-31, Tr. 564). The Staff witnesses identified the fuel handling accident, accidents related to earthquakes and tornados, and the accidents involving a drop of a heavy object onto a fuel rack in response to this Question. (Donahew and Zudans, prepared testimony at p. 2).

167. The Board is satisfied that the postulated accidents to which Question 4(c) refers have been adequately identified by the Licensee and the Staff.

168. With respect to Board Questions 4(d) and 4(f), Mr. Tramm stated that since the proposed modification will necessitate additional fuel moves, the likelihood, and corresponding risk of a fuel drop accident will increase slightly. The incremental risk will however be minimal since the number of fuel moves necessary to accomplish the modification will add less than 1% to the total number of fuel moves which will be accomplished during the plants lifetime. (Tramm, prepared testimony at p. 27, Tr. 564). The Staff testified that since the fuel which will be moved during the modification will have decayed at least one month prior to being moved, this will be a decrease by a factor of 10 in the magnitude or consequences of the postulated fuel handling accident because of significant radioactive decay of the gaseous fission products contained in the fuel. Thus, the Staff witnesses conclude that the risk from a fuel handling accident to the public, the plant and the environment will be decreased during the proposed modification. (Donohew and Zudans, prepared testimony at p. 3).

169. With respect to the accident scenario involving the drop of a shipping cask onto spent fuel assemblies, Messrs. Donahew and Zudans testified that the NRC Staff has under way a generic review of load handling operations in the vicinity of the spent fuel pools to determine the likelihood of a heavy load impacting fuel in the pool and, if necessary, the radiological consequences of such an

event. Until this review is completed, the Staff witnesses testified that a shipping cask will not be permitted near the pool. (Donohew and Zudans, prepared testimony at p. 7).

170. With respect to the remaining accidents identified in response to Question 4(c), both the Staff and the Licensee agree that there will be no increased risk to personnel, the general public or the environment as a result of the modification and/or operation of the Zion Station with subsequent increased spent fuel storage capacity. (Tramm, prepared testimony at pp. 25-33, Tr. 564; Donohew and Zudans, prepared testimony at pp. 2-9).

171. The Board agrees with the Staff that the risks associated with the fuel handling accident reviewed during the operating license proceedings for Zion Units 1 and 2 will be decreased during the modification of the pool. Furthermore, we are confident that the Licensee will not receive permission to utilize a shipping cask within the vicinity of the spent fuel pool until such time as the Staff has completed its review and evaluation of the potential radiological consequenses of a shipping cask falling into the pool. There is no reasonable basis for believing that the risks of the other postulated accidents identified in response to Question 4(c) would be increased as a result of the modification and/or subsequent operation of Zion Station. There, we find that Board Questions 4(c), 4(d) and 4(f) have been adequately answered.

172. With respect to Board Question 4(c), Mr. Leider described the Zion Station Emergency Operation Procedure Number 6 (EOP-6) which outlines the actions required in the event a fuel assembly is damaged or specific monitors indicate high radiation levels in the spent fuel pool area. EOP-6 is attached to Mr. Leider's prepared testimony as Attachment A. (Leider, prepared testimony at pp. 12-13, Tr. 758). Mr. Leider concluded that these procedures are sufficient to protect workmen and/or personnel during the period when the proposed modifications are being performed (Leider, prepared testimony at pp. 12-13, Tr. 758). The Staff does dispute this conclusion. (Kohler, prepared testimony at p. 1, Tr.1999).

173. On cross-examination, Mr. Leider was asked whether the automatic devices such as damper movement, automatic fan starter or chemical booster fan starter could be actuated manually from outside the containment or fuel handling building in the event these devices did not actuate automatically. Mr. Leider responded affirmatively. (Leider, Tr. 1937).

174. The Board agrees with Mr. Leider's opinion that EOP-6 actions would adequately protect workmen and/or plant personnel from the consequences of postulated accidents during the period when the proposed spent fuel pool modifications are being performed.

4. Design and/or Engineered Safeguards to Decrease Likelihood of Severe Pool Drainage Accident

Board Question 4(g) states:

> The Applicant and Staff are asked to describe any design and/or engineered safety features incorporated in the Zion spent fuel storage pool to decrease the likelihood of a severe pool drainage accident.

175. Mr. Tom Tramm testified on behalf of the Licensee, and Messrs. Gary Zech and Edward Lantz were the Staff witnesses regarding this Question.

