Offshore Power Systems

June 1, 1979

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U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

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Washington, D. C. 20555

Re: Offshore Power Systems, Docket No. STN 50-437

Mr. Chairman and Members of the Board:

Offshore Power Systems hereby files the attached "Applicant's Proposed Partial Findings of Fact in the Form of a Proposed Initial Decision" in accordance with the Board's Order dated May 2, 1979.

Service on the parties is documented by a Certificate of Service which is bound as the last three pages of the attached volume.

Respectfully submitted,

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454 cc: All Parties per Certificate of Service

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
OFFSHORE POWER SYSTEMS	)	Docket No. STN 50-437
	)	
(Manufacturing License for Floating	)	
Nuclear Power Plants)	)	

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

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June 1, 1979

454 ~~002~~ 003

TABLE OF CONTENTS

454 004

TABLE OF CONTENTS (CONT'D)

454 005

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
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APPLICANT'S PROPOSED PARTIAL FINDINGS OF FACT IN THE FORM OF A PROPOSED INITIAL DECISION

I. PRELIMINARY STATEMENT AND DESCRIPTION OF THE RECORD

A. INTRODUCTION

1. This proceeding involves the Application filed by Offshore Power Systems (Applicant) for a license authorizing the manufacture of eight standardized floating nuclear plants (FNPs) at its manufacturing facility located on Blount Island in Jacksonville, Florida. Offshore Power Systems (OPS) is an unincorporated joint venture of Westinghouse Electric Corporation (Westinghouse) and Westinghouse International Power Systems Company, Inc. (WIPSCO), Westinghouse having a 99% interest and WIPSCO having a 1% interest (Final Environmental Statement, Part II, September, 1976, NUREG-0056 (FES II), Vol. 1, p. 1-1).

2. The FNP will be a totally integrated power station mounted on a floating platform. The manufacture and assembly of the FNPs will be done on a production line basis at the Blount Island facility.

3. The instant Application for a manufacturing license was submitted to the Atomic Energy Commission (AEC)[1] on January 22, 1973. It was docketed by the Commission on July 5, 1973. This Application was the first one accepted by the Commission for licensing pursuant to the provisions of Appendix M to 10 CFR Part 50 pertaining to the manufacturing license option of design standardization.

4. Under Appendix M, an application for a manufacturing license must meet all of the requirements of 10 CFR Sections 50.34 (a)(1)-(9) and 50.34a(a) and (b), except that any required information or analyses relating to site matters shall be predicated on postulated site parameters which shall be specified in the application. Furthermore, under Appendix M, an applicant for a manufacturing license must submit with the application an environmental report as required of applicants for construction permits, provided, however, that such environmental report shall be directed at the manufacture of reactors at the manufacturing site and, in general terms, at the construction and operation of reactors at hypothetical sites having characteristics that fall within the postulated site parameters.

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[1]As of January 1, 1975, the Nuclear Regulatory Commission (NRC) assumed all the licensing responsibilities of the AEC under the Atomic Energy Act of 1954, as amended.

454 008

5. The instant Application, as docketed by the Commission, was accompanied by a Plant Design Report (PDR) and an Environmental Report (ER). On various occasions since original docketing the PDR has been amended and the ER has been supplemented. The Application, the PDR as amended, and the ER as supplemented have been admitted into evidence. Appendix A hereto lists by exhibit numbers the title, date and transcript admission page of the Application, the PDR, the ER and the ER supplements.

6. The NRC Regulatory Staff (Staff) performed a review of the Application. As a result of this review and its own independent study, the Staff prepared a Safety Evaluation Report (SER) and two Supplements thereto. This Report and the Supplements have been admitted into evidence. The Staff also prepared as part of its review a multi-part Final Environmental Statement (FES) which has been admitted into evidence. Appendix A hereto lists the title, publication number, date, and transcript admission page of the SER, its Supplements, and the FES.

