1.0 4.5 2.8 2.5 5.0 3.2 2.2 5.6 3.6 6.3 4.0 2.0 1.1 1.8 1.25 1.4 1.6

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

taken in their behalf in the event of a serious accident." 10 CFR §100.3(b). The staff testified that suc protective measures could be taken in the event of an accident.[136] Nevertheless, the record evidence on th projected population growth in the area is ambiguous.

At the oral argument, we asked LHSG to substantiate its claim of a "dynamic housing potential"[137] i the area stemming from a proposed Levittown. It was unable to do so.[138] Likewise, the applicant wa uncertain as to the summer population along the shore west of the reactor, within the present lo population zone.[139]

The most we can say on the basis of the present record is that it indicates a moderate growth in th area. Further consideration will have to be given to reduction of the low population zone if there is substantial increase in the nearby population. Any such reduction in the outer boundary of the lo population zone might necessitate changes such as an increase in the filter equipment through whic radioactive gases are released to the atmosphere following an accident, and/or more stringent restrictions o the allowable containment leakage rate.[140] With proper design planning, such modifications can b accomplished, if required, either before or after operation commences. In these circumstances, th Licensing Board committed no error in not requiring a reduction at this time of the distance at which dose in the low population zone are measured.[141]

E. LHSG takes strong exception to the Licensing Board's findings that the applicant's QA program an its proposed implementation comply with Commission criteria.[142] LHSG claims that the Board relie exclusively on "'promises' by LILCO", and that the record indicates "that LILCO's proposed quality assurance program is deficient in the very areas the ASLB said it is adequate."[143]

1. LHSG gives four references (the last of which is obviously irrelevant) for its claim that the applicant "was not even cognizant of the language of standard quality assurance practices."[144] None of the relevant references, involving more than 300 pages of testimony, gives a definition of "standard quality assurance practices", and none supports the proposition that the applicant was somehow deficient in its QA capability. For example, the most that the first reference and related testimony might show is that the staff and applicant witnesses—who were associated with the nuclear industry—were not particularly familiar with the QA terminology employed in the aircraft industry—with which industry the LHSG interrogator was associated.[145] Terminology does vary from industry to industry and it is not difficult to perceive why the witnesses professed unfamiliarity with the QA terminology utilized by the interrogator. A technical interrogator should, of course, frame his questions in language readily understandable to the witnesses.

Nor does the second reference (Tr. 1688-1714) support LHSG's claim. Rather, it reflects that confusion occurred when a second interrogator for LHSG attempted to question the applicant's witnesses using a set of questions prepared by the first interrogator. The Chairman of the Licensing Board was moved to remark at one point, "I do not believe that follows and I know you are reading it, but in view of the fact that he answered the previous question as he did, this question you just asked does not follow."[146]

The third reference (Tr. 5630-5858) covers a wide range of cross-examination. LHSG provides no specific indication as to which part, if any, of that testimony demonstrates that applicant's witnesses were "not even cognizant of the language of standard quality assurance practices." The mere reference to 229 pages of testimony is unacceptable.

2. LHSG goes on to pinpoint certain alleged substantive QA deficiencies. In a general sense, it asserts that the QA standards to be used at Shoreham—*i.e.*, those appearing in Appendix B to 10 CFR Part 50—do not measure up to the most stringent AEC QA standards. In that regard, the transcript

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[136] Tr. 5955-5958; 5962-5964.

[137] La Bastille, prepared testimony at p. 6, fol. Tr. 8030.

[138] App. Bd. Tr. 51; 134-5.

[139] App. Bd. Tr. 98.

[140] Indeed, the staff itself testified that plant modifications, including additional safety features, will be required if there should be population changes which have a significant effect on safety. Tr. 5045-5046; 5048; 5380.

[141] See 10 CFR §100.11(a)(2).

[142] Initial Decision, *supra*, 47-48, RAI-73-4 at 280.

[143] Brief, p. 28.

[144] Tr. 740-94, 1688-1714, 5630-5858, and supplementary prepared testimony of Roger C. Langevin, fol. Tr. 8464 (6 pp. plus attachments).

[145] Tr. 720-728, 742-744, 750-753, 807-809.

[146] Tr. 1711.

eferences cited by LHSG suggest that it is questioning the fact that the applicant does not use the AEC esearch and development QA standards for its industrial QA program. As LHSG's cross-examination of arious staff witnesses made clear,[147] the RDT standards were developed for the Commission research and evelopment reactors and were not necessarily tied to industrial processes and practice. The regulatory aff, on the other hand, has developed standards tied to such industrial codes as that of the ASTM. Many uch firm standards have been developed and more are being worked on in conjunction with all phases of he industry. The applicant is committed to abide by such standards.

With regard to LHSG's more specific QA criticisms, our initial review of the record led us to conclude hat the applicant's QA program needed clarification in various respects. We asked for such clarification at he oral argument[148] and, by letter dated July 24, 1973, the applicant provided us with an updated QA nanual. In our view, this manual shed sufficient additional light on the nature of the QA organization, the xtent of the QA program and the status of the training program for the applicant's QA personnel.

As permitted by our order of July 27, the intervenor filed comments on the applicant's revised QA program.[149]

a. As a general criticism, LHSG claims that the QA program "does not demonstrate a real understanding of the true requirements and basic philosophy of a dependable and safe QA program."[150] In this connection, it asserts that the applicant has placed the basic QA responsibility on its major suppliers; and that the program does not approach the scope of the QA program outlined in WASH-1250,[151] with respect to "personnel, training, specificity or level of authority."[152]

We disagree. The applicant is not expected to perform all the QA functions for its vendors—it does, however, have the responsibility for ensuring that its vendors or contractors have satisfactory programs and that they are properly implemented. The applicant's program is designed to enable it to fulfill these responsibilities, and as made clear at the oral argument,[153] it recognizes its prime responsibility for the QA management for the project.

Moreover, to be granted a construction permit, an applicant must satisfy the QA standards of 10 CFR Part 50, Appendix B. These standards underlie the discussion in WASH-1250. Our review of the applicant's revised QA program convinces us that it is adequate to meet the requirements of Appendix B. It also, therefore, is consistent with the standards described in WASH-1250.

In at least one respect, LHSG has apparently misunderstood the discussion in WASH-1250. In suggesting general goals for a QA program, it quotes the following statement from Chapter 2.0 of WASH-1250:[154] "One large power plant construction firm estimates that a minimum of some *25–30 additional people* are used *at the job site* to provide the additional quality assurance program required by AEC regulations . . .". What LHSG apparently overlooks is that these additional personnel include vendor and architect-engineer QA employees as well as those of the applicant. The record now before us gives no reason to question that there will be adequate QA staffing at this facility.

b. We now turn to several more specific criticisms (designated A-M) leveled by LHSG against the QA program.

Points *A, D, and E* relate to the organizational structure of the applicant's QA activities, and, more particularly, to whether the QA manager has sufficient organizational stature. The applicant's newly revised organization chart[155] places the Manager of Quality Assurance on an equal footing with the Manager of Nuclear Projects; both report to the Vice President, Engineering. The individual most involved in the scheduling and progress of construction is the Project Superintendent, who reports to the Project Manager who, in turn, reports to the Manager of Nuclear Projects. In our opinion, the QA Manager's organizational equality with the Nuclear Projects Manager is satisfactory.

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[147] Tr. 6666 *et seq.*

[148] App. Bd. Tr. 73-74, 77.

[149] LHSG August 10, 1973 Memorandum to Chairman of the Board.

[150] *Id.*, pp. 2-3.

[151] "The Safety of Nuclear Power Reactors (Light Water-Cooled) and Related Facilities", WASH-1250 (July, 1973). This is a study prepared by the Commission's former Division of Reactor Development and Technology (RDT) relating to the safety aspects of nuclear power reactors.

[152] LHSG August 10 Memorandum, p. 3.

[153] App. Bd. Tr. 140-141.

[154] LHSG August 10 Memorandum, pp. 1-2 (item E).

[155] Revised QA Manual, Exhibit 1.1, submitted to Appeal Board through applicant's letter of July 24, 1973.

We find unavailing LHSG's emphasis on the fact that, unlike the QA manager of the architect-engineer, the applicant's QA manager does not have the status of a vice president. Comparing, as LHSG does, the organizational titles of the applicant and Stone & Webster is, of course, comparing apples and oranges. Stone & Webster, which is involved in many large construction projects, obviously has more need for a QA vice president than does the applicant.

Points *B and C* are addressed to an asserted lack of information respecting the qualifications of the applicant's QA personnel. Particular stress is laid on the QA Manager. But his qualifications were fully described in evidence adduced at the hearing,[156] and were the subject of cross-examination.[157]

Point *F* questions whether the staff has reviewed the revised QA program. The staff's statement on the applicant's QA submission, made in its letter to this Board of August 10, 1973, answers this question. The communication indicates that the staff has reviewed the revised QA program and has found it "acceptable . . . in that it fully complies with 10 CFR Part 50, Appendix B."

Points *G, H, I and J* complain of the initial QA program of the applicant and, additionally, that the Stone & Webster QA program is not on the record. The short answer is that the applicant has submitted a revised QA program (which we have found to be satisfactory) and a description of the Stone & Webster program is, in fact, in the record.[158]

Points *K, L, and M* list a number of specific details which LHSG claims were improperly omitted from the QA program. It is apparent that LHSG does not understand the difference between a QA program and a QA manual. The program called for in Appendix B is a general outline of what is required in quality assurance. The QA manual available to engineers and QA personnel on site and at headquarters is the vehicle for covering matters of detail, such as those listed by LHSG.

In sum, while a portion of LHSG's initial QA exceptions relating to organizational structure and personnel was well taken, the QA program (as revised) is, in our opinion, satisfactory. It is, of course, the staff's ongoing responsibility to insure full implementation of the program by the applicant and its architect-engineer.

F. LHSG excepts to the findings of the Licensing Board concerning the "Control of Radioactive Releases."[159] The Board found, *inter alia*, that the applicant's commitment for control of releases of radioactivity "meets the Commission's 'as low as practicable' standard as set forth in Part 20."[160]

1. First, LHSG asserts that the Shoreham reactor will not be able to meet the condition imposed by the Licensing Board, namely, that emissions not exceed 1% of the 10 CFR Part 20 limits. This is so, according to LHSG, because of "the well publicized fact that the current generation of plants, notably Vermont Yankee, Oyster Creek, Monticello, Dresden, Ginna, etc., are not approaching 1% of 10 C.F.R. 20 on a regular basis without power cutbacks."[161]

LHSG ignores the fact that the older plants listed were originally designed and built to meet the standards of 10 CFR Part 20 rather than 1% of those standards. The Licensing Board gave extensive record references (initial decision, par. 52-54, footnotes 49-52) to the designs in Shoreham aimed at reducing radioactive emissions to below 1% of those allowed under 10 CFR Part 20. Moreover, as a condition of operation, the Shoreham reactor will be required to meet any more stringent radiation limits which may be set by Appendix I of 10 CFR Part 50 as finally adopted.

2. Second, the intervenor challenges the "1% commitment" on the basis that, even at this level, the public health and safety would not be protected. This claim appears to stem primarily from the testimony of Dr. Ernest Sternglass, which was properly disregarded by the Licensing Board in light of testimony adduced by the applicant, staff and Suffolk Scientists, which entirely discredited the Sternglass testimony. We have already dealt with the Sternglass methodology in our *Columbia University* decision,[162] and our discussion there is equally applicable here.

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[156] Summary of Application, p. A-5, fol. Tr. 403.

[157] Tr. 1681 *et seq.*

[158] PSAR, Appendix E. Submission of such a description is consistent with the requirements of 10 CFR Part 50, Appendix B.

[159] Initial Decision, *supra*, par. 52-55, RAI-73-4 at 281.

[160] *Id.*, par. 55.

[161] Brief, p. 29.

[162] *Trustees of Columbia University in the City of New York*, ALAB-50, WASH-1218 320, 336-34? (May 18, 1972); affirmed, *Morningside Renewal Council v. AEC*, ___ F. 2d ___, 5 ERC 1705 (July 5, 1973).

We concur in the Licensing Board's disposition of this issue.

G. LHSG attacks the Licensing Board's ruling excluding the issue of foreign sabotage from the proceeding, and deferring to the operating license stage final and detailed consideration of the possibility of industrial sabotage and the applicant's emergency plans.[163]

1. To deal first with the sabotage problem, LHSG does not appear to argue with the Board's decision insofar as the Atomic Energy Act is concerned.[164] Rather, it claims that the decision is "totally deficient in terms of NEPA" because the risks of sabotage (both foreign and industrial) should have been factored into the Board's cost-benefit analysis.[165] We think otherwise.

With respect to industrial sabotage, the Board's ruling was in accord with precedent.[166] Moreover, industrial sabotage could occasionally damage no worse than that resulting from a design basis accident. Releases of radioactivity which might accompany such accidents are already considered in the NEPA review of the various accidents.

As far as wartime sabotage is concerned, the Commission regulation which obviates the necessity of its consideration in a licensing proceeding (10 CFR §50.13) was upheld by the ruling of the District of Columbia Circuit in *Siegel* v. *AEC*, 400 F. 2d 778 (1968). The court there found the Commission's approach to be premised upon such considerations as

> (1) the impracticability, particularly in the case of civilian industry, of anticipating accurately the nature of enemy attack and of designing defenses against it, (2) the settled tradition of looking to the military to deal with this problem and the consequent sharing of its burdens by all citizens, and (3) the unavailability, through security classification and otherwise, of relevant information and the undesirability of ventilating what is available in public proceedings.[167]

Taking into account the "rule of reason" which we believe must govern the interpretation of NEPA,[168] we find the rationale for 10 CFR §50.13 to be as applicable to the Commission's NEPA responsibilities as it is to its health and safety responsibilities. We so construe that regulation.

2. We have already considered (see pp. 847-848, *supra*) the question of population estimates near the Shoreham reactor. The final determination with respect to the content of the necessary emergency plans must depend on the development of the population growth in the next few years. If, as the result of this growth, the low population zone and, therefore, the emissions from the plant must be reduced, emergency plans will have to be developed to fit the new situation. The Board correctly concluded[169] that the outline of the proposed emergency plan submitted by the applicant is sufficient at this time.[170]

H. Finally, LHSG asserts that the Licensing Board's conclusions regarding the adequacy of the PSAR for Shoreham were deficient.[171] It points to no specific deficiencies, but rather avers only that Shoreham is "larger than any operating BWR" and that "engineers and quality assurance experts were asking new questions regarding safety analyses for nuclear plants in comparison to similar analyses in other industries."[172] From all that we have been able to determine, LHSG is referring simply to questions which its own interrogators raised in cross-examining witnesses for the other parties. Apart from the fact that the witnesses provided answers to them, we fail to perceive how those questions relate to the claimed inadequacy of the PSAR.

As for the size of Shoreham, the record clearly reflects that the reactor's nuclear steam supply system with its containment and safeguards systems is similar in size to the systems of some other boiling water

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[163] Initial Decision, *supra*, par. 74-77, RAI-73-4 at 285.

[164] In any event, the decision is correct in that it conforms with Commission rules.

[165] Brief, p. 31.

[166] *Florida Power & Light Co.* (Turkey Point, Units 3 and 4), Commission Memorandum and Order, 3 AEC 173 (February 20, 1967); see also *Trustees of Columbia University in the City of New York*, ALAB-3, WASH-1218 15, 24-25 (May 26, 1970).

[167] 400 F. 2d at 782.

[168] See, *e.g.*, *N.R.D.C.* v. *Morton*, *supra*.

[169] Initial decision, *supra*, par. 77, RAI-73-4 at 285.

[170] See *Consumers Power Co.* (Midland, Units 1 and 2), ALAB-123, *supra*, RAI-73-5 at 342-343; see also *Pacific Gas & Electric Co.* (Diablo Canyon Nuclear Power Plant, Unit 2), ALAB-27, WASH-1218 152, 175-176 (June 14, 1971).

[171] Brief, p. 31.

[172] *Id.*, pp. 31, 32.

reactors now in operation, and that its steam supply system is essentially the same as those in other GE reactors presently under construction. We agree with the Licensing Board's conclusions that the Shoreham facility is not "novel or unproved" within the meaning of 10 CFR §100.2(b), and that the PSAR is adequate.

V. ADEQUACY OF COST-BENEFIT ANALYSIS

In point 4 of its brief, LHSG challenges the adequacy of the Licensing Board's cost-benefit analysis. It does so on the basis of the Board's assessment of both costs and benefits, its evaluation of alternatives, and the degree to which it quantified the costs and benefits.

A. LHSG asserts that the inadequacies in cost assessment were the result of the Board's failure adequately to consider the consequences of the fuel cycle, ECCS malfunction, Class 9 accidents, aquatic effects, unresolved safety problems, and low-level emissions. We have previously considered the Board's treatment of these matters and determined that that treatment was proper. Specifically, we concluded, with respect to each, either that the Board correctly did not inquire into its environmental impact or that the evaluation which it made of such impact was warranted by the record. Since LHSG's complaint of an inadequate NEPA cost assessment rests upon its conclusion (contrary to ours) that the Board's treatment was not acceptable, no further discussion of the complaint is called for here.

B. On the benefit side, LHSG asserts that the initial decision is deficient in that it "simply assumed that the electricity to be provided by Shoreham would be a benefit of high value."[173] LHSG goes on to assert that the record provides no warrant for this assumption, inasmuch as "no consideration of any kind was given to the uses to which the electricity would be put, or to whether these uses would be beneficial or detrimental." Further, LHSG would have had the Board consider the benefits and potentials of energy conservation. LHSG claims that "NEPA clearly requires" such an approach, but gives no further indication of what language in NEPA, or what decisions interpreting NEPA (if any), suggest that result.

1. The Board's findings on need for power were premised on information in the Final Environmental Statement, and the testimony of a witness representing the Federal Power Commission. The Board found the applicant's projection of power needs to be reasonable. While noting that LHSG had adduced evidence[174] to the effect that the applicant could reduce its future load by "further educating the public in conservation measures," the Board found that that evidence

> . . . contained little practical guidance for action beyond the significant effort already being made, and no estimate of how much the demand might be reduced . . .[175]

We think that this was an accurate appraisal.

2. We might dispose of LHSG's argument simply on the basis that the evidence does not support it. The exception raises, however, the more fundamental issue of whether questions concerning the nature of electrical demand are appropriate for consideration in a proceeding of this type. We have previously held that they are not, that their consideration would "expand the NEPA review well beyond the pale of what [is] required by NEPA," and that a licensing board is not required to analyze the use to which a utility's customers might put the power generated by a plant to ascertain whether that use would have an adverse environmental effect.[176] We continue to be of that opinion. But since this issue is a recurring one in licensing proceedings, we believe it appropriate to discuss at somewhat greater length our rationale.

NEPA, of course, requires that, "to the fullest extent possible," an agency prepare a detailed statement on the environmental impact of a proposed action.[177] As interpreted by the *Calvert Cliffs'* decision, the statute further requires an agency to "include all possible environmental factors in the decisional equation," and to perform a "balancing analysis" using these factors.[178]

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[173] Brief, p. 34.

[174] Tr. 14,509, *et seq.*

[175] Initial decision, *supra*, par. 100, RAI-73-4 at 289.

[176] *Consumers Power Co.* (Midland, Units 1 and 2), ALAB-123, *supra*, RAI-73-5 at 351-352. See also *Wisconsin Electric Power Co.* (Point Beach 2), ALAB-137, *supra*, RAI-73-7 at 497-498.

[177] 43 U.S.C. 4332(2)(C).

[178] *Calvert Cliffs' Coordinating Committee* v. *AEC*, *supra*, 449 F. 2d at 1113 (D.C. Cir. 1971).

NEPA omits any particularization of those environmental factors which must be considered or balanced. Thus, it does not specify whether the factors to be considered are just those directly flowing from the action in question, or whether certain secondary factors (such as the uses of electricity produced by a nuclear plant) must also be considered.

As we have pointed out, a "rule of reason" applies generally to the interpretation of NEPA.[179] That rule is applicable to all the procedural requirements of §102(2)(C), the impact-statement section of the statute.[180] Further, the reasonableness standard as applied to the consideration of environmental effects requires the prediction only of those environmental effects which, although not fully known, are "reasonably foreseeable."[181]

One decision of which we are aware has dealt directly with whether secondary effects of a federal action—such as the uses made of electricity—must be considered in the environmental review of that action. In *First National Bank of Homestead* v. *Watson*, _ F. Suppl. _, 5 ERC 1497 (D.D.C., 1973), the plaintiffs claimed that a federal official, in deciding to grant a charter for a proposed bank, had erroneously failed to consider the environmental cost of increased urbanization which could result from the lending program of that bank. In rejecting this argument, the court stressed the speculative nature of such an inquiry:

> [T]he facts of this case indicate only that the federal action will *possibly* allow others to set into motion projects which *possibly* will affect the local environment.[182]

Prediction of the environmental effects of the uses of electricity is no less speculative than prediction of the effects of the uses of money. The record indicates that the Shoreham facility is needed to satisfy normal residential, commercial and industrial demand, but that demand is comprised of numerous uses. Some of these may be deemed environmentally damaging; but, as the *Homestead* court pointed out:

> The Comptroller . . . could just as easily speculate that the bank would finance developments that would be beneficial to the environment.[183]

Assuming that some uses of electricity are more environmentally beneficial (or degrading, as the case may be) than others, the Commission would have no authority to dictate, or even influence, whether uses of electricity would be confined to those deemed by it to be beneficial. Indeed, the Commission has no particular expertise to do so. While this lack of Commission authority would not in itself justify our failure to treat an issue,[184] it militates toward that end where, as here, the consideration of uses would be purely speculative, and the result of that consideration could lead to no meaningful resolution of the issues involved, absent a thorough restructuring by Congress of some of the basic aspects of the American way of life. Thus,

> . . . the need for an overhaul of basic legislation certainly bears on the requirements of the Act. We do not suppose Congress intended an agency to devote itself to extended discussion of the environmental impact of alternatives so remote from reality as to depend on, say, the repeal of the antitrust laws.[185]

Nor could the Commission, if it denied the applicant a construction permit on the basis that there should be greater emphasis on conservation, dictate that the remaining capacity be used in a beneficial way. At the present time, Congress would have to intervene to effectuate those goals.

In short, these are legislative questions, beyond the realm both of the Commission's expertise and of its authority. A decision to restrict the growth of the country's electrical capacity to less than that demanded by its inhabitants would not be limited in its applicability to a single reactor but rather would involve broad economic, social and political consequences. Congress, and not the Commission, should make that determination. As we stated in *Point Beach 2:*

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[179] See pp. 836, 837-838, *supra;* see also *Wisconsin Electric Power Co.* (Point Beach Nuclear Plant, Unit 2), ALAB-137, *supra*, RAI-73-7 at 498.

[180] *Scientists' Institute* v. *AEC*, *supra*, 5 ERC at 1425-6.

[181] *Id.*, 5 ERC at 1426.

[182] 5 ERC at 1501.

[183] *Ibid.*

[184] *N.R.D.C.* v. *Morton*, *supra.*

[185] *Id.*, 458 F. 2d at 837.

Broad social questions such as this cannot be productively considered in a licensing proceeding involving an individual facility.[186]

NEPA does not require otherwise. It does not ask an agency

. . . to distinguish between power requirements and power demands [or] to balance the benefits of the development of additional electric power against its adverse effect on the environment.[187]

Accordingly, the Licensing Board committed no error in its treatment of these matters.

C. The third element in the intervenor's criticism of the Board's cost-benefit analysis is its assertion that the Board's evaluation of alternatives was "totally deficient".[188] LHSG claims generally that the Board gave inadequate consideration to the alternatives appearing in the record, but it refers specifically only to non-central generating sources (*e.g.*, solar energy) and combined cycle turbines.

In reviewing the record, we find that seventeen alternatives to the Shoreham facility were mentioned: (1) Abandonment of expansion—*i.e.*, "doing nothing"—, with the public reducing its demand for electricity to correspond with existing supply. (2) Purchase of power from outside the applicant's system. (3) Load shedding within the applicant's system. (4) Coal-fired plant. (5) Natural gas-fired plant. (6) Oil-fired plant. (7) Gas turbines. (8) Hydroelectric power. (9) Offshore wind-powered generators. (10) Combined cycle gas turbines. (11) Solar power (domestic uses). (12) Wind-powered generators (domestic uses). (13) Fuel cells (domestic uses). (14) Fusion power. (15) Magnetohydrodynamic (MHD). (16) Breeder reactors. (17) High temperature gas turbines for topping a conventional steam cycle.

1. The Licensing Board specifically considered fourteen of these alternatives.

Alternatives 1, 2 and 3, dealing with abandonment, outside purchase, and load shedding, are fully covered in paragraphs 179, 184, 185 and 186 of the initial decision.[189] Similarly, alternatives 4, 5, 6, 7 and 8 on the usage of coal, gas, oil, and hydroelectric power are discussed adequately in the initial decision, paragraphs 180 and 181.[190]

In paragraph 182, the Board discussed the use of solar power, local windmills and fuel cells (alternatives 11, 12 and 13). In addition to the treatment given by the Board to these items (with which we concur), we note that these sources of energy are at present limited to small-scale, decentralized usage. Even accepting the concept that decentralized sources of power may some day be capable of meeting the particular electrical demands for which centralized power sources are now requisite, no such decentralized source has yet been perfected. Significantly, LHSG's own witnesses doubted the adequacy of two of these sources as a practical alternative for meeting the particular needs which Shoreham is to be called upon to satisfy.[191] Furthermore, no overall costs of installation of such individual units were estimated by LHSG.

Also in paragraph 182, the Licensing Board mentioned alternatives 14 and 15, fusion reactors and MHD. We agree completely with the Board's assessment that these two alternatives, as well as the others mentioned in that paragraph, lack the technical maturity to be considered at this time as alternatives to the proposed Shoreham reactor.

The other alternative considered by the Licensing Board[192] is number 10, the combined cycle gas turbine. The Licensing Board's conclusion that this is not a feasible alternative is, in our opinion, supported by the weight of the evidence in the record. A witness for LHSG testified that combined cycle gas turbines would have an economic advantage over the nuclear reactor.[193] However, on the basis of no less reasonable assumptions, witnesses for both the applicant[194] and the staff[195] came to a conclusion opposite to that of the LHSG witness.

Further, the evidence does not sustain the LHSG contention that ". . . combined cycle units would be far more reliable than Shoreham". As far as reliability of individual units was concerned, this claim was

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[186] ALAB-137, *supra*, RAI-73-7 at 498.

[187] *Jicarilla Apache Tribe of Indians* v. *Morton, supra*, 471 F. 2d at 1280.

[188] Brief, pp. 35-37.

[189] RAI-73-4 at 302-303.

[190] *Id.*, at 302.

[191] Fuel cells–Kusko, Tr. 14, 209; Clark and Barber, Tr. 14,557-61; Solar Power–Kusko, Tr. 14,212.

[192] Initial Decision, *supra*, par. 183, RAI-73-4 at 302-303.

[193] Kusko, references appearing in intervenor's brief, pp. 35-36.

[194] Uhl, prepared testimony, following Tr. 14,911 at p. 15.

[195] Carter, prepared testimony, following Tr. 14,314.

explicitly refuted by the applicant's witness, who considered the combined cycle turbine to be in an embryonic stage of development and of unproven performance at the present time.[196] It may be that, all other things being equal, *system* reliability would be enhanced by use of a number of relatively small units (such as combined cycle) rather than one larger nuclear facility. But many other factors must be considered.[197]

Finally, with regard to environmental impacts, we accept the principle that a more efficient plant will have less wasted heat than a less efficient plant at the same electrical output. As discussed previously, however, we conclude that the thermal discharge from the Shoreham facility with the existing discharge system will not have a significant impact on the environment. Therefore, we remain unconvinced that use of combined cycle units would result in "less serious environmental impacts" than the Shoreham facility, particularly in view of the oxide gases created during gas turbine operation (FES, p. 11-23). For this reason and the others assigned, we do not consider combined cycle turbines to be a viable alternative to the Shoreham station.

2. The only alternatives mentioned in the record which were not specifically treated by the Licensing Board are the offshore wind-powered generators (number 9), the breeder reactor (number 16), and the high temperature gas turbines for topping a conventional steam cycle (number 17). Offshore wind-powered generators were not mentioned in the FES, but testimony on this concept was provided by LHSG. This scheme envisions "barrages" of wind stations in the Gulf of Maine–Georges Bank area of the Continental Shelf. The source of energy, the prevailing westerlies, would turn large wind turbines driving alternating current generators. This alternating current would be converted to direct current for use in first, distilling and second, electrolyzing seawater. The hydrogen thus produced would be stored under pressure and piped to a mainland distribution system.

We find this an intriguing concept, perhaps worthy of further research. But because of the societal and technical questions which must be answered before embracing such a concept, we fail to see how this could be considered a viable alternative to the Shoreham station.

The breeder reactor is, of course, now regarded as a possible future alternative to the light-water nuclear reactor. However, the initial commercial demonstration plant for the liquid metal breeder is just now being designed and is not expected to operate before 1980 at the earliest. Full-scale production of such plants, therefore, cannot be considered until an even later date, which excludes the breeder from any consideration as an alternative for Shoreham.

Finally, we do not regard as a viable alternative the use of high temperature gas turbines for topping a conventional steam cycle.[198] Such a system, with a high temperature gas turbine operating up to 3000°F as a topping unit to a conventional steam turbine plant, could be very efficient. However, the technology for gas turbines operating at these high temperatures has not been developed for commercial use.[199]

In summary, the Board's treatment of alternatives, as supplemented by our discussion above, completely satisfies the requirements of NEPA for the treatment of alternatives. See *N.R.D.C.* v. *Morton, supra.*

D. Lastly, LHSG insists that the Board's cost-benefit analysis failed to quantify " 'to the fullest extent practicable' environmental, economic and other cost and benefits."[200]

We have dealt with the quantification requirement at some length in *Midland.*[201] As we there pointed out, and as LHSG here acknowledges, not all costs or benefits must, or can, be quantified. Our review of the initial decision and the record convinces us that the Board adhered to the standards which we enunciated in *Midland.* The record indicates that many environmental factors were indeed quantified.[202] Moreover, the Board explicitly recognized that several considerations were "amenable only to qualitative or broadly subjective social assessment."[203] It also observed that it

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[196] Uhl, prepared testimony, *supra*, p. 22; Tr. 14,927-14,928.

[197] One such factor is the ease of system operation.

[198] FES, Section 10.2.2, p. 10-5.

[199] FES, Section 10.3, p. R-36, ref. 4.

[200] Brief, p. 37.

[201] *Consumers Power Co.* (Midland, Units 1 and 2), ALAB-123, *supra*, RAI-73-5 at 350-351.

[202] See, *e.g.*, FES, Ch. 11.

[203] Initial decision, *supra*, par. 166, RAI-73-4 at 300.

was not offered bases for reduction of some items of potential esthetic, recreational, economic and technical value to a sufficiently common denominator to allow the Board to make an exacting cost-benefit comparison.[204]

Finally, we note that, as in *Midland*, the intervenor here has

pointed to nothing which would indicate that costs which were considered only qualitatively could have been adequately quantified, or which would indicate that the Licensing Board did not take the non-quantifiable factors into account.[205]

Accordingly, we see no reason to disturb the Licensing Board's rulings with regard to quantification, or so much of its cost-benefit analysis as reflects such rulings.

VI. MISCELLANEOUS ISSUES

A. In point 5 of its brief, LHSG asserts that the Licensing Board had a duty to assure that the record was complete "by taking affirmative action on its own initiative," and that the Board violated that duty by not attempting to correct the "record deficiencies that characterized this proceeding."[206] The record deficiencies of which the intervenor is speaking, however, are the same substantive matters which the intervenor had claimed were dealt with improperly in the Board's environmental review, and which we have already considered—*i.e.,* environmental effects of the fuel cycle, ECCS failure, Class 9 accidents, alleged inadequacies in ecological data, the uses of electricity, energy conservation, quantification, and the validity of the Interim Acceptance Criteria. We have found the record on these subjects to be entirely adequate. Hence, whatever its obligation independently to investigate certain issues, the Board here fulfilled its responsibilities.[207]

B. By its letter to us of July 13, 1973, LHSG raised a new issue. Relying on a recent publication, it asserted that the applicant here has ordered a new plant to be built at the Shoreham site. It claimed that the environmental effects of this second plant should have been discussed in the impact statement or at the hearing, since the separate projects are "really part of an overall development plan."

In response at the oral argument, the applicant, through its counsel, admitted that it had entered into a contract to purchase a new reactor. But it further stated that "the site has not been determined", and that it was assessing the environmental desirability of some 22 or 23 locations, one of which was Shoreham.[208]

However that may be, there is no requirement that the environmental impact of "Shoreham No. 2" be considered in this proceeding. There is no indication in the record that the second plant is in any way connected with the first, or that there exists any "overall development plan" contemplating more than one plant at the Shoreham site. Moreover, if a second plant is built on the Shoreham site, the environmental review of that plant will of course factor in the environmental consequences of the first plant. The second plant could be licensed only if its environmental impact, together with that of the first, were to be found acceptable.

Our holding in *Point Beach 2* is dispositive of this question:

. . . NEPA and the Commission's regulations require a discussion of the environmental impact of the proposed licensing action under consideration. They do not require a discussion of the impact of future projects or, indeed, of any existing plants unless they interact with or have some demonstrated relationship to or "contact" with the project under consideration.[209]

C. By letter dated October 17, 1973, which was received by us subsequent to our preparation of the above portions of this decision, LHSG asked us for an "immediate reevaluation" of the Shoreham facility, and a "stay of construction in the interim", on the basis of a recent staff report (WASH-1270) entitled

[204] *Ibid.*

[205] *Consumers Power Co.* (Midland, Units 1 and 2), ALAB-123, *supra*, RAI-73-5 at 351.

[206] Brief, p. 39.

[207] For a further discussion of these responsibilities, see *Consumers Power Co.* (Midland, Units 1 and 2), ALAB-123, *supra*, RAI-73-5 at 334-336.

[208] App. Bd. Tr. 53.

[209] *Wisconsin Electric Power Co.* (Point Beach 2), ALAB-137, *supra*, RAI-73-7 at 495 (footnote omitted).

"Anticipated Transients Without Scram for Water-Cooled Power Reactors". The staff had forwarded this report to the applicant by letter dated October 10, 1973.

The report outlines the results of a staff study on the probability that a failure of the reactor control system to scram the reactor will occur simultaneously with any one of several anticipated transients. Contrary to the implication in LHSG's letter, this problem was not first identified by LHSG; rather, it was recognized by the staff early in this proceeding (SER, p. 48) and treated as one of the research and development matters associated with this reactor. Nor did the Licensing Board ignore this subject; indeed, it addressed it in its initial decision as part of the discussion of "Further Research and Development".[210]

In its October 10 letter, the staff directed the applicant to take one or more of the types of remedial action detailed in Appendix A of WASH-1270. A statement of the "approach" to be taken by the applicant is due by January 1, 1974. In this connection, with reference to reactors such as Shoreham, the report states: "The recirculation pump trip for boiling water reactor plants appears to be a satisfactory approach, although detailed system designs and performance analyses along the lines indicated in the staff licensing position should be provided to determine final acceptability".[211]

In short, we have here a situation in which an operational problem requiring further research and development work was identified early in the construction permit proceeding for this reactor and, as a result of such work, a generic solution now has been proposed. While, as the staff's letter points out, there remains to be determined the manner in which the generic proposal should be applied to Shoreham, this consideration scarcely warrants the suspension of the construction permit. The facility is still in the early stages of construction and sufficient time remains to take into account the determination as to the application of the generic proposal to it. That determination, as well as the generic proposal itself (if not then embodied in a formal regulation), may be challenged when the facility applies for an operating license.

In these circumstances, the relief requested by LHSG must be denied. (See p. 844, *supra*).

VII. CONCLUSION

For the reasons stated, the exceptions are *denied.* In accordance with our established practice, we have also examined those portions of the initial decision which were not the subject of an adequately briefed specific challenge by LHSG. That examination does not disclose any errors on the Board's part which would affect the validity of its conclusion that the authorization of the issuance of a construction permit was merited by the evidence adduced on both the health and safety and the environmental aspects of this reactor. Accordingly, the initial decision is *affirmed.*

It is so ORDERED.

FOR THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

Margaret E. DuFlo
Secretary to the Appeal Board

[210] Initial decision, *supra*, par. 49, RAI-73-4 at 280.

[211] WASH-1270, at p. 75.

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

ATOMIC SAFETY AND LICENSING APPEAL BOARD

Alan S. Rosenthal, Chairman
Dr. John H. Buck, Member
Dr. Lawrence R. Quarles, Member

In the Matter of

THE TOLEDO EDISON COMPANY, et al. — **Docket No. 50-34**

(Davis-Besse Nuclear Power Station)

Messrs. Gerald Charnoff and **Jay E. Silberg,** Washington, D.C., for the applicants, The Toledo Edison Company and The Cleveland Electric Illuminating Company.

Mr. Francis X. Davis for the AEC Regulatory Staff.

DECISION

October 30, 1973

(ALAB-157)

On March 24, 1971, pursuant to a Licensing Board authorization, a construction permit was issued to The Toledo Edison Company and The Cleveland Electric Illuminating Company for a pressurized water reactor (denominated Davis-Besse Nuclear Power Station) to be located at a site in Ottawa County, Ohio, on the southwestern shore of Lake Erie. On January 5, 1973, a notice was published (38 *F.R.* 904) to the effect that a hearing would be held (as required by Section B of Appendix D to 10 CFR Part 50) to consider whether "the construction permit should be continued, modified, terminated or appropriately conditioned to protect environmental values". Following the completion of this hearing, the Licensing Board rendered its initial decision on September 13, 1973, in which it determined that the construction permit could continue but should be amended to include certain specified environmental conditions.

1. The applicants filed two exceptions to this decision. One of the exceptions, which related to a condition imposed on the continuation of the construction permit, was subsequently withdrawn. The other exception, which the applicants continue to press,[1] is addressed to the denial in part by the Licensing Board of the applicants' motion to strike several of the contentions advanced by an intervenor, the Coalition for Safe Electric Power. That motion was filed, and acted upon, in July 1973.

We are declining to consider the exception on its merits. The initial decision and the record do not disclose that the applicants have suffered any prejudice whatsoever as a result of the Board's ruling on the motion to strike. Indeed, applicants themselves do not claim that, in its initial decision, the Licensing Board took any ultimate action with regard to the contentions in issue which was adverse to their position or might be detrimental to them in the slightest respect. Rather, we are told by the applicants that the purpose of the exception was simply "to seek clarification" of portions of two of our earlier decisions having a possible bearing upon the validity of their motion. In essence, then, what applicants appear to be seeking through the vehicle of the exception is an advisory opinion on the correctness of an interlocutory ruling of the Licensing Board which is now wholly academic, at least insofar as this particular proceeding is concerned.

[1] The regulatory staff has filed a brief in opposition to this exception.

It may be that, unlike Federal appellate judges (whose jurisdictions are subject to the limitations inherent in the "case or controversy" provisions of Article III, Section 2 of the United States Constitution), we are empowered to entertain, at the behest of a party, a question which arose during the course of proceedings before the trial body but had been stripped of any practical significance by the time the curtain on those proceedings had fallen. We perceive no good reason, however, why our review function should be so exercised here. To the contrary, the husbanding of the resources of this Board (among other considerations) mandates that, as a general rule at least, an appeal from a licensing board ruling be considered only if the appellant can establish that, in the final analysis, some discernible injury to it in the proceeding at bar has been sustained as a consequence of the ruling. This case does not appear to present any extraordinary circumstances warranting a departure from that general rule. Accordingly, the exception is being dismissed.[2]

2. Notwithstanding the dismissal of the applicants' exception, and the absence of exceptions on behalf of any of the parties to the proceeding, we have performed our customary review of the initial decision and the record upon which it was founded. That review has disclosed no error necessitating corrective action on the part of this Board. Our conclusion in this regard is based upon the assumption that the Licensing Board intended Condition (2) set forth in Paragraph 86c. of the initial decision[3] to embrace the terrestrial, aquatic and marsh monitoring programs discussed, respectively, at pp. 6-2, 6-3 and 12-6 of the Final Environmental Statement. In any event, Condition (2) is to be so construed and applied.

3. For the foregoing reasons, the applicants' exception is *dismissed* and the initial decision is *affirmed.*

It is so ORDERED.

FOR THE ATOMIC SAFETY AND LICENSING
APPEAL BOARD

Margaret E. DuFlo
Secretary to the
Appeal Board

[2] In *Mississippi Power and Light Co.* (Grand Gulf Nuclear Station, Units 1 and 2), ALAB-130, RAI-73-6 423, 425 (June 19, 1973) we portended this result by our observation:

Through the vehicle of exceptions to [the initial] decision, the parties will be free to challenge any determination made by the Board with respect to a particular contention—*so long as that determination had some bearing upon the conclusions expressed, or the result reached, in the decision.* [Emphasis supplied].

[3] Condition (2) provides (RAI-73-9 691, 713):

The Applicants shall submit, during the time of the operating license review, proposed environmental Technical Specifications governing the operation of the Davis-Besse facility which assure that the environmental impacts are not significantly different from those described in the FES.

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

LBP-73-35

ATOMIC SAFETY AND LICENSING BOARD

Thomas W. Reilly, Chairman
E. Leonard Cheatum, Member
Gustave A. Linenberger, Member

In the Matter of

COMMONWEALTH EDISON COMPANY

(Zion Station, Units 1 and 2)

Docket Nos. 50-295
50-304
October 5, 1973

HEADNOTES

1. In view of evidence that containment building could withstand impact of 200 knot vertical nose dive of 100,000 pound DC-9 type aircraft and that nearest airport never served planes that large, Licensing Board would not order changes to or further review of structural integrity of facility to protect against accidental or deliberate crash of aircraft.

2. In view of evidence that general frequency of aircraft hijacking has been calculated to be 1×10^{-6} per air carrier movement, coupled with fact that, in all air hijackings to date, not a single aircraft has ever been crashed into a nuclear facility, Licensing Board could find no basis to order further strengthening to structural integrity of facility to provide for remote possibility that the largest jumbo jet (Boeing 747) might someday deliberately be crashed into a nuclear facility.

3. Security plan for nuclear power plant would not be measured against what additional security measures could also be taken (how many more watchmen or security devices could be employed) but rather against what is the reasonable and customarily-followed standard in the same industry.

4. In the face of evidence that heat is a "nonresidiary contaminant" in that it dissipates rapidly in a lake as huge as Lake Michigan (320 miles long and 85 miles wide) and that the plume size is miniscule in relation to the heat-assimilative capacity of the entire lake, the Board could find no evidence to support Intervenors' contention that damage to the lake from plant operation "might be irreversible and widespread."

APPEARANCES

Michael J. Miller, Esq., **A. Daniel Feldman**, Esq., and **John W. Rowe**, Esq., of Isham, Lincoln & Beale, For the Applicant, Commonwealth Edison Company.

Robert J. Vollen, Esq., For the Intervenors, BPI, David Dinsmore Comey, Sierra Club, and the Metropolitan Sanitary District of Greater Chicago.

R. Rex Renfrow, III, Esq., **Howard M. Wilchins**, Esq., **Geoffrey P. Gitner**, Esq., **Frederic S. Gray**, Esq., and **Joseph Gallo**, Esq., For the AEC Regulatory Staff.

INITIAL DECISION

I. INTRODUCTION AND PRELIMINARY FACTS

1. This proceeding involves the application filed by the Commonwealth Edison Company (Applicant) for facility operating licenses authorizing operation of two pressurized water nuclear reactors known as the

Zion Nuclear Power Station, Units 1 and 2. Each unit is designed for operation at steady-state core power levels of up to 3,250 megawatts thermal (MWt). The plant site for this two-unit electric generating station is located on the Applicant's property on the western shore of Lake Michigan in the City of Zion, Lake County, Illinois.

2. The initial application for a construction permit and operating license for Unit 1 was filed with the Atomic Energy Commission (the Commission or "AEC") on July 12, 1967, and this application was assigned Docket No. 50-295. On August 15, 1967, the Applicant submitted Amendment 1 to its application, requesting a construction permit and operating license for two facilities, Units 1 and 2. The application for Unit 2 was assigned Docket No. 50-304. Following review of the two applications by the AEC's Regulatory Staff, an uncontested public hearing was held in September, 1968, in Waukegan, Illinois, before an Atomic Safety and Licensing Board. After the completion of the hearing and the issuance of the Board's initial decision, and pursuant to an Order of that Board, the Director of Regulation was authorized to issue construction permits. On December 26, 1968, the Director of Regulation issued provisional construction permits—number CPPR-58 for Zion Unit 1 and CPPR-59 for Zion Unit 2. Subsequently, upon request of the Applicant, the Commission extended the construction completion date for Zion Unit 1 (CPPR-58) to June 1, 1973 and for Zion Unit 2 (CPPR-59) to April 1, 1974.

3. On November 25, 1970, Applicant filed, as Amendment 12 to the application, the Final Safety Analysis Report (FSAR) required by §50.34(b) of Chapter 10 of Part 50 of the Code of Federal Regulations (10 CFR Part 50).

4. Applicant's Environmental Report was submitted on May 17, 1971. Four supplements were thereafter submitted as required by revised Appendix D to 10 CFR Part 50 published on September 9, 1971. In accordance with Paragraph 3, Section E of the Commission's regulations implementing the National Environmental Policy Act of 1969 (NEPA), Applicant submitted by letter dated October 18, 1971, a statement of reasons and supporting information why construction permits numbers CPPR-58 and CPPR-59 should not be suspended pending completion of the environmental review. The Director of Regulation subsequently determined that construction activities at the Zion Station should not be suspended pending completion of the NEPA environmental review (36 *F.R.* 23006).