176. Mr. Tramm stated on direct examination that the spent fuel pool, including the pool cooling system is designed as a Seismic Class 1 structure. The foundation of the pool is directly in the ground and is completely surrounded by earth. The pool is lined with stainless steel and is provided with leak channels embedded in the concrete to collect and carry off any water which should leak through the liner. Additionally, the bottom of the pool is reinforced in the shipping cask loading area to withstand a drop of a cask. Fuel casks are handled with a Seismic Class 1 designed overhead crane which is interlocked to prevent the carrying of a cask over the fuel in storage in the pool. Fuel assemblies are handled with a Seismic Class 1 designed bridge crane which travels above the pool. The fuel pool building is also a Seismic Class 1 design, which would withstand tornado loadings and tornado driven missiles (Tramm, Tr. 1028-1030).

177. On redirect examination, Mr. Tramm testified that the walls of the spent fuel pool are approximately six

feet thick concrete and the floor of the pool varies in thickness from three and one-half feet to nine feet. Furthermore, the base mat for the pool is about seven feet thick. The exterior of the concrete walls and floor is covered by a protective water proofing coating (Tramm, Tr. 1035-1036).

178. Mr. Zech and Mr. Lantz testified that there is a solid wall which separates the fuel handling building from the auxiliairy building. These witnesses confirmed the dimensions given by Mr. Tramm of the concrete base mat, floors and walls. The fuel pool is lined with a 3/16ths inch welded stainless steel liner. The leakage collection system is comprised of multiple drainage paths which collect into a common header. These leakage canals ultimately carry the water into the radwaste system (Zech and Lantz, Tr. 1854-1856). In response to a question from the Board, Mr. Zeck testified that due to the fact that the spent fuel pool is designed as a Seismic Class 1 structure, the Staff does not consider a massive failure of the spent fuel pool structure to be a credible event (Zech, Tr. 1865).

179. Mr. Tramm testified to the sources of makeup water for the spent fuel pool. The normal supply is from the demineralized flushing water system which can add water at about 200 gallons per minute. Second, water could be added directly to the spent fuel cooling system loops from the refueling water storage tank through permanently installed

piping. Approximately 100 to 250 gallons per minute could be supplied in this manner. Third, fire hoses which exist in the spent fuel pool area and the auxiliary building are connected to electric and diesel fire pumps in the Seismic Category 1 crib house structure. This system could be used to supply at least 1,000 gallons per minute to the pool. In addition to these three sources of water which are permanently installed, hoses could be hooked up to draw water from the primary water storage tank. The secondary water storage tank, and the service water supply system. Of these the service water system is a Seismic Category 1 source of water which has its own independent pumps (Tramm, Tr. 1032-1035).

180. The Board finds that the Licensee and Staff have adequately described the design and engineered safety features incorporated into the Zion Station spent fuel pool which would reduce the likelihood of a severe pool drainage accident. Based upon this testimony we are satisifed that these features preclude the possibility of a severe drainage accident in the Zion Station fuel pool.

5. Pool Liner Leak

Board Question 4(h) states:

> The Applicant and Staff are asked to provide a history of the apparent leak in the liner of the spent fuel pool. Specifically, the following should be addressed:
>
> (1) Has the leak intensified with time?
>
> (2) What is being done with the water leaking from the pool?

(3) Are there any technical specifications which limit the permitted leakage rate?

(4) Why has the leak not been repaired?

(5) How will possible future leaks be located and repaired if the proposed increase in storage capacity is permitted?

181. Mr. Tom Tramm and Mr. Jack Leider testified in response to this Question on behalf of the Licensee. The Staff witnesses were Messrs. Gary Zech and Joel Kohler.

182. Mr. Leider testified that when the Zion fuel pool was originally tested, several leaks in the vertical welds of the stainless steel liner were discovered (Leider, Tr. 1928). Subsequent to this testing, the welds were repaired (Leider, Tr. 1929). The Licensee had established a maximum permissible leakage rate of 50 gallons per day (Leider, Tr. 1927). Since the commencement of operation of Zion Station in 1973, the Licensee's records indicate that the amount of make up water put into the pool has been a constant 20 gallons per day (Leider, Tr. 1929). This make up rate represents the amount of water lost through evaporation, water removed from the pool during filter changing, demineralization bed changing, transfer of the bed from pool cooling to refueling water storage tank cleaning, as well as leakage through the liner (Leider, Tr. 1926). Mr. Leider stated that most of the water loss appears to be through evaporation (Leider, Tr. 1926). During the first week of

the hearings, the Licensee's fuel handling foreman at Zion Station conducted a three day sampling test and determined that the actual leakage rate from the fuel pool was approximately a quart a day (Leider, 1926-1927).