7. Pursuant to the Atomic Energy Act of 1954, as amended (AEA), the National Environmental Policy Act of 1969, as amended (NEPA), and the regulations of the AEC, the AEC published on December 10, 1973, a Notice of Receipt of Application for Manufacturing License and Availability of Applicant's Environmental Reports (Notice of Receipt) and a Notice of Hearing on Application for Manufacturing

454 008

License (Notice of Hearing) (38 Fed. Reg. 34008). The Notice of Receipt advised that the Application had been docketed under one option of the Commission's recently announced standardization policy for nuclear power plants and would be governed by the regulations set forth in Appendix M, 10 CFR Part 50. The Notice of Hearing set forth the requirements to be satisfied prior to the issuance of the requested manufacturing license. The Notice of Hearing also appointed this Atomic Safety and Licensing Board (Board) to conduct the hearing and provided that any person whose interest might be affected by the proceeding could file, by January 9, 1974, a petition for leave to intervene with respect to the issuance of the requested manufacturing license. By March 28, 1978 all of the Board's initial members had been replaced and the Board was reconstituted to consist of its present members.

B. ADMISSIONS AND WITHDRAWALS OF PARTIES

8. Petitions for leave to intervene were filed by the following persons or entities:

(a) Kenneth B. Walton on behalf of the City of Brigantine (Brigantine), New Jersey (subsequently, petitions for leave to intervene on behalf of the City of Brigantine were filed by Messrs. George W. Ward and Walter H. Bew on March 27 and 28, 1974; however, these latter two petitions were withdrawn in April, 1974);

454 009

(b) Natural Resources Defense Council, Inc. (NRDC), an environmental organization with a nationwide membership;

(c) Atlantic County Citizens Council on Environment (ACCCE), a New Jersey environmental organization;

(d) Board of Chosen Freeholders of Atlantic County, New J sey (Atlantic County), the governing body of Atlantic County, New Jersey;

(e) Bruce Doueck;

(f) Environmental Law Society of the University of Miami School of Law, Inc. (however, the Environmental Law Society withdrew its petition in February, 1974).

9. In February, 1974, the State of New Jersey filed a petition to participate as an interested State pursuant to 10 CFR Section 2.715(c).

10. Applicant and Staff filed answers to the petitions for leave to intervene filed by the aforementioned persons or entities. The Board heard argument regarding the petitions at prehearing conferences held on February 11, April 9 and April 30, 1974, and ultimately admitted NRDC and Atlantic County as intervening parties in its First Prehearing Conference Order dated April 15, 1974 and Brigantine

and ACCCE as intervening parties in its Second Prehearing Conference Order dated May 21, 1974. In addition, in its First Prehearing Conference Order the Board (a) denied the Doueck petition for leave to intervene for failure to set forth contentions with the particularity required by 10 CFR Section 2.714(a), and (b) permitted the State of New Jersey to participate in the proceeding pursuant to 10 CFR Section 2.715(c).

11. In its First and Second Prehearing Conference Orders the Board admitted certain contentions propounded by Brigantine, NRDC, Atlantic County and ACCCE as issues in controversy. The Board subsequently admitted other contentions as issues in controversy. Appendix B hereto lists the contentions admitted by the Board. In addition, Appendix B lists certain other matters which were the subject of inquiry in this proceeding.[2] The Board's findings of fact with regard to the contentions and certain other matters which were the subject of inquiry are set forth in Section IV. of this Initial Decision.

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[2]Since several of the admitted contentions in this proceeding pertained to the same subject matter, they were consolidated by topic for consideration at hearing. Appendix B reflects this consolidation and utilizes the Roman numeral numbering sequence and subject matter designations employed by the Applicant in its various mtions to establish schedule.

12. By letter dated March 25, 1975, Kenneth B. Walton filed a motion with the Board requesting the right to participate as an individual intervenor in this proceeding rather than as a representative of Brigantine. In our Memorandum and Order dated May 8, 1975, the Board granted Mr. Walton's request for individual intervention status and encouraged Brigantine to secure counsel to represent its interest. Subsequently, Brigantine did secure representation of counsel.

13. In August, 1975, Atlantic County filed a motion to amend and expand its contentions. In October, 1975 Brigantine also filed a motion to amend and expand its contentions. Applicant and Staff filed answers to these motions and this Board heard argument thereon at a prehearing conference held on December 2, 1975. In our Fourth Prehearing Conference Order dated December 29, 1975, the Board admitted certain of Brigantine's proposed amended and expanded contentions as issues in controversy. The Board in this Order denied all Atlantic County proposed amended and expanded contentions as either having been included within the original wording of previously admitted Atlantic County contentions or as failing to set forth a proper contention under applicable Commission regulations. The Brigantine amended and expanded contentions which were admitted as issues in controversy are listed in Appendix B hereto.