5. The Advisory Committee on Reactor Safeguards ("ACRS") has reviewed the application and issued reports dated August 17, 1972, and May 17, 1973, which have been available to the Board in this proceeding. (The ACRS Report is required by §182(b) of the Act, and §2.743(g) of the Commission's Rules, 10 CFR Part 2, requires that it be offered in evidence at the hearing.) The ACRS, for reasons set forth in those letters, has recommended that the Units be allowed to operate but that power levels not exceed 85 percent until after the first refueling of Unit 1, and the Applicant has agreed to such operating limitations. To the extent that concerns expressed by the ACRS are satisfied prior to the first refueling of Unit 1, the operating limitations may be released earlier than that time.

6. Pursuant to the Atomic Energy Act of 1954, as amended (the Act), and the Commission's Regulations, the Atomic Energy Commission on June 30, 1972 published a "Notice of Consideration of Issuance of Facility Operating Licenses and Notice of Opportunity for Hearing Pursuant to 10 CFR Part 50, Appendix D, Section C" (37 *F.R.* 12982). That Notice announced that the Commission was considering the issuance of operating licenses to the Commonwealth Edison Company for its Zion Station, Units 1 and 2, upon determining that the facilities had been constructed in accordance with the applications and construction permits, upon receiving a report from the Advisory Committee on Reactor Safeguards (ACRS), the submission of a favorable Safety Evaluation by the Commission's Directorate of Licensing, the completion of the required environmental review pursuant to 10 CFR Part 50, Appendix D, and upon a finding by the Commission that the applications complied with the requirements of the Act and the Regulations (10 CFR Chapter 1). The Notice further provided that the licenses would not be issued until the Commission inspected the facilities for conformance of construction with the applications and the construction permits and only after concluding that the issuance of said licenses will not be inimical to the common defense and security or to the health and safety of the public. The Notice also provided that the Applicant could request a hearing with respect to: (1) whether, considering those (environmental) matters covered by Appendix D to 10 CFR Part 50, the provisional construction permits should be continued, modified, terminated, or appropriately conditioned to protect environmental values; and (2) with respect to the issuance of the requested facility operating licenses. The Notice stated that "... any person whose interest may be affected by this proceeding may file a petition to intervene." The Notice specified when

and how requests for a hearing and petitions for leave to intervene were to be filed. The Notice also gave the addresses of two locations (Washington, D.C. and Waukegan, Illinois) where a large quantity of reference materials and documents were freely available for public inspection in connection with the license applications, environmental reports, etc.

7. On July 21, 1972, Mrs. Eileen Jenkins of Kenosha, Wisconsin, filed a document entitled "Petition to Intervene". On July 31, 1972, Businessmen for the Public Interest ("BPI"), the Metropolitan Sanitary District of Greater Chicago, the Sierra Club and David Dinsmore Comey filed a joint petition to intervene.

8. By Memorandum and Order dated September 29, 1972, the Commission concluded that a hearing should be held and admitted BPI and David Dinsmore Comey as intervenors party to the proceeding. (37 *F.R.* 20995, 10/5/72.) The Commission also concluded that the rights of the other petitioners were to be determined by an Atomic Safety and Licensing Board ("ASLB" or Board) after certain factual matters were clarified. The Memorandum and Order was accompanied by a Notice of Hearing on a Facility Operating License which named Jerome Garfinkel, Gustave A. Linenberger and Dr. E. Leonard Cheatum as members of the ASLB. Subsequently, Thomas W. Reilly, who had been the alternate chairman, was appointed Chairman of the Board (37 *F.R.* 25251).

9. On November 16, 1972, Applicant and Businessmen for the Public Interest, the Sierra Club, the Metropolitan Sanitary District of Greater Chicago and David Dinsmore Comey entered into an agreement regarding the scheduling of the evidentiary hearing. In addition, the other signatories agreed not to oppose Applicant's motion, pursuant to §50.57(c), for a fuel loading and low power testing license for Zion Unit 1.

10. A Special Prehearing Conference was held in Zion, Illinois, on November 17, 1972. In its Special Prehearing Conference Order of December 5, 1972, the Board ruled that the Sierra Club and Metropolitan Sanitary District of Greater Chicago be admitted as additional intervening parties. The petition of Mrs. Eileen Jenkins was denied but she was advised of her right to make a limited appearance at the evidentiary hearing. Pursuant to the agreement of the parties the Board directed the evidentiary hearing to commence on April 2, 1973.

11. Additional prehearing conferences were held on February 1, 1973, in Chicago, Illinois, and March 12, 1973, in Washington, D.C.

12. On March 7, 1973, Applicant, the Regulatory Staff (Staff) and Intervenors submitted a Stipulation with Regard to Contentions listing 13 contentions which Intervenors sought to have placed in issue in the evidentiary hearing as matters in controversy. Applicant and Staff objected to the admissibility of some of the contentions. The Board heard oral argument at the final prehearing conference of March 12, 1973, and ruled on the disputed contentions in its Final Prehearing Conference Order of March 15, 1973. All parties filed motions to reconsider the rulings on disputed contentions. After reviewing the motions and arguments, the Board revised and clarified its rulings in an Order dated March 27, 1973. The contentions admitted as issues and matters in controversy, subject to those orders and on which the Board heard evidence, may be briefly entitled: containment pressure, inputs to ECCS evaluation model, fuel densification, peaking factors, technical specifications, aircraft crashes, security plan, quality assurance, quality assurance documentation, operating qualifications, the probability of Class 9 accidents, and the environmental effects of an open-cycle cooling system on Lake Michigan. Intervenors subsequently filed a Motion for Reconsideration of the Board's ruling excluding a contention regarding steam generator tube ruptures and ECCS performance on April 25, 1973. The Board denied this motion during the evidentiary hearing (Tr. 1131-32).

13. The parties in this proceeding have engaged in two kinds of discovery—informal and formal. Applicant made its document files available to Intervenors in early 1972 (Tr. 85) prior to the time a Notice of Consideration of Issuance of Facility Operating Licenses had been published because Intervenors had, by that date, indicated their intention to oppose issuance of a full power license. Intervenors also met with Applicant's personnel and consultants to discuss their concerns (Tr. 83). With regard to Applicant's documents and technical staff, Intervenors have had virtually unlimited informal discovery (Tr. 111). In addition, the Regulatory Staff produced great numbers of documents for Intervenors[1] (Tr. 99-100). The parties engaged in active and extensive formal discovery through depositions, requests for admissions,

[1] Pursuant to discovery requests of Intervenors, the Regulatory Staff reproduced and sent to Intervenors over 8,000 pages of documents.

interrogatories and requests for production of documents after the first prehearing conference. The schedule for discovery and other procedural matters was fixed by an order of the Board rendered February 28, 1973, in response to a joint motion filed by all of the parties on February 27, 1973. It set March 15, 1973 as the final day for initiation of discovery, and March 20, 1973 as the final day for completion of discovery. Intervenor David D. Comey was deposed on March 15, 16, and 30, 1973, by Applicant and Staff. Walter E. Vetter, Construction Branch Chief of the Atomic Energy Commission, was deposed by Intervenors and Applicant on March 16, and 19, 1973.

14. On application of Intervenors, a subpoena was issued on March 6, 1973, for Mr. E. T. Murphy or another representative of Westinghouse Electric Corporation (Westinghouse) who had custody and knowledge of documents described therein. Westinghouse, a non-party, filed a timely motion to quash and Intervenors submitted a memorandum in support of their application. Applicant supported the motion to quash the subpoena. On March 27, 1973, the Board granted the motion to quash. The matter was subsequently referred to the Atomic Safety and Licensing Appeal Board (Appeal Board) in accordance with §2.730(f) of the Commission's rules. In a Memorandum and Order dated April 17, 1973, (ALAB-116), the Appeal Board reversed the order granting referral.

15. A portion of the documents in this proceeding were subject to protective orders because of their confidential nature. Applicant's Zion Station Security Plan was given to Intervenors under the terms of a protective order issued as part of the Final Prehearing Conference Order of March 15, 1973. Portions of Applicant's testimony dealing with inputs to the ECCS model and fuel densification were claimed to be proprietary to Westinghouse. Applicant moved for protective orders for this information on March 26, 1973, and May 4, 1973. Intervenors opposed these motions in their memoranda of March 27, 1973, and May 14, 1973. After reviewing the filings and hearing extensive argument during the evidentiary hearing the Board granted Applicant's motions and the documents were delivered to Intervenors, subject to such orders, for their use in this proceeding.

16. Intervenors filed Requests for Production of Documents from Applicant on March 14, and 15, 1973. Applicant responded by delivering some of the documents and objecting to some of the requests. In addition, some of the material was identified as proprietary to Westinghouse. Applicant also filed on April 3, 1973, a Motion for Protective Order Regarding Documents which Intervenors have Requested Be Produced. The Motion was granted after argument during the evidentiary hearing on April 4, 1973, and the documents were delivered to Intervenors (Tr. 682).

17. On April 2, 1973, the evidentiary hearing was convened in Waukegan, Illinois. Limited appearances were made by Mrs. Eileen Jenkins, Mr. George Louthan, State Senator John Conolly, Mr. Arnold Leder, Mayor W. Bruce Dunbar of Zion, Illinois, and Ms. Catherine Quigg.

18. On April 9, 1973, David D. Comey, one of the Intervenors, became ill and the hearing adjourned on April 10, 1973. The hearing was reconvened on May 15, 1973, in Chicago, Illinois, pursuant to a stipulation and motion of the parties (Tr. 1124). The hearing continued through June 15, 1973. On that date, Intervenors' counsel, Robert J. Vollen, Esq., was injured and was therefore unable to attend the hearing. By agreement of the parties, the evidentiary hearing proceeded on June 21, and 22, 1973, in the absence of Mr. Vollen. Those sessions were limited to the contention dealing with open-cycle cooling and Intervenors' interrogation was conducted by David D. Comey who had previously been allowed to act as a "Technical Interrogator" (Tr. 3667, 3670). The hearing then proceeded with Mr. Vollen present from July 9 through July 13, and July 17 through July 20, ending on the latter date.[2] The record was formally closed on July 27, 1973.

19. On July 20, 1973, Applicant presented to the Board and to the parties a motion regarding the closing of the record in this proceeding. The motion dealt with closing the evidentiary record for Zion Units 1 and 2, transmittal of Unit 2 construction quality assurance documents to the parties and the Board, notification of the parties and the Board of hot functional testing of Unit 2 and procedures for considering Unit 2 construction quality assurance matters arising subsequent to July 20, 1973. The Board heard oral argument on July 20, and directed the parties to submit written briefs on the matter. On July 27, 1973, the Board granted Applicant's motion, closing the evidentiary record as to all matters in controversy. The

[2] There are 40 volumes of daily hearing transcripts, ending with transcript page 5525. However, the complete recorded transcript totals closer to 6,000 pages since there are several volumes separately numbered for the *in camera* sessions.

parties were directed to submit written findings and briefs pursuant to the schedule contained in the Stipulation dated April 20, 1973. Applicant and the Staff were directed to furnish copies of all correspondence relating to Unit 2 construction quality assurance to Intervenors and to the Board and to inform the parties and the Board when hot functional testing on Unit 2 will be commenced.

20. The Board's July 27 Order Closing the Record provided a mechanism for affording the Intervenors, as well as all other parties, an opportunity to request an additional hearing limited to matters arising since the close of the public hearing in Chicago on July 20, 1973. The Order specifically referred to QA matters in Zion Unit 2 construction, but also envisioned, and provided for, the possibility that specific contentions in other areas might also be forthcoming. The entire mechanism for initiating a new, additional, limited hearing on Unit 2 hinged upon notice being filed with the Board, after service on all parties, requesting such hearing within ten days after the Applicant served notice of Unit 2 readiness for hot, functional testing (thus signifying completion of construction). The Board adopted the proposed mechanism for an additional, limited hearing on the theory that Unit 2 construction might possibly take another nine months, and conditions could change materially in that time (e.g., adherence by Applicant to QA program, etc.), and the Board wished to be certain that all parties had ample opportunity to question any materially changed circumstances over such a considerable time period. (The Intervenors objected to the mechanism for an additional hearing, arguing that as of July 20, 1973, the evidentiary record was full and complete, and that if the Applicant had not sustained its burden of proof on Zion 2 or any other facet of the case, that the license(s) should be denied.)

21. On September 4, the Applicant served notice on all parties and the Board that Unit 2 would be ready for hot, functional testing in two weeks. The ten day period from the date all parties were served such notice has long since come and gone, and no party has filed a request for an additional hearing, nor offered any correspondence or oral claims to any circumstances illustrating the need for a new hearing. Nor has the Board, after reviewing the entire evidentiary record of the hearing that ended in Chicago on July 20, detected any compelling need for an additional evidentiary proceeding. If, in fact, the remaining construction on Unit 2 had taken about nine more months (as indicated by the extension of Applicant's construction time limit on Unit 2 granted recently by the Director of Regulation) the Board, even in the absence of a specific request, would have exercised jurisdiction *sua sponte* to establish on an evidentiary record the QA performance of Applicant over remaining Unit 2 construction since July 20, 1973 and the Board fully intended to retain such jurisdiction in the present Initial Decision. However, the short period between July 20 and September 4 notice of readiness for hot functional testing, in the absence of filed contentions or evidence to the contrary, presents no basis to believe that conditions are materially different now from the way they were at close of the hearing. Accordingly, no supplemental hearing is being scheduled by the Board based upon the remaining Unit 2 construction.

Fuel Loading and Testing License

22. On January 26, 1973, Applicant filed a motion under the Commission's regulations for an order of the Board authorizing the Director of Regulation to make the appropriate findings under 10 CFR §50.57(c) and to issue a license for Zion Unit 1 for the loading of fuel and operation at not more than 50% power. Appended to the motion was the November 16, 1972 agreement between Applicant and Intervenors providing that Intervenors would not oppose the issuance of the license if the Director of Regulatory Operations had stated in writing by April 2, 1973, that Zion Unit 1 was ready for fuel loading. The Board issued such an order on February 7, 1973, and in response to a joint motion by all parties amended that order on February 27, 1973. On April 2, 1973, Counsel for the Regulatory Staff distributed to all parties copies of a memorandum dated March 31, 1973, from D. F. Knuth, Deputy Director of Field Operations, to A. Giambusso, Deputy Director for Reactor Projects (Tr. 506-507). This memorandum stated that Zion Unit 1 was ready for fuel loading. During the evidentiary hearing, the Board heard extensive argument from the parties regarding the language of the memorandum. On April 6, 1973, Counsel for the Staff announced that the Atomic Energy Commission was issuing the license previously authorized by the Board's order. Intervenors' requests for an order of the Board directing the Staff to withdraw the license and a stay were denied (Tr. 1012, 1013). Intervenors then moved for an emergency stay by telegram to the Appeal Board dated April 9, 1973. In its Memorandum and Order dated April 9, 1973, (ALAB-112), Intervenors' request was denied. The Directorate of Licensing issued Facility Operating License No. DPR-39 for Zion Unit 1 on April 6, 1973 (38 *F.R.* 9340-9341).

23. On May 16, 1973, Applicant filed a motion pursuant to 10 CFR §50.57(c) for an order authorizing the Director of Regulation to make appropriate findings and to amend operating license No. DPR-39 for Zion Unit 1 to allow further operation of Unit 1. Appended to that motion was the Stipulation entered into by all parties on April 20, 1973, providing that Intervenors would not oppose the motion by Applicant for operation of Unit 1 at designated levels, including not more than 480 hours at 75 percent power. The Stipulation authorized operation for not more than 37 days following the date on which Intervenors filed their proposed findings of fact. This authorization was to expire on August 6, 1973, if the record was not closed by July 1, 1973, as a result of factors beyond the control of Intervenors. On the last day of the evidentiary hearing, July 20, 1973, Robert Vollen, Counsel for Intervenors, acknowledged that the portion of the Stipulation regarding the expiration of the license on August 6, 1973 was not applicable (Tr. 5383). Accordingly, on July 24, 1973, the Board issued an order authorizing amendment of operating license No. DPR-39 to allow further operation of Zion Unit 1 in accordance with the agreement of the parties. This was followed by a September 20 Order, per stipulation, extending operation until the Board issues this Initial Decision, but with a limit of about 52% power (1700 MWt).

II. MATTERS IN CONTROVERSY AND ULTIMATE ISSUES TO BE DECIDED

24. By B.P.I.'s original "Petition to Intervene" dated July 31, 1972, B.P.I. and Mr. Comey originally filed hundreds of pages of "contentions," containing paragraphs and subparagraphs under a rather complex numbering system. However, by virtue of the March 7, 1973 "Stipulation With Regard to Contentions" signed and filed by all three parties (Applicant, Regulatory Staff and Joint Intervenors), the contentions were narrowed to thirteen separately numbered contentions, covering 59 pages. These were further narrowed by the Board's rejection of Contention Number 2,[3] with its four sub-parts (A through D) for reasons expressed in the Board's March 15 and March 27, 1973 Orders ruling on the motions and arguments of the parties. The Board also limited the evidentiary scope of five of the numbered contentions (3, 4, 5, 12 and 13) by virtue of those same Board Orders. Seven of the original 13 contentions were accepted by the Board as filed in the Stipulation of the parties.

25. The first ten of the twelve allowed contentions dealt with so-called "radiological health and safety" matters, whereas the last two dealt with the possible environmental effects of plant operation and whether potential adverse environmental impacts had been properly accounted for. The last numbered contention, "Contention 13: Open-Cycle Cooling System" was so vague and general that the Board, by its March 15, 1973 Order, very specifically delineated the scope of the evidence that would be accepted on that contention.

26. Thus, at the outset of the evidentiary hearing, the final revised contentions, stated briefly, consisted of the following twelve subject areas, the first ten of which may be classified as "radiological" and the last two as "environmental" matters:

Contention	
1	Containment Pressure
3	Nonconservative Inputs to ECCS Evaluation Model[4]
4	Fuel Densification[4]
5	Peaking Factors[4]
6	Technical Specifications
7	Aircraft Crashes
8	Security Plan
9	Quality Assurance
10	Quality Assurance Documentation
11	Operating Qualifications
12	Class 9 Accident Analyses (validity of assigning low probability)
13	Open-Cycle Cooling System (adverse environmental effects)

[3] All four sub-parts of Contention Number 2 dealt with the Emergency Core Cooling System Design.

[4] As specifically limited to the Zion Plant only, per Board's March 15 and March 27 rulings on contentions.

The substance of the contentions is set forth in more detail in the contention-by-contention discussion in the "Findings of Fact" section *infra.*

27. Beyond the radiological and environmental contentions that were specific matters in controversy between the parties, there are also certain other ultimate issues that are the responsibility of this Board to decide. Pursuant to the Commission's Notice of June 27, 1972 (37 *F.R.* 12982, published 6/30/72) and the National Environmental Policy Act of 1969 ("NEPA", P.L. 91-190), the Zion Station facilities are subject to the provisions of Section C of Appendix D to 10 CFR Part 50. Accordingly, the Board must also determine whether, with respect to those matters covered by Appendix D to 10 CFR Part 50, the construction permits should be continued, modified, terminated, or appropriately conditioned to protect environmental values. In accord with the mandate of the U. S. Court of Appeals in the *Calvert Cliffs* decision,[5] the Board would also be required to conduct an independent evaluation and balancing of environmental factors, assessing the benefits of the issuance of the proposed facility operating licenses and weighing these benefits against the environmental costs, but only if the environmental matters in controversy generated evidence or information that would affect the balancing of values already performed by the Commission's Regulatory Staff in its environmental impact analysis. Otherwise, the Licensing Board is limited to matters in controversy. *Consumers Power Co.* (Palisades Plant) ALAB-70, Sept. 27, 1972; 10 CFR §2.104(c)(7), §2.760a, and Appx. D to 10 CFR Part 50, §A(11). However, whether or not there is an independent balancing function to be performed by a licensing board, it is the view of this Board, and it so finds, that when an Agency's Final Environmental Impact Statement is part of the evidence to be reviewed by a licensing board, that board, to be in consonance with the *Calvert Cliffs* decision, has the duty of reviewing the adequacy of that detailed environmental statement, and of either making changes where possible or citing its specific deficiencies. In performing its responsibilities under NEPA and Appendix D to Part 50, the Board is not required to duplicate the Regulatory Staff's analysis, but must make an independent review of Staff proposals, with Board conclusions independently arrived at on the basis of evidence in the record, including the Staff's Final Environmental Statement. *Wisconsin Electric Power Co.* (Point Beach 2) ALAB-137, at 51, advance sheets, July 17, 1973. The Board's initial decision may include findings and conclusions which affirm or modify the contents of the Staff's detailed Final Environmental Statement. To the extent that findings and conclusions different from those in the Staff's FES are reached, the FES shall be deemed modified to that extent. 10 CFR 50, Appendix D, §A(11).

28. Another ultimate issue for this Board to decide, beyond the specific contentions or matters in controversy between the parties, is the question of whether the operation of the facilities as proposed will be in compliance with the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500, 86 Stat. 816) ("FWPCA"). If the State of Illinois now has Federally-approved water quality standards pursuant to §303 FWPCA, the Board must determine whether operation of the plant will be in compliance with those standards. Beyond this, and within the guidelines set forth in the EPA/AEC Memorandum of Understanding and the Interim Policy Statement[6] (IPS) on Implementation of §511 of the FWPCA, the Board must determine the adequacy of the facilities' effluent discharge system and monitoring capability where, as here, there is a "negative certification" by the state (see §401(a)(1) FWPCA) that there are *no* applicable effluent limitations under §§301(b) or 302 and no applicable standards established under §306 or 307 of the FWPCA. Since the "negative certification" by the State of Illinois operates so as to eliminate the applicability of §511(c)(2) which bars a Federal licensing agency from imposing "any effluent limitation other than" one established pursuant to FWPCA, the Board is left with the responsibility of making its determination of the adequacy of the facilities' effluent discharge and monitoring systems by means of the previously existing[7] NEPA–*Calvert Cliffs* environmental review procedures.

III. EVIDENTIARY PRESENTATIONS

A. RADIOLOGICAL HEALTH AND SAFETY MATTERS

29. Applicant's direct case on radiological matters consisted of the introduction of the Final Safety Analysis Report (10 volumes plus amendments), and the testimony of a number of company witnesses

[5] *Calvert Cliffs Coord. Committee* v. *AEC* (D. C. Cir. 1971) 449 F.2d 1109.

[6] 38 *F. R.* 2679, 2713, published Jan. 29, 1973.

[7] Pre-FWPCA Amendments of 1972.

(employees and officials of Applicant Commonwealth Edison Company) and expert witnesses responding to matters raised by the Intervenors' specific contentions. The company witnesses and expert witnesses sponsored into evidence a long series of documents, records, portions of company procedural manuals and reports to document or illustrate the Applicant's handling of the subject areas questioned by the Intervenors' contentions.

30. Applicant's witnesses in the radiological area included Mr. Byron Lee, Jr., Assistant to the President of Commonwealth Edison Company (Mr. Lee was later promoted to Vice President before the hearing terminated); Mr. Joseph C. LaVallee, project engineer for Sargent & Lundy on the Zion Station project; Mr. Lester Berkowitz, engineer and Program Manager for the Westinghouse Electric Corporation's Pressurized Water Reactor Systems Division. All three of these witnesses appeared initially to authenticate and sponsor into evidence the Final Safety Analysis Report (FSAR-App. Ex. 4), since all three had responsibility for supervising the preparation of portions thereof (Tr. 744-759, 767-780). These same witnesses later reappeared to testify on other matters. Other witnesses for Applicant on the radiological aspect were Mr. Nicholas Kershaw, a supervisory mechanical engineer employed by the Applicant, who testified as to the Zion Station Quality Assurance (QA) Plan and the Applicant's QA procedures (Tr. 881-945); Mr. Edwin Hemzy, an engineer and QA Coordinator for Engineering and Construction on nuclear power generating stations for the Applicant, who also testified in the QA area (Tr. 958-1237); Mr. William Warwick, a mechanical engineer and electronic engineer, who is employed by the General Electric Company as a Project Manager in the QA area on the Apollo Space Program, but whose unit was retained as a consultant by the Applicant to assist in the development of the Zion Station QA program (Tr. 1238-1349); Mr. William Murray, of the William J. Murray and Associates consulting firm, called by the Applicant to testify regarding expected air traffic and airport development at the Waukegan Airport vis-a-vis the airplane crash contention of Intervenors (Tr. 1586-1611, 1615-1641); Mr. John Losee, a chief pilot for the OMC Corp. operating out of Waukegan Airport, also on the plane crash contention (Tr. 1880-1902, 2407-2423); Mr. John Vallance, an engineer and member of the consulting firm of Pickard, Lowe & Associates, Inc., called to testify regarding probability studies made of the probability of an aircraft using Waukegan Airport colliding with Zion Station 3½ miles away (Tr. 1644-1661, 1667-1720); Dr. German R. Gurfinkel, Ph. D., Assoc. Prof. of Civil Engineering, University of Illinois, called to testify regarding a computational analysis of the potential effects of the crash of an aircraft into the reinforced concrete structures of Zion Station (Tr. 1721-1723); Mr. Jack Bitel, a Commonwealth Edison Company mechanical engineer, who had been a project engineer on the Applicant's Dresden and Quad Cities nuclear plant construction, and who has been Superintendent of Zion Station since 1970, with responsibility for operation of Zion Station, including development of and compliance with Technical Specifications (Intervenors' Contention 6) (Tr. 1798-1876, 1903-1931); Mr. Frank Palmer, an engineer employed by Applicant as the Superintendent of Production—Nuclear for all the Applicant's nuclear power plants, who participated in the preparation and implementation of the Zion Station Industrial Security Plan (Intervenors' Contention 8) (*in camera* Tr. 3A-108A, 5/23/73; *in camera* Tr. 3B-19B, 5/25/73). Mr. Byron Lee, Jr., Vice President of Commonwealth Edison Company, was recalled to give testimony on Intervenors' Contention 11—Operating Qualifications (Tr. 2224-2300). A panel of four expert witnesses from the Westinghouse Corporation was put on the witness stand to give testimony relating to Intervenors' Contentions 3, 4 and 5 (Nonconservative Inputs to ECCS Evaluation Model, Fuel Densification, and Peaking Factors), namely, Dr. John Roll, Ph. D. in Chemical Engineering, formerly Manager of Performance Analysis, Nuclear Fuel Division and now Assistant to the Engineering Manager, Nuclear Fuel Division, Westinghouse; Mr. Lowell Boman, mechanical engineer, formerly Manager of Thermal and Hydraulic Design in Core Engineering for Westinghouse, and now Engineering Branch II Manager, Nuclear Fuel Division, Westinghouse; Mr. George Uram, Senior Engineer in the Accident Analysis Section of the PWR Systems Division, Westinghouse; and Mr. Lester Berkowitz, chemical and nuclear engineer previously described herein (panel testimony: Tr. 2303, 2317-2347, 2351-2406, 2424-2458, *in camera* Tr. 1C-12C, 5/30/73, later declared non-proprietary and released, Tr. 2465-2557, 2575-2644, 2766-2807, 2832-2933, 3546-3606). A second panel of Westinghouse experts was put on by the Applicant to address the subject of containment pressure (Intervenors' Contention 1), which panel consisted of three engineers, Mr. Frank Bordelon, mechanical engineer and Manager of the Safeguards Analysis group in the PWR Systems Division, Westinghouse, who was responsible for analyses of the consequences of a postulated loss-of-coolant accident and who supervised the ECCS evaluation and containment energy release analyses for Zion

Station, Mr. Michael Mangan, electrical engineer and Manager of the Containment Systems group in the PWR Systems Division, Westinghouse, who was responsible for the analysis of containment pressure transients following postulated pipe ruptures, and Mr. John Connor, nuclear physicist and Senior Engineer in Technical Operations, Special Licensing Projects, PWR Systems Division, Westinghouse, who was responsible for reviewing the safety of design, construction and operation of the nuclear power system built by Westinghouse for the Zion Station (panel testimony: Tr. 4132-4219). Mr. Joseph C. LaVallee, project engineer for the architect-engineering firm of Sargent & Lundy, was recalled to testify on the subjects of containment pressure (Intervenors' Contention 1) (Tr. 4354-4389), main steam line check valves (Contention 10-QA Documentation) (Tr. 4399-4417), and Class 9 accidents (Contention 12) (Tr. 4418-4425).

31. Applicant called several witnesses on its rebuttal case in the radiological area. Mr. John Laasch, an engineer now with the Wisconsin State Highway Commission, but who was formerly employed by the Robert W. Hunt Company, a firm responsible for the quality control of concrete work on the Zion construction site, was called by the Applicant to give additional evidence in the QA area encompassed by Intervenors' Contention 10, and was produced mainly in response to a Board request for additional information in the QA area (Tr. 4426-4446, see explanation of counsel, 4435). Mr. Edwin Hemzy, engineer and QA Coordinator for the Applicant was recalled to testify in partial response to Intervenors' "surprise witness" Mr. Connolly, regarding the QA subjects of non-certificated or non-qualified welders, improper pre-heating of "rebars" and alleged improper handling of welding rods (Tr. 4603-4715). Mr. Robert Bremmer, a quality control engineer and Manager of the Quality Assurance Surveillance unit in the Westinghouse PWR Systems Division, was called by the Applicant in response to a Board request for additional information regarding the Zion QA program with respect to heat treatment of Westinghouse furnished valves (Tr. 1206-07, 4725-4767). Mr. Max Zar, structural engineer from the Sargent & Lundy firm, was called to testify regarding the identification and evaluation of the Class I welds made by the Walsh Construction Company and analysis of structural effects, in response to testimony of Intervenors' witness Connolly and Board questions arising therefrom (Zar, Tr. 4781-4812, 4848-4867). Mr. Levi Bird, supervising engineer in the Applicant's Station Construction Department, testified as to the document review and construction drawings review of the Walsh Construction Company welds (Tr. 4815-4832). Mr. David Dunn, a civil engineer and the Chicago District Manager for the Pittsburgh Testing Laboratory (PTL), testified regarding the testing of weldments performed by PTL by request of the Applicant (Tr. 4832-4848, 4868-4903). Mr. Michael Mangan of Westinghouse, previously identified, was recalled in response to Board questions regarding consideration given to painted surfaces in the determination of heat sinks and heat transfer rates, vis-a-vis containment peak pressures (Tr. 4981-4999). Other rebuttal witnesses included Mr. Robert Green of X-Ray Engineering Corp. (Tr. 4999-5023), Mr. Joseph Lella of Pittsburgh Testing Laboratories (Tr. 5023-5068), and Mr. Edward Potter, Commonwealth Edison Company senior engineer in metallurgical and non-destructive testing unit, materials section (Tr. 5069-5133), all three of whom testified to the testing of Walsh Company Class I welds. Mr. Edward Boyd, Commonwealth Edison Zion site quality assurance coordinator, testified to the review of Walsh Company records of welder qualifications (Tr. 5141-5212); Mr. Frederick McCarty, Assistant General Superintendent of the Walsh Construction Company at Zion, testified regarding the heating of rebars, handling of welding rods and welder qualifications (Tr. 5214-5273), and Mr. Tom Pettikas, a structural engineer for Sargent & Lundy, testified to concrete strength standards, hardness and testing of same at Zion (Tr. 5273-5296). Mr. Eugene Young, a quality control engineer from United Engineers & Constructors, testified to the inspection of thickness of the valves and valve walls at Zion (Tr. 5134-5140); Mr. Harold Wenzel, Sargent & Lundy engineer and concrete specialist, testified regarding concrete strength testing and cold weather effects (Tr. 5305-5345); and Mr. Adolph Walser, chief structural engineer for Sargent & Lundy, testified to the seismic analysis done for Zion Station (Tr. 5345-5354).

32. The Regulatory Staff's case in the radiological health and safety area consisted of the introduction into evidence of their Safety Evaluation Report (Staff Ex. 1), the required ACRS report, and other exhibits responding to questions raised by Intervenors' contentions, as well as a series of expert witnesses and AEC officials who testified regarding different aspects of the Regulatory Staff's analysis, review, surveillance and investigation of the Zion plant, its construction, and its applications for operating licenses. The Staff's witnesses included Mr. Ralph Birkel, Senior Project Manager, Pressurized Water Reactors (PWR) Branch No. 3, AEC Directorate of Licensing, and specifically the Project Manager for the Commission's safety review of the Zion Station application for operating licenses (Tr. 816); Mr. Walter Vetter, Chief, Reactor

Construction Branch, AEC Directorate of Regulatory Operations, supervisor of nine reactor inspectors including those assigned to inspect the Zion Station construction (Tr. 1350-1505). Mr. Darrel Eisenhut, Project Manager in the Gas-Cooled Reactors Branch, AEC Directorate of Licensing, had the function of reviewing the nuclear safety features of nuclear facilities and, specifically, performed the nuclear facility–nearby airport analysis for several nuclear plants including Zion (Tr. 1724-1791). Mr. R. Wayne Houston, Chief of the Operational Safety Branch, AEC Directorate of Licensing, had responsibility for evaluation of the technical and administrative competence of reactor operating organizations (*in camera* Tr. 19B-66B, 5/25/73, Tr. 2174-2219)[8]; Mr. Dennis Crutchfield, engineer and Project Leader, Pressurized Water Reactors Branch No. 3, AEC Directorate of Licensing, is responsible for the analysis and evaluation of safety features in nuclear power reactors (Tr. 2942-2990); Dr. Howard Richings, Ph. D. in nuclear physics and Senior Reactor Physicist in the Core Performance Branch, AEC Directorate of Licensing, is responsible for the technical analysis and evaluation of reactor systems from an integrated nuclear, thermal and hydraulic viewpoint so as to ensure safe operation under normal, abnormal and emergency operation conditions (Tr. 2990-3033). Mr. Walter Jensen, nuclear engineer and Systems Analyst, Containment Systems Branch, AEC Directorate of Licensing, is responsible for the technical analysis and evaluation of the public health and safety aspects of nuclear reactor containment systems (Tr. 4233-4314). Mr. Karl Goller, nuclear engineer and Chief, PWR Branch No. 3, AEC Directorate of Licensing, is responsible for the analysis of the nuclear safety aspects of nuclear reactor facilities, including a specific assignment to Zion Units 1 and 2 (Tr. 4908-4939). Mr. Lester Rubinstein, reactor engineer and Chief, Reactor Fuels Section, Core Performance Branch, AEC Directorate of Licensing, is responsible for analyzing and evaluating nuclear fuel systems for safety and, in particular, fuel performance and design adequacy of models for densification, creep, thermal performance, failure modes, etc., and he was presented to respond to Dr. Kendall's testimony on the thermal conductivity integral (Tr. 4940-4980, 5358-5377). Mr. William Collins, metallurgical engineer in the Technical Assistance Branch, AEC Directorate of Regulatory Operations, testified on weld quality (Tr. 5390-5438); Mr. James Knight, senior mechanical engineer, Mechanical Engineering Branch, AEC Directorate of Licensing, testified on the subject of steam line check valves (Tr. 5441-5462); and Mr. David Jeng, senior structural engineer in the AEC Directorate of Licensing, specializing in structural and earthquake engineering, testified on his review of Class I welds done by the Walsh Construction Company and an analysis of the adequacy, from a structural standpoint, of Class I structures in which reinforcement bars ("rebars") may have been heated before being bent (Tr. 5463-5478).

33. The Intervenors' case on radiological health and safety matters consisted of the testimony of Dr. Henry W. Kendall, Ph. D. in atomic and nuclear physics, a professor of physics at the Massachusetts Institute of Technology; the testimony of Mr. John Connolly, a welder from the Walsh Construction Company on the Zion site; and the introduction into evidence of some twenty evidentiary exhibits, together with extensive cross-examination of all the Applicant's witnesses and the Staff's witnesses. (Dr. Kendall, Tr. 1989-2167, 3333-3540; Mr. Connolly, Tr. 1513-1525.) Mr. David Comey also took the stand briefly on both *voir dire* as to his qualifications to be a technical cross-examiner (Tr. 808) pursuant to §2.733 of the Commission's Regulations, and later in rebuttal to a portion of testimony given by Staff witness Vetter (Comey, Tr. 1531-1581).

B. ENVIRONMENTAL MATTERS

34. Applicant's direct case on environmental matters consisted of the testimony of a series of expert witnesses—Dr. Donald Pritchard, Ph. D. in Oceanography, Director of the Chesapeake Bay Institute at Johns Hopkins University and Professor of Oceanography, Dept. of Earth and Planetary Sciences, Johns Hopkins Univ. (Tr. 2649-2679); Dr. Wesley O. Pipes, Ph. D. in Sanitary Engineering, Professor of Civil Engineering and Biological Sciences at Northwestern University (Tr. 3035-3070, 3294-3303); Dr. Jacob Verduin, Ph. D. in Biology, Professor of Botany, Southern Illinois University (Tr. 3078-3136); Dr. Donald McNaught, Ph. D. in Limnology (Zoology), Associate Professor in Dept. of Biological Sciences, State University of New York and Director of the Cranberry Lake Biological Station (Tr. 3137-3175); Dr. G. Fred Lee, Ph. D., Professor of Water Chemistry at the University of Wisconsin (Tr. 3230-3285); Mr. Orville Tranby, senior engineer in the Commonwealth Edison Company Mechanical and Structural Engineering Dept. (Tr. 3304-3324, 3649-3696); Dr. George McVehil, certified consulting meteorologist and Director of Technical Services for the Sierra Research Corporation, Environmental Systems Division, Boulder, Colorado (Tr. 3608-3648); Dr. Edward Raney, Ph. D. in aquatic biology, Professor of Zoology, Emeritus, Cornell University and presently Director of Ichthyological Associates, a group of aquatic biologists involved in ecological research (Tr. 3958-4035). Many of these witnesses also introduced tables, charts and other exhibits that illustrated various portions of their testimony. As part of its environmental case, the Applicant also introduced a copy of a letter from the Environmental Protection Agency (EPA) to the State of Illinois regarding approval of Illinois water quality standards (Appl. Ex. 85–Tr. 3041, 3043). Mr. James Fancher, an Edison Company Systems Environmental Engineer, was produced by the Applicant in response to a Board request for a witness who could give further testimony on the study of a fossil fuel plant as an alternative for nuclear operation (Tr. 4516-4543).

35. The Regulatory Staff's case on environmental matters consisted of the introduction into evidence of the AEC's Final Environmental (Impact) Statement (FES: Staff Ex. 7, Tr. 3188), the Environmental Technical Specifications for Zion Station (Staff Ex. 8, Tr. 3190), correspondence between the AEC's Assistant Director for Environmental Projects and Region 5 of EPA, with copies of material from the Illinois Environmental Protection Agency, regarding the Zion Station discharge permit (Staff Ex. 9, Tr. 3228), and other environmental exhibits, as well as the testimony of several AEC environmental witnesses—Mr. Charles Domeck, Environmental Project Manager, Environmental Projects Branch No. 1, AEC Directorate of Licensing (Tr. 3181-3229); Dr. Joseph Draley, Ph. D. in Chemistry, a member of the Argonne National Laboratory, specializing in effects of chemical discharges from nuclear power plants on the environment (Tr. 3286-3294); Mr. Barton Hoglund, an engineer and Assistant Director, Center for Environmental Studies, Argonne National Laboratory, specializing in thermal plume dispersion studies, and who also serves as Associate Program Director, Great Lakes Research Program, with responsibility for study of the physical aspects of thermal discharges into the Great Lakes (Tr. 3696-3733); Dr. James Carson, Ph. D., a meteorologist member of the Argonne National Laboratory (Tr. 3736-3758); Dr. Gary Marmer, Ph. D. in Physics, responsible for the study of heat dissipation systems and specifically, in the case of Zion Station, the study of alternative cooling systems (Tr. 3758-3787); Dr. John Bolen, Ph. D. in aquatic biology, member of the Environmental Specialists Branch, AEC Directorate of Licensing, responsible for the review of the biological sections of the FES and the Environmental Technical Specifications (Tr. 3792-3892); and Mr. Richard Roman, an engineer and task group leader in the Environmental Statement Project section of the Argonne National Laboratory (Tr. 3893-3945, 4567-4601). Mr. Roman was recalled by the Staff (Tr. 4567) to give further testimony, together with Dr. Donald Conner, Ph. D., also of ANL, in response to a Board request for further information in the cost-benefit analysis area of the FES (Tr. 4567-4601). Dr. Norman Frigerio, Ph. D. in biophysical chemistry, a senior consultant to the Environmental Statement Project "on loan" from the Division of Biology and Medicine of the Argonne National Laboratory (ANL), and Mr. John Collins, lead nuclear engineer in the Effluent Treatment Systems Branch of the AEC Directorate of Licensing, testified as a panel in response to a Board request for more information on the "rad waste" section of the FES (Tr. 4547-4560). Mr. Edson Case, a nuclear engineer who is the Deputy Director of the AEC Directorate of Licensing, testified to the basis for the Staff's judgment that there is an extremely small likelihood of a loss-of-coolant accident ("LOCA") accompanied by failure of the ECCS to prevent a breach of containment (Intervenors' Contention 12) so that there is a correspondingly low probability of environmental harm (Tr. 4447-4503).

36. The Intervenors' case on environmental matters consisted of the testimony of Dr. John Neess, Ph. D. in Zoology and Statistics and Professor of Zoology at the University of Wisconsin (Tr. 2681-2765); a portion of Dr. Henry Kendall's testimony (see, for example, p. 3 of his pre-filed direct testimony, following Tr. 3333); and extensive cross-examination of all of the Applicant's and Staff's witnesses.

[8] Several of the Staff's witnesses returned to testify on more than one subject area. For the purpose of this brief summary of the evidentiary presentations, only the first transcript reference is given.

IV. FINDINGS OF FACT

A. RADIOLOGICAL HEALTH AND SAFETY

Contention 1: Containment Pressure

1.1* Intervenors' first contention addresses a multiplicity of considerations relating to compliance with 10 CFR Part 50, Appendix A–General Design Criteria 16 and 50. Most of these considerations fall into two categories. One deals with whether, in calculating the peak containment pressure resulting from a double-ended pump suction leg break, the sources and mechanisms of release of available energy have been adequately accounted for and the calculational methods appropriately verified. The other deals with whether the energy absorbing characteristics of the containment structure and its contents have been properly evaluated.

1.2 In summary, the Zion Units 1 and 2 reactor containment structures have been designed for maximum internal pressure of 47 psig (direct testimony of M. Mangan, F. Bordelon, and J. Connor, p. 15, following Tr. 4162; direct testimony of G. C. Lainas, sponsored by W. Jensen, p. 1, following Tr. 4241). The Applicant evaluated the maximum peak pressure for the Zion containments resulting from a loss-of-coolant accident (LOCA), employing numerous conservative assumptions (FSAR, Amend. 28). The maximum peak pressure calculated by the Applicant for such an accident is 42.4 psig. (Mangan, *et al.*, p. 3). Using a more conservative assumption, the Staff has calculated a value of 43.8 psig (para. 1.14, *infra*).

1.3 The Applicant has performed a structural integrity test for the Unit 1 containment to demonstrate the adequacy of the containment structures (direct testimony of LaVallee, pp. 3-4, following Tr. 4355). Following the AEC procedures, the Applicant pressurized the containment to a peak pressure of 54 psig with no sign of any structural distress (LaVallee, pp. 3-4). The overall performance of the structure during the test demonstrated that it is capable of withstanding 1.15 times the design internal pressure and, consequently, the much lower calculated peak pressure for a LOCA (LaVallee, p. 4). A containment leak rate test at the design pressure of 47 psig was also performed on Unit 1 containment. It indicated a leakage rate of 0.0214 percent of the containment volume per day (Tr. 4388; Int. Ex. I-20). The Board notes that the Technical Specifications establish 0.1 percent as the maximum allowable rate for a design basis accident (Staff Ex. 2, p. 213). Under questioning by the Board, the witness testified that the measured leak rate would not be expected to increase if the containment pressure were kept at 47 psig for one month (Tr. 4389). Furthermore, no unacceptable strains would be expected after one month of being held at the test overpressure of 57 psig (Tr. 4387). Hence the Board finds no merit to Intervenors' statement (Intervenors' Proposed Findings, para. 1.2) that Applicant does not know at what pressure the containment for Zion Unit 1 would fail.

1.4 Although containment integrity is not, per se, an issue, during the hearing a matter involving a deflection in the Zion Unit 1 containment liner was brought before the Board. On May 23, 1973, the Applicant informed the Staff of this condition, which was identified during a surveillance program required by the Technical Specifications (Tr. 4913). The Technical Specifications require that a surveillance program be conducted of the containment to detect any deflection in the liner exceeding .25 inches (Staff Ex. 2, p. 219; Tr. 4912). This value was established to assure early detection of any deflection and not because reaching or exceeding it constitutes a hazardous condition whereby the liner might not perform as intended (Tr. 4912-13). The Zion Station Unit 1 containment liner deflection exceeded the .25 value by approximately .03 inches (Tr. 4914). The Staff testified that this deflection would have no effect on the performance of the containment liner (Tr. 4926, 4932). The Board finds that this matter does not impair containment integrity and will not affect the health and safety of the public.

1.5 With regard to the sources of energy that give rise to the containment peak pressure pulse, the first specific question that Intervenors raised is whether or not the Applicant and Staff have correctly considered the heat produced by the decay of radioactive waste products accumulated in the reactor fuel. The subject

*The paragraph numbering system for the contentions sections utilizes the number of the contention being discussed as the base number for each paragraph, i.e., 1.1, 1.2, etc., for Contention 1. Since there is no admitted Contention 2, there will be no Section 2 nor any paragraphs such as 2.1, 2.2, etc. Contentions discussed in a group, such as 9 and 10 utilize the number of the first contention in the group for all the paragraphs of that group, e.g., 9 and 10 will all be discussed under the Section 9 paragraph series, 9.1, 9.2, etc.

of decay heat was thoroughly discussed at the Emergency Core Cooling System (ECCS) rulemaking hearing and the Interim Acceptance Criteria of the Commission require the use of the proposed ANS standard for decay heat (ANS 5.1) with an added factor of 20% for uncertainties. This standard was used in calculating the containment pressure for Zion (direct testimony of H. J. Richings, p. 1, following Tr. 4048). The ANS draft standard (Staff Ex. 13) is based upon a 1961 report by K. Shur (Tr. 3406-3407). The 1972 annual meeting of the American Nuclear Society included a report by Dr. England on decay heat which compared the results of his study with the results of the 1961 Shur study (Staff Ex. 10; Tr. 3407). Shur later carried out an additional analysis which indicated that when certain corrections are fed into the England analysis, the England predictions are well within the ANS proposed standard (Staff Ex. 13; Tr. 3415). Oak Ridge National Laboratory has also finished a complete review of the decay heat phenomena based solely on experimental data which confirms the ANS + 20% standard (Richings, p. 5). The record also indicates that at the ANS meeting held in Chicago in June of this year, the ANS subcommittee recommended that the draft standard be adopted in toto (Tr. 4056-4057).