183. Mr. Leider further testified that the leakage goes through the leakoff lines into the drain collection tank and is handled as normal radwaste water. Thus, no water is leaking outside of the radwater system (Leider, Tr. 1922). This testimony was supported by Mr. Tramm (Tramm, Tr. 588).

184. Mr. Leider also testified that there are no technical specifications which limit the permitted leakage rate from the spent fuel pool (Leider, Tr. 1921).

185. Mr. Leider testified as to why the leak has not been repaired. State of the art leakage detection devices can optimumly locate a .005 gallon per minute leak. Such a leak would result in an excess of seven gallons per day total leakage. Mr. Leider concluded that it would therefore be practically impossible to locate a leak such as the Zion fuel pool leak of one quart per day (Leider, Tr. 1921-1923).

186. Mr. Leider described the methods by which possible future leaks would be located and repaired if the proposed increase in storage capacity were permitted. First, the Licensee would attempt to eliminate other possible

leakage pathways. This would entail the checking of drains, pumps, seals, valves and heat exchangers. Secondly, the water level of the pool would be decreased to a level which would not endager workers in the fuel pool area to eliminate leakage pathways from the top of the pool liner. If the leak had still not been located, a diver would be sent into the pool and would inspect the seam welds in the liner by means of a vacuum box. This exercise might necessitate the shuffling of fuel and/or the removal of racks to permit sufficient clearance for inspection by the divers. If reshuffling was not possible because of the amount of fuel stored in the pool, fuel could be temporarily stored in shipping casks or in the containment cavity. Once located, the liner could be welded as it was following the preoperational testing of the spent fuel pool (Leider, Tr. 1923-1925, 1928-1929).

187. The Staff witnesses testified that they had heard the Licensee's testimony relating to Board Question 4(h) and concurred. (Zech and Kohler, Tr. 1993).

188. The Board has evaluated the testimony of the Licensee relating to the leak in the Zion fuel pool and we are satisfied with the responses given to Question 4(h). We find that the amount of water that is currently leaking from the pool is negligible and does not represent a safety or environmental concern in view of the fact that the water is being contained and processed in the facility's radwaste system.

6. Component Cooling System Leak

Board Question 4(i) states:

> The Applicant and Staff are asked to address the contention made during limited appearance statements that the component cooling system has had a number of leaks which have not been repaired.

189. Mr. Tramm testified on behalf of the Licensee regarding Board Question 4(i). The component cooling system consists of pumps, valves, piping and heat exchangers. By design, some of these components leak water at a rate of about .2 gallons per minute through seals in rotating components such as pumps and valves. Leakage is detected by level changes in the surge tank which is alarmed in the control room (Tramm, Tr. 1037).

190. Early in 1978, Zion Station operating personnel noted that the leak rate had increased to approximately .4 gallons per minute. Plant engineering staff eventually traced the leak to one of three heat exchangers in the component cooling system. Due to difficulties in procurring the gaskets necessary to reassemble this heat exchanger, plant personnel did not repair the leak during the Spring, 1979 refueling outage as originally planned. The Licensee plans to perform this maintenance operation during the Fall, 1979 outage. In the meantime, about 200 gallons of water is being added to the system, approximately three times every two shifts (Tramm, Tr. 1037-1038).

191. In response to cross-examination by the Board, Mr. Tramm indicated that the water which leaks from the component cooling system flows to the service water system. He added that the component cooling system is monitored for radioactivity, and that no radioactivity has been detected in the system. Finally, Mr. Tramm noted that even if the leakage rate were to increase, there would be no impairment in the ability of the plant to continue operation or to shut down. (Tr. 1039-1040).

192. The Board finds that the Licensee has adequately answered Question 4(i) and that the component cooling system leak does not represent a threat to the safety of personnel or the general public, nor to the environment.

7. Increased Fuel Burnup Tests

Board Question 4(j) states:

> The Applicant and Staff are asked to report on the increased fuel burnup tests from the standpoint of the extent to which these subsequent spent fuel assemblies have been considered in the various analyses performed as part of this proceeding.

193. Drs. Johnson and O'Boyle testified on behalf of the Licensee in response to this Question. Messrs. Lobel, Zech and Donahew testified for the Staff in this regard.