14. On November 19, 1976, NRDC filed a motion to amend and expand its contentions. Also on November 19, 1976, counsel for ACCCE filed a joint motion on behalf of ACCCE and Atlantic County to amend

454 012

and expand their contentions. Applicant and Staff filed answers to these motions and the Board heard argument thereon on May 20, 1977.

15. On June 24, 1977, Brigantine filed a Notice of Withdrawal as a party to this proceeding. Said withdrawal was approved by Board Order dated July 27, 1977.

16. This Board, in its August 1, 1977 Memorandum and Order Re: Motions to Amend and Expand Contentions, admitted one proposed ACCCE/ Atlantic County contention as an issue in controversy. Additionally, in this Order the Board stated that in view of the withdrawal of Brigantine as a party, the Board would treat the one Brigantine proposed amended and expanded contention which it admitted as an issue in controversy at the May 20, 1977 argument as an issue retained by the Board. Finally, in this Order the Board requested Applicant and Staff to present evidence on a Board question pertaining to consideration of the utilization of heat pumps and of secondary and tertiary recovery from oil wells in the environmental assessment undertaken in connection with the Application. The ACCCE/Atlantic County contention, the Board issue and the Board question are listed in Appendix B hereto.

17. On June 15, 1976, Mr. Ernst J. Effenberger (Effenberger) made a limited appearance statement before the Board concerning turbine-generator matters (Tr. 999-1010). The Board requested Applicant and Staff to address the matters raised by Effenberger.

454 013

Subsequently the Board authorized withdrawal of the limited appearance statement and Eifenberger testified on turbine-generator matters as a witness for ACCCE.

18. In August, 1978, NRDC filed a motion to amend its contention. That motion was denied by Order dated September 11, 1978 and a motion to reconsider that Order was denied by Order dated November 9, 1978. For additional discussion of this matter, see paragraph 33, infra.

19. In April, 1977, Applicant filed a motion for reconsideration of that portion of this Board's May 21, 1974 Second Prehearing Conference Order which had admitted an ACCCE contention pertaining to breakwater stability as an issue in controversy. By Order dated April 20, 1977, the Board granted Applicant's motion and ruled that the ACCCE breakwater stability contention was site related and hence improper as a contention in this manufacturing license proceeding. Accordingly, this contention was dismissed.

C. DISCOVERY, HEARINGS AND MOTIONS FOR SUMMARY DISPOSITION

20. In its Second Prehearing Conference Order the Board opened discovery on all issues in controversy. Applicant, Staff and all intervenors engaged in some discovery thereafter, the majority of such discovery being conducted on an informal basis.

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21. A Notice of Evidentiary Hearing was issued by the Board on March 11, 1976. The Notice of Hearing stated that hearings would be held in Jacksonville, Florida, on March 23 and 24, 1976, for the purpose of consideration of the Staff's Final Environmental Statement, Part I (FES I) together with the Applicant's Environmental Report, Part I, as supplemented (ER I). These documents considered the environmental impact of manufacturing activities to be conducted at the Applicant's Blount Island facility. The Notice of Hearing also stated that limited appearance statements would be received at this Jacksonville hearing session. Finally, the Notice of Hearing advised that a public hearing session would be held in Atlantic City, New Jersey, on March 29, 1976, for the purpose of receiving limited appearance statements.

22. Evidentiary hearing sessions were held in Jacksonville on March 23-24, 1976. At the March 23, 1976 hearing, Applicant's witnesses authenticated and the Board admitted into evidence, the ER I.[3] In addition at the March 23, 1976 hearing, Staff witnesses authenticated, and the Board admitted into evidence, the FES I.[4]

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[3]Exhibits OPS-4 through OPS-10. The witnesses who authenticated these exhibits were Dr. John A. Nutant and Messrs. Thomas A. Mantia and Harlan L. Bowman. (Professional Qualifications admitted and incorporated into the record at Tr. 609.)

[4]FES was admitted into evidence at Tr. 642 and incorporated into the record following Tr. 637. Messrs. Fred J. Clark, Jr. and Roy Toma were the sponsoring witnesses. (Professional Qualifications admitted and incorporated into the record at Tr. 637.)