1.6 The Intervenors, on the other hand, contend that the ANS 5.1 standard ignores certain elements and that the best estimate for the heat generated in the core during the first 1,000 seconds of a LOCA would be ANS 5.1 plus 56% (Richings, p. 1; Staff Ex. 13). The Intervenors basis for this conclusion is the thesis by England and certain discussions which Intervenors have had with an individual who was involved in that project (direct testimony of H. W. Kendall, p. 6, following Tr. 3333). The England thesis was corrected after it was first published and the corrections resulted in the lowering of the predictions set forth in the original study (Tr. 3397-3398). The Intervenors agreed that the first 1,000 seconds were the most important from the point of the LOCA analysis for containment pressure (Tr. 3400). In addition, Intervenors' witness indicated that the England calculations presented to the ANS subcommittee in 1972 demonstrate that in the first 1,000 seconds following a LOCA, the England calculations are slightly in excess of 10% above the ANS standard, and thus, are well within the ANS plus 20% standard used by the Staff in their calculations (Tr. 3410). The Board finds Staff and Applicant's use of the ANS-5.1 standard plus 20% is conservative and appropriate for use in calculating containment pressure.

1.7 The second question raised by Intervenors is whether or not the Applicant's assumption of a value of 93 watts per centimeter for the thermal conductivity integral of UO_2 between 0°C and 2800°C is a conservative value for use in calculating containment pressure. The Intervenors contend that the thermal conductivity integral which would be most conservative and appropriate for Zion is 81 watts per centimeter. The effects of the fuel thermal conductivity on the amount of energy available to go into the containment have been evaluated by the Applicant on the basis of a thermal conductivity integral value of 93 watts per centimeter (direct testimony of J. Roll, L. Bowman, G. Uram, L. Berkowitz, p. 5, following Tr. 2405; Tr. 2436). This choice is justified by thermal conductivity data as reported by many experimenters and a comparison of these data with numerous in-pile measurements (Roll, *et al.*, p. 5; Tr. 2436-2440). Based upon the recommendations of their consultants, the Staff also finds it appropriate to use a conductivity integral value of 93 watts per centimeter for the temperature range 0 to 2800°C (Tr. 4960-4961). In addition, when experimenters designed fuel experiments using a value of 93 watts per centimeter, the measured results of a thermal analysis agreed well with predictions (Tr. 4961).

1.8 As a basis for Intervenors' claiming that a 93 watts per centimeter value is too high, Intervenors' witness, Dr. Kendall, cited a letter from Baston of Aerojet Nuclear Corporation (Tr. 3440). Dr. Kendall was unable to identify or quote experimentally derived values for the UO_2 thermal conductivity integral other than those presented in the Baston letter (Tr. 3458-3463). The values contained in the Baston letter are derived from the work of I. Devold, who lists the results for the conductivity integral from zero to 2800 degrees centigrade, as evaluated from 17 investigators, as ranging from 81 watts per centimeter to 130 watts per centimeter (Roll, *et al.*, p. 6). The conductivity integral of 81 watts per centimeter, listed by Devold and recommended by the Intervenors in their contention, was obtained by V. C. Howard and T. F. Gulvin (Roll, *et al.*, p. 6), with whom Dr. Kendall was unfamiliar (Tr. 3466). The Howard and Gulvin value of 81 watts per centimeter was obtained for UO_2 fuel fabricated at a relatively low temperature, below the range used for the Zion Station fuel (Roll, *et al.*, p. 6). The fuel fabrication technique is an important determinant of the UO_2 thermal conductivity integral (Tr. 2116-17). For that reason, the Howard and Gulvin results are inapplicable to the Zion fuel (Tr. 4955; Roll, *et al.*, pp. 6-7). Devold also notes that many investigators consider the UO_2 thermal conductivity integral results reported by Stora, *et al.*, 100 watts per centimeter with an accuracy of ±7% to be the most reliable reported to date (Roll, *et al.*, p. 7). The value determined by the Applicant and the Staff is consistent with the lower bound of the Stora results (Roll, *et al.*, p. 7). Based upon the entire body of data available to it, the Board finds that 93 watts per centimeter is an appropriate value for the UO_2 thermal conductivity integral.

1.9 The third question which Intervenors raise is whether the Applicant and Staff have given appropriate consideration to the increased stored energy in the fuel rods and the decreased heat transfer capability of the fuel rods due to fuel densification in their calculations of the peak containment pressure. The Applicant's calculations of core stored energy take into account the effects of fuel densification and the changes which it causes in the rate of heat generation in the fuel and in the size of the gap between the fuel pellets and the fuel cladding (Roll, *et al.*, pp. 4-5). The Applicant evaluated the thermal energy stored in the fuel by assuming "instant densification" of the UO_2 pellets at beginning of core life as required by the Staff (Roll, *et al.*, p. 5; Tr. 2427). This assumption is the most conservative that can be placed on the rate of fuel densification and results in calculating the maximum pellet-cladding gap space and highest fuel temperature at all points in time during reactor operation (Roll, *et al.*, p. 3; Tr. 2430-31; 5494).

1.10 The Applicant has assumed in its calculations of fuel pellet temperatures that there is uniform radial heat flow between the pellets and the cladding (Roll, *et al.*, p. 7). The Applicant analyzed the effect of non-uniform heat flow which occurs when there is a larger pellet-to-clad gap on one side of the fuel pellet than on the other side (Roll, *et al.*, pp. 7-8; Tr. 2854). The results demonstrate that the average temperature of UO_2 fuel pellets is higher by as much as 50° to 100°F for the case of a concentrically located pellet and uniform radial heat flow than for the case of a non-uniform radial heat flow between the pellet and the clad (Roll, *et al.*, p. 8; Tr. 2854).

1.11 In calculating the stored energy in the fuel pellets, the effect of fission-product gases as well as other factors which affect gap conductance with increased burnup has been adequately considered (Roll, *et al.*, p. 8). Fission-product gas release varies with fuel density, time of exposure, local temperature, and burnup (Tr. 2480-82). The effect of fission-product gases which build up over the exposure life of the fuel is to decrease the gap conductance (Roll, *et al.*, p. 8; direct testimony of D. Crutchfield, p. 21, following Tr. 2955). However, the effect of fission gas buildup on gap conductance is more than compensated by other factors, such as gap closure, so that calculated gap conductance actually increases during burnup (Roll, *et al.*, p. 8). Comparison of the fission-product gas releases predicted by the Westinghouse model and used by the Applicant with actual measurements taken at Beznau, Zorita, and Yankee reactors shows the Applicant has predicted values which conservatively overestimate the actual measurements by as much as an order of magnitude (Roll, *et al.*, p. 8; Crutchfield, p. 22). The Intervenors provided no contradictory evidence. The Staff, as well as Pacific Northwest Laboratories and Oak Ridge National Laboratory, reviewed the Westinghouse gas release model and found it acceptable (Crutchfield, p. 22). The Board finds that the Applicant and Staff have conservatively calculated the value of the stored energy in the fuel including such factors as fuel densification, pellet-to-clad eccentricity and fission-product gases.

1.12 The fourth question raised is whether or not there has been an adequate treatment of energy transferred from the secondary system via steam generator tubes. Applicant's analysis accounted for this phenomena (Mangan, *et al.*, p. 2; FSAR Amend. 24, p. Q14.28-2). The Staff's analysis also included this energy source in a conservative manner (Jensen, pp. 3-7). In particular, the contention asserted that the Applicant has not justified its choice of the heat transfer coefficient on the shell side of the steam generator tubes. Previously, this value was maintained at a high initial value, thus allowing an unrealistically high heat flow from the secondary to the primary side of the steam generators, and the limited ability of the core and loops to vent this amount of steam was not considered in the original calculations (Mangan, *et al.*, pp. 2, 10). In Applicant's current heat transfer model, the heat transfer coefficient on the shell side, when heat flow is from secondary to primary, is calculated using McAdam's recommended correlation which applies to turbulent boundary layers on vertical surfaces (Mangan, *et al.*, p. 10). This correlation, which is appropriate for the conditions on the secondary side, and the other heat transfer correlations used for modeling the steam generator have been described in considerable detail (Mangan, *et al.*, p. 10).

1.13 The Intervenors' fifth item questioned the Applicant's assumption that at the breakpoint the saturated water phase of the discharge flow is at total containment pressure and the steam phase is at the partial pressure of the steam in the containment. One element of Applicant's containment pressure analysis is the blowdown separation model which divides the flow from the break into steam and water and prescribes to each the appropriate pressure (Mangan, *et al.*, p. 14). This assumption was made in accordance with the Gibbs–Dalton law and is the most realistic assumption for the separation model (Mangan, *et al.*,

p. 14; Tr. 4194). In addition, the Staff's calculations used the alternative temperature flash assumption and resulted in a peak pressure only 0.5 psig higher than that calculated by the Applicant (Tr. 4194; Jensen, pp. 4-5). The Board finds that these calculations by both Applicant and Staff are adequate, and there is no substantive difference between results.

1.14 Intervenors' sixth item questions the Applicant's assumption that the core is quenched by the time at which reflooding of the core has reached the 8-foot elevation rather than the 10 or 12-foot level. The quench height is important because it determines when entrainment from the top of the core ceases. This is the point at which the stored energy from the core has been removed (Tr. 4171-72). Experimental data obtained from core thermocouples (FLECHT data) show that entrainment begins after the level in the core rises 20 inches and continues until the entire core is quenched (Mangan, *et al.*, p. 13). The FLECHT data further show that the 10-foot elevation has been quenched by the time the 8-foot level has been quenched (Mangan, *et al.*, p. 13, Tr. 4173; FSAR, p. Q14.28-5). This result is obtained for the high reflood rate calculated by the Applicant (Tr. 4179). Such a rate is conservative because secondary system energy is delivered more rapidly to the fluid, all of which passes through the primary side of the steam generator, and is characteristic of a pump suction LOCA (Tr. 4178-79; FSAR, Amend. 24, pp. Q14.28-2 and Q14.28-3). The reflood rate calculation is based on experimental data obtained under the FLECHT program, the conservation laws and empirical constants for resistances (Tr. 4179-80). In addition, if quenching is assumed when reflooding reaches the 10-foot elevation, the resulting peak containment pressure would be only 43.8 psig (versus 42.4 psig for Applicant's assumption), which is still within the design pressure (Tr. 4171). It is clear that the 10-foot quenching assumption is conservative (Jensen, p. 6). However, the Board finds that the Applicant's slightly less conservative assumption does not compromise his peak pressure calculation, nor render it unacceptable.

1.15 Intervenors' seventh item questions the Applicant's value for the initial fluid energy in the primary coolant system. Applicant's evaluation of initial fluid energy in the primary coolant system included conservative elements (Mangan, *et al.*, pp. 10-11). The fluid volume was evaluated from component dimensions plus allowance for margin on fluid volume, the temperatures are the maximum operating values plus an allowance of 4°F for instrument error, and the core power assumed is the engineered safeguard design rating (4% higher than the license application) plus an allowance for calorimetric error (Mangan, *et al.*, pp. 10-11).

1.16 Regarding heat transferred to injection water from the reactor internals and the walls of vessels and piping, the Applicant has testified that injection begins about 15 seconds after the accident and reaches full flow about 25 seconds after the accident (Tr. 4174-75). Blowdown is complete after 20 seconds (Tr. 4165). The thick and thin metal stored energy calculated by the Applicant during blowdown and reflood is given in the FSAR (FSAR, Amend. 28, Tables Q14.28-8, Q14.28-9). Mass and energy release rates during blowdown are also given in the FSAR (FSAR, Amend. 26, Table Q14.28-3). The core stored and thin metal energy that remain at the end of blowdown are brought out at a constant rate over the period between the end of blowdown and the end of entrainment; the energy from thick metal decays exponentially (Mangan, *et al.*, p. 12). The Board finds this treatment to be adequate and acceptable.

1.17 The Contention asserted that the Applicant has provided no justification for its assumptions of entrainment correlation values, energy release rates, or core exit quality, and that Applicant has failed to set forth tables of mass and energy released throughout blowdown and reflood phases of an accident as requested by the Staff. The Applicant in fact has described the methods used to calculate the rate of energy delivery to the containment (Mangan, *et al.*, pp. 12-13; FSAR, p. Q14.28). The rates were computed from conservation laws and applicable empirical data and employ conservative assumptions (Tr. 4185-86). Furthermore, the Applicant has listed the mass and energy release rates during blowdown and reflood (FSAR, Amend. 28, Tables Q14.28-3, Q14.28-4). Core exit quality has been calculated by performing an energy balance on the fluid entering and leaving the reactor core. The entrainment correlation has been developed on the basis of experimental data (FLECHT data). The model is conservative in that it does not take credit for fallback expected in the upper plenum region (Mangan, *et al.*, p. 13; FSAR, pp. Q14.28-4 & -5). Accordingly, the Board finds that the Applicant has made conservative assumptions in its calculations of the energy transferred to the containment, including energy transferred from the secondary system via the steam generator tubes.

1.18 Regarding calculations by Applicant and Staff, Intervenors allege that neither party used appropriately conservative assumptions for their analyses; that the Staff failed to establish comparability between Applicant's and its own computational methods; nor did the Staff even obtain program listings for Applicant's programs.

1.19 The record indicates that in their calculations, both the Staff and the Applicant made a number of conservative assumptions (Jensen, pp. 5-7); e.g.:

1. There are five fan coolers and three containment spray systems installed at Zion. For computational purposes only three fan coolers and two containment spray systems were assumed to be operating;

2. The calculations assumed that the core was quenched at a core elevation of ten feet;

3. During the reflood phase of the accident about 30% of the steam generated in the core and steam generators would pass through the ECCS injection water where condensation would occur; the calculations did not consider this decrease in energy; and

4. The computations assumed minimum containment heat removal with full operation of the ECCS systems for the containment pressure response.

1.20 The Staff testified that Applicant had analyzed the containment pressure response following a postulated LOCA by calculating the mass and energy release rates using the SATAN V, LOCTA and REFLOOD computer codes. However, with respect to the LOCTA code, Commonwealth extended the time that the core would remain in nucleate boiling. These mass and energy rates were then used as inputs to COCO, the Applicant's computer program used to calculate the containment pressure response. Both the SATAN V computer code and the LOCTA computer code have been approved by the Commission for calculating energy release during a LOCA (Jensen, pp. 2-3).

1.21 The Staff compared the results of its computer code FLOOD-1 to the Applicant's results using his computer program REFLOOD. A comparison of the results of FLOOD-1 with REFLOOD convinced the Staff to accept the REFLOOD program as a realistic method of computing core flow. The Staff independently analyzed the containment pressure response by using the CONTEMPT computer code. The result of this computation yields a calculated peak containment pressure of 44.3 psig. The applicant calculated a containment pressure of 43.8 psig using the COCO computer code. The difference between the Staff's and the Applicant's calculations of containment pressure, about 0.5 psig, can be attributed to the fact that CONTEMPT uses the temperature flash method of calculating energy distribution between the water and steam phases while COCO uses the pressure flash method to compute the energy distribution between the flashed liquid and the containment atmosphere (Jensen, pp. 4-5). Regarding Applicant's program listings, questioning by the Board established that a comparison of such listings is neither a necessary nor an effective way to establish comparability of computational methods (Tr. 4307-4308). Based upon the foregoing, the Board finds that the Staff successfully and adequately demonstrated the comparability of Applicant's computational methods with its own, without the need for comparing program listings.

1.22 Intervenors find that in a meeting on February 14, 1973, Staff advised Applicant that Staff's calculations yielded a peak pressure of 51.7 psig which was 5.7 psig greater than Applicants and greater than the containment design pressure of 47 psig (Intervenors' Findings, para. 1.3). (The Board notes an arithmetic inconsistency here.) The Applicant subsequently changed the input parameters and lowered the calculated peak pressure to 42.4 psig (*ibid.*). It is not clear what is to be inferred from this finding of Intervenors. The Applicant testified (Mangan, *et al.*, pp. 2-3) that the analysis was modified to consider the ability of the core and loop to vent the steam associated with reflooding, via a model described in Amendment 24 of the FSAR. Concurrent with this, the blowdown model was reviewed in detail and certain relatively minor modifications made, as presented in Amendment 24. Subsequently, additional refinements in the calculations were made. These included detailed calculations of the loop pressure drops based on local conditions (e.g., pressure, enthalpy, quality), fluid temperature in the lower plenum, and additional heat sinks which had been omitted previously. As reported in Amendment 26 to the PSAR, the peak pressure for the Zion Units is 42.4 psig (*ibid.*). Questioning by the Board established that the result discussed at the February 14, 1973 meeting came from a very rough preliminary calculation (Tr. 4299). The Board finds that the revisions and refinements made and reported by Applicant are appropriate and justified.

1.23 Turning now to the energy absorbing characteristics of the containment, Contention 1 alleges that the Applicant used, in its peak containment calculations, heat transfer coefficients to the containment surfaces and structural heat sinks, and a net free volume, which were unjustified. The evidence shows that the Applicant has justified these items. The Applicant uses a heat transfer coefficient to containment surfaces based on the work of Tagami, which tests indicate are appropriate (Mangan, *et al.*, p. 14). The Tagami work is based on data gathered by the Safety Assessments and Facilities Establishment (SAFE) Project sponsored by the Bureau of Atomic Energy in Japan (Mangan, *et al.*, p. 14). These data have been widely used in the calculation of post-accident heat removal in containments, and a study by the Idaho Nuclear Corporation for the AEC concluded that the correlation is conservative (Mangan, *et al.*, p. 14). Tests performed by Idaho Nuclear with a containment volume over 150 times greater than that used in the SAFE project confirm the conservatism of the correlation when applied to much larger volumes (Mangan, *et al.*, p. 14). Applicant has identified the items originally grouped under the heading miscellaneous steel structures and computed their exposed area (LaVallee, Table 1, p. 7). In addition, it has listed additional heat sinks totalling 118,932 ft.^{2} available in each containment that were not previously accounted for (LaVallee, Table 2, p. 8). In calculating containment pressure, Applicant assumed that all structural heat sinks are painted (Tr. 4982). Questioning by the Board elicited the response that the sensitivity of the containment pressure to paint thickness is such that the paint thickness could be increased by approximately a factor of 8 before the calculated pressure would reach the 47 psig containment design pressure (Tr. 4985). The Staff concluded that the heat transfer correlations were conservative and that the coefficients could be decreased by 60 percent without exceeding the containment design pressure (Jensen, p. 9). In view of the foregoing, the Board finds that heat transfer to containment surfaces and structural heat sinks has been adequately treated.

1.24 Intervenors also questioned the containment net free volume number of 2.715×10^6 ft.^{3}. The net free volume of the Zion containments was obtained by subtracting the sum of the volumes of all internal structures, as determined from "as built" drawings, from the gross internal volume (Tr. 4358). A 5% contingency was also added to the sum of the actual volumes of the internal structures to arrive at a conservative value (LaVallee, Table 1, p. 5). The Board finds this analysis to be appropriate, and adequately conservative.

1.25 Intervenors allege that the Staff has not conducted a sensitivity analysis or parametric study for the Zion Station containments. Testimony of record indicates that at least the following parametric effects were evaluated by the Staff:

1. The containment volume could be decreased by about 6.5% of the volume before the design pressure would be exceeded (Jensen, p. 8);

2. The surface area of the heat sinks could be underestimated by as much as 26% and the containment design pressure would not be exceeded (*ibid.*);

3. The heat transfer coefficients could be decreased by about 60% and the design pressure of the containment would not be exceeded (Jensen, p. 9); and

4. The total energy in the containment could be increased by 9% and containment design pressure would not be exceeded (*ibid.*).

The Board finds that the above controverts the allegation of Intervenors regarding parametric or sensitivity analyses. In addition, the Board finds that the first item above obviated the need for the Staff to make an independent determination of the net free volume. Board inquiry established that the 6.5% referred to is equivalent to the volume of contents, approximately, that Applicant calculated in arriving at the net free volume (Tr. 4301-4302).

1.26 Although certain of the above findings explicitly address the Zion Unit 1 containment structure, the Board considers these to be illustrative and concludes that there is no basis upon which to challenge the Unit 2 structure in the same context. Accordingly, based upon all of the above findings and the supportive record of evidence, the Board concludes that the Applicant and Staff have demonstrated that the calculations performed to determine the peak containment pressure have incorporated sufficient conservatism and that there is an adequate margin between the maximum calculated containment pressure and the capability of the containment. Thus, the Zion Station containment design meets General Design Criteria 16 and 50, and hence assures the protection of the public health and safety.

Contention 3: Nonconservative Inputs to ECCS Evaluation Model

3.1 In this Contention, Intervenors challenge the appropriateness of the evaluations of gap conductance, fuel conductivity, and peaking factors used in determining compliance of Zion Station Units 1 and 2 with the Interim Acceptance Criteria. However, the specifics of their peaking factor allegations are deferred, by Intervenors, to their Contention 5. Similarly, the Board will so defer its findings.

3.2 The Board has dealt with the subject of gap conductance in Contentions 1 and 4. In Contention 1, paragraphs 1.9 through 1.11, *supra,* deal with the appropriateness of the analyses of gap conductance, the Board's summary finding being stated in paragraph 1.11. Similarly, in Contention 4, paragraphs 4.1 through 4.18, *infra,* further address gap conductance, with the Board's summary finding being stated in paragraph 4.18.

3.3 The Board has also dealt with the subject of fuel conductivity (UO_2 conductivity integral) in Contentions 1 and 4. In Contention 1, paragraphs 1.7 and 1.8, *supra,* deal with the appropriateness of the value used, with the Board's summary finding being stated in paragraph 1.8. In Contention 4, paragraph 4.20, *supra,* states the Board's findings in this matter.

3.4 Incorporating the more detailed treatment and findings referenced above—none of which is meaningfully controverted by Intervenors—the Board concludes that the values used and analyses made for gap conductance and fuel conductivity are appropriate. Thereupon, the Board further concludes that insofar as these factors are concerned, both units of Zion Station can be operated, subject to conditions elsewhere imposed, such that the requirements of the Interim Acceptance Criteria are met.

Contention 4: Fuel Densification

4.1 Contention 4 challenges the consideration of fuel densification in analyzing normal operation, transients and postulated accidents for Zion Units 1 and 2. During the latter stages of construction of Zion Station Units 1 and 2, the phenomenon of in-pile densification of UO_2 fuel was identified as a matter of concern in several operating light water reactors (App. Ex. 73, p. 1-1; App. Ex. 74, p. 1.0-1). Fuel densification causes UO_2 fuel pellets to shrink in both the axial and radial directions (App. Ex. 74, p. 1.0-1).

4.2 The radial shrinkage results in a greater fuel-clad gap, lower gap thermal conductivity, and thus higher fuel temperatures. The axial shrinkage results in a decreased fuel column stack length, the potential for gaps in the fuel column, and an increase in linear power density. Because of decreased neutron absorption in the vicinity of the fuel column gap, power peaking occurs in the adjacent fuel rods (App. Ex. 73, p. 1-1; App. Ex. 74, p. 1.0-1; App. Ex. 82, WCAP-7982, p. 3-1; D. Crutchfield, p. 12).

4.3 On November 20, 1972, the Staff requested that the Applicant provide analyses for determining the effects of fuel densification on normal operation, transients and postulated accidents for Zion Units 1 and 2 (Crutchfield, p. 2). The Applicant submitted its analysis for Unit 1, including proposed revisions to the Technical Specifications, as Amendment 25 to its FSAR in January, 1973 (App. Ex. 73), with a minor revision in April, 1973 (App. Ex. 75). The analysis which considered the effect of fuel densification and the requirements of the Interim Policy Statement applicable to the loss-of-coolant accident evaluation concluded that Zion Unit 1 may be operated initially at 91.3% of rated power with the allowed power increasing as fuel burnup occurs (App. Ex. 73, p. 1-2; Fig. 5.5.B). On the basis of its review of the Applicant's analysis and on its own calculations, the Staff determined that Applicant has adequately accounted for the effects of fuel densification, and that Unit 1 can be operated initially at 91.3% of rated power, based solely upon fuel densification effects, without undue risk to the health and safety of the public (Crutchfield, p. 73). The Staff further concluded that sometime after the beginning of life, as fuel burnup occurs, it will be permissible for the Zion Station Unit 1 to be operated at 100% of rated power (Tr. 2977).

4.4 In April, 1973, the Applicant submitted its fuel densification report for Zion Station Unit 2 (App. Ex. 74). The methods of analysis used for this report are described in WCAP-7982 (App. Ex. 82), as modified by the Staff's fuel column gap size distribution requirement, and are identical to those used for Applicant's reports for Unit 1 (App. Ex. 73, pp. 1.0-2, 4.1-2; App. Ex. 74, pp. 1.0-2, 4.1-2; App. Ex. 75). The only physical differences between the Unit 1 and Unit 2 core designs are fuel densities, initial pre-pressurization levels of the fuel rods, and nominal fuel stack heights (Tr. 2844-A–2847). The fuel densification report for Unit 2 concluded that Unit 2 may be operated initially at 86.7% of rated power

with the allowed power increasing as fuel burnup occurs (App. Ex. 74, p. 1.0-2; *ibid.,* Fig. 5.5.B). The Staff has completed its review of this report and concludes that the Applicant has adequately accounted for the effects of fuel densification (Tr. 5481, 5483). The Staff determined that Unit 2 can be safely operated initially at 86.7% of rated power (based solely upon fuel densification effects) and that power can be increased to 100% of rated power prior to the end of the fuel cycle (Tr. 5485, 5492).

4.5 Unlike the Applicant, the Staff did not perform detailed calculations of the effects of fuel densification for Zion. It did, however, conduct a detailed review of the Westinghouse densification model, including independent calculations by the Staff to verify that model, in connection with its review of Point Beach Unit 2. The methods used by Westinghouse to evaluate Zion are the same as those used for Point Beach Unit 2 (Crutchfield, pp. 3-4). On the basis of its review of the Westinghouse model in the Point Beach proceeding, the Staff concluded that the model is also suitable for the Zion evaluation using slightly different parameters (Tr. 2979). Also, parametric information of a generic nature related to the rate and extent of densification has been submitted to the Regulatory Staff as part of the description of the Westinghouse fuel densification model which was used in the Zion Units 1 and 2 analyses (App. Ex. 82; Tr. 2429). The Staff found the Westinghouse model acceptable and appropriate for the Zion analysis (Crutchfield, p. 24).

4.6 The data submitted by Westinghouse show that there is essentially no effect of burnup (beyond the initial period of operation) or power on the extent of fuel densification, nor is there an effect of manufacturing conditions within the range of conditions under which the fuel for Zion Units 1 and 2 has been manufactured (Tr. 2431-34; 2880). The data do show that initial density has an effect on the extent of densification. However, the final density used in the Westinghouse model represents a bound of the data and, therefore, the fuel is not expected to densify beyond that value (Tr. 2431-33; App. Ex. 82, Fig. 4.2).

4.7 Applicant's in-core flux data show that densification does not occur instantaneously at beginning of life, but rather occurs gradually with burnup over a period between 14 and 2,000 hours after which time densification is essentially completed (Tr. 2430, 2880-81; Crutchfield, p. 7). In determining the effects of fuel densification on normal operation, transients, and postulated accidents, the Applicant assumed, as required by the Staff, that fuel pellet densification occurs instantaneously at zero burnup (Tr. 2427; App. Ex. 73, p. 4.1-1; App. Ex. 74, p. 4.1-1; Crutchfield, p. 9). This assumption is the most conservative that can be placed on the fuel densification rate, and maximizes the pellet to clad gap at zero burnup or beginning of life (BOL) (Tr. 2430-31; 5493-94).

4.8 In its fuel densification analysis for the Zion Station, the Applicant used the actual as-built geometric densities of Region 1 of Unit 1 and Regions 1 and 2 of Unit 2 as the initial unirradiated pellet density (Tr. 2510-2511; App. Ex. 73, App. Ex. 74, Table 3.1). The as-built value for a fuel region is the average density as determined from approximately 20,000–25,000 samples from that region which are selected in a random manner (Tr. 2512, 2517, 2902). For Regions 2 and 3 of Unit 1 and Region 3 of Unit 2, the Applicant assumed initial geometric densities since the as-built values were not available at the time of the analysis. Subsequent determination of the as-built values for Regions 2 and 3 of Unit 1 shows that the values assumed by the Applicant are appropriate (Tr. 2901-03; App. Ex. 73, App. Ex. 74, Table 3.1). The as-built density of Region 3 of Unit 2 was not available by the end of the hearing, but is not crucial to the analyses since Region 2 has the limiting low density (Tr. 2925; App. Ex. 74, p. 4.4-1). To account for differences in pellet density within a region, a measured variation in the density of the fuel pellet was used in the analysis. The variation in density within a region is approximately 1%, on a two sigma basis (Tr. 2518, 2898-99).

4.9 Pressurization of all fuel rods has been incorporated as a design feature for the fuel in Zion Station Units 1 and 2 (App. Ex. 73, App. Ex. 74, Table 3.1).

4.10 In normal reactor operation, the fuel rod cladding will slowly creep inward when subjected to a net external pressure and elevated temperatures and will eventually contact the fuel (Crutchfield, p. 14; App. Ex. 82, p. 1-1). This inward creep in the cladding has the beneficial effect of reducing the radial gap, increasing the gap conductivity, and thus, decreasing the fuel temperature as months of operation are accumulated (App. Ex. 73, App. Ex. 74, p. 5.4-1; Tr. 2891-92). Where an axial fuel column gap exists, the clad will continue to creep inward, and in some cases, can flatten (Tr. 2882-5).

4.11 Applicant's clad creepdown calculations were performed using the Westinghouse clad-creep model (App. Ex. 82, Section 2) which is based on measurements of fuel rods irradiated at operating nuclear power plants (Tr. 2525-26; Crutchfield, p. 14; App. Ex. 82, p. 2-3). The Staff testified that the cladding creepdown calculation method utilized for Zion is acceptable (Crutchfield, p. 15).

4.12 The Applicant's fuel densification analysis is based on the premise that the fuel cladding in the regions of the fuel column gaps will not flatten or collapse through one cycle of operation in each region of Zion Unit 1 (App. Ex. 73 as amended by App. Ex. 75, p. 2-1) and Zion Unit 2 (App. Ex. 74, p. 2.0-1). This premise is based on the clad flattening model which accounts for tube ovality, fast flux, clad temperature and cladding differential pressure and is found in Section 2 of the Westinghouse Fuel Densification Penalty Model (App. Ex. 82; Tr. 2434, 2529). The analyses for the Zion Units predict the minimum time to clad flattening to be 11,000, 25,000 and 26,000 effective full power hours for Regions 1, 2 and 3 of Unit 1 respectively (App. Ex. 73 as amended by App. Ex. 75, p. 2-1). The predicted minimum time to clad flattening for Unit 2, Regions 1, 2 and 3 are 17,000, 21,000, and 26,000 effective full power hours respectively (App. Ex. 74, p. 2.0-1). The scheduled time for the residence of the respective regions in a core is less than the predicted time to collapse (Tr. 7C-8C, *in camera*).

4.13 The objective of this model is to provide a conservative prediction of the time at which fuel clad flattening will occur (Tr. 2902-03). The model does not take credit for the buildup of fission gas pressure with exposure which would increase the minimum time to flattening (App. Ex. 73, p. 2.0-1; App. Ex. 74, p. 2.0-1). Comparison of model predictions with operating data indicates the model actually is conservative (Tr. 2903-04). For example, no clad flattening had occurred at Point Beach Unit 1 after 13,000 effective full power hours, whereas the analysis predicted that the earliest possible clad flattening would occur at 12,000 effective full power hours (App. Ex. 73, p. 2-1; App. Ex. 74, p. 2-1). Collapsed rods have never been observed at times earlier than predicted; in many cases, collapsed rods were not observed following operation beyond the predicted collapse time. In no case have collapsed rods ever been observed in a region of pressurized fuel (Tr. 2435). As noted in 4.9 above, pressurization of all fuel rods has been incorporated as a design feature for the Zion Station.

4.14 The Staff reviewed the Applicant's assumption that no fuel clad flattening would occur during the first cycle of operation of the Zion Units and found it reliable (Crutchfield, p. 15). It examined the Westinghouse model and found it to be valid (Crutchfield, p. 26). Further, the Staff independently calculated the minimum clad flattening times for Point Beach Unit 2 using the code BUCKLE and found that Westinghouse predictions were more conservative than its own (Crutchfield, p. 26). Accordingly, the Board finds adequate assurance that clad flattening will not occur during operation of the Zion Units with fuel exposure limited in accordance with the Applicant's analysis.

4.15 Radial shrinkage of the fuel pellets caused by fuel densification increases the gap between the fuel pellets and the fuel clad which in turn decreases the gap conductance and increases the fuel pellet temperature (Crutchfield, pp. 16-17; App. Ex. 73, p. 1.0-1; App. Ex. 74, p. 1.0-1). In its fuel densification analyses, the Applicant has calculated the minimum gap conductance. Its results are consistent with that calculated by the Staff using the GAPCON computer code (Crutchfield, p. 20). The GAPCON code conservatively calculates the values of gap conductance, as has been confirmed by comparison with empirical data (Crutchfield, p. 28).

4.16 In its gap conductance calculations, the Applicant has been required by the Staff to assume instant densification at beginning of core life without clad creepdown (Crutchfield, p. 19). Sensitivity analyses indicate that with the assumption of instantaneous densification at BOL, the BOL value of gap conductance is the lowest and thus most conservative value likely to be encountered during fuel life (Crutchfield, p. 20).

4.17 Applicant's calculational methods indicate that there is a monotonic increase in gap conductance as a function of reactor operation and thus a decrease in the fuel pellet temperature (Tr. 2891). The increase in gap conductance is due to the processes of clad creepdown and fuel swelling which decrease the gap between the fuel pellet and fuel clad (Crutchfield, pp. 18-19; Tr. 2976, 2983). These processes, however, are offset to some extent by the buildup of fission-product gases (Crutchfield, pp. 21-22; finding 1.11, *supra*). The net effect, after considering such things as creepdown, UO_2 swelling, and change in gas composition in the gap, is that gap conductance at the end of cycle one is approximately a factor of two higher than at BOL (Tr. 2891-2).

4.18 The Staff testified that an acceptable calculational method has been used to describe the creepdown effect that tends to increase gap conductance over fuel lifetime; Westinghouse's calculations of gap conductance are consistent with the Staff's calculations; and the gap conductance is not expected to go below the calculated BOL value (Crutchfield, pp. 42-43; Tr. 2976, 2985). Moreover, the assumption of

instantaneous densification results in more conservative values for gap conductance at all points in time than would result from alternative assumptions (Tr. 5494). The Board finds that the Westinghouse gap conductance calculational techniques result in conservative predictions for the Zion Units.

4.19 In addition to gap conductance, UO_2 conductivity and other parameters are considered in the calculation of fuel pin stored energy (Crutchfield, pp. 17-18). The Westinghouse thermal design model, including expressions for both UO_2 thermal conductivity and gap conductance, has been correlated to measure thermocouple data. In all cases, agreement between the calculated pellet temperatures and observations is good, thus confirming the adequacy of the model (App. Ex. 82, pp. 4-6, 4-7).

4.20 Westinghouse uses a value of 93 watts per centimeter for the UO_2 conductivity integral, which is appropriate, based on a thorough review of available data (findings 1.7, 1.8, *supra;* Roll, *et al.* pp. 5-7; Tr. 2405-2436). However, in calculating the stored energy for accident analysis, the pellet average temperature is increased to afford an additional measure of conservatism in the analysis. Therefore, the pellet stored energy or pellet average temperature is higher than would be determined by the value of 93 watts per centimeter (Tr. 2437-8; Crutchfield, p. 18). The Staff has examined the Westinghouse Design Code's thermal performance model, data, and assumptions and finds the results comparable to those independently calculated by GAPCON. The Staff concluded that gap conductance and stored energy are adequately treated (Crutchfield, pp. 42-43). The Board finds that these matters have been appropriately treated.

4.21 In Contention 4, the Intervenors also questioned Applicant's ability to operate within its design peaking factors due to the calibration procedures employed for the axial offset monitors. As set forth more fully in finding 5.5, the Board finds that this concern is not justified.

4.22 Fuel densification affects most of the design basis transients and postulated accidents analyzed in the Zion Station FSAR. In most instances, however, the penalties incurred can be absorbed without requiring additional restrictions on operation to meet the design basis criteria (App. Ex. 73, p. 5.1-1; App. Ex. 74, p. 5.1-1). The types of inc[illegible]nts which have been found to impose restrictions on the operation are those involving overpower transient[illegible] [illegible]hose [illegible]ffecting DNB safety limits, and the loss-of-coolant accident (App. Ex. 73, 74, pp. 5.1-1, 5.1-2).

4.23 The limiting criterion for overpower protection requires that the maximum fuel temperature be limited to a value less than the fuel centerline melting temperature (5080°F at BOL and decreasing by 58°F per 10,000 MWD/MTU) and peak rod power less than 21 kw/ft (App. Ex. 73, 74, pp. 4.4-3, 5.2-1). Overpower protection is provided by the overpower ΔT trip and the nuclear overpower trip. A calculated fuel centerline temperature of 4700°F has been selected as a basis for establishing overpower protection setpoints. The difference between the 4700°F limit and the fuel melting temperature provides a margin for uncertainties in evaluation (App. Ex. 73, 74, p. 5.2-1).

4.24 Fuel centerline temperatures have been calculated as a function of local linear power and fuel burnup with densification effects (App. Ex. 73, 74, Fig. 4.3). The calculations used as-built average densities of Region 1 for Unit 1 fuel and Region 2 for Unit 2 fuel which are the lowest densities and the most limiting regions of the respective cores (*ibid.*, p. 4.4-1). The results show that the maximum acceptable local linear power at BOL is 20.4 kw/ft for Unit 1 and 19.5 kw/ft for Unit 2 (*ibid.*, p. 5.2-1). Thus, the maximum overpower limit at BOL is 109.9% for Unit 1 and 103.1% for Unit 2 (*ibid.*, p. 5.2-1).

4.25 As burnup proceeds, the fuel centerline temperature calculations show that the fuel temperature for a given linear power density decreases due to cladding creepdown (*ibid.*, Fig. 5.1A, p. 5.2-2). After sufficient burnup, the allowable peak power will reach 21.1 kw/ft (*ibid.*, p. 5.2-2). Correspondingly, the maximum overpower limit becomes less restrictive with burnup until it reaches 115.4% for Unit 1 and 113.4% for Unit 2 (*ibid.*, p. 5.2-2, Fig. 5.1B).

4.26 The proposed revisions to the Technical Specifications include setpoints to account for the effects of fuel densification (*ibid.*, pp. 7.0-2 to 7.0-5). The setpoints will ensure that the maximum overpower limit is not exceeded (*ibid.*, p. 7.0-4).

4.27 The DNB core safety limits for both three- and four-loop operation have been determined, taking into account the effects of densification. Operation within these limits will insure that the DNBR is ≥1.30. The over-temperature ΔT reactor trip setpoints, providing primary DNB protection, have been checked against these core limits and are found to be valid and conservative as previously submitted in the Technical Specifications (*ibid.*, p. 5.3-1). The effects of densification during steady-state and transient operation of

Zion Units 1 and 2 will not cause the limits on DNBR, or cladding strain, or centerline temperature to become less conservative than the values previously established in the FSAR (Crutchfield, p. 72; Tr. 5483).

4.28 The effects of fuel densification in the analysis of postulated accidents have been considered by the Applicant and reviewed by the Staff (Crutchfield, p. 70). The assumed occurrence of fuel densification affected the analysis of the LOCA, the control rod ejection, the steamline rupture, and the locked-rotor accidents (Crutchfield, p. 61). The Staff has reviewed the Applicant's analysis of the loss-of-coolant, the control rod ejection, the steamline rupture, and locked-rotor accidents and concludes that the Applicant has considered the effects of densification on accident analysis in an acceptable manner (Crutchfield, p. 70).

4.29 The effects of fuel densification were evaluated by the Applicant in its revision of the loss-of-coolant accident transient analysis (App. Ex. 73, 74, p. 5.4-1). The Westinghouse evaluation model was used in the evaluation, and the peak clad temperature was limited to 2300°F as required by the Interim Acceptance Criteria (*ibid*., p. 5.4-1). The allowable peak rod power to meet the 2300°F limit set forth in the Interim Acceptance Criteria is 17.2 kw/ft for Unit 1 and 16.6 kw/ft for Unit 2 at BOL (*ibid*., p. 5.4-1). Thus, the maximum power at BOL is 91.3% and 86.7% for Unit 1 and Unit 2, respectively (*ibid*., p. 5.4-2).

4.30 The average fuel temperature decreases with operation because of clad creepdown and other effects, and consequently, higher peak local fuel rod power density is acceptable with increased burnup (*ibid*., p. 5.4-1, Fig. 5.5.A). Thus, the maximum permitted power level can increase to 100% (*ibid*., Fig. 5.5.B; Tr. 5492). The proposed revisions to the Technical Specifications have provided that these power limits shall not be exceeded (*ibid*., p. 7.0-5).

4.31 The Staff testified that the effects of densification were included in the Applicant's calculation of fuel rod behavior during loss-of-coolant accidents and that the LOCA analyses for both Units 1 and 2 are acceptable and comply with the June, 1971, Interim Acceptance Criteria (Crutchfield, pp. 63, 72; Tr. 5483).

4.32 The Staff has reviewed the Applicant's analyses of the effects of fuel densification on steady-state and transient operation and postulated accidents and has concluded that the effects have been taken into account in an acceptable manner (Crutchfield, pp. 59, 70; Tr. 5483).

4.33 On the basis of the evidence presented at the hearing, the Board concludes that the Applicant has adequately and conservatively accounted for the effects of UO_2 pellet densification in the fuel rods for Zion Station Units 1 and 2, and that these Units can be operated in compliance with the Interim Acceptance Criteria for Emergency Core Cooling Systems subject to the following *conditions:*

- Beginning of life maximum power as specified for each unit in 4.29, *supra,* based only upon fuel densification considerations;
- Time rate of increase to 100% of rated power for each unit as specified in 4.30, *supra,* based only upon fuel densification considerations;
- Staff's determination of limitations of first core residence times for each unit, to be incorporated into Technical Specifications (Tr. 5494), again based upon fuel densification considerations; and
- Proposed limitations to Technical Specifications as discussed in Applicant's Exhibit 73, pp. 7.0-1 *et seq.* for Unit 1 and Applicant's Exhibit 74, pp. 7.0-1 *et seq.* for Unit 2 as ultimately deemed appropriate by Staff.

Contention 5: Peaking Factors

5.1 Contentions 3 and 5 called into question the appropriateness of certain peaking factors employed in the design of the Zion Station and whether their use constitutes a compromise to compliance with the Interim Acceptance Criteria. Only in Contention 5 did Intervenors particularize their allegations. Consequently, the Board is addressing the peaking factors issue in this section of our findings.

5.2 The Applicant has calculated a design peaking factor or total heat flux hot channel factor (F_Q) of 2.70 for Zion Station Unit 1 (App. Ex. 75, Table 4.1) and 2.73 for Unit 2 (App. Ex. 74, Table 4.1). The difference between the total peaking factors for Unit 1 and Unit 2 results from the different power spike penalty attributed to densification due to differences in fuel design. Unit 2 has a larger power spike penalty, and thus, a larger F_Q (Tr. 2546; 2844A-2846). These design values establish the upper bound of the

operating peaking factors for the Zion reactors based on their present design and proposed methods of operation (App. Ex. 73, 74, p. 4.2-1).

5.3 In determining the value of the design peaking factors for Zion Units 1 and 2, Applicant performed a comprehensive upper bound analysis of the peaking factors as a function of the axial offset (flux difference), considering any allowable operating situation within its proposed Technical Specifications (Prepared testimony of J. Roll, *et al.,* pp. 2-3; Section 7 of App. Ex. 73, 74, 75). Several hundred plant maneuvers encompassing a wide range of anticipated and unanticipated situations were examined in this analysis. Several thousand values of the total peaking factor were determined. The results of the most limiting maneuvers have been plotted in Figure 4.2 of Applicant's Exhibits 73 and 74 and show that a peaking factor of 2.70 for Zion Unit 1 and 2.73 for Unit 2 exceed all of the plotted values if the axial offset is maintained between −15% and +9% (Tr. 2910-11; App. Ex. 73, Fig. 4.2; App. Ex. 74, Fig. 4.2).

5.4 Each point plotted in Figure 4.2 for both Zion Unit 1 and Unit 2 includes a power spike to account for the local power peaking due to densification. In addition, a 5% margin for nuclear uncertainty and a 3% engineering hot channel factor were included in the calculation prior to plotting each point (Tr. 2910-11). This conservatism and the limits imposed by the Technical Specifications insure that the curve of Figure 4.2 represents the upper bound on what the peaking factors can be in the Zion reactors (Tr. 2555). Operating experience with Westinghouse reactors provides additional assurance that the design peaking factors for the Zion reactors will not be exceeded during normal operation. The highest measured peaking factor in a Westinghouse reactor of current design, operating at high power and within the axial offset range of +15% to −15% is 2.4 (Tr. 2642, 3024).