194. Mr. Lobel testified that on March 7, 1979, the Licensee was granted permission to subject four fuel assemblies to additional burnup in the Zion reactor. Mr. Lobel stated that he supervised the preparation of an environmental

impact appraisal and safety evaluation pertaining to this proposal (Lobel, Tr. 1802-1805).

195. Dr. Johnson explained that he was familiar with studies which had been conducted with respect to fuel which had been exposed to a burnup of 58,000 megawatt-days per metric ton. These studies indicated that no unusual or unexpected changes in the properties of zircaloy had been observed in this fuel. Based upon this data, Dr. Johnson concluded that the fuel in question at Zion, which will be exposed to 48,000 or possibly 55,000 megawatt-days per metric ton burnup, should not behave differently than the fuel which was the subject of the earlier studies in terms of the effects on the zircaloy cladding (Johnson, Tr. 1276-1278; 1280). Mr. Lobel concurred with this opinion, stating that past experiences with similar fuel indicates that there is no likelihood of fuel failures as a result of the higher burnup tests (Lobel, Tr. 1807).

196. Dr. O'Boyle testified that the decay heat associated with the high burnup fuel would be approximately 9% lower for the first year of storage than fuel subject to normal burnup. After about one year of storage, the high burnup assemblies will have a slightly higher decay heat than normal burnup fuel stored for an equivalent length of time. However, since there is a substantial reduction in decay heat after one year of storage, on balance the decay heat from the high burnup assemblies will be lower than that from normal burnup fuel (Tr. 1789-1791).

197. Dr. O'Boyle stated that one could expect to have approximately 25% more longer-lived isotopes in the high burnup fuel assemblies than in normal burnup fuel. However, the more volatile fission products have shorter half-lives, in general. Therefore, the consequences of a drop accident involving a higher burnup assembly would be comparable to those produced by the drop of a normal burnup assembly. Moreover, the total fission product activity would be lower for high burnup fuel because of radioactive decay of the fission products with relatively short half-lives. Thus, Dr. O'Boyle concluded that the probability of activity release from any leaking higher burnup assemblies would be lower than for normal assemblies (Tr. 1795-1796, 1798-9).

8. Fuel Building and Ground Water Monitoring

Contentions 2(e)(1), 2(e)(2) and 2(e)(5) state:

> (e) The amendment request and supporting documentation do not adequately discuss monitoring procedures. In the light of the proposed modification and long term storage of nuclear spent fuel the Applicant should clarify the following;
>
> (1) The monitoring equipment that is used and the ranges of sensitivity.
>
> (2) The method by which incremental airborne radioactive emissions created by the spent fuel pool expansion will be measured.
>
> (5) Procedures to monitor groundwater movement in the vicinity of the plant to detect leakage from the spent fuel pool.

198. Although the parties sought to withdraw these contentions, the Board stated that it would like to hear evidence on these issues. The Board directed the parties to consider these contentions as Board questions (Tr. 730). Licensee presented William Nestel, a Senior Engineer in Licensee's Station Nuclear Engineering Division to testify about Fuel Building monitoring equipment and Dr. John C. Golden, Staff Radiologist at Commonwealth Edison Company, to discuss ground water monitoring at Zion Station. Intervenor did not present any evidence on these topics and the NRC Staff was excused from doing so by the Board after Licensee's testimony was heard (Tr. 1050-1).

199. Mr. Nestel testified that there are three area monitors in the spent fuel pool area located on the railing

of the spent fuel pool, on the fuel building crane, and adjacent to the cask decontamination area. Mr. Nestel gave the ranges of sensitivity of these monitors and their alarm functions (Nestel, Tr. 985-987).

200. Further, in the area of the pool there is a continuous air monitor for particulate activity. This continuous particulate activity monitor serves an alarm function. In addition it has a filter paper which is changed daily and counted with an internal proportional counter to provide a more sensitive measurement of airborne activity. The continuous air monitor also has an iodine cartridge which is counted once a week for iodine 131 and 133 (Nestel, Tr. 987-8, 992-3).

201. The Licensee conducts routine dose surveys on a monthly basis for any unexpected dose rates which might build up in the area undetected by the monitors (Nestel, Tr. 988-9). When any work is done in the spent fuel area, such as receiving new fuel or pulling items out of the pool, a radiation protection technician is present while the work is done with survey instruments appropriate to the job (Nestel, Tr. 989).

202. The Licensee takes air samples on a weekly basis to monitor airborne tritium (Nestel, Tr. 989-90). The pool water is sampled on a non-routine basis primarily for gross beta gamma activity and also on occasion for iodine, although Mr. Nestel was not clear on the frequency of this analysis. (Nestel, Tr. 988, 89).