454 015

23. Limited appearance statements were taken by the Board at hearing sessions held in Jacksonville, Florida, on March 23-24, 1976. Hearing sessions were convened in Atlantic City, New Jersey, on March 29-30, 1976, and limited appearance statements were received at those sessions. Limited appearance statements also were taken at a hearing session held in Bethesda, Maryland on June 15, 1976.

24. On May 11, 1976, the Board convened a special prehearing conference to consider the scheduling of hearing sessions, the status of discovery in the proceeding and other matters. At the special prehearing conference the Board heard argument regarding NRDC's opposition to the establishment of a hearing schedule in accordance with a Stipulation Concerning Hearing Schedule and Related Matters (Stipulation) dated March 8, 1976 which had been entered into by all parties to the proceeding with the exception of NRDC.

25. Following the May 11, 1976 special prehearing conference, the Board issued its Fifth Prehearing Conference Order dated May 17, 1976. In that Order the Board rejected the NRDC argument that evidentiary hearings could not begin until the full final environmental statement had been published. In that Order the Board also ordered the resumption of hearings on June 15, 1976. The Board further stated in its Order that all the conditions, limitations and qualifications in the Stipulation would be adhered to and that the schedule therein would be followed as closely as was reasonably practicable.

454 016

26. Pursuant to published notice, evidentiary hearings on radiological health and safety matters were held in Bethesda, Maryland, on June 15-18, 1976, in Washington, D.C., on July 6-9, 1976, in Silver Spring, Maryland, on July 26-27, 1976, and in Bethesda, Maryland on July 28-30, 1976, September 20-24, 1976, September 28-29, 1976, November 3-4, 1976, December 8-10, 1976, December 16-17, 1976, February 28-March 4, 1977, May 9-13, 1977, May 16-17, 1977. In addition to the hearings on FES I held on March 23-24, 1976, hearings on environmental issues relating to generic siting of FNPs were held in Bethesda, Maryland on May 17-20, 1977, July 10-13, 1978, and April 4, 1979.

27. On February 16, 1979, NRDC filed a motion seeking summary disposition with regard to its sole contention in this proceeding. This contention alleges that the Final Environmental Statement prepared by the Staff in connection with its review of the instant Application violates the requirements of NEPA in that it is not a programmatic impact statement. The Applicant's answer to the NRDC motion and the Applicant's cross-motion for summary disposition was filed on March 8, 1979. The Staff's response to the NRDC motion was filed March 13, 1979. The NRDC reply to Applicant and Staff responses and its opposition to Applicant's cross-motion was filed on April 16, 1979.

454 017

D. INTERLOCUTORY APPEALS FROM BOARD RULINGS

28. Applicant on March 17, 1977 filed a motion to establish schedule requesting, inter alia, a scheduling of hearings in May, 1977 to consider certain environmental contentions which had been admitted as issues in controversy. All previous hearing sessions devoted to consideration of admitted contentions had addressed radiological health and safety issues. On March 29, 1977, Brigantine filed a response in partial opposition to Applicant's motion to establish schedule in which Brigantine opposed the scheduling of any hearings on previously admitted environmental contentions, claiming that such scheduling contravened the provisions of the Stipulation. By Order dated April 12, 1977, the Board scheduled hearings on certain pending environmental contentions for the May, 1977 hearing sessions. On April 20, 1977, the Staff filed a motion to modify the scheduled May, 1977 hearing sessions. Brigantine again raised the Stipulation objection in an answer to the Staff motion dated April 26, 1977. On April 26, 1977, the Board issued an Order scheduling May, 1977 hearing sessions on one admitted environmental contention of Atlantic County pertaining to resort economics. On April 28, 1977, Atlantic County filed a motion for reconsideration of the Board's April 26, 1977 Order scheduling May, 1977 hearing sessions on the resort economics environmental contention. Atlantic County's motion for reconsideration and Brigantine's objection to environmental contention hearings were rejected by the Board at the May 9, 1977 hearing (Tr. 5505-5509). ACCCE made an oral motion for reconsideration of the May 9, 1977

ruling at the hearing session of May 10, 1977 which was rejected by the Board that day (Tr. 5643-5654). On May 19, 1977, Brigantine filed with the Atomic Safety and Licensing Appeal Board (Appeal Board) a pleading entitled "Application for Review of Hearing Board Ruling and for Stay of Further Hearings on Atlantic County Contention No. 1 (Resort Economics)". In that pleading Brigantine sought to have the Appeal Board review the determination of this Board that hearings could proceed with regard to consideration of Atlantic County's resort economics contention at the May, 1977 hearing sessions. The Appeal Board issued a Memorandum and Order dated May 20, 1977 in which it denied Brigantine's application for review on the ground that it was interlocutory and not appealable as a matter of right, and on the further ground that the Appeal Board saw no occasion to invoke its discretionary authority to undertake review of the matter.