5.5 The Applicant's proposed revisions to the Technical Specifications for the Zion Station assure that the axial offset limits of −15% to +9% for the Zion peaking factors, as set forth above, will not be violated (App. Ex. 73, pp. 7.0-5 and 7.0-9; App. Ex. 74, pp. 7.0-5 and 7.0-9). The Technical Specifications now require a monthly comparison of the in-core and ex-core axial imbalance, not only quarterly as alleged in Contention 4, and recalibration if the difference is greater than one percent (Staff Ex. 2, pp. 49-50; Richings p. 2). The additional specifications proposed by Applicant in their fuel densification analyses require that, at the proposed core power limit, the axial flux difference be maintained within the range from −12% to +6% thereby providing conservatism (App. Ex. 73, p. 7.0-5; App. Ex. 74, p. 7.0-5). No evidence was presented at the hearing which would indicate that Applicant's design peaking factors would be exceeded during the operation of the Zion Station, as limited by the proposed Technical Specifications, or that such operation with the calculated design peaking factors would result in a violation of the Interim Acceptance Criteria. The Staff has also determined that ex-core detector axial offset surveillance will prohibit the Zion reactors from exceeding the design peaking factors (Richings, pp. 1-2; Tr. 3028-32).

5.6 The proposed revisions to the Technical Specifications also restrict the power level at which the units may be operated so that the peak rod power level will not exceed that required to meet the Interim Acceptance Criteria (Tr. 2445-46; App. Ex. 73, p. 7.0-5; App. Ex. 74, p. 7.05). Initial power has been restricted to 91.3% of rated power for Unit 1 and 86.7% for Unit 2, with allowed operating power scheduled to increase with increased fuel burnup as shown on Applicant's Ex. 73, Fig. 5.5.B and Applicant's Ex. 74, Fig. 5.5.B. These conclusions have been confirmed by the Staff's review (Crutchfield, p. 3; Tr. 2977, 5484, 5485, 5494).

5.7 Intervenors contend that the revised design peaking factor $F_Q = 2.70$ has been arrived at by back-calculating from 2300°F using the LOCA transient code in order to meet the Interim Acceptance Criteria for ECCS. The evidence before the Board demonstrates that the design peaking factor is determined independently of the LOCA evaluation and has not been adjusted to meet the Interim Acceptance Criteria (Tr. 2547; 2631; 2633; 2910). The Applicant has testified that a limiting or required peaking factor that would meet the Interim Acceptance Criteria and allow full power operation at beginning of life could be calculated, but that it is not the same as the design peaking factor (Tr. 2908-09). The limiting peaking factor was not calculated because it would have no meaning (Tr. 2909). The methods actually employed for evaluating the design peaking factor have been described in considerable detail as summarized in findings 5.2, 5.3 and 5.4, *supra.*

5.8 Intervenors questioned the 1.03 value of F_Q^E which Applicant has included as an engineering hot channel factor to account for the effect of manufacturing tolerances on the peak local power density. Since the manufacture of early Westinghouse plants, improvements in manufacturing procedures, verified by statistical sampling, have resulted in a lowering of the value of F_Q^E to the current value of 1.03 (Roll, *et al.*,

p. 4). Statistical analyses of a large number of measurements of fuel diameter and enrichment have shown that the value of 1.03 used for F_Q^E represents a value which will not be exceeded by 99.865 percent of the population (Roll, *et al.*, p. 4). The Staff testified that the value of $F_Q^E = 1.03$ has been accepted for Westinghouse manufactured fuel since 1968 (Richings, p. 2).

5.9 Contention 5 also asserted that F_Q has been kept low by changing the nuclear uncertainty factors downward from 1.10 to 1.08 in calculating the nuclear enthalpy rise hot channel factor $F_{\Delta H}^N$. The Intervenors are mistaken in their assertion that this revision produces a non-conservative peaking factor since the design value of the nuclear enthalpy rise hot channel factor does not affect the design value of F_Q. They are independent. The change in the nuclear enthalpy rise hot channel factor only affects the DNB evaluation (Tr. 2539). The nuclear enthalpy rise hot channel factor $F_{\Delta H}^N$ has been reduced from 1.58 to 1.55 by reducing the nuclear uncertainty in $F_{\Delta H}^N$ from 10 percent to 8 percent (Tr. 2538; App. Ex. 73, p. 4.3-1). The change is based upon an analysis of data from operating reactors and a comparison of these data with calculations (Tr. 2538; App. Ex. 73, p. 4.3-1).

5.10 On the basis of the foregoing evidence, uncontroverted by Intervenors, the Board concludes that the Applicant has conservatively calculated the peaking factors for the Zion Units consistent with their present design and the operating conditions set forth in 4.33, *supra,* so that the use of these values does not compromise compliance with the Interim Acceptance Criteria.

Contention 6: Technical Specifications

6.1 In Contention 6, Intervenors assert that the Technical Specifications which were proposed by Applicant, as required by 10 CFR §50.36, for incorporation into the Zion operating licenses fail in eleven specific respects to conform with Criterion 21 of the General Design Criteria of Appendix A to 10 CFR Part 50. Contention 6 also asserts that in the absence of "failure test" data and a "reliability tree" there is inadequate assurance of the reliability of safety related equipment. These allegations are treated individually in the findings that follow. The Specifications originally proposed by Applicant have been reviewed and modified by the Staff, and admitted into evidence as Staff Exhibit 2.

6.2 The Technical Specifications permit operation of the Zion Station for as long as two hours after a high F_Z alarm (Staff Ex. 2, p. 46). The F_Z alarm is a part of the Axial Power Distribution Monitoring System which provides an early warning of unusual variations in the axial peaking factor (F_Z). The alarm is set below the level for F_Z, which corresponds to the design basis F_Q, so that the alarm indicates a deviation in power distribution prior to the time at which design rod power levels might be exceeded (direct testimony of J. Bitel, pp. 3-4, following Tr. 1801; 1802-03). The two-hour period of operation after a high F_Z alarm is provided to allow the operator an opportunity to determine whether the alarm accurately indicated the F_Z level, and if so, to correct the condition or to reduce power so that the rod power levels are not exceeded. The F_Z alarm is a surveillance system only and does not affect the automatic trip channel or have any operational control or protective functions (Bitel, p. 4; Tr. 1807). By contrast, the total peaking factor value (F_Q) is maintained throughout the fuel cycle by reference to the ex-core detector axial offset, which is one of several signals that are automatically fed to the overpower ΔT reactor trip channel (Bitel, p. 4).

6.3 Operation with both quadrant power tilt alarms inoperable is permitted for an undefined period of time (Staff Ex. 2, p. 48). Quadrant power tilt is a measure of the symmetry in the horizontal distribution of core power (Bitel, p. 5; Tr. 1808). Actuation of these alarms is not designed to initiate a reactor trip and merely serves to alert the operator to information yielded by the detector instrumentation. The Technical Specifications provide assurance that the operator will check the quadrant power tilt by requiring the operator to observe and log the power tilt ratio at frequent intervals when one or both alarms are out of service (Staff Ex. 2, p. 48; Bitel, p. 5; Tr. 1811).

6.4 The Technical Specifications permit operation with a quadrant power tilt ratio exceeding 1.02 for as long as 24 hours under certain conditions (Staff Ex. 2, p. 49). Two types of limitations are imposed upon the quadrant power tilt ratio. First, if an indicated quadrant power tilt ratio exceeds 1.02 but is less than 1.12, within two hours one of the following steps will be taken:

(a) correct the tilt; or

(b) determine, by measurement, core peaking factors and apply Specification 3.2.2.A; or

(c) reduce core power by 2% for each percent of quadrant power tilt beyond 1.0%.

If the indicated quadrant power tilt exceeds 1.02 for a period of 24 hours without known cause, the reactor must be put in the Hot Shutdown Condition. Second, if the indicated quadrant power tilt exceeds 1.12, the reactor must immediately be put in a Hot Shutdown Condition, except for testing at power levels below 50% (*ibid.*, pp. 48-49). Therefore, the actions required by the Technical Specifications provide the necessary overpower protection (Bitel, p. 6; Tr. 1814).

6.5 The Specifications permit operation with more than one control rod inoperable for as long as two hours (Staff Ex. 2, p. 52). The provision only applies if the malfunction is due to the electrical failure of the rod control system which is named rod urgent failure (*ibid.*, Bitel, p. 7). In all other instances the Technical Specifications require that action be taken to place the reactor in Hot Shutdown Condition if more than one control rod is inoperable. Where a rod urgent failure has occurred, the Technical Specifications provide for a two-hour period to attempt to return the affected assemblies to service (Staff Ex. 2, p. 52). The failure of the rod control system does not affect the ability of the operator to trip the unit as the control rods can be tripped independently (Bitel, p. 7).

6.6 Operation with one of two manual safety injection actuation channels inoperative for an undefined period is permitted by the Technical Specifications (Table 3.4-1, p. 129). The Zion safety injection system has both manual and automatic independent actuation channels and there are two of each of these channels, entirely redundant, any one of which can initiate safety injection (Bitel, p. 7; Tr. 1814). In addition, the automatic safety injection actuation system will override the blocking of the manual safety injection system (Tr. 1827). The Specifications require that if either of the automatic actuation channels is out of service, the operator must initiate action to reach Hot Shutdown within four hours. The Specifications also require action to reach Hot Shutdown if both manual actuation channels are out of service.

6.7 The Technical Specifications permit operation for as long as 48 hours with one of the three containment spray systems inoperable (Staff Ex. 2, p. 151). The three containment spray systems are designed to reduce containment pressure and to remove iodine from the containment atmosphere. If one containment spray system becomes inoperable, the containment pressure reduction function of the spray systems can be met by operation of the remaining spray systems and three of the five containment fan coolers. The operability of these systems is assured by promptly testing these systems when one of the spray systems becomes inoperable (*ibid.*, Bitel, p. 8; Tr. 1816-17). The iodine removal function can be handled by one of the containment spray systems since one system will deliver the amount of NaOH solution necessary to remove iodine in the specified amounts (Bitel, p. 8). However, if the operability of the two redundant spray systems cannot be demonstrated, the reactor must be brought to Hot Shutdown within four hours (Staff Ex. 2, p. 151-152).

6.8 The Technical Specifications permit operation with the spray additive tank inoperative for as long as eight hours (§3.6.1.D.E, p. 152). The spray additive tank is a highly reliable component since it is (1) a simple static device and (2) the pumping system and valves are redundant as parts of the three containment spray systems. The Technical Specifications permit reactor operation with the spray tank inoperative for up to eight hours to provide time (one hour) to verify the NaOH content when a low concentration has been indicated and to bring the concentration back to the required level (Bitel, p. 9; Tr. 1818). Since at least eight hours are required to reach cold shutdown in an orderly manner, there would be no significant safety benefit from commencing shutdown if the tank's contents can be quickly restored to specified conditions (Bitel, p. 9).

6.9 Operation with one of two safety injection pumps inoperable for as long as seven days is permitted by the Technical Specifications (Staff Ex. 2, p. 169). The Zion Station emergency core cooling system has multiple pumping systems to meet both high and low pressure pumping requirements, and either one of the two safeguard trains, which include the ECCS pumps (safety injection, charging and residual heat removal pumps), is capable of meeting the safety injection requirement. In the event that one of the safety injection pumps is inoperative, the remaining safety injection pump, both centrifugal charging pump systems and both residual heat removal pump systems, including their associated standby power supplies, will be tested immediately and daily thereafter to insure operability (Bitel, pp. 9-10; Staff Ex. 2, p. 169). This testing provides adequate assurance that the necessary pumping capability will be available during the period in which one of the safety injection pumps is inoperable.

6.10 Operation with one of two residual heat removal pumps inoperable is permitted for as long as seven days (Staff Ex. 2, p. 172). The function of such pumps can be met by either of the two systems, and in the event that one system is inoperative, the other system, both centrifugal charging pump systems and both injection systems, including their associated standby power supplies, are to be tested immediately and daily thereafter to insure their operability (Bitel, p. 10; Staff Ex. 2, p. 172).

6.11 The Specifications permit operation with a diesel-generator inoperable for as long as seven days (*ibid.*, p. 265). The Zion Station has five diesel generators on the site, two of which provide power for Unit 1, while two provide power for Unit 2. The fifth is a swing generator which can go to either unit (Tr. 1819). In addition, Zion Units 1 and 2 are served by separate offsite sources, so that if one power source fails the other power source is still intact. Also, Zion Unit 1 is interconnected to Zion Unit 2 so that electricity produced by either unit can be supplied to the other (Tr. 1926). If all of the offsite power failed and the interconnection between the units failed the onsite power requirements for either unit could be fulfilled by two diesel generators (Bitel, p. 10). In the event of the unavailability of offsite power or the inoperability of a diesel generator, tests of the operability of the remaining diesel generators must be conducted immediately and on a daily basis thereafter (Bitel, p. 10; Staff Ex. 2, p. 265).

6.12 The Technical Specifications provide for testing the emergency core cooling system motor operated valves once a month (Staff Ex. 2, p. 196). These valves are part of the redundant ECCS systems which must operate on a safety injection system signal. As a result, they are tested on the same time intervals as other parts of that system. The ECCS motor valves can be tested by use of the manual safety injection actuation system (Tr. 1820) and thus, the valves will be tested not only once a month, but also at any time a redundant safeguard train or component thereof is inoperable (Bitel, p. 10). The test interval of one month was based on the frequency of testing that would provide reliability and at the same time decrease wear on the equipment over the life of a plant (Staff Ex. 2, p. 196).

6.13 The second major subcontention raised by Intervenors in Contention 6 is whether or not, in the absence of "failure test" data or a "reliability tree" there is adequate assurance of the reliability of the components and systems at Zion in accordance with 10 CFR 50, Appendix A, Criterion 21. The Board notes that such failure test data and reliability tree concepts are not extracted from Criterion 21. The equipment for Zion was selected on the basis of engineering judgment by the Applicant with the objective of assuring a high degree of reliability in that equipment. Factors included in the evaluation are the experience and reliability of suppliers, the experience with identical or similar equipment in other nuclear or fossil fueled plants, and the experience with identical or similar equipment in other applications involving similar operating demands. In addition, Zion Units 1 and 2 have been or will be subjected to an extensive preoperational testing program and startup program (Bitel, p. 11). These tests include strict performance requirements for systems and components within the reactor. In addition, further testing requirements have been imposed on equipment for which reliability data are not available; for example, the diesel generators must meet a criteria of 297 successful starts out of 300 attempts to start. The testing program also included a test of the entire ECCS system for Zion and actual spray of water into the containment and measurement of flow distributions across the containment. Zion was the first station to undertake such a complete test (Tr. 1821-1824). Also, the Applicant regularly receives the Commission's reactor operating experience reports (ROE's) which then are routed to parties within the station itself who can properly utilize these documents (Tr. 1926-1929). Finally, the Staff testified that they have found a high degree of assurance that, if needed, safety feature functions would be performed as required (direct testimony of R. Birkel, p. 3, following Tr. 1930).

6.14 Based upon the record and the foregoing findings, the Board concludes as follows:

- The Technical Specifications contain sufficiently limited conditions for operations, restrictive out of service allowance periods, and stringent requirements for surveillance and testing as to meet the intent and objectives of Criterion 21, thereby controverting all of the eleven specific claims of Intervenors;

- The combination of judgment exercised by Applicant in selecting equipment, preoperational testing, and in service surveillance and testing provide adequate assurance of the reliability and availability of safety related equipment; and

- Hence, the Technical Specifications, as required regulatory conditions upon the operating licenses of the Zion Station, provide assurance that the plant can be operated so as to provide adequate protection to the health and safety of the public.

Contention 7: Aircraft Crashes

7.1 Intervenors contend that the probability of an aircraft using Waukegan Memorial Airport (3½ miles from the Zion plant) crashing into Zion Station is sufficiently high to require that further measures be taken to protect against an aircraft impact. By standard use of common sense and reasonableness, this must be taken to mean that (a) the probability of such a crash is something substantially more than, for example, the mere random everyday possibility of any individual airplane hitting any individual car out of thousands travelling along a crowded, rush-hour freeway a few miles from any given airport, and (b) that the reinforced concrete and steel structure of Zion Station is in some way not already sufficiently strong enough to withstand any reasonably anticipatable aircraft strike without seriously breaching the containment system or otherwise rendering the Station unable to protect the public against serious and substantial consequences of such an impact. The Intervenors allege that the statistical probabilities of such a crash "may not" have been "conservatively calculated." In analyzing the testimony bearing on this contention, the Board believes that evidence of the structural strength of the Zion Station buildings, and the present and planned usage of Waukegan Airport (activity, size of aircraft, etc.) are at least as helpful and meaningful as the precise differences in statistical probability figures argued so strenuously between the parties.

7.2 Waukegan Memorial Airport (WMA) is designated by the Federal Aviation Administration (FAA) as a general aviation airport and a general aviation reliever for O'Hare International Airport ("O'Hare") (prepared testimony of W. J. Murray, p. 2, following Tr. 1619). General aviation includes all aircraft operations except air carrier and military (Tr. 1621). An air carrier operation is defined as a scheduled (airline) operation on an assigned route certified by the appropriate Federal agency (Tr. 1621). General aviation reliever means that general aviation traffic can be diverted to WMA during congested periods at O'Hare (Murray, pp. 2-3).

7.3 WMA has two paved runways. Runway 5-23 is 4,600 feet long and has a 30,000 pound load-carrying capacity. Runway 14-32 is 3,750 feet long and has a 45,000 pound load-carrying capacity. Runway 5-23 is equipped with a partial instrument landing system ("ILS") including localizer, outer marker and non-directional beacon (Murray, p. 3). The extended centerline (i.e., an imaginary line extended from the runway outward) of Runway 5-23 to the northeast intersects the Lake Michigan shoreline approximately one and one-half miles north of the Zion Station (Tr. 1888). The top of the tallest structure at the Zion site is 359 feet above grade and the top of the reactor containment is 189 feet above grade (Eisenhut, Tr. 1731, p. 9). FAA regulations prohibit flight under visual flight rules at an altitude less than one thousand feet above a surface obstruction on the flight path (Tr. 2418, 2421-22; 14 CFR 91.79, cf.91.119).

7.4 A licensed commercial pilot testified for the Applicant. This individual was the chief pilot for Outboard Marine Corporation, had about 15,000 hours of flying time, holds ratings for a variety of single and multi-engine aircraft, has FAA certificates for commercial pilot, instrument rating and flight instructor rating and has been flying into WMA for about 25 years (Losee, Tr. 1880-83). It is the practice to fly at approximately two thousand feet above sea level or about 1300 feet above the ground when crossing the Lake Michigan shoreline on a landing approach to Runway 5-23 at WMA under visual flight rules (Tr. 1889). The traffic pattern for WMA under visual flight rules (VFR) is a rectangular pattern within one mile of the field at an altitude of between 800 and 1,200 feet above ground (Tr. 1882, 1901). Although no study has been performed to determine whether aircraft approaching or departing from WMA fly directly over Zion Station (Tr. 1710), Applicant's witness testified that he does not fly directly over Zion Station when making an approach to Runway 5-23 under visual flight rules (Tr. 1890-91). The only indication of Zion Station on air navigational charts is as a ground obstruction (Tr. 1889-90, and App. Ex. 63). There is no statistical evidence that just because pilots use a ground object as a visual landmark or reference point, that there are large numbers of accidents involving such landmarks (Tr. 3497), nor is there any evidence that because a pilot uses a landmark as a visual reference point that he, therefore, must fly directly over it or at an altitude as low as the landmark.

7.5 Aircraft utilizing the partial ILS system approaching WMA must approach WMA from the northeast and cross the Lake Michigan shoreline over the ILS outer marker, one and one-half miles north of the Zion Station. At that point, the aircraft must be at 2,000 feet altitude (mean sea level) or about 1,300 feet over the ground. In the event that an aircraft utilizing the ILS system is more than one-quarter mile either side of the outer marker, the pilot must exercise a missed approach procedure (Tr. 1885-87). At WMA, a missed approach involves an immediate climb to 2,300 feet msl, a climbing turn to the northwest (i.e., away from Zion), then directly eastbound back to the outer marker to start a holding pattern that is principally flown over Lake Michigan, until a new instrument approach is commenced at 2,300 feet, then descending to no lower than 2,000 feet til past the outer marker (which is also abeam Zion Station). (App. Ex. 63.) An instrument approach to Waukegan Airport, as in any instrument approach to any airport, consists of a very gradual descent, crossing known radio fixes at no lower than the FAA-prescribed minimum crossing altitudes. An aircraft proceeding westbound (226°) on the localizer instrument approach to Waukegan must stay at 2,000 feet msl until past the Outer Marker, which is approximately abeam, but 1½ miles away from Zion Station, with its maximum building height 1,150 feet *below* the lowest permissible aircraft altitude for that portion of the localizer instrument approach. The MDA (minimum descent altitude) for an aircraft when it *reaches the airport* on an instrument approach is 1,100 feet msl, which is still hundreds of feet above the top of the tallest Zion Station structure. At that point, by FAA Regulations, the pilot must have the runway clearly in sight, so that a safe landing is assured, or he must immediately execute a missed approach, involving the climbing right turn to 2,300 feet. (Zion Station is to the left of the instrument approach course; the missed approach climbing turn requires a right turn.) App. Ex. 63. All multi-engine aircraft weighing in excess of 12,500 pounds carry navigational equipment which would enable them to utilize the ILS localizer instrument approach system at WMA (Tr. 1883 and 1891). Any lighter aircraft flying an instrument approach to Waukegan airport must have the same instrument navigational equipment and fly the same precise, prescribed instrument procedures (i.e., the precise flight path and minimum altitudes shown on App. Ex. 63). See Federal Aviation Regulations, 14 CFR Parts 91, 95.

7.6 It is estimated that the present usage of WMA is approximately 55,000 local and 30,000 itinerant aircraft movements annually (Murray, p. 3). A local movement originates and terminates at the same airport with a maximum distance from the airport of less than 20 miles (Murray, p. 3). All other movements are itinerant. Each take-off and each landing is a separate movement (Murray, p. 3). All 85,000 movements at WMA are by general aviation aircraft (Tr. 1621). There are approximately 100 single-engine, 20 light multi-engine and two heavy multi-engine aircraft based at WMA. The single-engine aircraft weigh less than 4,000 pounds; the light multi-engine aircraft weigh less than 12,500 pounds; and the heavy multi-engine aircraft weigh less than 30,000 pounds (Murray, p. 3). Occasionally aircraft weighing in excess of 30,000 pounds utilize WMA, but most aircraft using the airport weigh less than 30,000 pounds (Tr. 2407-11).

7.7 The contention posed the probability of an aircraft landing or taking off from WMA crashing into the Zion facility and causing damage resulting in the inability to shut down the facility in a safe and orderly manner. Applicant conducted a study of potential effects of an aircraft crash into critical areas of Zion Station (App. Ex. 4, Report No. 2 for Question No. 2.28, FSAR). The "critical areas" are those structures containing equipment which is essential to a safe and orderly shutdown of the Station (Tr. 1672). The results of this study, stated in terms of ductility ratios, show that Zion Station can be safely shut down in the event an aircraft weighing 31,000 pounds crashes into the plant at a velocity of 150 miles per hour, a typical approach speed for aircraft of that weight (See App. Ex. 4, Report No. 2 for Question No. 2.28, FSAR and see Tr. 1887-88). Applicant retained German Gurfinkel, Associate Professor of Civil Engineering, University of Illinois, to determine whether the actual ductility ratio of the various structures analyzed for Zion Station exceeded the minimum ductility ratio required to assure prevention of penetration during an aircraft impact. Dr. Gurfinkel concluded that the actual ductility ratio for each of the various structures exceeded the minimum required ductility ratio so that Zion Station has the structural capability necessary to allow a safe and orderly shutdown of the plant following an aircraft impact assumed above (prepared testimony of G. R. Gurfinkel, p. 12, following Tr. 1721).

7.8 William J. Murray & Associates, a consulting firm specializing in airport planning and development, has been retained by the Waukegan Port District (the "District"), managers of the Waukegan Memorial Airport since 1959. The firm has designed and supervised all of the development projects and planning studies at WMA (Murray, p. 1). Mr. Murray testified as a witness for the Applicant. Mr. Murray and his firm had prepared an Airport Layout Plan (the "Plan"), completed in 1970, which outlines development at WMA based on projected facility requirements through 1990. The Plan was accepted by the District and approved by the Illinois Department of Aeronautics and the FAA. FAA approval does not constitute a commitment to fund any segment of the development outlined in the Plan (Murray, p. 2, and App. Ex. 28).

7.9 The portion of the Plan germane to the issues in this proceeding involves the development of Runway 5-23 in three stages. Stage I involves an extension to 6,000 feet, widening to 150 feet, strengthening to 115,000 pounds load-carrying capacity (although regular operation of aircraft weighing that much is not expected) and construction of an instrument landing system. Stage I is planned to meet the 1975 traffic levels projected for WMA. Stage II involves expansion of the runway to 6,700 feet and development of a parallel runway for utility use to meet projected 1980 traffic levels. Stage III involves lengthening of runway 5-23 to 8,000 feet to meet projected 1990 traffic levels (Murray, pp. 7-9, App. Ex. 29, 30 and 31, and Tr. 1629-30). Each stage of the expansion planned for WMA is contingent on receipt of State and Federal funds (Murray, pp. 9-10). If the runway expansion takes place, WMA will be capable of accommodating aircraft up to 120,000 pounds gross weight, equivalent to a McDonnell-Douglas DC-9 aircraft (Murray, p. 7, and Kendall, p. 2, following Tr. 3333). The Technical Specifications require the Applicant to monitor the expansion of WMA and report such expansion to the Regulatory Staff (Eisenhut, p. 9). In the event traffic at WMA increases at some point in the future so that the assumptions used by the Applicant and Staff in calculating the probabilities of an aircraft crash into the Zion Station become invalid, appropriate measures can then be taken. Moreover, physical expansion of WMA will require preparation of an Environmental Impact Statement (14 C.F.R. 152.45(a)(9)) and notification of the AEC before such expansion is authorized (36 *Fed. Reg.* 23688-9).

7.10 The Plan projects for the future approximately 142,000 local and 90,000 itinerant movements at WMA by 1990. Of the 232,000 movements projected, approximately 5,490 will be by aircraft weighing more than 12,500 pounds (Murray, p. 6). There are no statistics which indicate what fraction of the 5,490 movements will be by aircraft weighing in excess of 30,000 pounds (Murray, p. 4). It is possible that a commuter airline service certified by the FAA may interconnect WMA with larger airports in the future. Aircraft used in such an operation are restricted to 27,000 pounds gross weight by FAA regulations (Murray, p. 5). Similarly, since WMA serves an industrial area, an air cargo capability may be possibly developed in the future. Based on air cargo movement figures for Greater Rockford Airport, which is comparable to the size projected for WMA in 1990, the number of air cargo movements, if any, would average about 1 movement every two days for aircraft weighing in excess of 12,500 pounds (Murray, pp. 5-6). Substantial air cargo facilities are most likely to develop at airports predominately servicing commercial airlines (Tr. 2051). The FAA does not expect WMA to become a major commercial air carrier airport (Tr. 1748, and App. Ex. 62, p. 3).

7.11 Applicant retained Pickard, Lowe and Associates (Pickard, Lowe) to study the probability of an aircraft using WMA crashing into Zion Station. Pickard, Lowe submitted a report dated May 5, 1972, which was filed as Amendment 20 to the FSAR and a report dated August 2, 1972, which was filed as Amendment 22 to the FSAR regarding the probability of aircraft crashes into the Zion Station.

7.12 The AEC's past practice for requiring further review of the structural details of a nuclear facility because of the probability of an airplane crash into that facility is a probability greater than 1×10^{-6} (Eisenhut, p. 2-3). Pickard, Lowe estimated the probability of a crash by an aircraft weighing more than 30,000 pounds to be 1×10^{-7}. In that report, it was assumed there are 8,500 movements at WMA of aircraft weighing more than 30,000 pounds (prepared testimony of J. M. Vallance, p. 2-3, following Tr. 1645). The probability of a crash into the Zion facility by an aircraft weighing more than 12,500 pounds, based on the 5,490 movements of such aircraft actually projected for 1990, is approximately 0.7×10^{-7} (Vallance, p. 3). Since the number of movements of aircraft weighing more than 30,000 pounds is a fraction of the movements of aircraft weighing more than 12,500 pounds, the probability of a crash by an aircraft weighing more than 30,000 pounds is less than 1×10^{-7} (Vallance, p. 3-4).

7.13 Pickard, Lowe used a distribution function to calculate the probability of an aircraft hitting the ground at the specific location of the Zion site. The radial distribution correlation is based on 801 data points for landings and take-offs combined. A data base of 30 accidents was used to split the radial distribution correlation into its landing and take-off components. The angular distribution function used in estimating the probability initially analyzed seventeen data points representing accidents within a five-mile radius of an airport and fitting a curve through those data points to obtain a mathematical expression for the distribution function (Vallance, pp. 5-8). Expansion of the sample to thirty points resulted in a distribution function which gave estimates four percent greater than those obtained using seventeen points (Tr. 1707). Expansion to 49 points gave estimates ten percent greater than those obtained using 17 points (Tr. 1708). Such increases do not result in significant changes in the probability figures (Tr. 1659 and 1720).

7.14 The Staff testified that the past practice for the potential interaction of a nuclear facility with a nearby airport had been undertaken using the following criteria:

> If the probability of an aircraft crash into a nuclear facility was less than about one in a million per year, the aircraft-nuclear facility interaction was not examined further. If the probability of an aircraft crash into a nuclear facility was found to be on the order of one in a million or greater, the structural details of the facility were examined to determine if the facility had enough inherent structural capability to mitigate the consequences of an aircraft crash and thereby to substantially reduce the probability of a damaging strike (Tr. 1731, p. 3).

The guideline of 10^{-6} is the probability of a plane striking the target area of the plant, not the probability of causing an accident. Thus, the probability of a plane striking a facility in such a way as to cause a reactor-related uncontained accident is considerably lower than 10^{-6} (Tr. 1785). The Staff also stated that if the probability of an uncontained accident (i.e., breach of containment caused by a plane crash) was calculated to be 10^{-6} per reactor year from a specific identifiable cause it would be too high a number (Tr. 1785-6).

7.15 The Staff analysis was performed in two parts. The first part evaluated the potential interaction based on the present use of the airport and the second part evaluated the potential interaction based on an upper bound usage of the airport during the life of the facility (Tr. 1731, p. 2). Both of these base cases were calculated using actual crash data from the National Transportation Safety Board using fatal crash statistics occurring within five miles of the runway (Tr. 1731, p. 3; and Tr. 1743). (The use of the "fatal" crash statistics is considered reasonable by the Board in that any impact causing less than fatal injuries to the aircraft occupants is also quite unlikely to breach concrete containment buildings, etc.) A distribution of the number of crashes per square mile per aircraft movement as a function of distance from the runway was then determined. This distribution was based on an assumption of a 60° reference flight path, and each and *every* arriving or departing aircraft was assumed to fly directly over Zion (Tr. 1731, pp. 3-4). This approach is conservative since it eliminated any dependence on an angular distribution function and on the necessity of incorporating air traffic patterns into the analysis (Tr. 1731, pp. 3-4).

7.16 After the distribution function applicable to Zion was determined, it was then multiplied by the hypothesized target area of Zion and by the number of movements per year at Waukegan Airport. The resulting equation would yield the probability of a crash into a nuclear facility per year (Tr. 1731, p. 4). The analysis for present usage of the airport was based on approximately 80,000 movements (Tr. 1731, p. 5). This analysis was based on general aviation crash data (Tr. 1731, Table 1) and the resulting probability of a crash striking Zion was 9×10^{-7} per year (Tr. 1731, pp. 5-6).

7.17 A scoping analysis was then performed to determine the potential interaction of the two facilities should "a rather significant expansion" of WMA take place. This analysis assumed 200,000 movements per year (2½ times the present activity, an extreme "upper bound usage projection" that would place Waukegan's activity on a par with LaGuardia and J. F. Kennedy Airports in New York City). (See Tr. 1733, 1735.) The earliest time such a tremendous expansion could be expected to materialize would be in the last years of the 40-year life of the plant (Tr. 1734-35). The 200,000 movements were assumed to consist of 125,000 movements of general aviation aircraft and 75,000 movements of air carrier type aircraft (Tr. 1731, p. 6). For general aviation aircraft, it was assumed that one quarter of all these movements consisted of movements of airplanes with a weight of over 12,500 pounds. The probability of a crash into the facility for this type of aircraft was 1×10^{-6} per year (Tr. 1731, p. 6). Calculations for movements of aircraft weighing less than 12,500 pounds were not considered since a structural analysis showed aircraft of this weight would not affect Zion (Tr. 1740). In order to evaluate the probability associated with the remaining seventy-five thousand movements, crash data for air carrier movements were considered (Tr. 1731, p. 7). It was assumed that *all* 75,000 such movements were of aircraft as large as a DC-9. The resulting probability was calculated to be 5×10^{-6} per year (Tr. 1731, p. 7). The impact speed of these aircraft was considered to be 200 knots striking the facility in the worst possible configuration (Tr. 1741). Since the earliest time Waukegan Airport could possibly reach the tremendous volume of activity used in the Staff's overly conservative probability calculation is sometime near the end of the 40-year life of the plant (Tr. 1734), and in view of the FAA's doubts that Waukegan will ever be the kind of major commercial air carrier airport that could amass such activity figures (Tr. 1748), the monitoring requirement set forth in the Tech. Specs. (see 14.9 above) should adequately provide for any such drastic change in future airport usage.

7.18 Thus, two independent probability analyses of the likelihood of an aircraft crash into Zion Station have been performed. The analyses used varying assumptions concerning such key parameters as number of traffic movements, weight of aircraft and impact speed as well as varying techniques to establish the distribution function used in the probability analysis. Based on its review of both analyses, the Board concludes that based on present and projected future traffic levels, type of aircraft using WMA and the length, capacity and configuration of its runways, the probability of an aircraft crashing into the Zion facility so as to prevent the safe and orderly shutdown of the facility is sufficiently low so as not to require structural strengthening. Moreover, even assuming that WMA expands so that there are 75,000 movements of DC-9 type aircraft yearly, a figure far in excess of any statistical projection of activity at WMA, the probability of such an accident is still sufficiently low so that no structural strengthening of the facility is required.

7.19 The Intervenors presented testimony on the crash of an aircraft into Zion (Dr. Kendall, Tr. 3333, pp. 102; and 2038-2110). The Board has considered this testimony and finds that the Staff's analysis is sufficiently conservative to assure that the probability of an aircraft striking Zion is sufficiently low that Zion can be operated without undue risk for the public health and safety. The Board further finds that the likelihood of an accidental crash of an aircraft into Zion Station with such an impact as to breach the containment and cause an "uncontained" reactor accident is sufficiently low that it does not require any further review of, or changes to, the structural details of the facility.

7.20 The last issue raised by Intervenors under Contention 7 is whether or not Zion should be structurally strengthened because of a purposive crash of an aircraft into Zion. No statistical analysis of the probability of such a crash can be made, since such a crash has never occurred (Tr. 1695, pp. 9-10 and Tr. 1715-16). However, the frequency of hijacking has been calculated as 1×10^{-6} per movement for air carriers (Tr. 1645, p. 10). In addition, recent search procedures at commercial airports have reduced these occurrences substantially (Tr. 2105). The Staff also testified that the Zion containment, as built, could accommodate a crash of a DC-9 in a vertical nose dive at 200 knots into the top of the containment without breaching the containment (Tr. 1775).

7.21 The Board finds that the likelihood of a purposive crash of an aircraft into Zion is sufficiently low that it does not pose a risk to public health and safety, nor does it require further review of, or changes to, the structural integrity of the facility.

Contention 8—Security Plan

8.1 The Intervenors contend that the Zion Station Security Plan is inadequate to assure that damage to the plant from subversive actions, malicious mischief or other overt acts dangerous to the health and safety of the public will not occur. At the outset, the Board notes that any industrial security plan, once its details are known, is always susceptible to second-guessing or the ploy of "tell me how many guards and devices you have and I'll tell you how many more you should have." Thus the real question is not how many more guards and TV monitors a plant *could* have, but what is a reasonably adequate security system measured against standards commonly followed in the same industry. (Obviously, if Zion Station were not a power plant but a storehouse for currency or gold bars, and thus strongly attractive to a wide range of criminals, the security plan requirements would be much different.) Thus far, there have not been widespread attacks or violent subversive actions against power plants in the United States, nuclear or otherwise. Certainly, there is no evidence in the record of this proceeding indicating such experience, or that any such problem is imminent or is reasonably anticipated for the future. Should such an unfortunate state of affairs exist in the future, then, of course, across-the-board emergency "beefing up" of security plans would rapidly be adopted in many industries and types of installations.

8.2 Since any detailed discussion of a particular plant's security necessarily reveals the details of that plant's security system, and since this particular contention, at the request of Applicant, is the subject of a Board Order requiring confidential treatment (Protective Order, March 15, 1973), the Board's detailed findings on Contention 8 will not be included in the publicly-disseminated version of this Initial Decision. Instead, the detailed Findings of Fact on Contention 8 will be handled separately and given Restricted Distribution, i.e., only to the official parties in this case, who, in turn, are bound to confidentiality by the terms of the original protective Order.

8.3 For the information of all concerned, the Board has found the Zion Station Security Plan to be adequate and in reasonable agreement and compliance with generally accepted standards for industrial security systems prevailing in the nuclear power plant industry today, although the Board has ordered one condition, a minor staffing addition, in response to Staff evidence of a change in general standards pursuant to the Regulatory Staff's continuing review of plant security plans. (These first three paragraphs [8.1, 8.2, 8.3] under Contention 8 will appear in both the publicly-available Initial Decision and in the separately-filed "Restricted Distribution" version of *"Contention 8–Findings of Fact."*)

Contention 9–Quality Assurance, and

Contention 10–Quality Assurance Documentation

9.1 By agreement of the parties, these two contentions challenging the adequacy of the Applicant's Quality Assurance program for construction were admitted by the Board. The contentions further challenge the compliance of the program with 10 CFR 50, Appendix B. They also allege that certain quality deficiencies have been uncovered that demonstrate failure to comply with quality assurance requirements. Thus it is asserted that there is no assurance that the Zion Station has been constructed in conformity with the construction permits and other appropriate regulatory requirements.

9.2 The Zion construction Quality Assurance Plan (QAP) (App. Ex. 11) was first formulated during the construction permit hearings in 1968, prior to the AEC's adoption of Appendix B in July 1970 (prepared testimony of Kershaw, p. 6, following Tr. 896). The evolution of the QAP before and after the adoption of Appendix B is interwoven intimately with the details of both contentions. To whatever extent there may not have been compliance with Appendix B, the deciding issue in both contentions is the question of whether any such non-compliance has resulted in uncorrected or uncorrectable situations that prevent making the necessary findings requisite to the issuance of an operating license. Consequently, both contentions were dealt with jointly, to a large extent, in the instant hearing and will be addressed jointly herein.

9.3 It is noted that the instant proceeding encompasses both Unit 1 and Unit 2 of the Zion Station. These two contentions are unique, however, in that at the conclusion of the hearings Unit 2 was between 85% and 90% complete (Bird, under Board examination, Tr. 4830), permitting the possibility that further material evidence might later become available, regarding these contentions in relation to Unit 2. Hence, the Board's Order (Order Closing Record and Setting Dates for Proposed Findings, July 27, 1973) provided for the possibility of a further hearing on these two contentions with respect to Unit 2. Supportive of this provision in the Board's Order, Staff testimony indicated that the Applicant's planned quality documentation review program and its approval by Region III were yet to be accomplished (direct testimony of Vetter, p. 31, following Tr. 1360).

9.4 The Board has chosen to organize its treatment of the voluminous record on these two contentions (testimony on twelve separate days, including thousands of pages of transcript and exhibits), as follows:

(a) Staff experience with non-compliance of quality documentation,

(b) Applicant's efforts to develop an adequate quality assurance program,

(c) Intervenors' allegations, per contentions, regarding specific discrepancies, and the resolution of same,

(d) Issues raised during the hearing,

(e) Conclusions.

9.5 As indicated above, the QAP was initiated during 1968. Various initial procedures and their revisions bear dates from 1968 through February 1973 (App. Ex. 10). Appendix B to 10 CFR 50 became effective in July 1970 (35 *Fed. Reg.* 10498). Subsequent to this date, Region III informed the Applicant that the Zion Station construction would be inspected against Appendix B Criteria, including Criteria I and VII, i.e., QA Program Organization and Control of Purchased Equipment, Material and Services (direct testimony of Vetter, p. 10 following Tr. 1360). In response, Applicant maintained that Appendix B did not apply to the Zion Station (*ibid.*). Nevertheless, by December 1971 a great deal of effort had been expended on a voluntary basis to bring about quality assurance program improvements (*ibid.*, p. 11). Despite these improvements, there was little evidence of effort on the part of the Applicant "to restructure and staff the quality assurance program to prevent recurrence. . ." (*ibid.*, p. 12). Consequently, at a special management meeting in mid-December 1971, the Applicant was informed by Region III that immediate and effective corrective action was necessary. The Applicant agreed to initiate a corrective action program involving:

(a) Audit by outside groups,

(b) Addition of personnel,

(c) A QAP requirements training program,

(d) Review of site audits by GE Apollo team personnel,

(e) Increased vendor surveillance,

(f) Additional site audits by Corporate QA administrator, and

(g) Review of the QA manual by Apollo personnel (*ibid.*, p. 12, 13).

9.6 Despite the above corrective actions, non-conformance and violations continued to be identified. On May 10, 1972, senior management personnel for Applicant were informed that site personnel appeared to be ignoring the Appendix B Criterion VII requirement that quality documentation be available on site prior to the use or installation of materials, components, and equipment. Applicant agreed to and did initiate further corrective actions, (*ibid.*, p. 13) including detailed site procedures for quality documentation and verification (App. Ex. 13). The reservation was expressed by Applicant that some documentation deviations might be necessary in the event of a conflict with construction schedules. The Staff testified that subsequent to the above May 1972 date, no new instances of noncompliance with Criterion VII were identified (Vetter, pp. 13-14, following Tr. 1360). The Board notes, parenthetically, that the same testimony later contradicts itself by stating that December 1971 is the date beyond which no new instances of such noncompliance were observed (*ibid.*, p. 29, 30). Although not material to the findings herein, the Board is inclined to give credence to the later date, since the testimony in question mentions, as noted above, a meeting called on May 10, 1972, for the purpose of discussing just such Criterion VII problems. Significantly, the same Staff witness testified that "[s]ubsequent to approximately mid-May 1972, however, the Applicant formalized and implemented a program which adequately resolved the outstanding issues in the area of quality documentation" (*ibid.*, pp. 24-25).

9.7 In December, 1968, the Applicant requested outside assistance from the General Electric Company Apollo and Ground System Engineers (Project Apollo) in developing the Zion Station quality assurance program. This effort resulted in the issuance of two documents on December 17, 1968, "Guide for Quality Assurance Programs for the Construction of Nuclear Plants, and the Zion Station Quality Assurance Plan" (testimony of Warwick, p. 6, following Tr. 1246). The Project Apollo engineers had been closely associated with the development and use of the evolving NASA and military quality assurance documents that were in part the basis for the present Appendix B to 10 CFR Part 50, issued in July 1970 (*ibid.*, p. 4, 5).

9.8 Between March 2 and 12, 1970, at the request of the Applicant, Apollo Project personnel performed an audit and evaluation directed at determining the degree of implementation and compliance with the Zion QAP. Although the installation of Class I systems had not progressed far at this time, fourteen areas of the quality program were audited, resulting in recommendations of improvement in eleven, plus the recommendation—accepted by Applicant—to add qualified personnel to the QA organization. These recommendations were reviewed with the Applicant to assure that the QA program would be brought into compliance with the proposed Appendix B, just issued (March 1970) for comment (*ibid.*, p. 7-12).

9.9 In January 1971, another audit was performed, considerably broader in scope and coverage and included an evaluation of the Applicant's architect-engineer, as well. Numerous findings and recommendations were made and reviewed with the Applicant's General Office management, as well as site personnel. Annual follow-up audits were proposed. Accordingly, the next follow-up audit occurred in January 1972 and included analyses not only of previous General Electric audit deficiencies but also those resulting from AEC Region III site inspections. These analyses resulted in further recommendations and revisions to bring the QAP and its supporting procedures into compliance with the intent of Appendix B criteria. These were completed by April 21, 1972. Monthly internal re-audits of previous finding areas were instituted to insure progress in implementation of plan and procedure revisions appropriate to the progress of construction work and effect the closure of open audit findings. Bi-monthly re-audits by General Electric were performed during the balance of 1972. In anticipation of phasing over from construction activities to operational activities an effort paralleling the above was undertaken by the Applicant, directed toward the issue in March, 1972 of QAP-19, "Procedure for the Developing, Performing and Documenting Pre-Operational and Start-Up Test Programs." Supporting site procedures were developed that (material to these contentions) include verification of the quality assurance records related to the components within the system (*ibid.*, p. 13-25).

9.10 The Intervenors identify several specific areas of alleged discrepancies and/or non-compliance in Contentions 9 and 10. These are now addressed in the discussions that follow. In Contentions 9 and 10, Intervenors allege improper treatment of documentation with respect to wall thickness of all Class I values, including containment spray valves. These allegations were based upon Region III Compliance Reports which expressed concern over this matter. However, the Region III concern related only to containment spray valves and their quality documentation, which was resolved upon review of this documentation by Region III. Other referenced Region III reports dealt with a concern about all Class I valves in all nuclear plants and had no special relevance to the Zion Station containment spray valves (Vetter, pp. 15-16, following Tr. 1360; Tr. 1496-97).

9.11 During construction, however, a problem did arise regarding the wall thickness of main steam isolation valves (Tr. 1459). The pressure containing parts of the valve assemblies were designed in accordance with the requirements of ANSI B16.5 (App. Ex. 137). The containment spray valves were manufactured to the same specifications (Tr. 4615; App. Ex. 137B), requiring a wall thickness of 2.13 inches (Tr. 1463, 1504). Upon receipt of the valves, it was determined that some of the valves did not conform and that one of the Unit 2 valves had a thickness in one area of 1.4 inches (Tr. 1500). This valve was repaired (*ibid.*).