203. At Zion Station the ventilation exhaust from the fuel building where the spent fuel pool is located passes through an iodine filter and then is combined with ventilation streams from other parts of the plant (Nestel, Tr. 991, 998). There are a series of monitors on this combined stream. These include a particulate monitor and an iodine monitor. These monitors are interlocked with the charcoal filter system so that if a high level of iodine is detected charcoal filtering of the combined ventilation stream would be initiated (Nestel, Tr. 991-2).

204. In addition, the combined stream passes through a series of final effluent monitors on the auxiliary building stacks. These monitors have no trip function but they do have an alarm function for noble gasses. They detect noble gas releases and report them with a continuous readout in the control room (Nestel, Tr. 991-2, 995, 997). In addition the final effluent monitors have particulate and iodine filter cartridges which are analyzed weekly (Nestel, Tr. 991-2).

205. In response to Board questioning, Mr. Nestel testified that the only continuous monitoring of the air in the spent fuel pool area is based on an analysis of particulate activity. If there were an accidental release of gaseous activity, such as that which might be caused by a dropped fuel assembly, Mr. Nestel stated that the area monitors would indicate a change. Further, it would also be

reasonable to assume some particulate activity would accompany such a release (Nestel, Tr. 994, 997). However, if only noble gasses, such as Krypton-85, were being released the type of gas would only be identified by the final effluent monitors (Nestel, Tr. 995-6, 997). Mr. Nestel stated that it would be difficult to get a good air grab sample for Krypton-85 gas (Nestel, Tr. 996). With respect to airborne concentrations of tritium, Mr. Nestel also testified that there is no effective monitor available on the market. Accordingly, the Licensee monitors airborne tritium through weekly air grab samples (Nestel, Tr. 994).

206. In response to Board questioning, Mr. Nestel testified that it is possible, if necessary, to take a grab sample of pool water remotely from the spent fuel pool cooling system without going near the pool (Nestel, Tr. 999).

207. At the request of the Board, Mr. Nestel described the routine calibration and maintenance of the monitoring equipment (Nestel, Tr. 999-1002). In particular, he stated that daily source checks are conducted on all the monitors at Zion Station which will detect changes in the monitor performance (Nestel, Tr. 1001).

208. Dr. Golden testified that from 1970 through 1977 the Licensee monitored ground water in the Zion Station vicinity at three wells in the community of Zion to the west of the plant. In 1977 the Licensee requested a change in

the Station Technical Specifications to allow it to eliminate such ground water monitoring and after review by the Staff this change was granted. There were two reasons for stopping the monitoring of ground water at Zion. First, the only available monitoring wells were up-gradient from the Station and therefore it is highly doubtful that any radioactive materials released from the Station would be detected in these wells. Second, to Dr. Golden's knowledge, there is no discharge to the ground water from Zion Station, or from any other nuclear station (Golden, Tr. 1008-11, 1016).

209. Dr. Golden testified that ground water in the vicinity of the plant moves eastward into Lake Michigan. He described the Licensee's lake water monitoring program, which includes weekly monitoring of all public water intakes in the area of the plant from Kenosha in the north to Lake Forest in the south. In addition the Station collects samples from the plant intake and discharge structures. This lake water monitoring program has been conducted continuously since 1970 (Golden, Tr. 1012-3).

210. In response to Board questioning, Dr. Golden affirmed that the original purpose of the ground water monitoring program as well as the lake water monitoring program was to protect human health by detecting possible contamination of potable water supplies rather than to look at any discharges to the environment, per se (Golden, Tr. 1016-17, 1018, 1020). There is therefore no baseline information before or since plant operation which would allow one

to determine whether additional leakage from the spent fuel or other sources might be occurring by observing an increase in background levels (Golden, Tr. 1017).

211. Under questioning by the Board, Dr. Golden stated that the Licensee's monitoring program at public water supply intakes is able to detect radiation levels at least as low as the EPA standards for potable water supplies (Golden, Tr. 1022-6).