29. On February 2, 1978, Applicant filed a Motion for Relief in which it sought an order from this Board directing the Staff to file the Addendum to Part II of the Final Environmental Statement, Part II (FES II) not later than February 16, 1978, and to publish the Final Environmental Statement, Part III (FES III), not later than March 10, 1978. In its Motion for Relief, Applicant also sought declaratory relief in the nature of a directive from this Board to the Staff not to include within FES III an analysis of the environmental effects of an accident more severe in consequences than those within the design basis (the "Class 9 accident" issue). This Board in its Order dated February 23, 1978, denied Applicant's Motion for Relief.

454 018

Applicant on March 18, 19 8, filed a motion for recons ration of that Order. By Order dated March 30, 1978, the Board denied Applicant's motion for reconsideration. In this Order the Board did direct the Staff to publish FES III on or before April 24, 1978, and to publish the Final Addendum to FES II on or before June 6, 1978.

30. On April 7, 1978, the Staff petit the Appeal Board to direct certification of that portion of the Board's March 30, 1978, Order which required the Staff to publish the Final Addendum to FES II by June 16, 1978, and the FES III by April 24, 1978. On April 17, 1978, Applicant filed with the Appeal Board a pleading entitled "Applicant's Opposition to NRC Staff Petition for Order Directing Certification and Applicant's Cross-Petition". In this pleading, Applicant pposed Appeal Board certification of the Staff appeal regarding the authority of this Board on schedule matters but cross-petitioned seeking an order of the Appeal Board directing certification of the Class 9 accident issue.

31. By Order dated April 19, 1978, the Appeal Board granted both the petition of the Staff for certification of the issue pertaining to licensing board authority on schedule matters and the petition of the Applicant for certification of the Class 9 accident issue. After briefing, the certified questions were argued before the Appeal Board on May 25, 1978, and the Appeal Board issued its decision on August 21, 1978, (ALAB-489), 8 NRC 194 (1978). In that decision the Appeal Board refused to grant the declaratory relief sought by the

454 020

Applicant with regard to the Class 9 issue. The Appeal Board also held that a licensing board may direct the Staff to publish its environmental documents by specific dates if it, after affording the parties an opportunity to be heard on the matter, finds that no further delay is justified. However, in this proceeding the Appeal Board ruled that this Board's Order of March 30, 1978, setting a date for the filing of FES III and the FES II Addendum had not rested on such a finding and thus that portion of the March 30, 1978, Order was not allowed to stand. On September 1, 1978, Applicant moved for reconsideration of that portion of ALAB-489 relating to the Class 9 accident issue and, in the alternative, requested the Appeal Board to certify that issue to the Commission for its determination. The Appeal Board in ALAB-500 issued September 29, 1978, 8 NRC 212 (1978), denied Applicant's motion for reconsideration but exercised its authority to certify the Class 9 accident issue to the Commission.

32. By Order dated December 8, 1978, the Commission issued an Order accepting review of the question certified by the Appeal Board in ALAB-500. Briefs by certain of the parties to this proceeding as well as by amicus curiae parties have been filed with the Commission.

33. On August 9, 1978, NRDC filed a motion seeking Board permission to amend its sole contention in this proceeding. Following receipt of pleadings filed by Applicant and the Staff opposing the NRDC motion, this Board, by Order dated September 11, 1978, denied the

454 021

(1) The Applicant has described the proposed design of, and the site parameters postulated for, the reactors, including, but not limited to, the principal architectural and engineering criteria for the design, and has identified the major features or components incorporated therein for the protection of the health and safety of the public;

(2) Such further technical or design information as may be required to complete the Applicant's design report and which can reasonably be left for later consideration, will be supplied in a supplement to the design report;

(3) Safety features or components, if any, which require research and development have been described by the Applicant and the Applicant has 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

(4) On the basis of the foregoing, there is reasonable assurance that (i) such safety questions will be satisfactorily resolved before any of the proposed nuclear power reactors are removed from

454 022

the manufacturing site and (ii) taking into consideration the site criteria contained in 10 CFR Part 100, the proposed reactors can be constructed and operated at sites having characteristics that fall within the site parameters postulated for the design of the reactors without undue risk to the health and safety of the public.