9.12 A generic review of main steam line isolation valves was performed by the Atomic Energy Commission, and it was determined that in certain circumstances, the thickness requirements of code SP66 could be utilized instead of the requirements of ANSI B16.5. This was permitted if an analysis of the ultimate yield strength characteristics of the metal involved exceeded the difference in percentage of wall thickness variation. After repair of the aforementioned valve for Unit 2, all valves at the Zion facility met this requirement and on this basis, the valves were approved (Tr. 1500-1505). The Applicant's witness who supervised the examination of wall thickness of all Zion valves testified concerning the methods utilized in conducting such testing and reporting the results (Tr. 5002-04, 5013 and App. Ex. A-154). A second witness testified that he reviewed these reports to determine the acceptability of the valves and found that each valve met minimum wall requirements (Tr. 5135, 5138 and App. Ex. A-155).

9.13 To assure that the wall thickness of the Class I valves met the specifications, Applicant has established Site Procedure Z-5 to identify, measure, evaluate and document the measurements of all such valves (App. Ex. 138). The procedure further requires that corrective action be taken should any valve prove unacceptable. The wall thickness of all Class I valves at the Zion Station were ultrasonically tested by X-Ray Engineering Co., in accordance with Procedure Z-5 (Tr. 1500, 5001). This check included the containment spray valves. The results of that inspection demonstrate that their wall thicknesses meet the required specification (App. Ex. 155; Tr. 5137-5138).

9.14 In Contentions 9 and 10, Intervenors allege that there are discrepancies and/or instances of non-compliance with respect to the heat treatment of Class I valves, and associated documentation. These valves were made from materials which were heat treated in accordance with appropriate ASTM material specifications (Prepared testimony of R. Bremmer, p. 1-2, following Tr. 4731; App. Ex. 140 through 146). This has been assured by the supplier's (Westinghouse) approval, prior to valve manufacture, of all valve manufacturers' bills of material which reference the ASTM material specifications; Westinghouse review of material test reports on the materials used in each valve; and Westinghouse review of heat treating procedures used by the valve manufacturers (Bremmer, pp. 2-5). Westinghouse also performed quality assurance audits at valve manufacturing plants to assure that valve manufacturers were complying with heat treatment procedures (Bremmer, p. 5). The Applicant in turn audited both the Westinghouse reviews and the valve manufacturers' records (Ex. I-1, Tr. 4634). No discrepancies were noted by Applicant (Bremmer, p. 6), and Region III has concluded that sufficient information has been obtained to provide reasonable assurance that the required heat treatment had been accomplished (Vetter, p. 17 following Tr. 1360; Tr. 1400).

9.15 Intervenors contend that the Applicant failed to receive approval for a Defect Notice Disposition Request (DNDR) for valves employed at the Zion Station supplied by Westinghouse, as noted in Region III Inspection Report. In fact, however, the DNDR (App. Ex. 147) for the valves in question was received and approved by Westinghouse in accordance with its procedures. The DNDR stated that certain material test reports and certifications were not available for parts of the valves (Tr. 4745). Westinghouse engineers

evaluated this deficiency and determined that the valves could be employed despite the lack of these records since the valves had been hydrostatically shell tested and were to be used for non-critical applications (Bremmer, p. 7-8). Thus, the deviation was approved and releases were subsequently issued (App. Ex. 148, 149, 150, 151). Region III Compliance has acknowledged the adequacy of this disposition (Vetter, pp. 18-19). Subsequent to the above disposition, many of the material test reports and certifications became available and confirm that the original disposition was appropriate (Bremmer, p. 8).

9.16 Intervenors have stated, on the basis of a Region III Inspection Report, that four Unit 2 main steam isolation valves had been improperly stored with the potential opportunity for rusting and pitting from adverse environmental effects (Vetter, p. 19, following Tr. 1360). This apparently resulted from a torn plastic covering over the valves. This situation existed for approximately one week (Tr. 1213-14). On the day following the inspection, the quality assurance administrator for Commonwealth examined the valves and found foreign particles on the surface (Tr. 1212). On the next day the covering was repaired and the surfaces were restored to their initial condition. An examination for rusting and pitting indicated that none was present and the evidence shows no harm resulted from the temporary exposure of the valves (Tr. 1212-13, and Tr. 1360, p. 19).

9.17 The next specific item in Contention 9 deals with an allegation of improper weld rod control. However, since substantially broader and more detailed aspects of this portion of the Contention were introduced during the hearings, it will be dealt with in a later section.

9.18 Intervenors noted in their Contention that Region III had expressed concern with Applicant's substitution of ladder bottom cable trays for certain solid bottom trays, at variance with the FSAR. The Staff testified that the Applicant responded by performing engineering and design evaluations that established acceptable loading limitations (Vetter, p. 21, following Tr. 1360; Tr. 1454-1455). This change and its evaluation were documented by the Applicant in FSAR Amendment No. 19, dated February 25, 1972.

9.19 Intervenors have questioned the use of non-conforming aggregate, in the concrete for the Unit 2 containment slab, as to its non-conformance with the recommendations of ASTM C-33 relative to size and percentage of sizes. Specifically, in certain areas, 1½-inch aggregate was used in the foundation instead of ¾-inch aggregate (Tr. 5294). This was discovered by the Hunt Testing Laboratories during routine testing for the Applicant (Tr. 5232). It was documented by the Applicant prior to identification of the deviation by Region III (Vetter, pp. 21-22 following Tr. 1360). In addition to correcting the problem with the aggregate supplier whose grading screens were out of specification (Tr. 5232-3), test cylinders were run with the non-spec aggregate to determine whether the concrete in question met the appropriate strength criteria (Tr. 5282; App. Ex. 177 through 179). Results indicated that in all cases strength specifications had been met (Tr. 5290-5292), alleviating the concern of Region III (Vetter, *loc. cit.*).

9.20 Intervenors contend that Applicant violated ACI Code 306-66 through failure to measure and record concrete temperatures during curing on Class I structures. Applicant's contractor originally measured the temperatures of freshly poured concrete periodically but after the middle of 1969, a normal practice of continuously measuring and recording such temperatures was instituted (Tr. 5236). From the commencement of concrete work, however, Applicant employed additional measures, as recommended by industry standards (App. Ex. 174 F-G), to protect the concrete from damage due to temperature extremes (Tr. 5235). In hot weather, sprays and curing membranes were employed which prevent dehydration, the principal matter of concern (Tr. 5235). In cold weather, covers and insulated forms were used to prevent freezing (Tr. 5234-35). When these forms and covers are used, the exothermic nature of concrete curing causes the temperature to rise even in very cold weather thus assuring that freezing does not occur (Tr. 5317-18). On the occasion of pouring the Unit 1 reactor building base slab, due to highly adverse weather conditions and the large size of a concrete pour which prevented prompt covering, temperature control became a matter of concern. The absence of any deleterious impact due to the low temperatures experienced during that concrete pour is demonstrated by the frequent temperature recordings, which showed no temperatures low enough to cause damage (App. Ex. 173; Tr. 5319-20), as well as the behavior of the concrete during subsequent grinding and strength tests (Tr. 5245, 5260, 5312-22). This matter was resolved to the satisfaction of Region III (Vetter, pp. 22-23).

9.21 Intervenors have expressed themselves concerning problems with 8″ stainless steel piping, without further particularity. Applicant (Applicant's Proposed Findings, at para. 9,10 (27)) and Staff (Vetter, p. 23, following Tr. 1360; Staff's Proposed Findings, at para. 9-24) have assumed this to relate to a difficulty that

Applicant's in-service inspection contractor experienced with respect to obtaining meaningful baseline data during ultrasonic examination program of 311 welds common to eight inch stainless steel Class I piping systems. Intervenors did not contest this assumption. This program was being conducted in conformance with ASME Boiler and Pressure Vessel Code, Section XI, for reference in future in-service inspection requirements (Vetter, loc. cit., pp. 23-24). This Code permits the utilization of alternate techniques where difficulties or circumstances warrant. The Staff attested that, to their satisfaction, the Applicant's efforts to improve this technique or to resort to weld-parent metal radiography are appropriate and within the governing Code (*ibid.*).

9.22 During the course of the hearing, certain topics, judged by the Board to be within the scope of these contentions, were brought up as major expansions upon or outside of the original construction of the contentions. These are now addressed. Paragraph 9.17, *supra,* referred to and deferred discussion of weld rod control. Intervenors introduced an unanticipated (Tr. 1509) witness, John Connolly, an employee of one of the Applicant's construction contractors—The Walsh Construction Co. This witness testified to the handling of coated weld rods of a certain type in a manner at variance with instructions. He testified that he and certain named fellow employees had performed welding on certain structures of the Zion Station Unit I, prior to having been certified for such welding. He further testified that he had observed numerous occasions where concrete reinforcing bars—rebars—were heated to make bending easier. This, too, was a practice stated to be at variance with job site instructions (Tr. 1513-1525).

9.23 The welder certification issue does not address the question of weld quality, nor was any testimony offered by Intervenors that the welding performed by the identified welders was defective. Hence, two separable issues were addressed on the record: the extent to which uncertified welders may have performed work on Class I structures; and the extent to which any unacceptable welds may have resulted. Subsequent to the raising of this matter during the hearing, the Applicant, at the Staff's request, undertook a review of welder certifications for all contractors at Zion who had performed Class I work (Tr. 4665-4666). The results of this special effort was that a 100% audit was performed on all contractors (App. Ex. 161-172), with the exception of Pope-Morrison, which showed that their welders had been properly certified. Pope-Morrison had received prior audits (Tr. 5146-47). The Walsh Construction Co. welders named by Intervenors' witness referred to in para. 9.22, *supra,* had been certified by the time the subject testimony was presented. However, said certifications bore dates in March and April of 1973 (Int. Ex. 5 through 8). Moreover, Applicant was unable to demonstrate that all Class I welding performed by Walsh had been done by certified welders (Tr. 4654, 5143).

9.24 Testimony by Intervenors' witness referred to in para. 9.22, *supra,* established that coated, low-hydrogen weld electrodes had not always been oven stored in accordance with site procedures. Exposure of such electrodes to moisture can result in undesirable porosity and possibly subsequent cracking of the weldment (Tr. 4696-4607). Testimony of the Staff indicated there had also been violations of this site procedure in February and April of 1972. Corrective measures by the Applicant along with radiographic inspection of possibly affected welds resolved the concerns of that time period (Vetter, pp. 20-21, following Tr. 1360). In order to determine whether recently identified welder certification and weld rod control anomalies had resulted in any unacceptable welds, Applicant initiated an investigation of all Walsh Class I welding at Zion. The investigation directed that visual examinations, magnetic particle testing and hardness testing be performed (Tr. 4606). The results of the completed investigation on Unit 1 were presented during the hearing.

9.25 The Unit 1 investigation revealed approximately 4,900 welds on Class I structures performed by Walsh, with the exact number undeterminable because some connections are inaccessible (App. Ex. 134-135). Of these, 3,063 welds were inspected by visual and magnetic particle methods (App. Ex. 135). An additional 655 welds were only inspected visually due to inaccessibility for magnetic particle examination, while the remaining welds were not accessible for any type of inspection (App. Ex. 135). Of the Welds examined, 121 did not meet specifications (App. Ex. 136) and these have been corrected with the exception of two which are inaccessible (Tr. 5029; Int. Ex. 24). The latter have been reviewed and were determined to meet strength requirements (Int. Ex. 24). The Staff has reviewed and approved of Applicant's examination procedures and its corrective action taken on defective welds (Tr. 5401-03). Those welds which were inaccessible for examination were analyzed for margin of strength and an acceptable minimum margin was found to exist (Tr. 4784-86). In addition, an analysis of the welds which were inaccessible because they had been buried in concrete demonstrated that the integrity of the structures in

which they are located would not be compromised if all such welds were totally lacking (Tr. 4787). The strength of the concrete alone is sufficient to withstand all design basis accidents (Tr. 4787). The Staff has also determined by its own review that a sufficient margin of strength exists for those welds which were inaccessible for examination. (Prepared testimony of D. Jeng, p. 2, following Tr. 5466). Of the welds found to be unacceptable by visual and magnetic particle examination, only five were found to exhibit excessive porosity (Tr. 4670-71, 4889; App. Ex. 136). To determine the strength of these welds, samples of the Walsh welds were subjected to hardness testing (Tr. 5071). From such testing, an analysis of the tensile strength of the weld to the tensile strength of the base metal was performed (Tr. 5118-19). The results of this analysis indicate that the Walsh welds possess the requisite tensile strength (Tr. 5119; App. Ex. 156-60). Applicant further testified that the materials being welded were relatively low carbon steel and hence not as susceptible to hydrogen damage as high carbon steels (Tr. 5124-5125).

9.26 Sargent and Lundy, the architect-engineer (A-E) for Zion analyzed all Class I welds made by Walsh which did not receive both visual examination and magnetic particle testing. These welds include three categories (i) welds which were visually inspected but not magnetic particle tested, because testing equipment couldn't reach them, (ii) those which were embedded in concrete and received no examination and (iii) those which were otherwise inaccessible and received no examination (Tr. 4784). Initially, the A-E made calculations to determine the load that each beam connection was supposed to carry. They then considered the carrying capacity of the weld connections based on the assumption that the welds were properly made. Comparing these figures, they were able to calculate a capacity to load ratio, i.e., the number of times by which the capacity exceeds the design load (Tr. 4784-85). Commonwealth calculated this minimum capacity to load factor to vary from a factor of two to about 14 or 15, relating to welds not encased in concrete, and concluded, on the basis of the success ratio for welds which had received both visual examination and magnetic particle testing, that these welds were capable of carrying the design loads (Tr. 4785-4786). In analyzing the welds encased in concrete, Commonwealth assumed there was zero weld. Calculations showed that there was sufficient strength in the concrete alone to carry the projected loads (Tr. 4787), and thus, there would be no reason to doubt that the members in question meet the design criteria set forth in the PSAR (Tr. 4788). The Staff conducted a similar independent review and also concluded that the Class I welds under consideration were sufficient to meet their design loads (Direct testimony of D. C. Jeng, p. 2, following Tr. 5466).

9.27 The remaining issue relating to the work practices of the Walsh Construction Company is that of whether Class I structural integrity was compromised because reinforcement bar was heated on numerous occasions in the process of being bent (Tr. 1522-24). The Applicant has acknowledged that rebar was heated and bent at Zion (Tr. 5217-5227). Commonwealth testified that heating was always a last resort when it proved impossible to cold bend the rebar and that procedures were followed to allow bending with a minimum of heat (Tr. 5224). Subsequent to the receipt of Intervenors' testimony relating to rebar heating, the site quality assurance coordinator was instructed to have a test made on the rebar to determine the effect of heating it (Tr. 4608). The quality assurance coordinator instructed Walsh to conduct a test duplicating as nearly as possible the heat conditions under which rebar was previously bent in the field (Tr. 5159). The coordinator personally witnessed the activity and determined through the use of a temperature indicating crayon that the bars were heated to between 1100 to 1300 degrees but were not bent (Tr. 5160-5162). Pittsburgh Testing Laboratories received the bars and tested them for yield strength, tensile strength and elongation. They concluded that in all cases the rebar exceeded specification requirements (Tr. 4841; and App. Ex. 153). In addition to the aforementioned tests, structural engineers for Sargent and Lundy made an analysis of the effect of heating rebar (Tr. 4790-4791). After consultations with Commonwealth and the contractors, Sargent and Lundy specified twenty areas in which they knew bars were heated or where they may have been heated (*Id.*). Sargent and Lundy next calculated the loadings of the bars and compared them with the capability of the bars in place, assuming the bars had not been degraded. On the basis of this analysis they calculated capability to actual loadings and found a ratio of capability to actual load of 1.6 to 1 up to 10 to 1 (Tr. 4791), and concluded that the safety of these elements has not been reduced below the applicable design criteria (Tr. 4791-4792). The Staff also analyzed the effects of the hot bending of rebar at Zion. The Staff independently analyzed plant drawings for the facility and confirmed 23 locations where reinforcement bar was or might have been heated in the process of being bent. After reviewing the loadings and capacity of the rebar in question, the Staff concluded that the structures involved are adequate to meet their design load (Jeng, pp. 2-3, following Tr. 5466; Tr. 5470-5474).

9.28 During the proceeding, the Board expressed concern about the construction of the base slab for Unit 1 by a series of pours, due to cold weather, rather than in a monolithic pour as was the original intent of the Applicant. The concern regarded the integrity of the slab with respect to the accelerational forces of a design basis earthquake. A witness for the Applicant testified that there was no requirement for a monolithic pour; and that, indeed, the Unit 2 slab had been a segmented pour even though done in ideal weather (Tr. 5257). Another witness for the Applicant testified that the analysis of seismic loads was done by modeling the structure considering mass geometry and running a computer program to determine the maximum forces in the structural elements to which the structure is subjected due to a seismic load event. These forces then became the input of the structural analysis and construction joints were designed to transfer the loads to which they were subjected in such a way that the slabs would behave like a monolithic structure (Tr. 5352-5353). Both dynamic loads and static loads were considered, and an authority on concrete from Applicant's A-E testified that the resultant structure will meet all design load requirements (Tr. 5349).

9.29 In his testimony on May 17, 1973, before this Board, a Staff witness testified that his concern relating to the main steam line check valves had not yet been alleviated (Tr. 1481). The Board then stated desire to have a witness provided on this subject matter who could answer its concern (Tr. 1234-36). It was shown that the main steam line check valves are necessary to prevent the blowdown of more than one steam generator under the hypothesized occurrence of a steam line rupture at a point between the containment penetration and an isolation valve coupled with a concurrent single active failure of any of the motor operated main steam isolation valves (direct testimony of J. P. Knight, p. 1, following Tr. 5442). At the time these valves were designed, a maraging steel was selected as the base material; it was later determined that maraging steel is inappropriate for use in a steam environment (Tr. 4403-04). As the result new disks were installed made of lower strength but much higher ductility carbon steel. The reduced strength was compensated for by reducing the opening angle, increasing the thickness of the disk and installing three mechanical stops which will prevent the valve disk from opening more than seven degrees from the full closed position (Knight, p. 2, following Tr. 5442; Tr. 4402). Witnesses for the Staff and Commonwealth testified that the current analysis demonstrated that the valves may be safely operated at power levels up to and including 85 percent of rated power (Knight, *ibid.*, p. 6; Tr. 4402). However, it was indicated by both Staff and Applicant that no determination has been made as to the appropriate modifications necessary to allow the plant to operate up to 100% of rated power (Tr. 4405; Knight, *ibid.*, pp. 6-7), but the current analysis is such that the Staff, after applying reasonable conservatism, is only recommending operation of the modified valves at power levels up to and including 85% of rated full power *for the life of the facility.* In addition, the Staff has recommended an inspection program to monitor the condition of the valves and to look for unacceptable erosion (Knight, *ibid.*, p. 6).

9.30 Intervenors, in para. 9.12 of their Proposed Findings, contend that there are numerous quality deviations cited by Applicant for which no resolution has been implemented. A list of these is presented, drawn from two of Applicant's exhibits (App. Ex. 6 accompanying direct testimony of N. A. Kershaw, following Tr. 896; and App. Ex. 14, accompanying direct testimony of E. J. Hemzy, following Tr. 958). The Intervenors neither offered nor elicited testimony regarding the lack of ultimate resolution of the cited deviations, which were not contained in the statements of Contentions 9 and 10. Applicant's Ex. 6 was offered as an example of a Monthly Deviation Status Report and was introduced by Applicant with the observation that all deviations had been resolved (Kershaw, p. 13, *ibid.*). Applicant's Ex. 14 was offered to cover deviations subsequent to those shown in Ex. 6. Accompanying testimony of Applicant indicated that Commonwealth and the AEC both directed their attention to these matters until satisfactory resolution and corrective action were achieved.

9.31 Based upon a careful review of the record, the Board has presented its findings, with respect to Contentions 9 and 10, in the preceding paragraphs 9.5 through 9.30. The conclusions of the Board are set forth in the remaining paragraphs that follow, below.

9.32 The Board concludes that the Applicant, despite repeated AEC audits and admonitions, was unnecessarily slow to adopt the requirements of 10 CFR 50, Appendix B, as a rigorously implemented policy of management. This is only partially mitigated by the fact that construction of the Zion Station was well started when Appendix B became effective.

9.33 Applicant's retention of a well qualified outside consultant—the General Electric Co. Apollo Team—during most of the construction phase is favorably noted. The multiplicity of independent audits

and corrective actions resulting therefrom lead the Board to conclude that the Applicant clearly demonstrated a commitment to conform to the objectives of Appendix B.

9.34 Paragraphs 9.10 through 9.21, *supra*, deal with specific allegations in the statement of contentions. With the exception of the practices of the Walsh Construction Co. addressed below, the Board concludes that all discrepancies and items of non-compliance have been satisfactorily resolved for both units of the Zion Station. This conclusion embraces the integrity of hardware and structures, in addition to quality assurance documentation.

9.35 Regarding the discrepant practices of employees of the Walsh Construction Co., dealt with above in paragraphs 9.22 through 9.27, the Board concludes that a rigorous adherence, by the Applicant, to Criterion VII of Appendix B could have prevented the need for much after-the-fact reviews, examinations, and testing. Nevertheless, the Board also concludes, with respect to Unit 1, that Applicant and Staff have taken adequate measures to verify and document that no compromise to the safety and integrity of the facility has resulted.

9.36 The Board concludes from the evidence of record that there is no impairment of the seismic resistance capabilities of the Unit 1 reactor and containment slab, resulting from the manner in which it was poured (see para. 9.28, *supra*).

9.37 The Board concludes that Applicant and Staff have made an adequate analysis of the interim modifications to the main steam line check valves for the Zion Station. The Board concurs with the proposed confirmatory surveillance program for these valves and concludes that the recommended operating limitation of 85% of rated full power is appropriate for both units, until such time as the Applicant can satisfy the Staff regarding measures that will permit the limitation to be relaxed or removed. Accordingly, the Board adopts the above-mentioned operating limitation and valve surveillance program as *conditions* to be placed upon the operating licenses of both units.

9.38 At the conclusion of the hearing, the Applicant had not completed his review of any existing deficiencies, and their resolution, that may have occurred with Unit 2, resulting from the activities of the Walsh Construction Co. We do not condone those practices of the Applicant that have permitted deficiencies to occur. For a properly implemented quality assurance program will emphasize the prevention of deficiencies rather than their resolution. However, the record substantiates that Applicant and Staff have focused considerable and detailed attention upon the upgrading of the Zion Station quality assurance program, and specifically upon adequate resolution of the Unit 1 deficiencies derived from the actions of the Walsh Co. Accordingly, there being no basis for finding otherwise, the Board concludes that the Applicant may prudently be expected to adequately resolve any deficiencies requisite to the proper completion of Unit 2 in a manner providing for assurance of the health and safety of the public. Similarly, the Board finds no evidentiary basis for disregarding the presumption of administrative regularity in concluding that the Staff will require and assure the proper completion of Unit 2. *Arkansas Power & Light Co.*, ALAB-94 (Jan. 18, 1973), RAI-73-1 at 28, citing *U. S.* v. *Chemical Foundation*, 272 U. S. 1 (1926).

Contention 11: Operating Qualifications

11.1 In the statement of this Contention, Intervenors cite as the basis for their allegation the prior performance of the Applicant in operating nuclear power stations. Seven reported violations of Dresden Technical Specifications for Units 2 and 3 are then cited to substantiate that this prior performance does not permit an affirmative finding for the Zion Station.

11.2 Applicant's direct case was based upon the testimony of one of its Corporate Officers (direct testimony of B. O. Lee, following Tr. 2227). (It is noted that between preparation of the written testimony and its presentation, the witness was promoted to Vice President.) Since the start-up of Dresden Unit 1 in August, 1960, the Applicant has had 19 reactor years of experience in the operation of nuclear power plants. To date, the Applicant has operated four other nuclear units, two further units at Dresden and two units at Quad Cities. In 1972, approximately one-quarter of the 54 billion kilowatt hours generated by the Applicant were generated by nuclear power (*ibid.*, p. 4).

11.3 Many of Applicant's management personnel have had training and experience in nuclear areas. Applicant has more than 125 management people assigned to nuclear projects in its general offices, and an additional 196 management personnel assigned to its three nuclear generating stations. All of these people have had extensive training needed to meet AEC and industry standards. Applicant employs 64 engineers with nuclear degrees. Over two-thirds of these hold advanced degrees in the field (*ibid.*, pp. 3-4). The four individuals most directly responsible for the daily operation of Zion, the Station Superintendent, his assistant, the Superintendent of Generating Stations–Nuclear, and the Superintendent of Nuclear and Fossil Systems, have a combined total of about 57 years of preoperational and operational experience in the nuclear section of Applicant's Production Department, as well as extensive fossil station experience (*ibid.*, p. 8; Tr. 2251-52).

11.4 Applicant's organizational structure has been developed to reflect its growing nuclear operations and evolving Commission regulations. A major example of such change has been the establishment of designated quality assurance personnel so as to completely separate quality assurance functions from line organization (Lee, *ibid.*, pp. 4-5). Applicant has also designated a vice president whose office is responsible for communication with the Regulatory Staff and coordinating nuclear activities (*ibid.*, p. 5; Tr. 2225). In prior years, it designated a nuclear review board to review and audit facility operations and advise those company personnel with direct authority for day-to-day operations (Lee, *ibid.*, pp. 5-6; Tr. 2236-37). In order to more firmly establish this control function, the responsibilities of the board have been transferred to the Superintendent of Nuclear and Fossil Systems in regard to the Zion and Quad Cities stations and will be transferred for Dresden some time in the future (Lee, *ibid.*, p. 7; Tr. 2225-26). The Applicant has raised its technical staff supervision to the level of superintendent to give it the necessary authority to perform its function of review, audit and quality control. The Applicant also created the position of Superintendent of Production–Nuclear to which all superintendents of nuclear stations report. This position has been filled by an experienced nuclear station operator, thereby assuring that the home office supervision of nuclear generating facility operations is conducted by a person who is familiar with the requirements of such operation (Lee, pp. 6-7).

11.5 With respect to violations of Technical Specifications, the majority of such violations occurred during the initial operation of Dresden 2. Since that time, the record on that unit has greatly improved and the start-up experience at Dresden Unit 3 and Quad Cities Units 1 and 2 has been much better (App Ex. 69). All violations, including those referenced in the contention, are reviewed by both a Nuclear Review Board reporting to the President or the Superintendent of Nuclear and Fossil Systems and corporate management. While some of the Technical Specification violations are trivial, such as the failure to report an event by telegram as well as telephone, Applicant has acted to minimize violations (Lee, p. 10). These efforts have included the reassignment and focusing of responsibilities as well as steps to prevent the recurrence of specific events (Lee, pp. 8-10). In addition, the lack of severity of these violations may be judged by the fact that with respect to not endangering the actual health and safety of the public, Applicant's record over 19 reactor years of operation has been perfect (Lee, p. 10).

11.6 The Staff has concluded that the Applicant is qualified to operate Zion Station after reviewing Applicant's plans for operation as well as the inspection reports of the Directorate of Regulatory Operations (prepared Testimony of W. Houston, pp. 5-6, following Tr. 2185). Additionally, Staff's witness reviewed in testimony each of the inspection reports associated with the Dresden Station violations cited by Intervenors. He cited, from these reports, adequate responses by Applicant's organization, as well as evidence of corrective measures resulting therefrom (*ibid.*, pp. 3-5).

11.7 The Board takes cognizance of the undesirable violations of Technical Specifications by Applicant at the Dresden Station, as cited by Intervenors. However, we note that the statistics on violations at the Dresden and Quad Cities Stations show a definite improvement with time, indicative of an improvement process. Efforts by the Applicant to improve organization, and lines of communication, and to maintain well qualified personnel on their staff appear to us to be appropriately taken. The Staff shows evidence of an adequate degree of surveillance and attention to the matter of compliance. Accordingly, based on the testimony and the findings from same, the Board concludes that there is reasonable assurance that Applicant is technically qualified to operate Zion Station in a manner properly protective of the health and safety of the public.

Contention 12: Probability of Occurrence of Class 9 Accidents

12.1 The Board's Final Prehearing Conference Order excluded consideration of the consequences of this class of accidents. Further, note that the generic bases for not requiring applicants to analyze this class of accidents are only challengeable before the Commission. However, said bases (multiple physical barrier defenses against radioactivity releases, a high level of quality assurance, conservative design and continued

testing & surveillance), as the result of this Board's above-mentioned Order, are subject to challenge with respect to applicability to the specific facility under consideration. This Contention then turns solely on the question of whether the subject Applicant has met the burden of satisfying or providing the above bases. However, the question of quantitatively assigning a value to that probability of occurrence that would invalidate the said bases invokes subjective judgment factors that render impractical the resolution of this issue based solely on a specific, precise probability assessment. Rather, it would seem more appropriate to judge this issue upon the question of whether the Applicant has met the intent of the bases in the context of industry standards and Commission requirements, and thereby can be said to reasonably fall within the requirement of the Annex to Appendix D that there be a "high degree of assurance that potential accidents in this class are . . . sufficiently remote in probability that the environmental risk is extremely low . . . ."

12.2 The Intervenors direct case in support of this Contention is based upon a portion of the direct testimony of one witness (direct testimony of Dr. H. W. Kendall, following Tr. 3333). Part of the Contention 12 portion of this testimony was stricken from the record, leaving basically the following allegations:

- The Final Environmental Statement does not address the "environmental impact involving sequences of successive failures of engineered safety features and the reactor containment." "The Staff's position with respect to the low probability of major accidents is purely speculative and lacks any evidentiary basis." (Kendall, *ibid.*, p. 3)

- If such an accident occurred at Zion Station, the fission product deposition into Lake Michigan could result in a concentration of strontium-90 at levels which would prohibit continued use of Lake Michigan as a source of drinking water (*ibid.*).

12.3 The Board notes that this testimony does not address with particularity any challenge, specific to the design and construction of the Zion Station, that goes to the bases for assigning a low probability of occurrence to Class 9 accidents. The Proposed Findings of the Intervenors also do not specifically address the matter at issue, in the same manner (Intervenors' Proposed Finding, para. 12.1-12.9).

12.4 The Board observes that since the Zion Station Final Environmental Statement asserts (at VI-2) that the probability of occurrence of Class 9 accidents is extremely low, the area in question can be considered to relate to the adequacy of that Statement. However, absent any challenge to the specifics of design and construction of the Zion Station, itself (in the context of this Contention), the issue basically goes to the core of the expertise and judgment, regarding powerplant safety, developed by the Atomic Energy Commission and its Staff over many years. Thus, the Board finds appropriate the fact that Applicant's Proposed Findings (para. 12(1)-12(10)) rely almost entirely upon Staff testimony directed toward this area of discussion.

12.5 The Staff has reached a judgment as to the probability of occurrence of Class 9 accidents at Zion by assessing the probability of occurrence of a sudden, major loss-of-coolant accident (LOCA) and by assessing the probability of serious failure of the ECCS (Tr. 4456). In assessing the probability that a sudden major LOCA might occur, the Staff utilized studies concerning the probability of a sudden major break in conventional piping to piping in a nuclear plant (*ibid.*) This was done by recognition that nuclear codes require more design analysis and inspections, both pre-operational and in-service (Tr. 4457-58). On the basis of the above nuclear requirements, the Staff's judgment is that the probability of a sudden major LOCA at Zion would be 10^{-4} or 10^{-5} (Tr. 4458).

12.6 The Staff further assessed the probability of serious failure of the ECCS. There are not adequate statistics available to determine this probability (Tr. 4459, 4470-71). However, the Staff has assessed the probability of failure based upon the requirements placed on the design and testing of the system. The Staff judgment concerning the probability of serious failure of ECCS is 10^{-3} or 10^{-4} per reactor year (Tr. 4459).

12.7 Based upon the above analysis, the Staff has reached a judgment as to the probability of occurrence of the illustrated Class 9 accident at Zion to be less than 10^{-7} per reactor year (Tr. 4454).

12.8 The Board finds that there are qualitative factors which form the basis for the Staff's judgment as to the probability of occurrence of a Class 9 accident at Zion. These qualitative factors can be divided into three interrelated subject areas. The first area is design of the plant to conservative standards. The conservative standards provide assurance that the plant has a maximum tolerance for errors, off-normal operation and component malfunction (direct testimony of E. G. Case, p. 7, following Tr. 4453). Examples of these qualitative factors in the above subject area are the specification of conservative performance criteria, the selection of fuel, coolant core structural materials with inherent stability and safety characteristics, selection and use of plant component materials with established properties, and design of plant components so as to allow continuous or periodic monitoring (*ibid.*, pp. 8-9).

12.9 The second area of qualitative factors, used by the Staff as a basis for its judgment, is protection devices and systems used for assurance that anticipated transients and off-normal conditions will be detected and either arrested, or accommodated, safely. Examples of these devices and systems are a fast acting reactor shutdown system, activated by redundant and independent instrument channels, design features which limit the rate of increase of reactor power or radioactivity, independent supplies of off-site as well as on-site power for emergency use, and leak detection systems which indicate failures of reactor fuel cladding integrity and coolant leakage from the primary coolant system (*ibid.*, pp. 10-12).

12.10 The third area providing qualitative bases for the staff judgment is the additional margins in plant design which would protect the public even in the event of the unlikely occurrence of an accident. Examples of measures which provide additional safety margins are the ECCS and reactor containment (*ibid.*, pp. 12-13).

12.11 The Board also finds that safety reviews conducted by the AEC, including siting reviews, design reviews, and construction and operation reviews provide further bases for the Staff's conclusion (*ibid.*, pp. 14-17).

12.12 Based upon the record of evidence and the foregoing findings, the Board concludes that there exists an adequate basis for ascribing an extremely low probability to the occurrence of Class 9 accidents at the Zion Station. Therefore, the Board further concludes that the adequacy of the Final Environmental Statement is not impaired through lack of assessment of the environmental impact of such occurrences.

B. ENVIRONMENTAL MATTERS

Contention 13

13.1 The questions to be resolved, in the context of the Board's Final Prehearing Conference Order dated March 15, 1973, limiting Intervenors' Contention 13, may be briefly summarized as follows:

A. (1) Is the pre-operational limnological data adequate for baseline (bench mark) use? (2) Is the post-operational monitoring plan adequate for detecting adverse limnological effects in time to prevent irreversible damage?

B. Does the testimony provide specific examples of plant operations which can be reasonably described as irreversibly damaging to environmental quality of the lake in its entirety—or to a biologically significant portion of it?

C. Is there any limnological evidence for local adverse effects possibly spreading to remainder of the lake?

D. Is there evidence that risks of open cycle cooling outweigh benefits from available alternatives?

13.2 As a general observation, the Applicant's efforts to acquire physical, chemical and biological baseline data at the Zion site are impressive. It is probably the most intensive and productive series of studies ever conducted on an inshore area of Lake Michigan. From their inception the studies have been under the scrutiny and advice of excellent consultants, some of whom have special, nationally-recognized expertise on the limnology of the Great Lakes, including their biological characteristics. They were called as witnesses for the Applicant. Their responses to sharp questioning by Intervenors, the Staff and the Board were direct, candid, and quite objective.

13.3 On balance, from the evidence of record, the Board must conclude with affirmative answers for A(1) and A(2) of the posed questions (13.1 above), and with negative answers for B, C and D.

13.4 The Intervenors presented only one witness, Doctor Neess, in support of Contention 13. (Tr. 2681-2765) His direct testimony had a basic weakness. This was in his comparison of shallower and much smaller Lake Erie with Lake Michigan in its responsiveness to factors contributing to eutrophication. Citing Lake Erie as an example, Dr. Neess expressed grave concern that Lake Michigan *may* be in such a precipitous state that the addition of heat from isolated point sources such as Zion Station *might* perturb the asserted unstable state of the Lake irreversibly toward eutrophication and cause its total loss as a useful natural resource. In general terms the comparison appealed to the Board as initially valid. Its weakness was

in relation to the direct or indirect effects of the designed operation of Zion Station on Lake Michigan as a whole, or on a biologically significant portion thereof. His emphasis on the importance of the cumulative effects of human interference in moving the Lake toward a eutrophic state extended to the addition of heated water discharges. The Board acknowledges the importance of higher temperature in stimulating biological processes, but no evidence was presented to support a finding that the heated water discharge of Zion would have other than a very local effect on the biological processes in the Lake, or that the heat effect was cumulative and could be irreversible or widespread. As far as the entire lake is concerned, the effect of added heat from Zion would be so minute as to be unmeasurable. In his preoccupation with developing the theoretical importance of the heated water discharge, he tended to neglect discussion of the primary importance of plant nutrients, particularly phosphorus, in stimulation and supporting the eutrophication process (cf. testimony of Dr. Verduin, Tr. 3080, p. 13 & App. Ex. 104, Dr. Lee, Tr. 3250-51). However, in cross-examination he agreed that the nutrient level was a "major and sometimes primary factor" in the rate of eutrophication (Tr. 2752).

13.5 Dr. Neess, in his responses to cross-examination, would not or could not bring himself to concede clear evidence contrary to his position. Such evidence he dismissed as inconclusive, yet it was much stronger than any he presented in support of his own position. However, Dr. Neess freely admitted, in response to a Board question, that he could not identify any one single species of biota that might, with reasonable probability, be eliminated from Lake Michigan as a result of operation of the Zion plant (Tr. 2747).

13.6 Lake Michigan is generally described as an oligotrophic body of water, a lake with low nutrient concentration and biological productivity. Local inshore areas exist which tend toward being mesotrophic-eutrophic. Inshore waters in the Zion region have been characterized as mesotrophic or intermediate with respect to nutrients (Staff Ex. 7, p. II-13).

13.7 Lake Michigan, with the exception of Green Bay and some harbors, is near saturation with respect to dissolved oxygen. The percent saturation of dissolved oxygen in samples collected to the 20-foot depth contour off Zion Station in August, October and December, 1969, was well above the minimum saturation limit of 80 percent (Staff Ex. 7, p. II-13).

13.8 Concentrations of chloride, sulfate and total dissolved solids have been increasing substantially over the past ninety years. Available chemical data are not sufficient to demonstrate a lakewide increase in dissolved phosphate, but there is considerable evidence that increasing levels of phosphorus have been entering the lake in recent years (Staff Ex. 7, pp. II-13 and II-15).

13.9 The condenser cooling water from Zion Station will be discharged, at full power, at a velocity of 9.5 feet per second. The effect of this relatively high velocity is to maximize the amount of mixing with the cooler ambient water due to momentum entrainment and turbulent diffusion, and to delay the time (and lessen the temperature) at which surface cooling to the atmosphere becomes the dominant process for reducing the temperature of the discharge. The result of this high velocity discharge is a very rapid reduction in the temperature of water discharged down to 1 or 2 degrees above ambient, and a correspondingly short transit time through the plume for any molecule of water discharged by the station and for any biota in that parcel of water (prepared testimony of D. W. Pritchard, pp. 2-4, following Tr. 2651).

13.10 The size of the isotherms defining each of the Zion Station discharge plumes at full power operation in the summertime were predicted by Applicant's witness D. W. Pritchard to be as follows: (in each case the isotherm encloses an area in which the temperature is equal to or more than the number of

°F	Acres	Transit Times
14	0.27	18 seconds
10	0.57	35 seconds
7	1.4	1.3 minutes
5	3.9	3.5 minutes
4	7.5	6.1 minutes
3	13	9.9 minutes
2	28	20.5 minutes
1	108	1.3 hours

(Pritchard, p. 61).

degrees above ambient shown on the left column—see Fig. III-7, FES, p. III-14; the right hand entry in the preceding table shows the time it will take a particular water molecule to move from the point of discharge to the isoline).

13.11 Because the density of water changes with temperature, the size of the area within any isoline varies slightly with seasonal changes in temperature. Dr. Pritchard therefore included a calculation of the plume size and transit time for typical fall and winter ambient water temperatures (40° and 33°, respectively). In each case, the plume sizes are slightly larger and the transit times slightly longer. The predictions are:

For 40° ambient water:

°F	Acres	Transit Times
14	0.22	17 seconds
10	0.41	30 seconds
7	1.1	1.4 minutes
5	4.1	5.4 minutes
4	10.0	11.2 minutes
3	19.0	17.3 minutes
2	45.5	34.9 minutes
1	193	2.2 hours

(Pritchard, p. 62)

For 33° ambient water:

°F	Acres	Transit Times
14	0.21	17 seconds
10	0.38	30 seconds
7	1.2	1.8 minutes
5	4.3	6.2 minutes
4	11.0	14 minutes
3	27.4	26 minutes
2	97	1.1 hours
1	799	6.1 hours

(Pritchard, p. 63)

13.12 In each case, the size of the plume included within the 3°F isotherm is substantially smaller than the area allowed by the federally-approved Illinois temperature standard for Lake Michigan, which requires that the area within the 3°F isotherm be no larger than the area of a circle having a radius of 1,000 feet (such a circle has an area of 72 acres). (Regulations, Illinois Pollution Control Board, Chapter 3, Rule 206(e)).

13.13 Mr. Barton Hoglund, Assistant Director of the Center for Environmental Studies, Argonne National Laboratory, expressed skepticism regarding the acreage forecast by Dr. Pritchard (prepared testimony of B. M. Hoglund, pp. 9-10, following Tr. 3698). His skepticism was based on a mathematical extrapolation of a physical model of the proposed Donald C. Cook Nuclear Plant, and on the physical model of the proposed Nine Mile Point Nuclear Station. The plume sizes predicted for Nine Mile Point were of the same size predicted for the Zion discharge, but the diffuser used there was of a multiport design which uses the available mixing water more effectively than does the Zion design. Mr. Hoglund was therefore skeptical that the Zion discharge could be as efficient as the Nine Mile Point discharge. The Pritchard predictions are, however, corroborated by several other sets of data taken from actual plants or from test plumes (Pritchard, filed Dir. Testy., Tr. 2651, pp. 63-66).

13.14 The precise sizes of the Zion discharge plume cannot be determined prior to the time the plant goes into operation. They will then be determined by a plume measurement program which the Applicant has proposed and which is required by the Environmental Technical Specifications (Staff Ex. 8, Table 2.4, Section A). The plume sizes predicted by Dr. Pritchard are not contradicted by any evidence in the record, and it is likely that the acreage included within the 3°F isotherm will be less than is allowed by the applicable Illinois standard.

13.15 As a result of the rapid dilution achieved by the high velocity discharge, more than 90 percent of the heat added by Zion Station will not be dissipated to the atmosphere (Pritchard, p. 29) until the discharge is reduced to 2°F above ambient. Essentially all of it is dissipated to the atmosphere, however, primarily from areas in which the plume is less than 1° above the ambient water temperature. The mean residence time of the heat put into the Lake by the Zion Station will be from 4 to 11 days, depending on the season (Tr. 2662-64).

13.16 At temperatures as low as 1° above ambient, the plume is indistinguishable from the surrounding waters, whose natural variation in temperature from place to place is 5° or more (Tr. 2674-75). Water used for cooling purposes by Zion Station does not tend to recirculate to the station under normal operation, because the rate of mixing with the open lake waters, through currents, up-welling, eddies and turbulent diffusion is so large that substantially different water masses lie offshore of the station each day (Hoglund, Tr. 3698, pp. 1-9).

13.17 The design of the Zion Station discharge, and particularly the relatively short periods of time during which any waterborne biota will be subject to temperature increments of more than 2° or 3°F above ambient, served as the basis for the predictions, by the Applicant's witnesses who followed Dr. Pritchard, that no adverse effects on the ecology of Lake Michigan would occur.

13.18 The plume areas estimated by both Applicant and Staff are miniscule when compared to the heat assimilative capacity of the lake. The lake is approximately 320 miles long and 85 miles wide. Heat is a non-residentiary contaminant. Eventually all the heat discharged into the lake will be transferred to the atmosphere. The Applicant testified that the mean residence time for heat put into the lake by other than natural processes would be 4 to 11 days (Tr. 2662-64). Each year the lake "resets" itself by returning to a vertically isothermal condition. This occurs when the temperature of the lake cools to 4°C and below each winter and is the same from bottom to surface (Tr. 3698, p. 3).

13.19 The location and design of the Zion discharge orifices will enhance rapid assimilation and cooling of the waste heat from the Zion discharge system. A high velocity discharge (9.5 feet/sec) will allow rapid initial dilution. Placement of the two discharge orifices 760 feet from shore will allow inside, shoreside dilution and prevent a blending shoreline current often observed with shoreline discharges. The orifices will be at a depth ranging from eight to 12 feet. As the buoyant jet rises there will be an opportunity for vertical mixing and dilution. If the jet were discharged at the lake's surface there would not be any vertical mixing as the heated water, being less dense than the cooler water, would float on the surface, spreading laterally (Staff Ex. 7, p. III-10; Tr. 2651, p. 11).

13.20 The discharge design will also deter plume interaction between the two discharges. The jets are located 154 feet on either side of the center line of the intake pipe. The north jet is faced at an angle 45° NE to the shoreline. The south jet faces the SE at 45°. Both jets are at an angle of 90° to each other (*Id.*).

13.21 The Staff's witness Mr. Bart M. Hoglund described the several physical processes governing mixing between the so-called beach zone, inshore zone and open lake zone of Lake Michigan and concluded that no permanent barriers to such mixing exist. Vertical stratification during the spring and summer inhibits vertical mixing across the thermocline but the cooling of the entire Lake to 4°C during the winter produces complete vertical mixing on an annual basis. Development of the thermal bar in the spring temporarily inhibits horizontal mixing near the surface but not in the subsurface waters. Neither phenomenon will have a significant effect on the dispersion of heat and chemical wastes discharged from Zion Station (Hoglund, Tr. 3698, pp. 1-9).

13.22 Mr. Hoglund considers Applicant's monitoring program to be satisfactory for defining the physical dimensions and determining the environmental impact of the thermal plume but expressed concern over Applicant's technique for determining ambient temperature during rare upwelling conditions (Hoglund, Tr. 3698, pp. 12-13, and Tr. 3713-18 and 3731).