212. The Board finds that the monitoring systems described above are satisfactory.

III. CONCLUSIONS OF LAW

The Licensing Board has thoroughly reviewed and evaluated the evidence submitted by all parties in respect of Intervenor's contentions, and in response to the Licensing Board's own questions. The Licensing Board has also considered the proposed findings of fact and conclusions of law submitted by the parties. Those proposed findings of fact and conclusions of law not adopted herein by the Licensing Board are rejected. The Licensing Board makes the following conclusions of law:

(1) The issuance of the license amendments requested in this proceeding is not a major Commission action significantly affecting the quality of the human environment and therefore it does not require the preparation of an environmental impact statement under the National Environmental Policy Act of 1969, 42 U.S.C. §4321, et seq., and Part 51 of the Commission's regulations, 10 C.F.R. Part 51. The Council on Environmental Quality's new NEPA regulations, 40 CFR §1500 et seq., 43 Fed. Reg. 55978 are not applicable to this proposal, but if they were they would have been satisfied.

(2) Contrary to the assertion in Intervenor's Contention 2(b), the Commission's "Notice of Intent to Prepare Generic Environmental Impact Statement on Handling and Storage of Spent Light Water Power Reactor Fuel," 40 Fed. Reg. 42801 (September 16, 1975), does not prohibit non-emergency licensing actions designed to ameliorate a possible shortage of spent fuel storage capacity prior to completion of the Generic Environmental Impact Statement. Portland General Electric Company, (Trojan Nuclear Plant) ALAB-531, 9 NRC ____ (March 21, 1979)(slip opinion at 14). The Board has applied, weighed and balanced the Five Factors mentioned in the Commission's Notice of Intent and concludes that they favor issuance of the requested license amendment at this time.

(3) Because the Board has found that the proposed action will not significantly affect the human environment, the Board concludes that it is not required by law to consider the alternatives of shutting down or curtailing the output of Zion Station as raised in Intervenor's

Contention 2(c). Portland General Electric Co., (Trojan Nuclear Plant) ALAB-531, 9 NRC ____ (March 21, 1979) (slip opinion at 5). Nevertheless, the Board has considered Intervenor's contention 2(b) and as stated in our Findings of Fact above we conclude that these are not realistic alternatives to issuance of the proposed license amendments.

(4) There is reasonable assurance that the activities authorized by the requested operating license amendments can be conducted without endangering the health and safety of the public provided that the conditions set forth in the Order, below, are incorporated into the Licenses.

(5) The activities authorized by the requested operating license amendments will be conducted in compliance with the Commission's regulations.

(6) The issuance of the requested operating license amendments will not be inimicable to the common defense and security or to the health and safety of the public provided the conditions set forth in the Order, below are incorporated into the licenses.

IV. ORDER

Wherefore, it is ORDERED, in accordance with the Atomic Energy Act, as amended and the regulations of the Nuclear Regulatory Commission, and based on the findings and conclusions set forth herein, that the Director of Nuclear Reactor Regulation is authorized to make appropriate findings in accordance with the Commission's regulations and to issue the appropriate license amendments authorizing the requested replacement of spent fuel storage racks at Zion Station.

The aforementioned license amendments shall contain the following conditions:

(1) Fuel stored in the spent fuel pool shall have a U^{235} loading less than or equal to 40.6 grams per axial centimeter.

(2) No loads heavier than the weight of a single spent fuel assembly plus the tool for moving that assembly shall be carried over fuel stored in the spent fuel pool. The spent fuel handling tool, the burnable poison tool, the rod cluster control changing fixture and the thimble plug shall not be carried at heights greater than two feet over fuel stored in the spent fuel pool.

(3) The Licensee shall not discharge from the Zion reactors into the spent fuel pool 193 or more spent fuel assemblies (one full core) before at least 10 days have elapsed since completion any refueling discharge of spent fuel assemblies from the Zion reactors to the spent fuel pool.

It is further ORDERED in accordance with 10 CFR §§2.760, 2.762, 2.764, 2.785, and 2.786, that this Initial

Decision shall be effective immediately and shall constitute the final action of the Commission forty-five days after the issuance thereof, subject to any review pursuant to the above-cited Rules of Practice.

IT IS SO ORDERED.

THE ATOMIC SAFETY AND LICENSING BOARD

_____

John F. Wolf, Esq., Chairman

_____

Dr. Linda W. Little, Member

_____

Dr. Forrest J. Remick, Member

Dated at Bethesda, Maryland

this ____ day of _____,

1979.

APPENDIX A

LIST OF EXHIBITS ADMITTED IN EVIDENCE

A. Licensee's Exhibit Number:

1. Spent Fuel Racks Receiving Inspection Checklist

2. Diagrams prepared by Mr. Tramm describing:

   (a) heat removal pathway from the spent fuel pool and from the reactor;

   (b) normal heat removal pathway from the reactor via the power conversion system.