(b) Whether the Applicant is technically qualified to design and manufacture the proposed nuclear power reactors;

(c) Whether the Applicant is financially qualified to design and manufacture the proposed reactors; and

(d) Whether the issuance of a license for manufacture of the reactors will be inimical to the common defense and security or to the health and safety of the public.

B. DESCRIPTION OF THE FNP AND SITE ENVELOPE

35. The basic shape of the FNP platform will be approximately square with overall dimensions of 400 by 378 feet. The plant systems and structures, in general, will be arranged on top of the basic platform structure. Within the platform structure, there will be 44-foot-deep bulkheads which extend the full length of the platform in

454 023

perpendicular directions. These bulkheads will form the basic support structure for the hull bottom, sides, and main deck. (PDR, Section 1.2.1; SER, Section 1.4). For convenience, the description of the FNP is divided into seven basic areas discussed below. The nuclear steam supply system and the site envelope are discussed separately below.

Safeguards Area

36. Four trains of engineering safeguards systems will be provided. Each will be located in a compartment separate from the others and each will have its own diesel generator. The equipment in each train will be arranged in similar vertical configurations to maximize the separation between trains. In order to ensure availability of equipment vital to safe shutdown in the event of the sinking emergency, three of the four safeguard trains of equipment will be located in three separated watertight compartments. (PDR, Sections 1.2.2.4 and 8.3.1; SER, Section 1.4.1).

Containment Area

37. The containment will house the reactor and reactor coolant system. The containment system for the FNP will consist of a containment vessel and a shield building. The containment vessel will be a free-standing, welded steel cylindrical structure. A concrete shield building will enclose the containment and will provide an annulus within which any leakage from the containment following an

454 024

accident will be collected prior to filtration and release to the environment. The containment fluid systems for the FNP include containment spray systems, containment isolation systems, an annulus filtration system and a combustible gas control system. The containment will utilize an ice condenser. (PDR, Sections 1.2.3, 6.2 and 6.4.2; SER, Sections 1.4.2 and 6.2).

Auxiliary Area

38. The auxiliary area will house the spent fuel pit and radwaste treatment systems. Spent fuel transfer equipment is designed such that the spent fuel pit will not be endangered by an accident involving the drop of a spent fuel cask. Each FNP will have radwaste systems to provide for controlled handling and treatment of liquid, gaseous and solid wastes. The liquid waste treatment system will process wastes from equipment and floor drains, decontamination operations, laboratory wastes and laundry and shower wastes. The gaseous waste treatment system will provide holdup capacity to allow decay of short lived noble gases stripped from the primary coolant and treatment of ventilation exhausts through high efficiency particulate air and charcoal filters. The solid waste treatment system will provide for the solidification, packaging and storage of radioactive wastes generated during FNP operation prior to shipment offsite to a licensed facility for burial. (PDR, Sections 1.2.2.2, 11.2, 11.3 and 11.5; SER, Sections 1.4.3 and 11.1).

454 025

Control Area

39. The control room will be located in the control area. The control room will be surrounded by radiological shielding and will be provided with a ventilation system incorporating dual air intakes and the capability of filtered recirculation. (PDR, Sections 1.2.2.5 and 6.5; SER, Sections 1.4.4 and 6.4).

Turbine-Generator Area

40. The turbine generator area houses the steam and power conversion system. The steam and power conversion system for the FNP will be of conventional design, similar to those of previously approved pressurized water reactor plants but with certain features provided to accomodate platform movements, such as a spring-mounted turbine foundation and vacuum-balanced condenser. The system will be designed to remove heat energy from the reactor coolant by four steam generators and convert it to electrical energy by the steam driven turbine-generator unit. The condenser will transfer unusable heat in the cycle to the condenser cooling water. The entire system will be designed for the maximum expected energy from the nuclear steam supply system. (PDR, Sections 1.2.2.6 and 3.7.2.1.1.8, Chapter 10; SER, Sections 1.4.5 and 10.1).