13.23 Mr. Hoglund does not expect the thermal discharge from Zion Station to have a significant effect on shoreline ice (Hoglund, pp. 13-14). When the ambient Lake temperature is below 50°F and the vertical thickness of the plume is at its maximum, there is a remote possibility that discharge water at approximately 1°F above ambient will be recirculated through the intake for short periods (Tr. 2668, 3720).

13.24 No evidence was presented that could contradict a finding that the Lake is capable of assimilating the waste heat from the Zion discharge. We also find that there is no physical barrier or impediment to dilution of the heated effluent to the open lake waters.

13.25 Applicant's witness Dr. Wesley O. Pipes discussed the possible effects of the Zion cooling water discharge on the benthic community in the area of the discharge. The benthic community in the Zion region of Lake Michigan does not vary spatially with respect to species composition but does so vary with respect to relative species abundance. More than 99% of the benthic organisms collected by Industrial Bio-Test Laboratories of Northbrook, Illinois (Pipes, Table II) belong to the following invertebrate classes: Crustacea, Oligochaeta, Pelecypoda, Insecta and Gastropoda. Almost all of the crustaceans belonged to the species, *Pontoporeia affinis,* which is characteristic of a deep oligotropic lake such as Lake Michigan. The most common oligochaete was the species, *Stylodrilus heringianus,* also characteristic of an oligotrophic lake (prepared testimony of W. O. Pipes, pp. 16-18, following Tr. 3040). None of the species collected were unique to the Zion region of Lake Michigan (Tr. 3297).

13.26 The data on benthic communities collected in 1970-72 shows that the abundance of benthic organisms increases with depth, significant differences occurring at 10, 20, 30 and 40 feet. Significant differences in the composition of the benthic community were found to depend on the particle size and organic content of the bottom sediment. Small particle size and high nutrient enrichment were usually found between the 40 and 90 foot depths (Pipes, pp. 20-21). The high velocity discharge is expected to scour an area of approximately five acres in front of the discharge structure. At normal water levels the discharge structure is approximately twelve feet below the surface of the lake. Benthic organisms are not found in great abundance at depths less than forty feet. Dr. Pipes would not consider the elimination of the relatively sparse benthic community in the five acres of the bottom scoured by the discharge jets to be significant ecologically and does not expect significant deterioration of the benthic community over any other area (Pipes, pp. 22-23, and Tr. 3068).

13.27 There is a slight possibility that the species of the benthic community at the 40 to 90 foot depths may be changed by the deposit of planktonic organisms destroyed during condenser passage; Dr. Pipes has recommended monitoring for this effect (Pipes, p. 21, 24-25, and Tr. 3066-67). It is also possible that fish may be attracted at certain times by the elevated temperatures in the thermal plume and feed heavily on benthic organisms (Pipes, p. 21).

13.28 Since the thermal discharge will not affect the two factors naturally controlling the abundance and composition of the benthic community, water depth and sediment composition, any effect on the benthic community can be reversed by terminating the thermal discharge from Zion Station and allowing dissipation to the atmosphere of any excess heat that may have accumulated in the lake (Pipes, Tr. 3040, p. 23, and Tr. 3065-66). Plant physiologists have established that plant metabolism increases with temperature provided physiologically damaging temperatures are not exceeded. Since temperatures in the Zion thermal plume are not expected to approach such levels, the only effect of the Zion cooling water discharge on phytoplankton should be an increase in metabolic rate (prepared testimony of J. Verduin, p. 2, following Tr. 3080).

13.29 Phytoplankton entrained in the Zion plume will be in a temperature zone causing metabolic stimulation of greater than six percent for less than two minutes out of the two hours such phytoplankton spend in the plume (App. Ex. 86). Most phytoplankton will not have passed through the condensers (Verduin, p. 3). A mathematical analysis of metabolic stimulation shows that the net photosynthetic gain for phytoplankton entrained in the plume is about two percent per day. Applicant's witness Dr. Verduin concluded that such gain would not significantly affect phytoplankton (Verduin, pp. 3-4).

13.30 Phytoplankton passing through the condensers at Applicant's Waukegan Power Plant do not suffer visible mechanical damage. A decline in ^{14}C-uptake noted for samples stored longer than 27 hours indicates that phytoplankton do suffer some physiological damage from condenser passage (Verduin, p. 4-5, and App. Ex. 87). The Zion Monitoring Program includes ^{14}C-uptake studies on phytoplankton to detect whether a similar effect will be caused by condenser passage at Zion (Verduin, p. 5). Dr. Verduin reviewed the literature on physiological damage caused by condenser passage and concluded that decreases in phytoplankton metabolism are related to lethal temperature and not to mechanical abrasion (Verduin, pp. 5-7).

13.31 Dr. Verduin compared data on phytoplankton populations observed in the Waukegan region of Lake Michigan with data on phytoplankton in the Zion region (App. Ex. 88). The average phytoplankton population density in the Waukegan region was sixteen percent higher than in the Zion region. Dr. Verduin attributed the difference to nutrient additions from the Waukegan Sanitary District rather than thermal discharges from Applicant's Waukegan power plant (Verduin, Tr. 3080, p. 8).

13.32 The first three major component species for phytoplankton in the Zion and Waukegan regions are identical. The differences in the fourth and fifth major component species were attributed by Dr. Verduin to nutrient additions rather than thermal discharges (Verduin, pp. 8-9). None of the species collected was unique to the Zion region (Tr. 3094). Blue-green nuisance forms were not present in the major component data. Specifically, *Aphanizomenon flosaque,* the first rank dominant in the Lake Erie summer blooms, was not present. The one blue-green species that appeared frequently, *Coelosphaerium naegelianum* is not a member of the *Anabaena-Microcystis-Aphanizomenon* complex which are notorius "bloom formers" (Verduin, pp. 9-10). Dr. Verduin estimated that nutrients in the Zion region of Lake Michigan would have to increase by a factor of at least five before there would be a detectable appearance of blue-green algae (Tr. 3098-99).

13.33 Phytoplankton communities in the region area are presently dominanted by diatom genera. The species diversity is large and population levels are low indicating a relatively nutrient-poor environment (Verduin, p. 10). Phytoplankton growth in the Zion region is controlled by the interaction between three factors: the phosphorous supply which most severely limits growth, the light supply which limits photosynthesis with increasing severity as water depth increases and the silicon supply which is in the limiting range for diatom growth. Dr. Verduin expects the thermal discharge from Zion Station to have negligible influence on phytoplankton growth, especially since the Zion region of Lake Michigan is nutrient poor (Verduin, pp. 12-13).

13.34 Dr. Verduin also analyzed the expected influence of the Zion Station thermal discharge on periphyton growth. A dominant member of the periphyton community, *Cladophora glomerata,* has assumed nuisance proportions in Lakes Erie and Ontario because of the nutrient additions being injected into those lakes (Verduin, p. 14). A survey of the bottom substrate at ninety-three locations in the Zion region showed that substrate suitable for periphyton growth existed at only one station, or about one percent of the bottom in the Zion region (Verduin, p. 17).

13.35 Even if the high velocity discharge erodes the sandy bottom and exposes substrate suitable for periphyton growth, the light supply is in the range of a severely limiting factor because *Cladophora* grows best at surface light intensity and light supplies at the bottom in the vicinity of the discharge average about thirty percent of surface light intensity (Verduin, pp. 17-18).

13.36 On the basis of the foregoing, the Board concludes that Zion thermal discharge is not likely to cause an increase in periphyton growth.

13.37 Zooplankton are the essential food chain link between the primary producers, the phytoplankton, and the higher aquatic life forms. Zooplankton, because of their small size, will be entrained in the Zion intake system and will be subjected to condenser passage. The Applicant examined the thermal and mechanical damage due to condenser passage and estimated the significance on lake ecology (Tr. 3139, p. 6).

13.38 Bio-Test Laboratories conducted a series of experiments at the Waukegan Power Station. They imitated the conditions that zooplankton would be subjected to at Zion. They found that eight percent of the zooplankton entrained were rendered immobile (Tr. 3140-41, 3163). This figure is conservative as actual condenser passage time at Zion will be less than half as long at Zion than it was at Waukegan. The annual zooplankton loss, based on eight percent immobility will be approximately 1.27×10^6 pounds per year. This is insignificant when compared to the total lake population and zooplankton reproductive rates which will replenish this loss within one day (Tr. 3154-55 and Tr. 3139, pp. 8-9). Indeed, there was testimony that were the immobility rate to reach 50 percent, the loss would still be insignificant to total lake populations (Tr. 3172).

13.39 The zooplankton population in the Zion region of Lake Michigan is comprised of immature copepods (57% of the population), cladocerans (36%) and adult copepods (7%). Seasonal variations are noticeable with copepods dominating in the spring and cladocerans dominating in August and September. The most common adults, in order, are *Cyclops bicuspidatus, Diaptomus spp., Cyclops vernalis, Bosmina longirostis* and *Daphnia vetrocurva* (prepared testimony of D. C. McNaught, p. 10, following Tr. 3139). None of the species collected are unique to the Zion region of Lake Michigan (Tr. 3148). Effects of condenser passage on zooplankton were examined at the Waukegan plant by Bio-Test for a 21–23°F temperature difference across the condenser to simulate condenser passage to Zion (McNaught, p. 4).

13.40 The Waukegan study determined that 2.1% of entrained zooplankton suffered immotility due to thermal stress, while 6% were rendered immotile due to mechanical abrasion (McNaught, p. 4, and App.

Ex. 95). Approximately 25% of the organisms initially immobilized recovered after twenty-four hours. Mechanical effects fluctuate with seasonal changes in species composition and size, the highest percentage immotility occurring in February and March when the large species appear. Immotility from thermal stress does not occur unless the discharge temperature exceeds the lethal temperature, a situation that is not expected to occur at Zion Station (McNaught, pp. 4-6). Observations elsewhere and laboratory studies conducted by Bio-Test support the conclusion that thermal stress experienced during condenser passage has little effect on the zooplankton survival rate (McNaught, pp. 2-4, 7-8).

13.41 Zooplankton exhibit high intrinsic growth rate so that the population will be quickly restored to environmental carrying capacity after condenser passage. Dr. McNaught estimated that recovery from the effects of condenser passage will take one day in summer and four days in winter (McNaught, p. 11, and App. Ex. 99).

13.42 On the basis of the foregoing the Board finds that the effect on zooplankton of passage through the Zion condensers will be minimal and such population reduction as occurs will be reversed rapidly through natural reproduction.

13.43 Applicant's witness Dr. Edward C. Raney described the Lake Michigan fishery and fish stocking programs conducted in 1972. Dr. Raney expects recreational fisheries to continue improving, but does not foresee improved commercial fishing in southern Lake Michigan except possibly for alewives (prepared testimony of Dr. Raney, p. 7, following Tr. 3960), principally because few men choose the difficult life of a commercial fisherman these days (Tr. 4034).

13.44 Bio-Test conducted studies of the fish population in the Waukegan-Zion region of Lake Michigan in 1971 and 1972. The major species by weight were alewife (66.8%), lake trout (12.4%), smelt (10.8%) and bloater (6.1%) in 1971 and alewife (76.01%), smelt (10.19%), lake trout (4.5%) and bloater (4.22%) in 1972. Sport fish such as coho, chinook, brown trout and rainbow trout accounted for 1.9% of the total catch by weight but only 0.05% by numbers. Yellow perch, both a sport and commercial fish, accounted for only 1.74% of the total catch by weight and 0.43% by numbers. Other commercial species such as herring, whitefish and turbot accounted for less than 1% of the total weight (Raney, pp. 8-9).

13.45 The distribution of fish in an area changes daily depending primarily on the preferred temperature of the species but also on daily migrations, abundance of food organisms and the necessity for finding suitable spawning substrate.

13.46 The heated discharge from Zion is not expected to have an important effect on the commercial and sport fish of the lake. Such species are relatively inabundant in the Zion vicinity, since they prefer deeper, open waters (Staff Ex. 7, pp. V-11-12) A certain number of fish are expected to be attracted to the warm discharge waters. Fish are able to detect small temperature differences and will move toward a preferable temperature range.

13.47 Fishes can acclimate to a given temperature not exceeding lethal limits and, once acclimated, will acclimate more readily to increases in temperature. Fishes do adapt to seasonal variations in temperatures as well as daily variations from place to place and will follow a temperature gradient to their preferred temperature. Fishes can perceive temperature differences of much less than 1°F and do avoid lethal temperatures, if possible (Raney, pp. 12-13).

13.48 Occasional fish kills have been caused by sudden temperature changes in heated water outfalls. Such kills involve mainly young fish unable to swim away from the affected area. The high velocity discharge of the cooling water at Zion Station tends to keep fish away from that portion of the plume having temperatures in excess of 8°F above ambient thereby eliminating the possibility of fish kills caused by sudden shutdowns in winter. In addition Bio-Test studies indicate fish are able to withstand sudden temperature decreases of at least 8°F (Raney, pp. 17-18, and Tr. 3979, and 3990-92).

13.49 Less than five acres of the plume will experience temperatures in excess of 5°F above ambient and be denied to fish as a potential living area (Raney, p. 17).

13.50 A species of fish which is acclimated to a given temperature may move toward or away from a higher or lower temperature depending upon its preferred temperature. Differences in temperature up to 5°F have little effect on the species of fish found in the Zion-Waukegan area (Raney, pp. 15-16).

13.51 At varying times during the year alewives, yellow perch, chinook salmon, lake trout and rainbow trout are expected to be attracted to the plume, especially when the ambient temperature falls below preferred temperatures. In no case are such fish expected to remain in the plume if avoidance temperatures are exceeded (Raney, pp. 18-20).

13.52 Recent observations at other large power stations confirm the rarity of fish kills caused by the discharges of thermal effluents (Raney, p. 20).

13.53 Based on the foregoing the Board concludes that there is no possibility of substantial fish kills caused by the high-velocity discharge of heated water from Zion Station. No evidence was shown that would indicate potentially significant damage to fish populations from thermal shock, gas-bubble disease or oxygen deficiencies in the Zion waters.

13.54 In order to prevent entrainment of fish by the intake system the Applicant will surround the intake structure with a 1" x 1" mesh net. This net will be in use from mid-March to mid-November. The velocity at the nets will be 0.3 feet/second (Staff Ex. 7, pp. V-13, 14).

13.55 The intake velocity at the net is low enough to enable larger fish such as salmon, trout and bloater to swim away from the net. Dr. Raney does not foresee significant fish kills at the Zion intake when the net is in place. During the winter the net will be replaced by a screen on the intake structure to prevent destruction of the net by ice. Dr. Raney is studying alternatives to the screen system for further reducing fish mortality at the intake including a guidance system for directing entrained fish back to the lake (Raney, pp. 22-23). Applicant will make modifications to the existing design if operating experience indicates that substantial fish kills are occurring (FES, Staff Ex. 7, p. iv.).

13.56 The proposed nets will limit entrainment during seasons when the larger fish species are more abundant in the Zion vicinity, e.g., trout, salmonids, bloater, yellow perch and alewife. Fish are expected to be attracted to the warm water which is recirculated to the intake structure during winter. Intake flow velocity will then increase to 3.7 feet/second (Staff Ex. 7, pp. V-6, 7).

13.57 The facility technical specifications also require the Applicant to monitor the number of fish impinged during both winter and non-winter operation. Further, the Applicant has been required to develop and submit for Staff review contingent intake modifications designed to reduce fish entrainment and to be prepared to make such modifications within a reasonably specified time period, if post-operational monitoring indicates such is warranted (FES, Staff Ex. 7, pp. iv; V-8). The Applicant has already arranged to conduct studies of the effectiveness of the winter screens (Tr. 3960, p. 23).

13.58 The mesh size of the nets is not small enough to prevent the entrainment of very small fish and eggs. Entrainment of such organisms should not be significant because the 2600 foot offshore location of the intake structure is located where fewer juveniles and eggs will be present and because of the relatively small use of the area for fish spawning (FES, Staff Ex. 7, p. V-6; and Tr. 3963-64).

13.59 The Staff testified that they were presently unable to quantitatively assess how many fish would need to be killed or injured before they would require the Applicant to modify the intake structure (Staff Ex. 7, p. V-7; and Tr. 3872-75). The Staff has required the Applicant to institute a rigorous and sensitive operational monitoring program. There has not been any evidence or indication that excessive or dangerous kills are expected. Applicant and Staff have cooperated in designing and implementing systems which are designed to prevent such an occurrence.

13.60 The Board cannot at this point in time predict the probable numbers or species of fish which may be killed by the intake structure. Moreover, the Board cannot in the abstract lay down a numerical rule as to what will comprise a fish kill large enough to justify imposition by the Commission of a requirement for installation of an additional guidance system.

13.61 In order to develop a reasonably effective system for rapid detection of "excessive numbers of juvenile and adult fish mortalities" resulting "from operation of the condenser cooling system" (FES Staff Ex. 7, p. iv), that would trigger the Staff's proposed contingent design modifications to the condenser cooling water intake structure (reducing intake velocity), the Board concludes that the Applicant's license should be *conditioned* upon inclusion of fish population studies at Applicant's off-shore remote control points. That is, this condition will assure that the Applicant utilizes the control points *outside* the influence of the thermal plume (south of the site at the Dead River outlet and four miles north of the site, FES-Staff Ex. 7, p. V-25) to monitor the quantity and quality of fish populations in the area in all seasons of the year, so as to provide meaningful base line data against which to rapidly assess the significance of any relatively large numbers of juvenile and adult fish mortalities resulting from the operation of the condenser cooling water system. (The FES should also be deemed modified in this respect.) The frequency of the fish population study at remote control points may be worked into the already-planned post-operational field studies of fish spawning grounds, so as to minimize additional expense. As soon as scientifically reliable fish population statistics have been gathered sufficient for the base line purposes desired, the frequency of the off-shore fish population monitoring program may be decreased, to be subsequently activated promptly whenever an abnormally high fish mortality is observed at the intake screens or forebay. This emergency monitoring should yield data on the magnitude or significance of such newly observed mortality figures, in relation to the size of the populations from which they were derived.

13.62 Applicant's witness Dr. G. Fred Lee reviewed the effects of temperature variations on the chemistry of natural waters, emphasizing eutrophication and the chemical parameters of water quality.

13.63 A molecule of particulate matter entrained in the intake water at Zion Station is exposed to a 20°F temperature gradient across the condenser before being discharged to Lake Michigan some two minutes later and cools to ambient lake temperature in a few hours. The vast majority of chemical molecules entrained in the thermal plume have not passed through the condensers. For such molecules the exposure to temperatures greater than 2°F above ambient lasts approximately one hour in the winter and less than one-half hour in the summer (prepared testimony of G. F. Lee, Part IA, p. 2, following Tr. 3232).

13.64 Dr. Lee gave examples of how natural temperature fluctuations in bodies of water may have a significant effect on the dissociation and solubility constants of dissolved chemical species. Such effects are largely reversible and cause little change in the overall water quality. Dr. Lee does not expect the slight temperature increase in the small area affected by the Zion plume to have an effect more significant than that caused by natural temperature variations experienced in Lake Michigan near Zion Station (Lee, Part IA, pp. 3-7).

13.65 Normal sorption processes such as the uptake of phosphate by clay minerals show little temperature dependence. Any chemical species whose concentration might be influenced by the sorption process would be unaffected by small variations in temperature (Lee, Part IA, pp. 7-8).

13.66 It has been estimated that the rate of a chemical reaction doubles with each 10°C increase in temperature. The temperature dependence of most chemical reactions does not necessarily mean that heating a mass of water will result in a significant change in chemical parameters. There must also be a large amount of chemical pollutants contained in the mass of heated water or two masses with distinctly different chemical characteristics must be mixed just before heating. Neither condition is satisfied in the region of Lake Michigan affected by the Zion Station thermal plume. When compared with the time-temperature history estimated for the Zion plume, the time rates of change for the chemical parameters of water quality in the Zion region are sufficiently slow that significant changes in the chemical parameters are unlikely. Dr. Lee noted that many chemical-biochemical transformations in natural waters actually diminish pollutants thereby improving water quality so that any increase in reaction rates caused by the thermal plume is not necessarily undesirable (Lee, Part IA, pp. 9-10).

13.67 If the water is grossly polluted and elevated temperatures persist for hours, it is possible that a body of water containing organic wastes could have amounts of oxygen adequate to maintain fish life only at temperatures less than such elevated temperatures. Neither condition necessary for such critical depletion in dissolved oxygen concentration is satisfied in the waters off Zion Station. In addition the turbulence of the high-velocity discharge tends to retard loss of the supersaturation of the cooling water to the atmosphere and thereby counters any development of a dissolved oxygen deficit (Lee, Part IA, pp. 14-15).

13.68 Dr. Lee identified the three major factors governing algae growth in lakes as temperature of water, amount of light penetration in the water and amount of aquatic plant nutrients in the water. Algae in natural waters require several days to double in number. Short-term natural variations in lake temperatures during summer cannot be correlated to changes in the number and types of algae present. For example, blue-green algae blooms in Lake Mendota, Wisconsin are caused by nutrient transfer from the hypolimnion to the epilimnion during passage of cold fronts. Although algae grow more rapidly as temperature increases, the total amount of algae present in a body of water is primarily dependent on the availability of nutrients. The relatively short time during which water will be entrained in the Zion Station thermal plume is insufficient to measurably alter the rate of remineralization of nitrogen and phosphorus compounds and increase the availability of nutrients in the water. The succession of algae in a lake proceeds from diatoms to green to blue-green algae as the water warms in the spring and summer. Blue-green algae often cause a greater deterioration in water quality than diatoms or green algae. Dr. Lee did not consider the length of time that algae will be entrained in the Zion Station thermal plume sufficient to cause a change in the rate of growth or number of blue-green algae (Lee, Part IA, pp. 15-19).

13.69 Based on the foregoing, the Board concludes that operation of Zion Station with the open cycle cooling system discharging relatively small volumes of heated water to a nutrient-limited environment will

not accelerate the eutrophication of Lake Michigan.

13.70 Dr. Lee gave two examples of lakes, Lake Waubesa and Kegonsa in Wisconsin and Lake Washington in Washington, which showed improved water quality after discharges of nutrient-rich waste were terminated (Le, Part IA, pp. 20-21).

13.71 Dr. Lee investigated the possibility that supersaturation of dissolved gases in the Zion thermal plume might cause embolism in fish. Short periods of exposure to grossly supersaturated conditions do not cause gas embolism in fish (Lee, Part IB, p. 3). Exposure to a dissolved gas supersaturation above 110 percent for a sufficient time is lethal to some fish. The dissolved gas supersaturation in the Zion thermal plume will exceed 110 percent over an area no greater than five acres. An organism entrained at the discharge point will be exposed to lethal levels of supersaturation for no more than three minutes (Lee, Part IB, p. 7).

13.72 Bio-Test has conducted extensive studies in the region of Lake Michigan near Applicant's Waukegan power plant (Lee, Part II). Dr. Lee concluded, on the basis of the data obtained in those studies, that operation of the Waukegan plant with once-through cooling has not affected various parameters of water quality (Lee, Part II, Table 1) other than causing a local increase in temperature and dissolved oxygen saturation (Lee, Part II, p. 4).

13.73 Dr. Lee has identified excessive discharges of phosphorus as the primary cause of deterioration in the water quality of Lake Michigan (Ex. A-104). Total phosphorous discharges to the lake will be reduced from approximately 18 million lbs. in 1971 to approximately six million lbs. in 1973 as a result of state and federal action initiated in 1968. Since most of the phosphorous is absorbed into the bottom sediments and does not remain suspended in the water column, Lake Michigan will reach a lower equilibrium level attributable to the substantial reduction in phosphorous discharges in 10 to 15 years rather than 100 years as commonly asserted. Dr. Lee expects such reductions to reverse the recent trend toward eutrophication and significantly improve the water quality of the lake (Lee, Part III).

13.74 Unlike other effluent discharges which leave a residue in the receiving water, no excess heat remains in the water after a thermal discharge is terminated because heat is continuously dissipated to the atmosphere (Lee, Part IA, p. 19).

13.75 The Board concludes that the effects, if any, of the thermal discharge from Zion Station on the water quality of Lake Michigan will be completely reversible.

13.76 Dr. Lee expressed concern that chemicals present in cooling tower blowdown water would have a much greater effect on water quality of the lake than thermal effluent discharges from the open-cycle cooling system constructed for Zion Station (App. Ex. 105, 106). Specifically, assuming only sulfuric acid and chlorine are used for conditioning cooling tower blowdown water, the chemical characteristics of such blowdown water at Zion Station would greatly exceed the Water Quality Standards of the State of Illinois for a variety of chemicals including phosphorus unless extremely complex water treatment measures such as ion exchange or osmosis were to be implemented (Lee, Part IV).

13.77 In May 1969 Applicant began pre-operational monitoring of the aquatic environment in Lake Michigan near Zion Station. Applicant's pre-operational monitoring program (the "pre-op program") followed the recommendations submitted to the Lake Michigan Enforcement Conference (LMEC) by the Kittrell committee in February 1969 (Pipes, pp. 1-2).

13.78 In the fall of 1969 Applicant concluded that the pre-op program might not provide sufficient data for a determination of whether or not condenser water discharges cause very subtle changes in aquatic communities and satisfy the temperature criteria then expected to be proposed to the LMEC in 1970. Dr. Pipes was requested to assist in developing a study plan for gathering the necessary information (Pipes, pp. 2-3).

13.79 Applicant retained specialists in the various scientific disciplines involved in its study plans. In addition to the experts who have testified on behalf of the Applicant in this proceeding, John Ayers from the University of Michigan and Andrew Robertson then from the University of Oklahoma participated in the pre-op program. Applicant will continue to retain the best scientists available throughout the operational monitoring program (Pipes, p. 3-4).

13.80 The 1969-70 studies were organized on the assumptions that any damage to the Lake Michigan ecology caused by condenser water discharge from Zion Station would proceed by a process capable of description by scientifically verifiable hypotheses and any effects on aquatic organisms caused by temperature variations would be more intense and easily measured at larger temperature changes and longer exposure time (Pipes, pp. 4-5).

13.81 In the fall of 1970 Applicant's consultants testified before the LMEC concerning possible ecological effects of the high velocity discharge designed for Zion Station. In general Applicant's consultants concluded that ecological effects were quite unlikely but would be reversible should any occur and recommended that Zion Station be allowed to proceed with open cycle cooling subject to back-fitting with a closed-cycle cooling system should unexpected ecological damage occur (Pipes, pp. 8-9).

13.82 In November 1972 the LMEC appointed a committee to review ongoing cooling water discharge studies and consider what additional studies might be necessary to determine if a multiplicity of heated water discharges would cause lake-wide effects (Pipes, p. 11).

13.83 Following distribution of copies of the original study plan, Applicant received comments from scientists at various laboratories suggesting additions to the study plans as well as improvements in methodology. In early 1971 Applicant revised its study plans for several projects and developed plans for additional projects in response to such comments and an evaluation of the data that had been collected (Pipes, p. 11).

13.84 Part of Applicant's pre-op program is directed toward obtaining a description of various aquatic communities in terms of species composition and species abundance and collecting the baseline data necessary for detecting any changes in such species caused by the cooling water discharge from Zion Station. Applicant has collected data on phytoplankton, zooplankton, periphyton, benthic and nekton communities (Pipes, pp. 13 and 15).

13.85 Natural variations in physical, chemical and biological parameters of environmental quality may occur naturally at different times in the same location or in different locations at the same time. Applicant has taken great care in designing the operational monitoring program to account for such spatial and time-related fluctuations so that the locations sampled to determine discharge effects will be identical except for the elevated temperature caused by the thermal discharge from Zion Station (Pipes, pp. 13-15).

13.86 Drs. Lee, McNaught, Pipes, Raney and Verduin expressed confidence in the capability of the operational monitoring program to detect any significant change in the ecology of Lake Michigan attributable to the discharge of heated water from Zion Station (Tr. 3061, 3099, 3124, 3164-66,3276-77 and 4022-23).

13.87 Intervenors' witness on the issue of environmental damage was Dr. John Neess, Professor of Zoology at the University of Wisconsin. Dr. Neess did not testify that the Zion Station discharge would cause widespread or irreversible environmental effects on the aquatic biota of Lake Michigan. Instead, he testified that the possibility of such effects could not be dismissed out of hand, and that, in his judgment, the economic costs associated with alternative cooling systems were justified by the existence of any risk that harm would occur (Tr. 2683, et seq.).

13.88 Dr. Neess did not identify any mechanism which would or might cause adverse widespread or irreversible effects in the lake. Instead, he referred to the general complexity of all aquatic ecosystems, and pointed to Lake Erie as an example of a large body of water in which widespread and, at least thus far, irreversible adverse changes have occurred. His thesis was that ecological change is difficult to predict in advance, and that, in the absence of predictive ability, one must take every step to lessen the risk of causing ecological change (prepared testimony of J. C. Neess, pp. 6-7, following Tr. 2683).

13.89 The Board is not able to find that the discharge of condenser cooling water to the lake is wholly free of risk to the aquatic biota. No man can absolutely guarantee future events. But the Board is persuaded that the hearing record does support a finding that no substantial risk is being taken by using open cycle cooling at Zion Station. Dr. Neess, while regarding Lake Michigan as being in the process of decline, agreed with the Board that it was an oligotrophic lake, not really comparable to Lake Erie's present or recent past condition (Tr. 2732, 2750). The lake receives large quantities of heat every day from the atmosphere—much more heat than comes from any one or several power plants. Since heat from any source is only heat, so far as the lake and the biota are concerned, the Board cannot find any likelihood that the limited amount of additional heat from Zion Station will produce any different effects than have natural variations in temperature, which, as Dr. Neess admitted, the lake has been able to survive without any apparent difficulty (Tr. 2708-2713). In that sense, this is quite different from those ecological changes, such as chemical changes or the addition of another species of predator, which Dr. Neess used as examples of the changes which concern him (Tr. 2703).

13.90 Dr. Neess's concern about risk to the lake appears to stem from his reluctance to predict the effect of any variation from the present status of the lake. He declined, for example, to predict that any

improvement in water quality will result from the reduction in phosphorus input to the lake from 18 million to 6 million pounds per year, which is currently taking place. He also believed it was not possible to tell whether reducing phosphorus input will make the lake worse or will leave it just the same (Tr. 2760-64). The Board believes it much more likely that the discharge of cooling water from Zion Station will leave the lake just as it now is, than that the reduction in phosphorus input will have that effect.

13.91 Dr. Neess's judgment that the possibility of any risk mandates the use of the alternative of closed cycle cooling did not include any assessment of the adverse environmental effects of closed cycle evaporative cooling. His judgment is thus based on a standard and on factors different from those this Board is required to use.

13.92 Applicant's Monitoring Program, with the addition of the Board's fish population monitoring condition set forth in paragraph *13.61* above, together with the *conditions* set forth in the *FES* (Staff Ex. 7, summarized on p. iv), will be adequate to detect any significant change in the aquatic environment caused by the use of an open-cycle cooling system in sufficient time to prevent irreversible damage. The record is barren of any evidence that Applicant's open-cycle cooling system will cause irreversible damage to any biologically significant area of Lake Michigan or that local adverse effects will spread to the remainder of the lake.

13.93 The Board has reviewed the "pre-op" study programs and the biological information gathered by the Applicant. The Applicant's pre-operational monitoring programs appear to be comprehensive and adequate. The Intervenor failed to offer any substantial contradictory evidence as to the adequacy of the pre-op program. We find that the Applicant's pre-op program satisfies the need for baseline data from which the environmental impact caused by Zion can be measured (See App. Ex. 83).

13.94 The post-operational monitoring programs are contained in the Zion Technical Specifications (Staff Ex. 8). The Board finds that the technical specifications will provide a sensitive monitor on impacts from Zion, once the Board's condition relative to off-shore fish population is added to the program, and, assuming, of course, the inclusion of the environmental conditions set forth in the FES (Staff Ex. 7), listed on p. iv therein, which conditions the Board incorporates by reference.

13.95 Based upon a review of all the environmental evidence and testimony of record in this proceeding, the Board finds that the facts do not support the Intervenors' allegations as set forth in their Contention 13, and that the Applicant has met its burden of disproving those allegations.

13.96 Of course, there is an overlapping in the environmental evidence between the testimony in rebuttal to the Intervenors' (environmental) Contention 13 and the testimony in substantiation of the required NEPA review. Accordingly, many of the findings in the succeeding "NEPA" section of this decision (IV-C, findings commencing with para. 14.1), can also be seen to specifically answer some of the allegations and implications of Intervenors' Contention 13. Likewise, many of the Findings in this section 13 would also respond to the question of adequacy of the required FES and NEPA review.

C. COMPLIANCE WITH NEPA, APPENDIX D TO 10 CFR 50, AND FWPCA

14.1 Section 102(2)(c) of the National Environmental Policy Act ("NEPA") mandates that:

> all agencies of the Federal Government shall include in every . . . report on proposals for . . . major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on:
>
> (i) the environmental impact of the proposed action,
>
> (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
>
> (iii) alternatives to the proposed action,
>
> (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
>
> (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

14.2 Applicant submitted to the AEC its Zion Nuclear Power Station Environmental Report pursuant to the then current requirements in 10 CFR 50, Appendix D. Following the AEC's revision of Appendix D on September 9, 1971 (36 *Fed. Reg.* 18071), Applicant submitted separately Supplements I through V to the Environmental Report.

14.3 Notice of Availability of Supplements I and II was published on December 30, 1971 (36 *Fed Reg.* 25242). Notice of Availability of Supplements III through V was published on June 30, 1972 (37 *Fed. Reg.* 12982). After the Environmental Report was received by the AEC, a Notice of Availability was published on December 30, 1971 (36 *Fed. Reg.* 25242); and the Environmental Report as supplemented was otherwise made available to the public as required by paragraph A.6 of Appendix D to 10 CFR 50 (Staff Ex. 7, p. xv). Thereafter a draft environmental statement related to Zion Station, Units 1 and 2, dated June, 1972, was prepared by the Regulatory Staff. Notice of Availability of the draft statement was published on June 30, 1972 (37 *Fed. Reg.* 12982). Copies of the draft statement were transmitted to the appropriate agencies and officials as required by Paragraph A.6 of Appendix D (Staff Ex. 7, p. XII-1).

14.4 Comments in response to the draft statement were received from the Departments of Agriculture, the Army, Commerce, the Interior and Transportation, the Environmental Protection Agency, the Federal Power Commission, the Illinois Environmental Protection Agency, the Northeastern Illinois Planning Commission, The Metropolitan Sanitary District of Greater Chicago, Commonwealth Edison Company, the Advisory Council on Historic Preservation and two members of the De Paul University faculty (Staff Ex. 7, Appendices E through Q), the Final Environmental Statement was prepared by the Regulatory Staff.

14.5 The FES sets forth detailed statements on the environmental impact of construction and operation of Zion Units 1 and 2 (Staff Ex. 7, §§IV & V); adverse effects which cannot be avoided (Staff Ex. 7, §VII); alternatives to the operation of Zion Units 1 and 2 as built (Staff Ex. 7, §XI. A); the relationship between local short-term uses and the maintenance and enhancement of long-term productivity (Staff Ex. 7, §VIII); and irreversible and irretrievable commitments of resources (Staff Ex. 7, §IX). In addition, the FES includes a discussion of problems and objections raised in the comments received on the draft detailed statement and the disposition thereof (Staff Ex. 7, §XII).

14.6 The FES contains a cost-benefit analysis and discussion of alternatives to Zion Units 1 and 2 as built which would alter the environmental impact (Staff Ex. 7, §XI). These include alternative land uses, alternative power sources and alternative heat dissipation systems which would lessen the thermal impact of the facility on Lake Michigan (Staff Ex.7, §XI.A). The Staff rejected all of these alternatives on economic or environmental grounds (Staff Ex. 7, §XI.A.4) and concluded, based on comparative evaluations, that none of the alternatives considered produces a significant environmental benefit or reduction in environmental cost in comparison to the present system. Further, the Staff concluded that all of the alternatives result in economic costs that cannot be balanced by economic or environmental benefits (Staff Ex. 7, pp. XI-17 through XI-26).

14.7 Applicant submitted a summary of the economic and environmental aspects of alternatives to Zion Units 1 and 2 (Staff Ex. 7, Table XI-3, pp. XI-19 and XI-20). Applicant's data supporting Table XI-3 is contained in Supplement II to the Environmental Report (Staff Ex. 7, p. XI-18). The Board finds that Applicant's cost-benefit summary contains sufficient data to aid the Commission in its development of an independent cost-benefit analysis. The FES sets out a list of licenses, permits and other approvals of Federal and State agencies which are required for Zion Units 1 and 2 prior to operation (Staff Ex. 7, §I-B).

14.8 The FES considers in detail radiological environmental effects including normal operation effects, effects of transportation of fuel and solid waste, and the impact of postulated accidents (Staff Ex. 7, §§V.D., V.F. and VI.B). The Staff has concluded, as a result of the above-described evaluations and analyses and after weighing the environmental, economic, technical, and other benefits from the Zion Nuclear Power Station against the environmental costs and considering available alternatives, that the action called for is issuance of the operating license requested.

14.9 On December 5, 1972, the appropriate Notice was published, and the FES made available to the public and various Governmental agencies as required by Paragraph A.9 of Appendix D (37 *Fed. Reg.* 25870).

14.10 On the basis of the foregoing, the Board concludes that the requirements of Paragraphs A.6, A.7, A.8 and A.9 of Appendix D to 10 CFR 50 have been complied with.

14.11 The Board adopts the following sections of the FES as written: §I. Introduction; §II. The Site; §III. The Plant; §IV. Environmental Impact of Site Preparation and Plant Construction; §VII. Adverse

Effects Which Cannot Be Avoided; §VIII. Short Term Uses and Long Term Productivity; §IX. Irreversible and Irretrievable Commitments of Resources; and §X. The Need For Power. These Sections supply the data which form the basis from which a discussion of the environmental impact of operation must proceed. No evidence has been introduced in this proceeding which controverts the data set forth in these Sections.

14.12 In view of the foregoing, the Board finds that due consideration has been given to environmental quality standards promulgated by other agencies; and the environmental impact of Zion Units 1 and 2 has been considered with respect to matters covered by such standards in the cost-benefit analysis.

14.13 Section V.A of the FES deals with the environmental impact of plant operation on land use. The Zion Nuclear Power Station, Units 1 and 2, is located on a 250-acre site on the shore of Lake Michigan in Zion, Illinois, approximately equidistant between Chicago, Illinois and Milwaukee, Wisconsin. The land occupied by the site was previously sparsely occupied by privately owned cottages and was used mainly for recreational purposes. The surrounding areas have a similar character. If plans for extending the state park north of the site materialize, Zion Station will be essentially an "island" in the park. The removal of the 250-acre site from the proposed future recreational area will not in itself produce a significant impact on use of the surrounding land.

14.14 The Staff's witness Dr. Joseph E. Draley supplemented his findings in the FES, §§III.D.3, V.B.3, XII.E and Summary and Conclusions Part 3-g, on chemical and sanitary releases from Zion Station. Table III-4 of the FES (Staff Ex. 7) does not show the quantity of chemicals removed from the lake water and subsequently discharged during resin regeneration. Such chemicals have the same composition as that shown for the lake water in Table II-1 of the FES and comprise about 19% of the total waste from the makeup water purification system (prepared testimony of J. E. Draley, pp. 1-2, following Tr. 3287). The concentration of phosphate and nitrate will be increased by an insignificant amount (0.0036%) compared to inputs from other sources. The release of such nontoxic waste has an insignificant impact on Lake Michigan when compared to the normal increase in total dissolved solids (Draley, p. 5).

14.15 Sodium hypochlorite will be added to the service water for three 15-minute periods each day but the concentration of chlorine in the discharge water will be less than the 0.04 parts per million Environmental Protection Agency criteria for waters containing sensitive species of fish (Draley, pp. 3-5). Such chlorine discharges will not harm the biota in Lake Michigan.

14.16 An additional amount (0.43 lb/day) of phosphate will be discharged if Amway S-A-8 detergent (8.7% phosphate) is chosen for use at Zion Station but the change in local phosphate concentration would be quite small compared to normal seasonal variations (Draley, pp. 5-6).

14.17 Leakage of the primary coolant in the generator may result in the discharge of boron neutralized with trisodium phosphate. The local concentrations of boron and phosphate in the lake will show little long-range effect. Although an effect may be detectable for short periods, the phosphate concentration will be only one-fifth of the EPA criteria and the boron concentration only one two-hundredth of the Illinois standard (Draley, pp. 6-7).

14.18 The intake structure for the open-cycle cooling system at Zion Station is located approximately 2,600 feet offshore. Passage through the condensers raises the water temperature by no more than 20°F. The heated water is discharged to the lake by two high velocity jets located approximately 760 feet offshore (prepared testimony of R. D. Roman, p. 1, following Tr. 3910).

14.19 The Staff's witness Mr. R. D. Roman summarized the factors supporting the Staff's conclusion that open-cycle cooling is environmentally acceptable at Zion Station. Chemical wastes discharged in the cooling water will not exceed acceptable levels and natural mixing between the so-called zones of the lake will prevent build-up of such concentrations to unacceptable levels. The Staff feels that fish kills at the intake could be a major impact and recommended monitoring requirements to detect such kills and preparation of design modifications to reduce such kills should the numbers become excessive. Other impacts such as plankton mortality due to condenser passage, sediment transport and sinking plume effects on pelagic and benthic organisms are expected to be minor. Applicant's monitoring program is sufficient to detect any environmental damage that might result from operation of Zion Station with open-cycle cooling. Any environmental damage would be reversible. The Staff determined that any alternative cooling system would cause significant terrestrial impacts and concluded that change to an alternative cooling system would impose an unnecessary expense on Applicant (Roman, pp. 4-7).

14.20 Between June 1971 and June 1972 three states, Illinois, Michigan and Wisconsin, adopted regulations permitting plants under construction to proceed with open cycle cooling systems provided monitoring programs were implemented to detect any significant ecological damage caused by cooling water discharges. In January 1973 the Federal Environmental Protection Agency approved the Illinois temperature regulations for Lake Michigan (Pipes, pp. 10-11, and App. Ex. 85).

14.21 While there is no contention in this case regarding the environmental effect of normal releases of radiation from Zion Station, the Board requested testimony on that subject from the Staff. The Staff's witness Dr. Norman Frigerio confirmed that the Staff made an independent determination of the level of exposure of people, plants and animals caused by the release of radioactive nuclides from Zion Station (Staff Ex. 9, pp. V-26 and V-27, and direct testimony of N. A. Frigerio, p. 1, following Tr. 4549). As requested by the Board, Dr. Frigerio provided a comparison between the radionuclide doses and the criteria in 10 CFR Parts 20 and 50 (Frigerio, p. 1). In general such doses are less than one percent of those set forth in 10 CFR Parts 20 and 50.

14.22 The Chi/Q values given in the FES were obtained from Zion Station data but the model was modified to allow for the possibility that the stability frequency data might be questionable. An independent analysis using data from the Milwaukee airport verified the adequacy of the Zion model as modified (Frigerio, p. 2).

14.23 The Staff's witness Mr. John T. Collins confirmed that the releases listed in Tables III-2 and III-3 of the FES were determined independently by the Staff (Tr. 4551).

14.24 NEPA requires that "all agencies of the Federal Government shall include in every . . . report on proposals for . . . major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on *alternatives* to the proposed action" (42 U.S.C.A. 4332(2)(c)(iii), emphasis added).

14.25 The FES discussion of alternatives to the proposed action and a cost-benefit analysis of their environmental effects appear in §XI. Included is a detailed discussion of the following alternatives: abandoning Zion Station, converting Zion Station to fossil fuels, using cooling towers to dissipate waste heat, using a cooling pond or a spray cooling system and using alternative means to clean the condensers (Staff Ex. 7, pp. XI-1-17). The cost-benefit analysis made for the existing Plant design was compared with a number of the alternatives to determine the reasonableness of the existing design relative to viable alternatives in terms of environmental values (Staff Ex. 7, pp. XI-17-26).

14.26 Applicant's witness Dr. George E. McVehil evaluated the atmospheric effects that would be caused by operation of cooling towers at Zion Station.

14.27 Several features of Lake Michigan create unique problems for cooling tower operation. On-shore winds during spring and summer carry moist, cool air inland creating a stable situation with weak mixing. Little additional water is required for saturation. The temperature difference between land and water causes "lake-breeze circulation," a local atmospheric circulation of offshore air five to fifteen miles inland, initially at low altitude but rising to an altitude of several thousand feet before circulating back over the lake. Cooling tower plumes could form highly persistent haze and cloud layers in such closed circulation (prepared testimony of G. E. McVehil, pp. 9-10, following Tr. 3611).

14.28 Dr. McVehil's study indicates that mechanical draft cooling towers would cause surface fog for as many as 650 hours per year (App. Ex. 121). From 50 to 90 hours of fog would occur 1½ to 2½ miles north of the plant. Waukegan Memorial Airport would be subject to between 20 and 40 hours of fog each year. Such fog can be expected on as many as 150 days per year and as many as 25 days at a single location. Most of the fog will occur during the winter months (App. Ex. 123) between midnight and 10:00 A.M. and should last no more than four hours (McVehil, pp. 26-29). Cooling tower fog would coincide with natural fog about 35 percent of the total hours further reducing visibility (McVehil, pp. 33-34).

14.29 Natural draft and hybrid cooling towers would cause considerably less surface fog:

Type	Hours of fog per year
250 ft. hybrid	25–100
350 ft. natural draft	15–75
500 ft. natural draft	5–40

(App. Ex. 125).

14.30 Since approximatly 56% of the total hours of such fog would occur at below freezing temperatures, light icing should be expected on local highways (McVehil, pp. 34-35, and Tr. 3642).

14.31 Plumes from cooling towers would persist as far as twenty miles from the plant. Plume width increases with distance from the plant, typically spanning two miles at a distance of ten miles (McVehil, pp. 31 and 34).