3. Zion Station Final Safety Analysis Report -- Sections 9.3, 9.4, 9.5 (omitting diagrams)

4. Zion Station Fuel Pool Modification Licensing Report prepared by Nuclear Services Corporation

5. Addendum to Licensee's Exhibit 4 regarding 3.2 enriched fuel

6. Proprietary Blueprint regarding Zion Station and Dresden high density fuel storage tube specifications prepared by Nuclear Services Corporation.

7. Zion Station Final Safety Analysis Report -- Diagrams omitted from Licensee's Exhibit 3:

   (a) Figure 9.3-1, sheet 1 -- diagram of component cooling system;

   (b) Figure 9.3-1, sheet 2 -- diagram of component cooling system;

   (c) Figure depicting residual heat removal system;

   (d) Figure 9.5-1 -- diagram of the spent fuel pool cooling and cleanup piping.

B. Staff's Exhibit Number:

1A. Safety Evaluation Report for Zion Station Fuel Pool Modification

1B. Environmental Impact Appraisal for Zion Station Fuel Pool Modification

2. Safety Evaluation Report and Environmental Impact Appraisal regarding high burnup program for Zion Station

C. Intervenor's Exhibit Number:

2. Letter from Mr. Jurgens to Mr. Osness, May 11, 1979, regarding shipment of non-conforming Boral tubes from Brooks and Perkins to Leckenby

3. Letter from Mr. Weber to Mr. Shewski, June 8, 1979, regarding shipment of non-conforming Boral tubes from Brooks and Perkins to Leckenby

4. Summary of Commonwealth Edison rates from Commonwealth Edison Data Book

5. Chart prepared by Dr. A. B. Johnson entitled "U.S. Spent Fuel Inventory Versus Time"

D. Intervenor's In Camera Exhibit Number:

1. Brooks and Perkins -- Report on Stainless Steel-Boral Galvanic Couples for PWR Environments

2. Battelle Columbus Boral Report

3. Letter from Mr. Steptoe to Ms. Sekuler pertaining to Intervenor's In Camera Exhibits 1 and 2.

APPENDIX B

ISHAM, LINCOLN & BEALE

COUNSELORS AT LAW

ONE FIRST NATIONAL PLAZA FORTY-SECOND FLOOR
CHICAGO ILLINOIS 60603

TELEPHONE 312 558-7500 TELEX 2-5288

July 3, 1979

Ms. Susan Sekuler
Assistant Attorney General
Environmental Control Division
Office of the Attorney General
of the State of Illinois
188 West Randolph Street
Chicago, Illinois 60601

Dear Ms. Sekuler:

This letter is to confirm the agreement in principle we reached in respect of contention 2(n) at the spent fuel hearings in Zion in June. Should the Board authorize the requested replacement of storage racks in the Zion spent fuel pool, Commonwealth Edison will follow the practices and controls for limiting occupational exposure described in the affidavit of John P. Leider, attached to Applicant's Motion for Summary Disposition dated January 9, 1979. The Nuclear Regulatory Commission has indicated that it will review and enforce the commitments made by Commonwealth Edison during these proceedings. Nevertheless, to provide additional assurance that occupational exposures will be maintained As Low As Reasonably Achievable ("ALARA") during the proposed reracking, Commonwealth Edison will:

(1) invite the State's designated representative, who shall be an employee of an appropriate State agency such as the Illinois Department of Public Health,* to observe the rack replacement operation; and

(2) provide your office with a report summarizing the occupational exposures experienced during the job.

Because the commitments and reviews outlined above should ensure that occupational doses will be ALARA, the State will not urge the Licensing Board to impose additional technical specifications dealing with this subject.

POOR ORIGINAL

922 252

* [illegible] Harman Center, [illegible] in the event that [illegible] of them is available, another [illegible] agreed upon by the Commonwealth Edison [illegible] the Office of the Illinois Attorney General.
S.S.

O.K. with Edison
PPS

By entering this agreement the State does not withdraw or waive any other contention or objection which it has raised or will raise in respect of the proposed rack replacement. The agreement only relates to the occupational exposure issue if the Board grants Commonwealth Edison Company's application to replace the racks in the Zion spent fuel pool.

I am authorized to state that the NRC Staff has no objection to this arrangement. If this letter accurately reflects our agreement, please sign the original and return it to me. I will submit it to the Board as an attachment to Applicant's proposed findings of fact.