Power Transmission Area

41. The power transmission area will house the main and auxiliary transformers as well as various switchyard equipment.

454 026

Terminal facilities on the FNP for plant-to-shore 345 KV transmission circuits also will be provided. (PDR, Sections 1.2.2.7 and 2.10.1; SER, Sections 1.4.6 and 8.2).

Administration and Service Area

42. The administration and service area will contain the hotel, administrative and health physics facilities. (PDR, Section 1.2.2.3; SER, Section 1.4.7).

Nuclear Steam Supply System

43. The Westinghouse RESAR-3 (Consolidated Version) nuclear steam supply system without loop stop valves will be the nuclear steam supply system for the FNP. The proposed initial power for the FNP is 3411 megawatts, thermal. The nuclear steam supply system consists of a pressurized water reactor, a four-loop reactor coolant system, and associated support systems. The reactor core will contain 193 fuel assemblies, each containing 264 fuel rods (17 x 17 array) of slightly enriched uranium encapsulated in Zircaloy tubes. Upper and lower reactor internals will provide support, location, orientation, and guidance for the fuel assemblies and their control rods as well as defining a flow path for the reactor coolant. (PDR, Section 1.2.3, Chapter 4; SER, Sections 1.5 and 4.1).

44. The reactor coolant system will consist of four essentially identical loops of piping, reactor coolant pumps, and steam generators. Reactor coolant will circulate through the core, where it

454 027

will be heated; it will then go to the steam generator, where the heated coolant will transmit heat to the feedwater, thus producing steam. The coolant pressure will be controlled by a pressurizer and ancillary equipment attached to one loop. (PDR, Section 5.1; SER, Section 1.5).

45. Four auxiliary support systems will perform several functions necessary for reactor and reactor coolant system operation. The chemical and volume control system will maintain water inventory in the reactor coolant system and will provide flow to the seal system of the reactor coolant pumps; it will also control the coolant chemistry, including boron concentration and the purity of the reactor coolant. The boron recycle system will process effluent from the reactor coolant system and chemical and volume control system to remove particulate matter, fission products, activation products, and to reconcentrate boric acid. This processing will minimize plant discharges by enabling the boric acid solution and reactor grade water to be recycled. The safety injection system will function as part of the emergency core cooling system. Other plant systems performing as part of the emergency core cooling system will be the residual heat removal system and the upper head injection system. The safety injection system and the upper head injection system will supply highly concentrated borated water to the reactor coolant system in the event of a loss-of-coolant accident, or a steam line rupture. These systems will use pressurized accumulators for rapid response, and high, intermediate, and low head pumping systems for continuous injection

454 028

and long-term recirculation cooling. The residual heat removal system will remove heat from the reactor core during normal plant cooldown and refueling and will provide low head injection and recirculation as part of the safety injection system. (PDR, Sections 6.3 and 9.3; SER, Section 1.5).

46. Many features of the design of the FNP are similar to those approved previously for land based nuclear power plants now under construction or in operation, especially the McGuire Nuclear Station Units 1 and 2 (Docket Nos. 50-369 and 50-370), and the Catawba Nuclear Station Units 1 and 2 (Docket Nos. 50-413 and 50-414). (SER, Section 1.5).

Site Envelope

47. In accordance with 10 CFR Part 50, Appendix M, the Applicant has developed site envelope parameters which will assure that the FNP is not subjected at an operating site to conditions for which it has not been designed. Further, in accordance with Appendix M, a detailed review will be made of each individual site during construction permit proceedings to ascertain that the site falls within the site envelope parameters. (PDR, Chapter 2; SER, Section 1.6). A contention concerning the appropriateness of the site envelope parameters was raised by Brigantine in this proceeding. The Board's Findings of fact regarding this contention are set forth in Section IV. F, infra.

454 029

C. SAFETY EVALUATION OF THE FNP

48. The Applicant in its PDR[5] has described the proposed design of, and site parameters postulated for, the FNPs, including, but not limited to, the principal architectural and engineering criteria for the design, and has identified the major features or components incorporated therein for the protection of the health and safety of the public. Further technical or design information, as may be required to complete Applicant's design report and which can reasonably be left for later consideration, will be supplied in an amendment to the design report. The PDR also describes the quality assurance to be applied to the design, fabrication, construction, and testing of the facility. (PDR, passim).