14.32 The Staff's witness Dr. Carson evaluated the meteorological impact of open and closed cycle cooling at Zion Station. Open cycle cooling will result in a small localized increase in the incidence of steam fog over the thermal plume. Shoreline ice formations will not be induced by the increased steam fog (prepared testimony of Dr. Carson, pp. 2-4, following Tr. 3740). Natural draft cooling towers create visible plumes extending more than ten miles in some instances. Mechanical draft cooling towers can create extensive surface fogging and icing. Dr. Carson felt that hybrid towers would produce plumes similar to those produced by natural draft towers. Dr. Carson did not specifically analyze the potential impact of cooling towers at Zion Station (Carson, pp. 4-6, and Tr. 3757-58).

14.33 Cooling towers, a cooling lake and a spray canal were evaluated by Applicant as alternatives to the open-cycle cooling system designed for Zion Station. Applicant's ability to install such alternatives at Zion Station is restrained by the height limitation imposed on structures near Waukegan Memorial Airport, the potential impact of such alternatives on the proposed state park extension north of the Zion site and on the proposed expressway along the western boundary of the site, and the maximum rate at which the State of Illinois is permitted to divert water from Lake Michigan (prepared testimony of O. Tranby, pp. 1-2, following Tr. 3305).

14.34 Applicant did not make a detailed study of mechanical draft evaporative cooling towers because the plumes from such towers are released only sixty feet from ground level causing undesirable ground fog from time to time (Tranby, pp. 3-4).

14.35 Applicant performed detailed cost and feasibility estimates for hybrid mechanical draft cooling towers, each having a 250-foot hyberbolic discharge stack for plume dispersal. Installation of such towers would require major modifications in the circulating and service water systems (Tranby, pp. 4-5). The cost of backfitting Zion Station to accommodate such towers is $32,838,000 (Tranby, p. 6). Operation of such towers would reduce plant capacity by 159,133 kilowatts, more electricity than is consumed by any other industrial facility in northern Illinois (Tranby, pp. 6-7). The total cost of building and operating hybrid cooling towers is $124,026,000 (App. Ex. 107).

14.36 Applicant investigated several designs for natural draft evaporative cooling towers. Five hundred foot towers would provide the best plume dispersal of the alternatives but would conflict with the 250-foot height limitation imposed by the FAA. If tower height is restricted to 250 feet, it might not be possible to meet airflow requirements throughout the year. The total cost of such towers, including initial investment, capacity losses, operating costs and maintenance costs, is $120,000,000 (Tranby, pp. 7-8).

14.37 Non-evaporative dry cooling towers would require approximately 300 to 360 acres of land in addition to that available on the present Zion site (Tranby, p. 9). The total cost for building and operating such towers is $463,882,000 (App. Ex. 108).

14.38 Mr. Tranby felt that the operating experience with the so-called wet/dry cooling towers was too limited to merit further consideration of such towers for Zion Station (Tranby, p. 10).

14.39 Problems associated with the acquisition of approximately 3,000 acres of land virtually eliminate a cooling lake as an alternative to open-cycle cooling. Available sites lie west of the City of Zion, necessitating several miles of very expensive piping and a very large electrical consumption for pumping the water through the pipes between the plant and the lake (Tranby, pp. 10-11).

14.40 A spray canal would have to be approximately 20,000 feet long with a 600-foot buffer zone on either side to lessen the impact of ground level fogging, would require more than 500 acres and would cause substantial capability losses. The total cost for a spray canal would be approximately the same as that for mechanical draft cooling towers (Tranby, pp. 12-13).

14.41 The Staff's witness Dr. Gary J. Marmer estimated the land requirements and capital costs for various alternative cooling systems proposed for Zion Station. A cooling lake, spray pond and spray canal each require more land than is available on the Zion site. Expansion of the site into the Illinois Beach State Park or the proposed addition to the Park is unacceptable because the area is unique, containing the only dune land in Illinois. The closest available land is three to four miles from the site, west of the City of Zion. The Staff has not required Applicant to submit a detailed feasibility study for such inland siting because of the severe terrestrial impact of such siting (prepared testimony of G. J. Marmer, pp. 1-2, following Tr. 3762).

14.42 The capital cost for construction of a 3,000 acre cooling pond at other Lake Michigan nuclear stations has been estimated to range from $36,000,000 to $83,000,000 (Marmer, Table 1, p. 7). Such estimates did not include the cost of a transport system for a pond sited inland. The Staff estimated that the capital cost, excluding transport system, of a spray canal at Zion Station would be $41,000,000. There are no spray ponds, existing or planned, having the surface area required for Zion Station (Marmer, pp. 2-3).

14.43 The backfitting of dry cooling towers at Zion Station would require replacement of the condensers and, probably, the low pressure turbine to prevent damage and/or plant shutdown at the high turbine back pressures that would occur during high dry-bulb temperature conditions. Approximately forty acres of land would be needed just for the base of such towers and the capital cost, excluding costs of backfitting, would be $50,000,000 to $100,000,000. Loss of capability would be more than ten percent during high dry-bulb temperature conditions (Marmer, pp. 3-4, and Tr. 3764-65).

14.44 Standard wet mechanical-draft towers would require seven acres for the base alone and several times that for adequate spacing of the towers. The disadvantages of such towers compared to open-cycle cooling include greater operation and maintenance cost, decreased plant capacity and the release of 60,000 lb/day (vs. 638 lb/day for open-cycle cooling) of dissolved solids to the lake. Treatment of the blowdown water for removal of the dissolved solids would be very expensive (Marmer, pp. 4-5, and Tr. 3763-64). The capital cost of such towers would be $78,400,000 (Marmer, Table 2, p. 8).

14.45 Natural-draft wet cooling towers would require approximately twenty acres for the base and release dissolved solids to the lake at approximately the same rate as wet mechanical-draft towers. The present worth of such towers, including backfitting and loss capability, is $124,000,000 (Marmer, p. 5).

14.46 Applicant's proposed hybrid cooling towers would require less land than wet natural-draft towers and would cost approximately as much as mechanical draft towers (Marmer, pp. 5-6).

14.47 On the whole, we find, after giving consideration to the adverse air quality effects of cooling towers, the nearly 60,000 KW of additional electricity they would require, the loss in capacity at Zion Station due to increased turbine back pressure with a concomitant environmental cost to create that capacity somewhere else, that the non-water quality environmental costs of closed cycle cooling exceed the probable benefits, which are essentially nil. This conclusion appears clear without even giving weight to the very large dollar costs connected with backfitting the station. Zion Station represents one situation, and there may be others, where the best, as well as most practicable, cooling water technique appears to be a high velocity discharge.

14.48 The economic costs of the Plant include a capital investment of $423,000,000 in materials and labor for construction of the facility (Staff Ex. 7, p. XI-17).

14.49 The environmental costs of the Plant consist of the diversion of approximately 250 acres of lakefront land for siting of the Plant and a six mile long tract for transmission line right-of-way. No significant adverse aquatic impacts are expected to result from the release of small concentrations of chemicals to Lake Michigan. It is not expected that thermal discharges into the lake from the once-through cooling system will produce significant damage to the aquatic ecosystem. Small amounts of liquid radwaste will be released into Lake Michigan. Radionuclides will be released to the atmosphere from the gaseous radwaste system. There is a possibility that an unacceptably large quantity of fish will be trapped in the Station's forebay so that modification of the intake structure might be required (Staff Ex. 7, XI-18). (See also Bd. Finding 13.61)

14.50 The economic benefits of the Plant include the generation of 14 billion kilowatt hours of electricity per year. Operation of the Plant will result in an annual payroll of about $2,000,000. Construction of the Plant generated a total payroll estimated at $115,000,000 (Staff Ex. 7, p. XI-17).

14.51 Operation of the Plant will allow Applicant to continue the program of planned retirement of several obsolete and environmentally undesirable fossil fueled power stations (Staff Ex. 7, p. XI-17).

14.52 The Staff has quantified all factors capable of quantification (Tr. 4593, Staff Ex. 7, Tables XI-3 and XI-4). In weighing the costs and the benefits of the Plant as constructed, particularly in view of the increasing need for electric generating capacity, the Licensing Board concludes that the minor environmental costs are more than counterbalanced by the benefits of the electrical power generated. In reviewing the adequacy of the Staff's assessment of the costs and benefits of the Plant in terms of alternatives, together with all the environmental evidence in the record of this proceeding, the Licensing Board reaches a conclusion similar to that reached by the Regulatory Staff, i.e., that none of the

alternatives considered produces a significant environmental benefit or reduction in environmental cost in comparison to the Plant as designed and constructed. All of the alternatives result in economic costs that cannot be balanced by economic or environmental benefits (Staff Ex. 7, pp. XI-23, XI-24).

14.53 The demand for electric power is constantly increasing throughout the Country; and without regular installations of new generating capacity, a public utility cannot provide the needed power. Applicant's forecasts of peak load demands and generating capacity through 1980 show that, without Zion Units 1 and 2, such demand would exceed generating capacity starting in 1975; and the deficiency would increase with time (Staff Ex. 7, Table X-2, pp. X-3 and XI-4).

14.54 Applicant requires a minimum generating capacity reserve margin of about fourteen percent (Staff Ex. 7, p. X-1). Without Zion Station in service, the reserve margin will be only 6.4% in 1973 and will steadily decrease thereafter with negative reserves from 1975 on (Staff Ex. 7, Table X-2, pp. X-3 and X-4). Applicant is an active participant in several regional power purchase agreements. Without Zion Units 1 and 2 in operation, such power pools do not appear to have sufficient reserves to meet Applicant's present or projected needs. The Board concludes that the generating capacity of Zion Station is needed by the Applicant to meet the public demand for power and assure adequate system reliability via sufficient reserve margins.

14.55 With respect to compliance with the Federal Water Pollution Control Act Amendments of 1972 (FWPCA), the State of Illinois certified that "there are no effluent limitations or other limitations established pursuant to Sections 301(b) or 302 of the Federal Water Pollution Control Act Amendments of 1972 nor any standards established pursuant to the provisions of Section 306 or 307 of the Act which are in effect at this time" (Staff Ex. 9). Accordingly, the Board finds compliance with §401(a).

14.56 The State of Illinois further certified that "the discharges of condenser cooling water and process water from the Zion generating station of Commonwealth Edison Company at Zion, Illinois are expected to meet all applicable effluent and water quality standards established by the Illinois Pollution Control Board" (Staff Ex. 9). (See also 14.14 thru 14.20 above.)

14.57 The U. S. Environmental Protection Agency (EPA) has notified the Governor of the State of Illinois that pursuant to §303(a)(1) of the FWPCA all Illinois interstate water quality standards are approved, except for minor changes now being cooperatively worked out between the federal EPA and the Illinois EPA, which changes are not material to the present proceeding. The Applicant is required to conform to such Federally approved State water quality standards. (App. Ex. 85, Tr. 3041-3043; Staff Ex. 9). (See also 14.20 above.)

14.58 Based upon the foregoing and all the evidence in the record regarding the level of chemical and thermal discharges to result from operation of Zion Station, the Board finds that the discharges resulting from operation of Zion Units 1 and 2 will not violate the Federally approved State of Illinois water quality standards.

V. INTERVENORS PROPOSED FINDINGS

37.* There is no requirement that a Licensing Board discuss, *seriatim*, each and every proposed finding offered by parties to a license proceeding, nor will we attempt to do so here. *Wisconsin Elec. Power Co.* (Point Beach 2), ALAB-78 (Nov. 10, 1972), WASH-1218 Suppl. 1, at 519; *Long Island Lighting Co.* (Shoreham Sta.), LBP-73-13 (Apr. 12, 1973), RAI-73-4, at 306. A decision which sufficiently informs a party of the disposition of its contentions meets the requirements of the Administrative Procedure Act and the Commission's Rules of Practice. ALAB-78 and LBP-73-13, *supra.* However, we have reviewed each of the Intervenors' proposed findings and offer the following general comments about the tenor of them, to give some indication of why the Board has not adopted some of them, beyond simply balancing conflicting evidence.

38. Many of the Intervenors' proposed findings are based upon isolated sentences and "admissions" simply unsupported by any objective analysis of the totality of any witness' testimony on the contentions in issue.

*The paragraph numbering system now returns to the one being used prior to the Findings of Facts on the contentions.

39. Intervenors' Proposed Finding 1.7 cites an Applicant's witness as admitting that "if the paint thickness inside the Zion containment were thicker by a factor of 3 *and* the heat transfer coefficient of the paint were lower by a factor of 3 than the value assumed (in the Westinghouse computation), the design peak pressure of 47 psig would be exceeded in the event of the design basis accident." (Emphasis added.) However, the Intervenors never introduced any evidence or testimony to show that the paint thickness is, or could reasonably be expected to be, three times the estimated thickness, or that the heat transfer coefficient is, or could be, only one-third of that value used in the computation. This proposed finding also ignores, or perhaps is an attempt to circumvent the effect of, the same witness' prior testimony (Mangan, Tr. 4984-86) that in order to even *reach* design pressure of 47 psig from the calculated, conservative value of 42.4 psig (which was the computed result after allowing for estimated paint thickness and presuming that *all* structural heat sinks are painted though many might not be—Tr. 4982), that the paint thickness would have to be increased by a factor of eight (Tr. 4985).

40. Intervenors' Proposed Finding 6.2 is a quoted excerpt from a book by Igor Bazovsky. There is no evidence or testimony in the record cited to show where either Mr. Bazovsky, his opinions or his book were attempted to be offered in evidence in this proceeding. Similarly, Intervenors' Proposed Finding 13.5 consists of quoted excerpts from a private study done under Government contract by Burns & Roe, Inc., a portion of whose out-of-context conclusions this Board is asked to adopt as Findings under the theory of "official notice." Again, no transcript evidence or testimony is cited to tie this publication in with anything that transpired during the evidentiary proceeding.

41. Intervenors' Proposed Finding 6.4 recites the fact that the Superintendent of Zion Station did not request reliability data from Pacific Pump on the low head safety injection pumps, although he had personally contacted Pacific Pump, and that "to his knowledge Pacific Pump had never supplied Applicant with any reliability data nor had the Applicant ever requested any" (citing Tr. 1852). Similar points are made in Intervenors' Proposed Finding 6.5, including the residual heat removal pumps. But a careful reading of the testimony in this area (Tr. 1850-1858), discloses that: (1) the engineering department did the procurement of the equipment (Tr. 1851, L. 15-18), not the operating department, which was this witness' area of concern (Tr. 1855, L. 5-7); (2) the engineering department would be the department concerned with obtaining "reliability data" from vendors, if desired, not Mr. Bitel's operating department (Tr. 1855, L. 1-13; 1856, L. 21-25); (3) the reason Mr. Bitel contacted Pacific Pump had nothing to do with collecting "reliability data" (which was not his function) but to review the availability of spare parts and equipment for the pumps and to get information on disassembling times, how long it would take Applicant's employees to work on the equipment (Tr. 1852, L. 9-16); and (4) it not being within the province of the operating department, he simply *did not know* whether Pacific Pump had ever provided Commonwealth Edison with "reliability data" on the pumps, nor whether Commonwealth Edison had ever asked Pacific Pump to supply such data (Tr. 1852, L. 9-24). This last appears to be far different from the affirmative allegation: ". . . *to his knowledge* Pacific Pump had never supplied Applicant with any reliability data nor had Applicant ever requested any." (Emphasis added.) Asking the right question of the wrong witness is not sufficient to transform an "I don't know" into affirmative evidence or into a binding, damaging admission. Throughout this entire section of testimony on reliability of certain equipment (Tr. 1850-1861), it is clear that the witness, Mr. Bitel, had nothing to do with requesting or receiving "reliability data" from vendors, that was strictly within the province of the company's engineering department, and that his information regarding reliability of equipment was based upon experience and reliability (reputation) of vendors, operating experience in other plants using the same or similar equipment and, in some cases, "a rather severe test program"—i.e., 297 successful starts of the emergency diesel generators out of 300 tries, otherwise initiating the program again but then requiring 450 test starts (Tr. 1859-60), each "start" commencing from a cold condition (Tr. 1821-22). It should also be noted that the Intervenors never attempted to introduce any evidence whatsoever that the subject "reliability data" is ever customarily produced to purchasers, or even routinely accumulated or possessed by typical vendors of this type of equipment in the regular, ordinary course of such business.

42. Intervenors' Proposed Finding 7.5 includes the statement: "Zion Station is about a mile and a half from runway 23 at Waukegan Memorial Airport (Tr. 2413)." It is true that on page 2413 witness Losee made such a statement, but on transcript pages 2414 and 2415 he admitted he had been in error and he corrected himself (twice) to give the more accurate mileage—three miles. (Charts in evidence clearly indicate the distance to be about 3½ miles.)

43. Intervenors' Proposed Findings 7.13, 7.14 and 7.15 urge the use of the general aviation accident rate (higher than air carrier rates) in estimating the potential for plane crashes around Waukegan Airport and the Zion site. However, the Intervenors also criticize the Staff in Intervenors' Proposed Finding 7.1 for not using the damage consequences of the "wide-bodied jets weighing more than 426,000 pounds" (strictly air carrier type aircraft, i.e., scheduled airline type aircraft). Thus it appears that the Intervenors would have the Board determine accident rate potential by use of the higher-incidence general aviation statistics, but determine the potential damage consequences to reinforced concrete powerplant buildings by use of the largest air carrier aircraft flying today.

44. Intervenors' Proposed Finding 9.2 (2nd. para.) quotes from the SER (p. 18-2), ending with ". . . tangible results were disappointingly meager." But Intervenors failed to include the immediately succeeding two sentences in the same paragraph, which very substantially mitigate the apparently shocking seriousness of the partial quotation.

45. Intervenors' Proposed Finding 14.1 states that: "The Atomic Energy Commission Regulatory Staff has concluded that Zion Station Unit 1 can be operated up to a power level of *only* 163 megawatts thermal, approximately 5% of rated power," citing a transcript reference. (Emphasis added.) However, as all parties to this proceeding are clearly aware, both from copies of correspondence that have been served on all parties and from the Staff's own official posture in supporting the Applicant's petition for full-term licenses up to near full power, the 5% limitation was only a very temporary limitation, pending resolution of obviously temporary technical considerations that existed at the time that particular "admission" was made (July 18), and subsequently superseded by authorizations for higher power level operation.

46. Intervenors based many proposed findings on the testimony of Dr. Kendall, whose testimony was consistently in opposition to the licensing of this nuclear powerplant. But the Board has had the opportunity to observe Dr. Kendall on the witness stand—his demeanor, manner of answering questions and, at times, his manner of avoiding answering some very specific questions on cross-examination. Much of his testimony was quite generic in its opposition to nuclear powerplant operation, i.e., it was the kind of articulate and technical criticism (e.g., questioning whether values used are suitably conservative, alleged uncertainties involving input parameters under the Interim Acceptance Criteria, and his continuing doubts regarding other aspects of the ECCS, etc., Tr. 2000, 2112, 2117, 3333 at 4-7) that could be directed against the licensing or operation of any and all nuclear powerplants, not just Zion Station. In fact, Dr. Kendall very candidly admitted that he was firmly opposed to the full power licensing or operation of any nuclear powerplant in this country today (Tr. 3506). This is not to deprecate his sincerity or his high professional standing in the academic community. However, in spite of his impressive background at M.I.T. and the filed summary of his professional qualifications that would appear to place him at the center of top authorities in the nuclear field, his testimony on *voir dire* and cross-examination, when compared with that of certain Staff and Applicant nuclear engineer and nuclear physicist witnesses, revealed that Dr. Kendall's knowledge, level of practical, working experience and depth of detailed, current expertise in the precise radiological areas to which he was testifying simply did not equal that of such other witnesses (Dr. Richings, Mr. Rubinstein, or Mr. Crutchfield, or the Westinghouse witness panels of Dr. Roll, Messrs. Boman, Uram, and Berkowitz, and Messrs. Mangan, Bordelon and Connor).

47. The Board has reviewed the entire record of the proceeding, and all of the proposed findings of fact and conclusions of law submitted by the parties. All of the proposed findings of fact and conclusions submitted by the parties which are not incorporated directly or inferentially in this Initial Decision are herewith rejected as being unsupported in law or fact, or as unnecessary to the rendering of this Initial Decision.

VI. PERMISSIBLE POWER LEVELS

48. The application in this proceeding requests authority to operate Zion Units 1 and 2 at steady-state levels up to a maximum of 3,250 megawatts thermal each. Based upon the record in this proceeding, the Board has determined that Unit 1 can be operated with its current fuel at a maximum power of 91.3% of the level specified in the application at the beginning of fuel life, and Unit 2 at a maximum power of 86.7% of that level at the beginning of its fuel life. (See Findings relative to Fuel Densification, *supra.*) These permissible power levels can increase to 100% of the level applied for, with respect to each Unit, in accordance with fuel burnup as specified on Fig. 5.5.B of App. Ex. 73 for Unit 1 and Fig. 5.5.B of App.

Ex. 74 for Unit 2. The Board is aware that the ACRS has recommended that neither Unit be operated in excess of 85% of its capacity until later after the first refueling of Zion Unit 1. While this Board has found that, with respect to the matters in controversy before it raised by the contentions of the Intervenors, the Units can be operated at higher power levels, not all of the matters which may have been considered by the ACRS were issues in this proceeding. Applicant has not requested that this Board issue an order which would compel the Director of Regulation to issue licenses for power levels above 85% prior to the time that the ACRS approves such action.

49. In mid-January, 1973, as a result of an EEI Quality Assurance Task Force meeting, a potential problem with the discs used in the main steamline check valves at the Zion facility was identified (Tr. 4401). After inspection, the discs in the check valves for Unit 1 were found to have linear indications and, after consultation with the valve vendor, Schutte Koerting, it was determined that the material out of which the discs were made, a maraging steel of very high tensile strength, might not be suitable for a steam environment (Tr. 4401-02). At the time the maraging steel was evaluated by Applicant's Architect-Engineer, the lack of suitability of maraging steel in a steam environment was unknown (Tr. 4416-17). The maraging steel discs have been replaced with a disc made out of carbon steel suitable for use in a steam environment and the amount of travel for the replacement discs has been restricted from 55 degrees to 7 degrees (Tr. 4402, 4408). The new discs have been analyzed for operation at power levels up to 85% of full rated power for the lifetime of the plant and have been found satisfactory (Tr. 4402; prepared testimony of Knight following Tr. 5442, at p. 5). Studies of valve operation of 100% power levels are continuing, subject to the review of the Regulatory Staff, and various alternatives, including continued use of the present valves, may be acceptable (Tr. 4405, 5444; Knight, p. 7). Critical valve and disc measurements and performance will be monitored during initial operation of Zion Unit 1 (Knight, pp. 5-6).

VII. CONCLUSIONS OF LAW

In the Commission's Notice of Hearing on a Facility Operating License for the Commonwealth Edison Company's Zion Station, the Commission directed this Board to resolve the matters in controversy among the parties and the matters covered by 10 CFR Part 50, Appendix D, Section C. Based upon the foregoing Findings of Fact which are supported by reliable, probative and substantial evidence as required by the Administrative Procedure Act and the Commission's Rules of Practice, and upon consideration of the entire evidentiary record in this proceeding, the Board concludes as follows:

A. With respect to the issues before it concerning the requirements of the Atomic Energy Act of 1954, as amended, and the Rules and Regulations of the Commission relating to public health and safety:

1. A review of the entire evidentiary record of the proceeding fails to disclose any substantial evidentiary basis for the Intervenor's allowed contentions.

2. The Applicant for the requested facility operating licenses has met its burden of proof and, further, has disproved, by clear convincing, reliable and substantial evidence, all of the Intervenors' allowed contentions.

3. Construction of Zion Unit 1 has been completed, construction of Zion Unit 2 has been substantially completed, and there is reasonable assurance that construction of Zion Unit 2 will be completed in conformity with the construction permit, as amended, the provisions of the Act and the Rules and Regulations of the Commission.

4. The Units will operate in conformity with the application, as amended, the provisions of the Act, and the Rules and Regulations of the Commission.

5. There is reasonable assurance that the activities to be authorized by the operating license can be conducted without endangering the health and safety of the public and that such activities will be conducted in compliance with the Regulations of the Commission.

6. The Applicant is technically and financially qualified to engage in the activities to be authorized by the operating license in accordance with the Regulations of the Commission.*

*Since none of the issues before this Board involved the satisfaction of the applicable provisions of 10 CFR Part 140, "Financial Protection Requirements and Indemnity Agreements," this Board has made no findings concerning compliance with that regulation. However, the Board has received no evidence which would question Applicant's compliance.

7. The issuance of the license will not be inimical to the common defense and security, or to the health and safety of the public.

B. With respect to environmental matters:

1. A review of the entire evidentiary record fails to disclose any substantial evidentiary basis for the Intervenors' environmental contentions.

2. The requirements of NEPA, Section 102(2)(C) and Section 102(2)(D), and Appendix D, 10 CFR Part 50, of the Commission's Regulations have been complied with in this proceeding.

3. Having independently reviewed the Regulatory Staff's final balancing among the conflicting environmental factors in the record of this proceeding and having independently weighed the environmental, economic, technical, and other benefits against environmental costs and considered available alternatives, the Board has determined that Construction Permit #CPPR-59 for Zion Station should not be modified or terminated and that the appropriate action is to authorize operation of Zion Station, Units 1 and 2, with the present open-cycle cooling system, subject to the environmental conditions set forth above in the Findings and in the ORDER, *infra.*

4. Having reviewed the adequacy of the Regulatory Staff's Final Environmental Statement and having made certain changes and amendments thereto in the body of this Decision, the Board finds that the Final Environmental Statement, as amended, is adequate and complete within the purposes and intent of the National Environmental Policy Act.

5. The requirements of the Federal Water Pollution Control Act Amendments have been complied with and the Applicant's proposed operations will not violate said Act.

VIII. ORDER

WHEREFORE, IT IS ORDERED, in accordance with the Atomic Energy Act of 1954, as amended, and the Commission's Rules and Regulations, that the Director of Regulation is authorized in accordance with this initial decision to issue to Commonwealth Edison Company operating licenses for a term of 40 years, authorizing operation of the Zion Nuclear Power Station Units 1 and 2 at steady state power levels up to a maximum of 3,250 megawatts thermal each. Said operating licenses for Units 1 and 2 shall be subject to the restrictions resulting from the matters set forth in paragraphs 48 and 49, and the *conditions* set forth in Findings 4.33, 8.10, 8.18, 9.37, 13.61 and 13.92. (Finding 4.33 relates to fuel densification conditions; 8.10 and 8.18 relate to Security Plan conditions; 9.37 is a QA condition; and 13.61 and 13.92 relate to environmental conditions.) The conditions set forth in the Final Environmental Statement, Staff Ex. 7, p. iv, paragraph 7, are incorporated herein by reference and made a part of this Decision.

IT IS FURTHER ORDERED, in accordance with Sections 2.760, 2.762, 2.764, 2.785, and 2.786 of the Commission's Rules of Practice, that this Initial Decision shall be effective immediately and shall constitute the final action of the Commission forty-five (45) days after the date of issuance hereof, subject to any review pursuant to the Rules of Practice. Exceptions to this Initial Decision and supporting briefs may be filed by any party within *seven* (7) days after the service of this Initial Decision. Within fifteen (15) days thereafter (20 days in the case of the Regulatory Staff) any party filing such exceptions shall file a brief in support of such exceptions. Within fifteen (15) days after service of the brief of appellant (20 days in the case of the Regulatory Staff) any other party may file a brief in support of, or in opposition to, the exception.

THE ATOMIC SAFETY AND LICENSING BOARD

Dr. E. L. Cheatum, Member

G. A. Linenberger, Member

Thomas W. Reilly, Esq., Chairman

Issued at Washington, D. C.
this 5th day of October, 1973.

Attachment: Appendix A

APPENDIX A

The complete record of this proceeding[1] is set forth below. The tabulation also includes exhibits identified but not received in evidence, but this distinction is clearly specified.

1. There are 47 separate volumes of transcripts,[2] however, the first three are non-evidentiary records of the three prehearing conferences (Nov. 17, 1972, Feb. 1, 1973, and March 12, 1973). There are several other transcripts that contain no evidence because only preliminary motions were being argued, or because the session that particular day solely concerned arrangements for a continuance due to the illness of one of the principals. Three volumes concern *in camera* hearing sessions, and such transcripts have their own supplemental pagination system (May 23: 1A-108A, May 25: 1B-68B, May 30: 1C-12C). The other transcripts cover pages 1 through 5525, with the evidentiary hearing starting on page 328 (April 2, 1973) and ending on page 5525 (July 20, 1973).

2. The Applicant identified 180 evidentiary exhibits; not all of which were admitted in evidence; the Staff identified 14 exhibits, not all of which were admitted in evidence; and the Joint Intervenors identified 24 exhibits, not all of which were admitted in evidence.

The Applicant identified the following exhibits, admitted into evidence unless otherwise noted:

[1] Commission Notices, pleadings, assorted motions and Board orders are in the *Zion* public docket file.
[2] All are subject to the Board's Order Correcting Transcript dated 9/13/73.

Applicant Exhibit

1	Qualif. of Byron O. Lee
2	Qualif. of Joseph C. La Vallee, Jr.
3	Qualif. of Lester Berkowitz
4	Final Safety Analysis Report—10 vols. inc. 27 amdmts., emerg. plan & tech. specs.
5	Guide for the Quality Assurance Program for the Construction of Nuclear Generating Units
6	Monthly Deviation Status Report
7	Station Construction Superintendent
8	Professional Qualifications of Edwin J. Hemzy
9	Quality Assurance Procedures—Appendix D—Organization Charts
10	Chronology of Zion QA Manual Revision
11	Quality Assurance Plan
12	Equipment Releases—Status Log
13	Zion Site Procedures, Z-1, Z-2, Z-4, Z-9
14	Site Construction Deficiencies—Status Report Log
15	Summary of Contentions
16	Summary of Significant Deficiencies Reported Since April, 1972
17	(3p.) Biog. of Warwick
18	(1p.) Zion QA Program vs. 10 CFR 50, Appx. B
19	(1p.) Eval. Design & S&L Function/Areas
20	(1p.) Finding Analysis—Action Priority
21	Mar. 6, '71 Memo. from Walter Vetter to Jas. Henderson, Chief, Reactor Constr. Br.
22	Mar. 30, '71 Letter from Boyce Greer to CECO, Att. Byron Lee
*(23 thru 27)	(Five Region III Inspection Reports) (NOT OFFERED)
28	Jun. 16, '71 Letter from S. Dickson, State Airpt. Engineer to A. Landolt, Director, Ill. Dept. of Aeronautics
29	Map entitled "Stage I Development" (of Waukegan Airport)
30	Map entitled "Stage II Development" (of Waukegan Airport)
31	Map entitled "Stage III Development" (of Waukegan Airport)
*(32)	(Jeppesen Instrument Approach Chart, Waukegan Airport) (WITHDRAWN)
*(33)	(FAA Instrument Approach Chart, Waukegan Airport) (WITHDRAWN)
34	Chart of angular correlat. of (or probabil. of) A/C accidents
35	Chart of angular correlat. of (or probabil. of) A/C accidents
36 thru 61	Corresp. to "Exhs. 1-26" annexed to Dr. German Gurfinkel's testimony
*(62)	Supplem. Report No. 1 to ACRS Zion Oper. Lic. Review, dated 1/27, AEC #2S, re: Interaction Zion Plant & Waukegan Airport (NOT OFFERED)
63	FAA instrumt. approach procedure for Waukegan Airport
64	Zion Sta. Security Plan, (37p.)
*(65)	One transcript page from ECCS Hearings, Vol. 23, Mar. 2, 1972 (NOT OFFERED)
*(66)	AEC Certif. of Medical History, Facility Operator's or Senior Operator's License (NOT RECEIVED)
67 thru 69	Exhs. 1, 2 and 3 attached to Byron Lee's Dir. Testimony on Oper. Qualif.
70	Prof. Qualif. of Lowell Boman
71	Prof. Qualif. of George Uram
72	Prof. Qualif. of Dr. John Roll
73	Fuel Densif. at Zion Unit 1
74	WCAP-8122, Fuel Densif. at Zion Unit 2
75	Part of Amdmt. 28 to FSAR, Addendum 28, Fuel Densif., Zion Unit 1, Apr. '73

*Not in evidence.

Applicant Exhibit

73A, 74A, 75A	Non-prop. versions of 73, 74, 75
76 thru 81	Corresp. to "Figures 1-5" Re: Dr. Pritchard's Testimony
82	WCAP-7982, Fuel Densification Model
82A	WCAP-7984, Fuel Densification Model
83 and 84	Corresp. to Table 1 & 2, Re: Dr. Pipes' Testimony
85	Letter from EPA to State of Illinois
86	Table 1, Re: Dr. Verduin's testimony
87 thru 89	Corresp. to Figure 1, 2, 3A, Re: Dr. Verduin's testimony
90 thru 92	Corresp. to Table 2, 3, 4, Re: Dr. Verduin's testimony
93	Figure 3, Re: Dr. Verduin's testimony
94	Table 1, Re: Dr. McNaught's testimony
95	Figure 1, Re: Dr. McNaught's testimony
96 thru 98	Table 2, 3, 4, Re: Dr. McNaught's testimony
99	Table 6 Re: Dr. McNaught's testimony
100	Table 5 Re: Dr. McNaught's testimony
101	Table 7 Re: Dr. McNaught's testimony
102	Figure 2 Re: Dr. McNaught's testimony
103	Table 8 Re: Dr. McNaught's testimony
104	Phosph., Wtr. Qual. & Eutroph. of Lake Michigan
105	Pot. Problms. of Blowdown
106	Eff. Blowdown Water on Recvg. Water Qual.
107 & 108	Ex. A & B of Wit Tranby Prep. Test.
109 thru 125	Figures 1–4, Tables 1–13, annexed to testimony of G. E. McVehil

Board's Exhibit

*(A)	Analysis of Cost & Environmental Impacts of Zion Nuclear Power Station & Major Non-Nuclear Alternatives (NOT EVIDENCE) Merely summary of other evid.
*(B)	Analysis of Costs & Environmental Impacts of Possible Cooling Systems for Zion Nuclear Power Station (NOT EVIDENCE) Merely summary of other evid.

Applicant Exhibit

126	Professional Qualifications of Frank M. Bordelon
127	Professional Qualifications of John C. Connor
128	Professional Qualifications of Michael A. Mangan
129	Standard Method of Test for Compressive Strength of Molded Concrete Cylinders, ASTM C-39-66
130	Standard Method for Making and Curing Concrete Compression and Flexure Test Specimens in the Field, ASTM Designation C-31-66
*(131)	Mathematical formula (NOT OFFERED)
132 & 133	Site Procedures for Inspection of Structural Welding
134	Welding Performed by Walsh Construction Company at Zion Station
135	(2p.) Handwritten tables: "Zion Unit 1 Structural Steel, Weld Inspection Summary," dated 7/9/73
136	(1p.) Handwritten tables: "Zion Unit 1 Structural Steel, Unacceptable Welds, Summary Sheet," 7/9/73
137A	Attachment 1, Corresponding Technical Specifications—USAS B16.5
137B	Page 6 of 137A
138	Commonwealth Edison Co. Station Construction Dept. Site Procedure for Class I Valve Wall Thickness Measurement

*Not in evidence.

Applicant Exhibit

139	Prof. Qualif. of Robert Bremmer
140	ASTM Standard A182-65
141	ASTM Standard A216-69
142	ASTM Standard A276-67
143	ASTM Standard A240-69
144	ASTM Standard A351-65
145	ASTM Standard A455-68
146	ASTM Standard A564-66
147	Defect Notice Disposition Request No. 86075-1
148	Supplier Quality Control Release No. S-1211
149	Supplier Quality Control Release No. S-1212
150	Supplier Quality Control Release No. S-1240
151	Supplier Quality Control Release No. S-1241
152	Qualif. of Max Zar
153	Pittsburgh Testing Lab. Report of Tensile Test of Heated Reinforcing Steel Bars from Zion Station
154	Written procedure of X-Ray Engineering Co.
155	Inspection report
156	Table I, Summary of Hardness Measurements
157	Table II, Summary of Hardness Measurements
158	Table III, Summary of Hardness Measurements
159	Laboratory test data on specimen weld
160	Operational Analysis Dept. Report—Field hardness tests of structural welds
161 thru 172	Audit reports
173	Concrete pour temperature forms
174A thru H	S&L Standard specs for concrete work
175	Deviation report form
176	Deviation report form
177	Letter 5-28-69, Pettikas to CE
178	Letter 10-13-69, Pettikas to CE
179	Letter 12-5-69, Pettikas to CE
180	Computer run

The Staff identified the following exhibits:

Staff Exhibit

1	Safety Evaluation Report
2	Radiological Tech. Specs., Appx. A to lic. (approx. 333p.)
3	Appx. A, Safety Guide 17 "Protection vs. Industrial Sabotage"
4	Appx. B, Draft Proposed Standard ANS-3.3, "Industrial Security for Nuclear Plants"
5	ACRS letter, May 17, 1973
*(6)	Staff Technical Report, Nov. 14, 1972 (WITHDRAWN)
7	FES and Errata
8	App. B, Environ. Tech. Specs.
9	EPA Correspondence
10	ANS-5 Mtg. Minutes
11	ANS Transactions (pp. 443, 444)

*Not in evidence.

12	Bettis Lab U^{235} Fission Prod. Decay Energy—'72 Re-evaluation
13	ANS Proposed Standard, Decay Energy Release Rates
14	Letter, 6-8-73, to Commonwealth Edison from R. C. DeYoung

The Intervenors identified the following exhibits:

Intervenors' Exhibit	
1	(16p.) CECO Employee Inspection Trip Report re: confirming heat treatment of valves
2	(16p.) Eval. of CECO's QA Program for Zion, Mar. 2-10, '70, G.E. Co., Apollo Systems, Daytona Beach, Florida
3	(7p.) AEC Reg. III, Report of Constr. Insp., RO Insp. Report 050-295/73-08
4	(10p.) AEC Reg. III, Report of Constr. Insp., RO Insp. Report 050-295/73-10
5	(1p.) Ptsb. Testing Lab. re: welder Michael Sweeney
6	(1p.) Ptsb. Testing Lab. re: welder Harold Witzman
7	(1p.) Ptsb. Testing Lab. re: welder Eugene Woodell
8	(1p.) Ptsb. Testing Lab. re: welder John Connolly
9	(3p.) Comey's handwritten notes of visit to RO:III, N. Vetter, Feb. 24
10	(1p.) Memor. #2AM-83, Dr. Hanauer to Mr. Eisenhut re: Probability figure used for probability of an A/C hitting a nuclear facility & causing a nuclear accid.
11	Revision to Security Plan
12	Revisions to Zion Station Security Plan
*(13)	Letter, Yates to Roman, 3/27/73 (NOT OFFERED)
*(14)	Letter, Potts to Pemberton, 6/4/71 (NOT OFFERED)
*(15)	Letter, Pemberton to Koehler, 5/11/71 (NOT OFFERED)
*(16)	Lake Mich. Enf. Conf. Recommendations (NOT OFFERED)
17	ECCS Doc. R-50-1, Testimony of Ford & Kendall
18	Letter from Birkel to DeYoung dated March 1, 1973
19	Letter from DeYoung to Commonwealth Edison dated June 15, 1973
20	Letter from Goller to Commonwealth Edison dated May 25, 1973
21	Letter 5-24-73, Knuth to CE
22	Exh. 1, Walsh Constr. Co., Structural Steel Crew Personnel not Certified to Perform Welding
23	Letter 7-3-73, Knuth to CE
24	Testimony of Weld Quality by W. J. Collins

[END OF APPENDIX A]

*Not in evidence.

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Michael Glaser, Chairman
Franklin C. Daiber, Member
Lester Kornblith, Jr., Member

In the Matter of

SOUTHERN CALIFORNIA EDISON COMPANY — Docket Nos. 50-361
SAN DIEGO GAS & ELECTRIC COMPANY — 50-362

(San Onofre Nuclear Generating Station, Units 2 and 3)

Construction Permit — October 15, 1973

HEADNOTE OR DIGEST

Assuming the geologic model set forth in the Regulatory Staff's Safety Evaluation, the question of whether design basis earthquake of 0.67 g was reasonably conservative, was resolved by the Atomic Safety & Licensing Board by according greater weight to empirical data rather than a theoretical mathematical model.

APPEARANCES

Charles R. Kocher, Esq., **David N. Barry, III,** Esq., **Kingsley B. Hines,** Esq., and **Richard Durant,** Esq., for the Applicant, Southern California Edison Company

David R. Pigott, Esq., **Frank S. Bayley, III,** Esq., and **Allan J. Thompson,** Esq., for the Applicant, San Diego Gas and Electric Company

Bruce Sharp, Esq., and **Raymond L. Lachman,** Esq., for the Consolidated Intervenors

Alan R. Watts, Esq., for the Cities of Anaheim, Benning and Riverside

Lawrence Q. Garcia, Esq., and **Tucker W. Peterson,** Esq., for the State of California and the Public Utility Commission of the State of California

Lawrence J. Chandler, Esq., and **Martin Malsch,** Esq., for the AEC Regulatory Staff

INITIAL DECISION

I. PRELIMINARY STATEMENT

1. This proceeding involves the application of Southern California Edison Company (SCE) and the San Diego Gas and Electric Company (SDGE), collectively referred to herein as Applicants, pursuant to

Section 103 of the Atomic Energy Act of 1954, as amended (Act),[1] for authority to construct two pressurized water nuclear reactors designated as the San Onofre Nuclear Generating Station, Units 2 and 3 (the facilities), each of which is designed for initial operation at approximately 3390 thermal megawatts, with a net electrical output of approximately 1140 megawatts, at a site located at Camp Pendleton, San Diego County, California.

2. An application, dated May 28, 1970, was filed with the United States Atomic Energy Commission (Commission) by SCE and SDGE for licenses to construct and operate the proposed facilities.[2] Eighteen amendments to the application were subsequently filed with the Commission by the Applicants. The application was filed under the provisions of Section 104(b) of the Act, but is being processed, as indicated, under the provisions of Section 103 of the Act by reason of the provisions of Public Law 91-560, enacted December 19, 1970.

3. The application was reviewed by the Regulatory Staff (Staff) of the Commission. Thereafter, the Staff issued a report entitled *SAFETY EVALUATION BY THE DIRECTORATE OF LICENSING, U. S. ATOMIC ENERGY COMMISSION, IN THE MATTER OF SOUTHERN CALIFORNIA EDISON COMPANY AND SAN DIEGO GAS & ELECTRIC COMPANY, SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3, DOCKET NOS. 50-361 AND 50-362,* dated October 20, 1972.[3] The report concludes that the proposed facilities can be constructed and operated at the proposed location without undue risk to the health and safety of the public.[4]

4. The application was also reviewed by the Advisory Committee on Reactor Safeguards (ACRS). The ACRS also issued a report entitled *REPORT ON SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 AND 3,* dated July 21, 1972, which is included as Appendix B to the Staff's report.[5] The ACRS report concludes that if due consideration is given to expressed concerns, the proposed facilities can be constructed with reasonable assurance that they can be operated without undue risk to the health and safety of the public.

5. In accordance with the requirements of Appendix D to 10 CFR Part 50, the Applicants submitted an environmental report. The Staff prepared and issued Draft and Final Environmental Statements as required by Appendix D and by the National Environmental Policy Act of 1969 (NEPA). All of these are described in Paragraph 99, *infra.*

6. In accordance with Section 189 of the Act, Notice of Hearing on the application for construction permits was published in the *Federal Register* on August 10, 1972.[6] An Atomic Safety and Licensing Board (Board) was established and its membership published in the *Federal Register* on August 24, 1972.[7]

7. The Board held an initial prehearing conference, pursuant to Section 2.751a[8] of the Rules of Practice of the Commission on October 5, 1972, in San Clemente, California.

8. At the initial prehearing conference, the Board granted the timely-filed petition for leave to intervene of the Cities of Anaheim, Benning and Riverside, California[9] (Cities), and consolidated the Cities' participation with Applicants SCE and SDGE pursuant to Section 2.715a of the Commission's Rules of Practice.[10] The Board also heard oral argument from the parties on the petitions for leave to intervene filed by the American Association of University Women (AAUW) and Groups United Against Radiation Danger (GUARD), and Scenic Shoreline Preservation Conference, Inc. (Scenic Shoreline). Upon consideration of oral argument and the pleadings filed by the parties in connection with these petitions for leave to

[1] 42 U.S.C., § §2011, *et seq.*

[2] Applicants' Exhibits 1-A through 1-G, Tr. 390-391, 393. For convenience, these will usually be cited as one Exhibit, Applicants' Exhibit 1. This exhibit includes the Preliminary Safety Analysis Report (PSAR).

[3] Staff's Exhibit 1, Tr. 394, 1262. (Hereafter referred to as "SSE").

[4] *Ibid.*, p. 111.

[5] Staff's Exhibit 1-A, Tr. 394, 1262.

[6] 37 *Fed. Reg.* 16117.

[7] 37 *Fed. Reg.* 17079.

[8] 10 CFR §2.751a (Supp. 1972).

[9] Prehearing Conference Order, p. 6, October 31, 1972; Tr. 61).

[10] The Board subsequently denied motions for reconsideration of its action granting the Cities' intervention, and consolidating their participation with the Applicants. Order Denying Application for Reconsideration and Modifying Consolidation, December 27, 1972.

intervene, the Board determined that the petitions alleged enough facts to demonstrate sufficient interest in the proceeding and that the public interest warranted affording the petitioners an additional opportunity to amend, clarify and supplement their original petitions. Accordingly, the Board granted these petitioners additional time to file supplemental petitions.[11] For purposes of such supplemental filing, as well as any participation in the proceeding, the Board also consolidated these petitioners.

9. The Board also granted the requests of Mr. Larry E. Moss and Mr. David Sakai to make limited appearances in the proceeding. The Board denied the petition for intervention filed by the Orange County Peoples' Lobby.