Sincerely yours,

Philip P. Steptoe

PPS/kb

CC: Service List

Assistant Attorney General

APPENDIX C - COMMITMENTS MADE BY LICENSEE

During the course of the hearings, the following have been proposed as technical specifications to be included in any license amendments which may issue as a result of this proceeding.

(1) The Staff intends to issue a technical specification which will limit maximum fuel loading in the fuel assemblies to 40.6 grams of uranium - 235 per axial centimeter of fuel assembly (Staff Ex. 1A, Section 2.1).

(2) The Staff also intends to issue a technical specification which will preclude the movement of any loads heavier than the weight of a spent fuel assembly plus the tool for moving that assembly over the fuel in the racks. The technical specification will also preclude the movement of certain tools at heights greater than 2 feet over racks containing stored fuel (Staff Ex. 1A, Section 2.3).

(3) The Licensee has testified in response to a Board question that it would not object to a technical specification restricting fuel movements during the unloading of a full core to require that a full core not be discharged in less than 10 days after completion of a refueling discharge (Tramm, Tr. 1510).

In addition, during the course of these proceedings the Licensee has made the following commitments:

(1) The Licensee will not handle any heavy loads in the vicinity of the spent fuel pool without first notifying the NRC (Staff Ex. 1A, Section 2.3; Zech, prepared testimony at p. 2, Tr. 1958). This commit actually pre-dates these proceedings.

(2) The Licensee will use a continuous air particulate monitor with a continuous readout during the proposed rack replacement. This commitment is found in a letter dated January 9, 1979 from John Rowe to Russell Eggert which is attached to "Applicant's Motion for Summary Disposition" of the same date.

(3) During the proposed rack replacement operation the Licensee will follow the practices and controls for limiting occupational exposure described in the affidavit of John P. Leider attached to Applicant's Motion for Summary Disposition dated January 9, 1979. In addition, the Licensee will invite the State of Illinois' designated representative, who shall be an employee of an appropriate state agency such as the Illinois Department of Public Health, to observe the rack replacement operation, and the Licensee will also provide the Office of the Attorney General of the State of Illinois with a report summarizing the occupational exposures experienced during the job. These commitments are found in a letter from Philip Steptoe to Susan Sekuler, which is attached to these Findings of Fact as Appendix B.

(4) The Licensee has made a commitment that after the racks are installed in the pool but before spent fuel is placed in them, the Licensee will conduct neutron attenurtion tests which will assure with a 95% confidence level that K effective of .95 will not be exceeded due to any missing Boral places in the Zion spent fuel pool (Zech, Tr. 1994, Tramm, Tr. 2010).

(5) The Licensee has also made a commitment that in the unlikely event that it is discovered that a Boral plate is missing on one of the sides of any tube, the Licensee will plug the tube which has the missing plate to make it impossible to insert a fuel assembly into that tube. In addition, the Licensee will check all of the other tubes in all of the racks for missing plates with neutron attenuation testing (Tramm, Tr. 1947-8, 1950).

(6) The Licensee has made a commitment to carry out the corrosion surveillance program described in Dr. Draley's testimony (Draley, prepared testimony at pp. 7-9, Attachment 5, Tr. 1290, 1302-3). This program includes the commitment that the surveillance program will be put into effect when the new racks are installed (Draley, prepared testimony at p. 8, Tr. 1290, 1321).

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of Commonwealth Edison Company (Zion Station, Units 1 and 2)	)))	Docket Nos. 50-295 50-304

CERTIFICATE OF SERVICE

I hereby certify that copies of "Licensee's Proposed Findings of Fact and Conclusions of Law" dated July 16, 1979, have been served upon the following by deposit in the United States mail, first class, postage prepaid, this 16th day of July, 1979:

John F. Wolf, Esq.
3409 Shepherd Street
Chevy Chase, Maryland 20015

Susan N. Sekuler
Assistant Attorney General
Environmental Control Division
Office of the Attorney General
188 West Randolph St.
Chicago, Illinois 60601

Dr. Linda W. Little
Research Triangle Institute
P. O. Box 12194
Research Triangle Park,
North Carolina 27709

Docketing and Service
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Richard Goddard
Steven Goldberg
Guy Cunningham
Myron Karman
Office of the Executive Legal Director
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dr. Forrest J. Remick
305 East Hamilton Avenue
State College, Pennsylvania 16801

Atomic Safety and Licensing Appeal Board Panel
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Richard E. Webb, Ph.D.
2858 111th Street
Toledo, Ohio 43611

Rick Konter
617 Piper Lane
Lake Villa, Illinois 60046

Philip P. Steptoe