10. On November 28 and 29, 1972, the Board held a second prehearing conference in Los Angeles, California, at which the Board held further oral argument on the supplemental petitions of GUARD and Scenic Shoreline, as consolidated,[12] and after completion of argument granted intervention.[13] GUARD and Scenic Shoreline are hereinafter styled "Consolidated Intervenors." The Board also approved a stipulation between the parties specifying nine issues to be contested in the proceeding,[14] as follows:

1. Whether the operating history of San Onofre Nuclear Generating Station Unit No. 1 reveals design defects in that unit which demonstrate that the Applicants are not technically qualified to design and construct San Onofre Nuclear Generating Station Units Nos. 2 and 3.

2. Whether, assuming the geologic model set forth in the Regulatory Staff's Safety Evaluation, 0.67 g is a reasonably conservative design basis earthquake for San Onofre Nuclear Generating Station Units Nos. 2 and 3.

3. Whether adequate routes are or will be available to enable development of a plan for the evacuation of population where required as the result of a nuclear incident at San Onofre Nuclear Generating Station Units Nos. 2 and 3.

4. Whether the projected population distributions comply with the criteria set forth in 10 CFR Part 100.

5. Whether adequate safeguards can be provided to prevent uncontrolled release in excess of licensed limits of radioactive materials to the environment as a result of intrusion of a domestic saboteur.

6. (a) Whether Applicants' thermal dispersion model reasonably predicts the configuration of the 4° isotherm. (b) Whether the adverse impact, if any, on benthic organisms and migratory fish species within the 4° isotherm has reasonably been estimated by Applicants. (c) If the resolution of issue (a) or (b) is negative, whether significant changes in the predictions of environmental impact of the project are likely to result.

7. Whether geothermal energy constitutes a practical alternative to San Onofre Nuclear Generating Station Units Nos. 2 and 3.

8. Whether Applicants' projections of their need for power consider all factors required to be considered in this proceeding, and reasonably reflect anticipated load growth during the period for which San Onofre Nuclear Generating Station Units Nos. 2 and 3 are proposed.

9. Whether underground siting of a nuclear generating facility of comparable design in the general vicinity of San Onofre is a practical alternative to the construction of San Onofre Nuclear Generating Station Units Nos. 2 and 3.

11. The Board also ruled that stipulated issue No. 9 should be considered as a threshold matter in the health and safety aspects of this proceeding, even though the issue was framed as an environmental contention.[15]

12. The Board also designated as uncontested the following issues specified in the Notice of Hearing, since no contentions were raised by any parties to this proceeding with respect to them:[16]

[11] The Board cautioned the petitioners, however, that the Board's decision in this respect should not be regarded as an invitation to ignore the Commission's Rules of Practice. (Prehearing Conference Order, p. 7, October 31, 1972.)

[12] AAUW did not join in the supplemental petitions for leave to intervene. The Board, however, granted AAUW permission to make a limited appearance in the proceeding.

[13] Tr. 165-174.

[14] Tr. 226.

[15] Tr. 225-225.

[16] Tr. 163-166.

1. Whether in accordance with the provisions of 10 CFR §50.35(a):

(a) The Applicants have described the proposed design of the facilities including, but not limited to, the principal architectural and engineering criteria for the design, and have identified the major features or components incorporated therein for the protection of the health and safety of the public;

(b) Such further technical or design information as may be required to complete the safety analysis, and which can reasonably be left for later consideration, will be supplied in the final safety analysis report;

(c) Safety features or components, if any, which require research and development have been described by the Applicants and the Applicants have identified, and there will be conducted, a research and development program reasonably designed to resolve any safety questions associated with such features or components; and

(d) On the basis of the foregoing, there is reasonable assurance that (i) such safety questions will be satisfactorily resolved at or before the latest date stated in the application for completion of construction of the proposed facilities, and (ii) taking into consideration the site criteria contained in 10 CFR Part 100, the proposed facilities can be constructed and operated at the proposed location without undue risk to the health and safety of the public.

2. Whether the Applicant is financially qualified to design and construct the proposed facilities.

13. Public evidentiary hearings on the health and safety aspects of the application commenced on January 16, 1973,[17] at San Diego, California, and continued until January 23, 1973, at which time the hearings were continued, at Applicants' request, until March 13, 1973. Further public evidentiary hearings on the health and safety aspects recommenced on March 13, 1973, at San Clemente, California, and were completed on March 15, 1973.

14. From May 14, 1973 through May 22, 1973, the Board held evidentiary hearings in San Diego, California, on the environmental aspects of the application. The record was formally closed by order of the Board on June 25, 1973.

15. At the commencement of the public evidentiary hearings on the health and safety aspects of Applicants' application, the Board heard seventeen parties make limited appearances.[18] For the most part, the parties making limited appearances opposed a grant of construction permits to Applicants.

16. During the health and safety public hearings held in January, 1973, Applicants presented five witnesses. The Consolidated Intervenors presented five witnesses, and the Staff offered three witnesses.

17. At the recommencement of the health and safety public hearings in March, 1973, Applicants presented four witnesses, including two company officers, one representing each of the Applicants. Consolidated Intervenors presented two witnesses, and the Staff presented four witnesses.

18. At the opening of the public hearings on the environmental aspects of the application on May 14, 1973, the Board heard seventeen persons make limited appearances,[19] the most significant of whom included Mr. J. Watson on behalf of the Regional Director, Bureau of Sport Fisheries and Wildlife, United States Department of the Interior,[20] and Mr. Ralph Mall, Marine Resources Department, California Fish and Game Department of the State of California.[21]

19. Mr. Watson indicated that while the Bureau of Sport Fisheries and Wildlife had not exhaustively reviewed the Final Environmental Statement (FES), it had noted a number of items referred to which, in the Bureau's opinion, required additional attention. Mr. Watson further indicated that the Bureau's comments had not been transmitted to the Commission in sufficient time to be included in the FES, and requested that the Bureau's comments be made a part of the record. Mr. Watson, on behalf of the Bureau, expressed concern over the FES's lack of discussion in certain areas where the Bureau has a principal interest. For example, Mr. Watson stated that the FES's discussion of entrainment of organisms did not

[17] At the commencement of these public hearings, Mr. Lawrence Garcia, representing the People of the State of California and the California Public Utilities Commission requested leave to intervene by those organizations pursuant to 10 CFR §2.715(c). After hearing argument on this requested intervention, the Board granted it. (Tr. 300.)

[18] Tr. 280-340, 353-354, 440-457.

[19] Tr. 1863-1918.

[20] Tr. 1872-1876.

[21] Tr. 1880, 1916-1918.

include the data upon which the mortality rate of 30% was indicated. Moreover, Mr. Watson felt more detailed consideration should have been given to the impact of fish losses. Finally, Mr. Watson expressed concern over adequate protection for enhancement of fish and wildlife as a result of construction and operation of the San Onofre Units. The Board has thoroughly considered Mr. Watson's limited appearance statement made on behalf of the Bureau, and evaluated it in light of the Board's overall responsibility for determining whether the proposed construction is consistent with the NEPA.[22]

20. Mr. Mall indicated that his Department had raised a number of questions regarding temperature measurement, specifically the measurement of the ambient temperature of the ocean, which the Department felt had been made on a subjective basis, and had not received answer to the same.[23]

21. As during the health and safety public hearings, those parties making limited appearances generally opposed approval of construction authority to Applicants.

22. The Board has carefully reviewed each of the limited appearance statements made during both the health and safety and environmental phases of this proceeding. We have weighed the contentions raised in such limited appearances, and have, to the extent appropriate, considered each of these contentions in arriving at the Board's findings of fact and conclusions set forth in this decision. The Board appreciates being informed by the limited appearance parties of their contentions respecting Applicants' proposed facilities, and has found such appearances useful in rendering this decision.

23. The Board, on the first day of the evidentiary hearing, urged the parties to respond as quickly as possible to the questions raised by the persons making limited appearances. On the second hearing day, the Applicants responded by stating that they had identified questions in only two of the limited appearance statements, to which they would provide answers in the course of the hearing.[24] The Staff then gave its analysis, identifying questions from essentially all of the limited appearance statements. The Staff answered some of the questions and identified publicly available documents that answered others. For the rest, the Staff identified the portion of the hearing in which they would be answered and, finally, the Staff agreed to supply copies of pertinent portions of its answers to those people raising the questions.[25] Following these responses, the Board indicated to the Applicants that it felt that the Applicants' unresponsiveness to the limited appearances reflected an incorrect interpretation of the Board's original directive that the parties reply to the limited appearances. The Board, therefore, suggested that they reconsider their responses. The Board also repeated a suggestion made during an earlier bench conference[26] that it might be desirable to present a responsible senior officer of the companies to respond to some of the questions that appeared to involve company policies, rather than facts.[27] The Applicants subsequently presented a senior official of each company[28] and three other witnesses[29] who more adequately responded to the matters raised. The parties subsequently sent copies of appropriate transcript excerpts to the interested persons. Limited appearances made at the environmental sessions were handled in a similar manner. The exchanges described above and the Board's review of all of the limited appearance statements persuades us that the Applicants may not have adequately apprised the public of the nature and potential effects of the proposed new facilities. Accordingly, we hope that the Applicants will endeavor in the future to expend greater efforts to fully inform the public in this regard.

24. During the evidentiary sessions on environmental issues, the Applicants presented eight witnesses. The Consolidated Intervenors presented five witnesses and the Staff presented five.

25. Applicants submitted their proposed findings of fact and conclusions of law under date of July 10, 1973. Consolidated Intervenors submitted their proposed findings of fact and conclusions of law under date of July 23, 1973. The Staff submitted their proposed findings of fact and conclusions of law, in the form of

[22] The comments of the Department of the Interior and the Staff's response are found in Staff's Exhibit 4.

[23] The comments of Mr. Mall's agency, also received too late for inclusion in the FES, and the Staff's responses are included in Staff's Exhibit 3.

[24] Tr. 513-517.

[25] Tr. 518-527.

[26] Tr. 376-378.

[27] Tr. 527-533.

[28] Tr. 1434-1502.

[29] Tr. 1505-1540.

comments on Applicants' submission, under date of August 6, 1973. Thereafter, Applicants filed replies to the Consolidated Intervenors' submission under date of August 2, 1973 and to the Staff's submission under date of August 16, 1973.[30]

26. The Staff requested leave to file a legal brief with respect to Consolidated Intervenors' proposed findings of fact and conclusion of law numbers 71 through 82, in which these intervenors raised legal argument under California real property law regarding the Applicants' authority to exclude persons from the exclusion area of the proposed facilities, or otherwise control the activities of persons in such areas. By Order of the Board dated September 11, 1973, the Staff was granted leave to file its brief. Accordingly, the Staff submitted its brief on September 13, 1973. Neither Intervenors nor Applicants filed a reply. The Board has considered the Staff's brief in conjunction with Intervenors' findings and conclusions respecting contested issues Nos. 3 and 4, which are set forth below.

27. Under date of August 31, 1973, Mrs. Lyn Harris Hicks, Chairman, GUARD, unbeknownst to its counsel filed with the Chairman of the Board "additional findings" which GUARD "judge[s] essential to be brought to the attention of the Board, 'off-the-record,' if necessary." These "additional findings" were received by the Chairman on September 12, 1973, and were promptly forwarded to the Public Proceedings Branch of the Commission for service on all parties to the proceeding. These "additional findings" are not authorized by the Commission's rules, were filed out of time, and no leave to file the same has been requested of the Board. Accordingly, we reject them *in toto*.[31]

28. The Board has considered the proposed findings and conclusion of the parties, and has accepted them to the extent indicated in this Decision. The Board rejects all other proposed findings and conclusion, as being either unsupported in the record, or of no decisional significance.

II. FINDINGS OF FACT

A. HEALTH AND SAFETY ASPECTS

1. Design and Site

29. The application contains a description of the site and the basis for its suitability, a detailed description of the proposed facility, including those reactor systems and features that are essential to safety, an analysis of the safety features provided for in the facility design, and an evaluation of various postulated accidents and hazards involved in the operation of such a facility and the engineered safety features provided to limit their effects. It also includes a description of the technical qualifications of the Applicants and their contractors to design and construct the facility, and a description of the Applicants' quality assurance criteria and plans for the conduct of operations.[32]

30. The record shows that Applicants have adequately described the proposed design of the facilities, including the principal architectural and engineering criteria for the design, and has identified the major features and components incorporated therein for the protection of the health and safety of the public, including:

[30] The Board notes in passing that the Applicants' "Proposed Findings of Fact and Conclusions of Law in the Form of an Initial Decision" were of little assistance to the Board in preparation of this initial decision. The discussion of the evidence regarding the issues in contention was far from adequate and the discussion of the uncontested matters ranged from negligible to nonexistent. The Staff's "Proposed Findings of Fact and Conclusions of Law," which consisted only of proposed modifications to the Applicants' submission, was, for the most part, equally defective. The Consolidated Intervenors' "Proposed Findings of Fact and Conclusions of Law," which properly dealt only with the issues in contention, were considerably more specific in dealing with the evidence, but included a substantial amount of irrelevant material. As is evident from this decision, the Board was not able to agree with the Consolidated Intervenors as to the conclusions to be drawn from the evidence.

[31] GUARD was represented by counsel throughout these proceedings. As noted above, these findings were submitted without the knowledge or advice of counsel, who has expressly and properly, we think, disclaimed responsibility for them. In any event, our review of these "additional findings" indicated that nothing contained therein would warrant our acceptance of them under the circumstances.

[32] PSAR, §§1-15 and Appendices (Applicants' Exhibit 1).

(a) The design of the plant's major systems and components, which bear significantly on the acceptability of the facility at the proposed site under the site criteria guidelines identified in 10 CFR Part 100, has been analyzed and evaluated by the Applicants and the Staff. The design of the engineered safety features and the consequences of postulated accidents have been analyzed by the Applicants and evaluated by the Staff at a power level of 3390 MWt.[33] Both evaluations demonstrate that the criteria set forth in 10 CFR Part 100 will be complied with.[34]

(b) Geological and seismological studies show that the San Onofre site is located in a region requiring special attention to seismic design. Structures and equipment important to safety will be designed for the design-basis earthquake which has a defined horizontal ground acceleration of 67% of gravity. This is twice as severe as the design value for the operational-basis earthquake.[35] The basis for selection of the design-basis earthquake is discussed in detail in Paragraphs 63-79, *infra*.

(c) From a foundation standpoint, the site is suitable for construction of the structures of the facility.[36]

(d) The plant will be protected against tsunamis by a sea wall extending to elevation +30 MLLW. The sea wall is designed to withstand, without loss of functional capability, the design-basis earthquake followed by the maximum tsunami, with coincident storm-wave action.[37]

(e) The Applicants and the AEC Staff have calculated potential off-site doses for the three postulated design-basis accidents that are normally analyzed for pressurized water reactors. The assumptions and results of the Applicants' calculations are shown in Subsection 14.5 of the PSAR and the assumptions and results of the AEC Staff calculations are shown in Section 3.1.8 and Appendix F of the SSE. Both the Applicants and the AEC Staff conclude that the calculated radiological doses that might result from design-basis accidents are well within the guideline values given in 10 CFR Part 100.[38]

(f) The Applicants have provided an analysis demonstrating the ability of the ECCS design to meet the applicable requirements of the Commission's Interim Acceptance Criteria.[39] The Staff concluded that the Applicants' ECCS design is in accordance with such criteria.[40] The Applicants have agreed to resolve those problems posed by the ACRS in its letter of July 21, 1972, in a manner satisfactory to the AEC Regulatory Staff and the ACRS.[41]

31. During the second prehearing conference on November 29, 1973, the Board propounded to Applicants and Staff certain questions relating to health and safety issues.[42] Applicants have answered those questions addressed to them.[43] Staff has answered the one addressed to it.[44] The Board is satisfied with the responses to its questions. One of the questions related to the radiation exposures expected to be received by the personnel operating and maintaining Units 2 and 3, comparable experience data from Unit 1, and steps being taken to minimize such exposure as a result of the experience gained at Unit 1.[45] In their answer, Applicants stated that the total exposure of employees expected at Units 2 and 3 is 128 man-rems per year, compared to actual figures of 97 and 238 for the two most recent years at Unit 1, and identified a significant number of actions they planned to take to improve the design of new units.[46]

[33] Applicants' Exhibit 1, §14; SSE, pp. 2-3, 27-28.

[34] SSE, p. 111.

[35] Applicants' Exhibit 1, §§2.9, 2.10 and Appendices 2A-2F; SSE, pp. 15-17.

[36] Applicants' Exhibit 1, §§2.9.6, 2.9.7 and Appendix 2H; SSE pp. 18-19; Staff's Exhibit 10.

[37] Applicants' Exhibit 1, §2.8.8 (including changes in Amendment 18) and Appendix 2G; SSE, pp. 17-18; Staff's Exhibit 9.

[38] Applicants' Exhibit 1, §14.5; SSE, p. 28.

[39] Applicants' Exhibit 1, §6.2.

[40] SSE, pp. 61-64.

[41] SSE, pp. 106-107 and Sections cited therein.

[42] Tr. 227-231.

[43] Applicants' Exhibit 6.

[44] Staff's Exhibit 11.

[45] Tr. 231.

[46] Applicants' Exhibit 6, pp. 16-20.

32. While the record reflects certain ongoing investigations, the Staff is of the opinion that such further information can reasonably be left for later consideration.[47]

33. The Applicants have set forth the manner in which the facility will be designed to conform with the Commission's General Design Criteria in 10 CFR Part 50, Appendix A,[48] and Safety Guides.[49] The Staff has found that the proposed design will conform to the General Design Criteria and Safety Guides, as well as to other appropriate rules, codes and standards.[50]

2. Technical Qualifications

34. Southern California Edison Company nuclear experience includes participation in the Sodium Reactor Experiment. Both Applicants were responsible for the design, construction and operation of San Onofre Unit 1, which began commercial operation on January 1, 1968.[51] The Southern California Edison Company Engineering and Construction Department includes 388 graduates in Engineering or a related field, representing over 320 man-years of experience in nuclear engineering design and in nuclear plant construction or operation.[52] The comparable San Diego Gas and Electric Company organization includes 36 graduate engineers supplemented as needed by temporary employees.[53] Within SCE's Engineering and Construction Department, responsibility for technical activities related to the nuclear design of Units 2 and 3 lies in the Nuclear Engineering Services organization. This group consists of 29 persons, all of whom are graduates in technical fields. Eighteen hold master degrees and 6 hold doctorates. Collectively, they represent 186 man-years of nuclear engineering experience.[54]

35. The Nuclear Steam Supply System will be supplied by Combustion Engineering, Incorporated.[55] Its experience in design of pressurized water reactors for utility service goes back to 1958 and it was a supplier of fuel and components prior to that date. Several nuclear power plants for which it supplied the Nuclear Steam Supply Systems are now in operation.[56] The architect-engineer for the project will be the Bechtel Corporation. Bechtel has been involved in the construction of nuclear facilities since 1949 and of commercial nuclear power plants since 1955. Bechtel has under design or construction or has completed about 60,000 megawatts of generating capacity, over one-third of which is nuclear.[57]

36. The Applicants have described the quality assurance program to be implemented for the design and construction of the facility.[58] The Staff reviewed the program and concluded, subject to certain commitments made by the Applicants to correct identified deficiencies,[59] that the quality assurance program is designed to meet the intent of Appendix B of 10 CFR Part 50, and will be adequately implemented prior to the issuance of a construction permit.[60] Subsequent enforcement correspondence between the Division of Compliance (now Directorate of Regulatory Operations) and the Applicants affirms that the necessary corrective steps have been taken.[61]

37. One of the issues in contention involved the technical qualifications of the Applicants. The Board has found the evidence does not demonstrate that the Applicants were not technically qualified. The evidence and finding are discussed in Paragraphs 46 to 50, *infra.*

38. The Staff concluded that the Applicants are technically qualified to design and construct the proposed facilities.[62]

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[47] SSE, pp. 94-98, 111.
[48] Applicants' Exhibit 1, § 1.7.
[49] *Ibid.*, p. 1.8-h (the Safety Guides referred to are now known as "Regulatory Guides").
[50] SSE, p. 2.
[51] Applicants' Exhibit 1, p. 1.5-2.
[52] Testimony of Baskin, p. 7, following Tr. 397.
[53] Applicants' Exhibit 1, pp. 1.5-4, 1.5-5.
[54] Testimony of Baskin, pp. 6-7, following Tr. 397.
[55] Applicants' Exhibit 1, p. 1.5-1.
[56] *Ibid.*, pp. 1.5-8 to 1.5-10.
[57] *Ibid.*, pp. 1.5-11 to 1.5-16.
[58] *Ibid.*, Appendix A; Testimony of Baskin, pp. 8-9, following Tr. 397.
[59] One of these involved an item identified by the ACRS.
[60] SSE, pp. 102-105.
[61] Staff's Exhibit 8.
[62] SSE, p. 111.

3. Financial Qualifications

39. The Applicants are California corporations principally engaged in the business of purchasing, generating, transmitting, distributing and selling electricity and electric energy in southern California. The Applicants will finance the cost of construction from funds available for construction of additions to their utility properties. Such funds are obtained from treasury funds on hand, funds available from internal sources (principally unappropriated earnings and provisions for depreciation), short term bank loans, and sales of securities. Approximately 35% of the funds required for design and construction by SCE and 9% of those required by SDGE will come from internally generated funds. The Staff has concluded that the Applicants are financially qualified to design and construct the proposed facility.[63]

4. Common Defense and Security

40. The activities to be conducted under the construction permits will be within the jurisdiction of the United States and all of the directors and principal officers of the Applicants are United States citizens. The Applicants are not owned, dominated or controlled by an alien, a foreign corporation, or a foreign government.[64]

41. The activities to be conducted do not involve any restricted data, but the Applicants have agreed to safeguard any such data which might become involved in accordance with the Commission's regulations.[65]

42. The Applicants will obtain fuel as it is needed from sources of supply available for civilian purposes, so that no diversion of special nuclear material from military purposes will be involved. The Staff has concluded that the activities to be performed will not be inimical to the common defense and security.[66]

5. Review by Staff and ACRS

43. The Staff review, performed both by Staff members and Commission consultants, consisted of a thorough independent evaluation of all of the technical information submitted by the Applicants concerning the proposed plant and of a comparison of the plant with similar plants and systems. Included in this comprehensive review was a study of the physical characteristics of the site and its environs (with special attention to geological and seismological matters), of the planned facility design (including the reactor components, the cooling system, the containment and engineered safety features, and radwaste systems), of the technical and financial qualifications of the Applicants to construct the facility, and of the plans for the conduct of operations at the site. In addition, the Applicants have established a quality assurance program which was reviewed by the Staff and found to meet the quality assurance criteria of the Commission. The effect of the operation of the plant on the common defense and security was studied, and consequences of various assumed accidents were calculated. The results of the Staff review are reflected in the Staff Safety Evaluation which was issued on October 20, 1972, and in the Staff's testimony.

44. The Atomic Energy Commission's Advisory Committee on Reactor Safeguards conducted an independent review of the application. In a letter to the Chairman of the Commission, dated July 21, 1972, the ACRS identified a number of items requiring further consideration.[67] The Staff's Safety Evaluation lists these and identifies the Staff's action taken thereon.[68] The ACRS concluded that these matters can be resolved during construction and that, if due consideration is given to the identified items, the plant "can be constructed with reasonable assurance that it can be operated without undue risk to the health and safety of the public."[69]

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[63] Applicants' Exhibit 1-A, pp. 3, 5, 6, 12; SSE pp. 108-109, 112, and Appendix G.
[64] Applicants' Exhibit 1-A, pp. 3-8; SSE p. 109.
[65] Applicants' Exhibit 1-A, p. 14; SSE p. 109.
[66] SSE, p. 109.
[67] SSE, Appendix B.
[68] SSE, pp. 105-108.
[69] SSE, p. B-3.

6. Contested Issues

45. The first five of the stipulated issues in contention[70] involve matters considered in the context of health and safety matters. These are individually discussed in the following paragraphs.

a. Issue No. 1

46. The first issue in contention is "whether the operating history of San Onofre Nuclear Generating Station Unit No. 1 reveals design defects in that unit which demonstrate the Applicants are not technically qualified to design and construct San Onofre Nuclear Generating Station Units Nos. 2 and 3." The issue was carefully drawn to preclude a general consideration of the operating experience at Unit 1, which is not relevant to the issues set forth in the Notice of Hearing, and to limit it to those matters relevant to this proceeding; i.e., the competence of the Applicants to design and construct Units 2 and 3.[71]

47. The Applicants' witness, Mr. Kenneth Baskin, Chief of Nuclear Engineering Services, testified that operation of Unit 1 had disclosed defects in the original design that could be considered potentially related to safety. The incidents giving rise to such disclosures were:

(1) two localized electrical fires due to overloaded conductors;

(2) boric acid crystallization causing blockage of flow in two of the available flow paths;

(3) leakage in excess of allowable design limits from two small isolation valves; and

(4) core transient analyses indicating that certain control rod movements might, under certain circumstances, cause axial power distribution more adverse than that previously predicted.

Appropriate corrective actions were taken in each case. None of the incidents resulted in releases of radioactivity to the environment in excess of licensed limits or otherwise endangered the health and safety of the public.[72]

48. The Staff's witness, Mr. John Sears, identified a fifth occurrence which, in his opinion, resulted from a design deficiency. This involved the failure of a tsunami gate, evidently due to faulty design of its support structure.[73]

49. Both witnesses were cross-examined extensively by the Consolidated Intervenors.[74] Although the cross-examination led to additional details of these five incidents, no additional incidents were disclosed. One occurrence involving apparent improper design of a component was identified.[75]

50. The Board has reviewed the testimony regarding design-related incidents and finds that, although there is evidence of a few design deficiencies in Unit 1, the number and significance of them fall far short of demonstrating that the Applicants are not technically qualified to design and construct Units 2 and 3.

b. Issue No. 2

51. The second issue agreed to by stipulation of the parties is "*whether, assuming the geological model set forth in the Regulatory Staff's Safety Evaluation,* 0.67 g is a reasonably conservative design basis earthquake for the San Onofre Nuclear Generating Station Units Nos. 2 and 3"[76] (emphasis added). Although the stipulated issue is based on assumption of the Staff's geological model (and it is decided on that basis herein), the Board's duty to decide whether "the proposed facilities can be constructed and operated at the proposed location without undue risk to the health and safety of the public"[77] requires us to determine the adequacy of the Staff's model and we first address that matter. We will also include some background information from the record, in order to place the issue in perspective.

[70] Paragraph 10, *supra.*

[71] Tr. 131-132, 134-135, 165.

[72] Testimony of Baskin, pp. 2-6, following Tr. 397.

[73] Tr. 1263-1264.

[74] Tr. 407-477; Tr. 1264-1317.

[75] Tr. 1282-1285.

[76] Stipulation dated November 29, 1972, and attached to Prehearing Conference Order of December 11, 1972.

[77] Notice of Hearing dated August 2, 1972.

52. In their application, as originally submitted to the Commission, Applicants presented general information on the site geology[78] and two reports by their consultants. The first, by Converse, Davis, and Associates,[79] described an investigation which included: a review of previous investigations conducted for Unit 1; examination, logging, and mapping of various geological features of the site and surrounding area; a review of published and unpublished literature on the geology of the region; and radiometric dating of shell fragments from the marine terraces.[80] The consultant concluded that:

(1) The probability of ground displacement within the plant site during its lifetime is very low and does not warrant specific design or location of Units 2 and 3 to accommodate or avoid such an occurrence;

(2) The probability of ground displacement on the Cristianitos fault during the life of the plant is very low;

(3) The significant faults in the area are the San Andreas (60 miles distant), the San Jacinto (45 miles distant), the Whittier-Elsinore (25 miles distant), and the projection of Fault "A"[81] (5 miles distant) and other minor offshore faults; and that, while the major faults are likely to be the sources of future earthquakes, the relative degrees of activity and the possibilities of ground displacement on them are lower for those near the site and higher for those farther from the site; and

(4) The probability is extremely low of new faults forming in or near the site in the event of ground displacement on faults in the region.[82]

The second report, by Marine Advisers, Inc.,[83] described a continuous seismic profiling investigation of the continental shelf off San Onofre. This investigation included about 200 miles of profiling using several different profiling systems. The conclusions, in summary, were that

(1) No faults were found to project toward or through the proposed site;

(2) There is a minor fault, designated "E", one mile offshore and a major fault, "A", at the edge of the continental shelf five miles offshore;

(3) The linear, continuous, disturbed zone of Fault "A" varies in width from 1000 to 3000 feet and south of San Onofre the fault may have more than one branch;

(4) No sea-floor topographic expression of Fault "A" was discernible;

(5) Fault "A" was located with confidence north to offshore from Dana Point, but detection of its northern continuance between Dana Point and Newport Beach was inconclusive;

(6) A possible submarine branch of the Newport-Inglewood Fault was detected off Newport Beach, but the relationship of Fault "A" with the Newport-Inglewood Fault or with other faults north of Dana Point could not be resolved;

(7) The submarine extension of the Cristianitos Fault turns southeast and does not cross the shelf to intersect Fault "A"; and

(8) Fault "E", which was detected one mile offshore of the proposed site, strikes diagonally south across the inner portion of the shelf, dies out in the outer shelf structures, and does not intersect Fault "A".[84]

53. Concurrent with the two investigations described above, seismic and foundation studies were carried out by a third consultant, Dames and Moore.[85] The seismic portion of the investigation included: review of prior onshore and offshore geologic studies (but with no apparent reference to the concurrent investigations described above); review of regional seismic history; in-place geophysical measurements and laboratory testing to evaluate the physical properties of the site materials; selection of appropriate earthquakes for the operating basis and design basis earthquakes; and preparation of response spectra and earthquake time

[78] Applicants' Exhibit 1-C, § 2.9.

[79] Applicants' Exhibit 1-C, Appendix 2A.

[80] *Ibid.*, pp. 1-2.

[81] [illegible] is an offshore fault, roughly parallel to the shore, finally referred to as part of the Santa Monica–Baja, California zone of deformation.

[82] *Ibid.*, pp. 3-4.

[83] Applicants' Exhibit 1-D, Appendix 2B (Second Section).

[84] *Ibid.*, pp. 3-4.

[85] Applicants' Exhibit 1-D, Appendix 2B (First Section).

histories.[86] After studying ground motion that would result at the site for various postulated earthquakes on each of the faults in the region, the consultants recommended the adoption of a design basis earthquake of 0.40 g horizontal acceleration. This was based on a postulated earthquake on a postulated offshore extension of the Newport-Inglewood Fault zone of magnitude 7.3. (This postulated offshore extension is the same as Fault "A".) The basis for selection of magnitude 7.3 was that it was one magnitude larger than the magnitude 6.3 Long Beach earthquake on the Newport-Inglewood fault in 1933.[87] Because an additional degree of conservatism was desired by the Applicants, the value was raised to 0.50 g[88] and the design spectra prepared on this basis.[89] The recommended operating basis earthquake was 0.25 g.[90]

54. The two paragraphs immediately above describe the state of the record at the time of submission of the original PSAR in May of 1970. Subsequently the Applicants convened a group of consultants, known as the Board of Technical Review (BTR), to give further consideration to the seismic implication of the inferred offshore geological structure.[91] The report of that Board, dated January 11, 1971,[92] shows that the BTR study covered three principal subjects—the structural features of the continental shelf offshore from the site, the Newport-Inglewood zone of deformation, and the ground motion at San Onofre. The study of the shelf began with re-examination of all available data. This, in turn, led to the procurement of additional information in the form of rock samples from the ocean floor and new seismic profiles. The second phase of the shelf study consisted of interpretation of the new data and reinterpretation of the earlier data in light thereof. The BTR's conclusion was that many of the previously identified faults did not in fact exist, that the faults that do exist are short discontinuous features, and that there is no evidence of pronounced displacement.[93] The second subject of the BTR study was the nature, relationships and tectonic analysis of the Newport-Inglewood Zone. After reviewing the general geological structures and tectonic framework of the West Coast, the BTR concludes that the Newport-Inglewood Zone is essentially restricted to the Los Angeles Basin and that it reflects post-Oligocene movements truncated on the northwest by the Malibu-Santa Monica fault zone of the Transverse Ranges and terminating to the southeast offshore between Newport Beach and Laguna Beach. The latter limit (which is about 25 miles northwest of San Onofre) is assumed because no similar structural zone lies farther southeast.[94] From the above, the BTR has concluded that the ground motion at the site should be estimated based on a large earthquake on the portions of the Newport-Inglewood Zone northwest of Laguna Beach. They have done this by comparing earthquake data recorded during the 1968 Borrego Mountain earthquake at the site, at Long Beach, and at Vernon. The data from this comparison were used as a basis for extrapolating data measured at Long Beach and Vernon during the 1933 Long Beach Earthquake to predicted motions at the site for the Long Beach Earthquake. This yielded an estimate of 0.07 g for the zero-period acceleration at the site. They also calculated the acceleration for a 45-kilometer rupture (the Long Beach Earthquake involved a 30 km rupture) and for a 90 km rupture (which they estimate to be the entire length of the Newport-Inglewood Zone) with the same southeastern terminating point; these two calculations yielded accelerations of 0.13 g and 0.17 g, respectively.[95] In light of this report from the BTR, the Applicants determined that the operating and design basis earthquakes should be based on an earthquake postulated on the San Andreas Fault.[96] The values of acceleration that were proposed by the Applicants for the operating and design basis earthquakes are no longer in the PSAR (because of subsequent amendments),[97] but the site acceleration predicted by Dames and Moore for the postulated San Andreas Earthquake was 0.25 g

[86] Applicants' Exhibit 1-C, pp. 2.10-1, 2.10-2.

[87] Applicants' Exhibit 1-D, Appendix 2B, pp. III-37.

[88] *Ibid.*, pp. III-38, III-39.

[89] These spectra are no longer in the Application, having been superceded by subsequent amendment. The current spectra appear in Applicants' Exhibit 1-C, Figure 2.10-2.

[90] Applicants' Exhibit 1-D, Appendix 2B, pp. III-36.

[91] Applicants' Exhibit 1-C, p. 2.10-2.

[92] Applicants' Exhibit 1-D, Appendix 2C.

[93] *Ibid.*, pp. 1-10.

[94] *Ibid.*, pp. 11-22.

[95] *Ibid.*, pp. 28-33.

[96] *Ibid.*, p. 2C-2.

[97] Applicants' Exhibit 1-C, p. 2.10-6.

(compared to 0.40 g calculated by Dames and Moore for the earlier-postulated magnitude 7.3 earthquake five miles offshore from the site).[98]

55. On March 1, 1971, the Staff wrote to the Applicants requesting certain additional analyses.[99] The Applicants responded to this letter on June 17, 1971,[100] with "Responses to AEC Questions Concerning Seismology and Geology."[101] This response summarizes the information on offshore geology contained in the BTR report and indicates the bases for the Applicants' conclusion that a major earthquake located offshore is not credible. It further indicates that, despite this conclusion, the design will be based on such a hypothetical earthquake. This hypothetical earthquake has a rupture length of 25 miles or longer.

56. On July 2, 1971, the United States Geological Survey (USGS) provided a preliminary report of their review of the San Onofre geology.[102] Their report states that they reviewed the Application, "amendments, and supplements including the report by the Applicants' Board of Technical Review." By implication, this did not include the "Responses" discussed immediately above. As part of this review, the USGS also made field examinations and examined data obtained in the Oceanside-La Jolla offshore area by the USGS in a 1970 AEC-sponsored research program and USGS data on faults in the onshore area between Dana Point and Mexico. In general, the USGS had no quarrel with the data provided by the Applicants, nor with most of their conclusions. The Survey did, however, conclude that, on the basis of the available data, "There appears to be a linear zone of deformation. . .that extends south-eastward from Santa Monica to at least the Mexican Border" and that "it appears that the potential for large earthquakes at any place on the zone cannot be precluded at present."[103]

57. The record shows that, following the submission of the USGS preliminary report, a series of meetings was held between Applicants and Staff for further discussion of geological and seismological considerations between August 21, 1971 and February 10, 1972, culminating in the submission of an additional report by Applicants on April 3, 1972. Additional meetings were held on April 28, May 31, and June 8 and another submittal was made on June 29, 1972.[104] The April 3, 1972 report[105] describes further investigations performed for the Applicants by additional consultants, the interpretations of their findings, and the seismic design basis. Summarizing the findings of the latest, and previous, investigations, the Applicants concluded, although there is a fault in basement rocks at depths of 10,000 feet or more that is about 40 miles long and passes about 5 miles from the site, that: (1) displacement on the fault, even at the deepest level of investigation, dies out to the northwest near Laguna Beach and to the southeast near Oceanside; (2) at higher levels the fault shows much less displacement and appears as a series of short, discontinuous breaks; (3) the fault is not connected with other faults at its extremities; (4) no evidence was found of post-Miocene activity on the fault; and (5) there is no macroseismicity associated with the fault. Based on the foregoing, they conclude that "significant activity has not occurred on the South Coast Offshore Fault in post-Miocene time. This fault must not have generated a large earthquake since upper Miocene time; i.e., millions of years ago."[106] Regarding the design basis earthquake, the Applicants concluded that "although all investigations indicated that significant nearby offshore fault rupture need not be considered in the design basis, the applications(sic) hypothesized such events and conservatively determined the resulting site accelerations."[107] "Although the maximum site acceleration, indicated by the various conservatively hypothesized events as previously described, is 0.4 g, for additional conservatism the Applicants will use a design basis earthquake (DBE) site acceleration of"[108] 0.5 g.[109]

[98] Applicants' Exhibit 1-D, Appendix 2B, pp. III-34, III-35.

[99] The letter is not in the record of this proceeding.

[100] SSE, p. A-2, item 25.

[101] Applicants' Exhibit 1-D, Appendix 2D.

[102] SSE, pp. C-17 to C-36.

[103] *Ibid.*, pp. C-34, C-35.

[104] SSE, Appendix A contains a chronology of these matters.

[105] Applicants' Exhibit 1-D, Appendix 2E.

[106] *Ibid.*, pp. 2E-17, 2E-18.

[107] *Ibid.*, p. 2.

[108] *Ibid.*, p. 2E-21.

[109] *Ibid.*, p. 2. The figure currently given on page 2E-21 is 0.67 g, but it was raised to this amount by subsequent amendment.

58. On June 29, 1973, the Applicants submitted Amendment 14 to their application, apparently as a result of the meetings described above, adopting a design basis earthquake acceleration of 0.67 g and a corresponding operating basis earthquake acceleration of 0.33 g.[110]

59. On July 2, 1972, the USGS submitted its final report.[111] In this report, which supplements the earlier report (Paragraph 56, *supra*), the USGS summarizes the pertinent data considered previously and "treats in appropriate detail the large amount of offshore geophysical data acquired since the preliminary review."[112] To summarize the USGS's summary, they disagree with the Applicants' interpretation of the data. They state that:

> The data presented by the Applicant lead us to the conclusion that the Newport-Inglewood zone of folds and faults, the South Coast Offshore fault, and the Rose Canyon fault zone cannot be disassociated. Instead, an extensive linear zone of deformation, at least 240 km long, extending from the Santa Monica Mountains to at least Baja California, seems well established by the present evidence. This was the tentative assessment. . .in the preliminary review. . .(and it) is greatly enhanced by the new information, and is still pertinent. . . . It is concluded, therefore, that deformation on the Newport-Inglewood zone has gone on intermittently or continuously since at least middle Miocene and no evidence has been presented to show that the stress system is inactive or altered. As a number of earthquakes have occurred near the north end of the zone in historic time (the largest is the 1933 Long Beach M 6.3 earthquake) and the south end shows evidence of movement in Quaternary and possibly Holocene time, the Santa Monica to Baja California zone of deformation must be considered potentially active and capable of an earthquake whose magnitude could be commensurate with the length of the zone.[113]

60. On July 10, 1972, the Seismological Investigations Group, National Oceanic and Atmospheric Administration (NOAA) (the Staff's seismological consultant) submitted its report.[114] NOAA stated that it had reviewed the Applicants' evaluation of the site seismicity and had made its own evaluation. It pointed out the importance of the interpretation of the geologic and tectonic setting of the site to the evaluation of the earthquake potential and cited the conclusion of the USGS cited in Paragraph 59, *supra*. It went on to take note of research in progress aimed toward prediction of the maximum responses possible from strong earthquakes and the optimism that there will be future improvements in understanding of the relationship between geologic structures and earthquakes. NOAA further stated that such theories and developments, though promising and exciting, would have to be used cautiously until sufficient data have established their validity. NOAA concluded, as a result of its review of the seismological characteristics, and with the geological characteristics as defined by the USGS, that:

> An acceleration of ⅔ g, resulting from a strong X intensity (MM) event, (should) be used to represent the ground motion from the maximum earthquake likely to affect this site. However, the accelerogram may contain a few peaks between ⅔ and ¾ g during the ⅔ g interval. These accelerations could result from an earthquake occurring within a few miles from the site. Also, it must be assumed that a similar earthquake could occur at any point along this zone of deformation.[115]

On October 13, 1972, NOAA further explained their conclusion by stating:

> The few peaks with accelerations between ⅔ and ¾ g that may occur on the accelerogram will not exceed a total of five. In addition, it is unlikely that more than two of these peaks will occur consecutively.[116]

61. The paragraphs above describe the state of the record at the start of the hearing. The Applicants' submittals, contained in Volumes I, II, III, and IV of the PSAR, are in total five inches thick. The Board has described this history for the purpose of illustrating the effort that has been exerted by both the Applicants

[110] *Ibid.*, pp. 2E-21, 2E-23.
[111] SSE, pp. C-4 through C-16.
[112] *Ibid.*, p. C-5.
[113] *Ibid.*, pp. C-14, C-15.
[114] SSE, pp. D-3 through D-7.
[115] *Ibid.*
[116] SSE, p. D-2.

and their consultants and the Staff and its consultants to determine the relevant data and to reach sound conclusions thereon. It has become apparent to the Board, both from the record existing at the start and from the testimony during the hearing, that an honest difference of opinion exists between the experts on the two sides as to the proper geological model to use, i.e., whether there is a long continuous zone of deformation near the site which must be considered as the potential location of a major earthquake, or whether the nearby zone constitutes only a smaller, isolated fault and one need consider only a smaller earthquake commensurate with that shorter fault and larger earthquakes on more distant faults. The Applicants ultimately (prior to the hearing) agreed to accept the Staff's more conservative view as the basis for their design. Accordingly, they agreed to the stipulation cited in Paragraph 51, *supra*, which specifies that the adequacy of the design basis earthquake will be litigated in the framework of "the geological model set forth in the Regulatory Staff's Safety Evaluation." This model, of course, is the one set forth by the USGS in the quoted sections of report in Paragraph 59, *supra*. The Board has reviewed the information in the record and the Staff's evaluation of that information and finds that the Staff's model is the appropriate one for use in evaluating the effect of these facilities on the health and safety of the public. We note the Applicants' reluctance to concede that the Staff's model is a true representation of the situation. This was indicated by their effort to introduce prepared testimony attempting to counter the Staff's model[117] and specifically stated in the Applicants' reply to the Staff's proposed findings.[118] As we stated above, the interpretation of the geological data is susceptible to differences of opinion and future discoveries may well prove the Applicants' interpretation to be correct. Indeed, there may even be a small preponderance of evidence presently in their favor. The importance of the matter from a safety point of view and the lack of overwhelming evidence that the Applicants' interpretation is correct, however, require this Board to adopt the more conservative position, i.e., that the Staff's model is the one to be used in evaluating the propriety of an 0.67 g design basis earthquake.

62. At this point, it is appropriate that we mention the Applicants' proposed geological and seismological testimony. This testimony, provided for the January hearing on health and safety matters and distributed to the Board and parties on January 6, 1973, consisted of question and answer testimony of three geologists, Dr. Hill, Dr. Moore, and Dr. Jahns[119] and of Dr. Smith, a seismologist. The geological testimony was based primarily on the material in the PSAR and described above.[120] The direction that it takes is epitomized by the Applicants' trial brief where, after summarizing Dr. Hill's testimony, it is stated as the argument that "Dr. Hill's testimony indicates that the geological model postulated by the United States Geological Survey in its report to the United States Atomic Energy Commission is a conservative model."[121] An identical statement is made regarding Dr. Moore's testimony.[122] Dr. Jahns' testimony is not described in the trial brief. Consolidated Intervenors' Counsel moved *in limine* that the entire testimony of the three geologists and part of the testimony of Dr. Smith be deemed "irrelevant in that it does not direct itself to an issue which has been placed in contention for these hearings."[123] After hearing Consolidated Intervenors' Counsel's arguments, the Board received the views of Applicants' Counsel. He took the position that the "Staff's geological model" consisted of a set of conclusions and that ". . .it is relevant in discussing the conservatism of the G-value that the basic geologic conclusions be examined," and that "the conservatism of the geologic conclusions are relevant to the conservatism of the G-value." The Staff agreed in substance with the Consolidated Intervenors. It went on to point out that, although in theory it would be useful to have information explaining the details of the geologic model, "the testimony. . .is not directed to that issue; they are directed to quarreling with the model rather than explaining it." The Staff also pointed out that with regard to the Board's charge to decide the ultimate issues in the Notice of Hearing, the Board could rely upon information in the record and that, although the

[117] See Paragraph 62, *infra*.
[118] E.g., "The. . .Staff's Proposed Finding. . .appears to suggest that the Applicants have accepted the geologic conclusions of the Regulatory Staff and its consultants. On the contrary, the record is clear that the Applicants have done no more than *assume* such geologic conclusions" (emphasis original), and ". . .if geology were in issue in this proceeding, the record contains substantial probative evidence leading to conclusions different from those of the Regulatory Staff" (both quotations from page 5 of "Applicants' Reply to the A.E.C. Regulatory Staff's Proposed Findings of Fact and Conclusions of Law" dated August 16, 1973).
[119] Dr. Jahns' testimony was submitted separately.
[120] Paragraphs 52-55, 57 and 58, *supra*.
[121] Applicants' Trial Brief, p. 7.
[122] *Ibid.*, p. 10.
[123] Tr. 883.