49. The Staff performed a technical review and evaluation of the data submitted by Applicant in the license Application and in the PDR. As a result of this review and its own independent studies, the Staff prepared the SER and its Supplements.[6] The SER analyzes and

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[5] Exhibit OPS-21, admitted into evidence at Tr. 1031. The witnesses who authenticated the PDR were Dr. Dee H. Walker and Messrs. P. Blair Haga and Robert A. Bruce. (Professional qualifications admitted and incorporated into the record at Tr. 1024.)

[6] SER and SER Supplement No. 1 were admitted and incorporated into the record at Tr. 1043. The witness sponsoring the testimony was Mr. Ralph A. Birkel. (Professional qualifications admitted and incorporated into the record at Tr. 1038.) SER Supplement No. 2 was published on October 8, 1976.

454 030

evaluates the following topics among others: postulated site parameters, including seimology, geology, hydrolog and meteorology; the design, fabrication, construction, testing, and expected performance of the FNP's structures, systems, and components important to safety; the response of the facility to various anticipated operating transients and to a broad spectrum of postulated accidents including design basis accidents; plans for conducting plant operations, the steps to be taken for industrial security, as well as the financial and technical qualifications of the Applicant (SER, passim).

50. In sum, we have examined Applicant's manufacturing license Application, the PDR, and the Staff's SER as supplemented and find that appropriate site parameters have been postulated. We further find that the FNP is designed adequately to take into account the postulated site parameters, including meteorological, hydrological, and geological conditions. Additionally, we find that there are a reasonable number of sites along the East and Gulf coasts that meet the FNP site envelope parameters. (Tr. 1489; SER, Section 1.6).

D. RESEARCH AND DEVELOPMENT

51. Applicant has described in the PDR safety features or components which require research and development. (PDR, Section 1.5). Applicant's R&D programs, which are essentially developmental in nature, are aimed at verifying certain aspects of the FNP design. The objectives and schedules for completion are summarized in the PDR.

52. The Board finds that Applicant has identified safety features or components which require research and development and that Applicant will conduct a research and development program reasonably designed to resolve any safety questions associated with such features or components.

E. REASONABLE ASSURANCE

53. On the basis of the foregoing, the Board finds that there is reasonable assurance that (i) any safety questions associated with safety features or components which require research and development will be satisfactorily resolved before any of the FNPs are removed from the manufacturing site and (ii) taking into consideration the site criteria contained in 10 CFR Part 100, the FNPs can be constructed and operated at sites having characteristics that fall within the site parameters postulated for the design of the FNPs without undue risk to the health and safety of the public.

F. TECHNICAL QUALIFICATIONS OF APPLICANT

54. The PDR sets forth the Applicant's technical qualifications. (PDR, Section 13.1). The Staff, in the SER, determined that the Applicant is technically qualified. (SER, Section 22.0). The Applicant's technical qualifications were not contested in this proceeding. Against this background and in light of our own review of the record,

the Board finds that the Applicant is technically qualified to design and manufacture the FNPs.

G. FINANCIAL QUALIFICATIONS OF APPLICANT

55. The Application sets forth the Applicant's financial qualifications. Included in the Application is data indicating that the relevant costs for manufacture of the FNPs can be financed in the ordinary course of Applicant's business (Application, Section 6 passim). After reviewing the Applicant's data and subjecting that information to an independent check, the Staff concluded that the Applicant is financially qualified (SER Supp. No. 1, Section 1). Neither the Applicant's nor the Staff's financial determinations were contested during this proceeding. Against this background and in light of our own review of the record, the Board finds that the Applicant is financially qualified to design and manufacture the FNPs.

H. COMMON DEFENSE AND SECURITY

56. The activities to be conducted under the manufacturing license applied for will be within the jurisdiction of the United States (PDR, Section 1.1.1).

57. Applicant is not owned, dominated, or controlled by an alien, a foreign corporation, or a foreign government. The activities to be conducted do not involve any restricted data, but Applicant has

454 033

agreed to safeguard any such data which might become involved in accordance with the requirements of 10 CFR Part 50. No nuclear fuel will be secured or supplied in connection with the activities to performed pursuant to this license. For these reasons, and in the absence from the record of any evidence to the contrary, we find that the activities to be performed will not be inimical to the common defense and security.

III. FINDINGS OF FACT - COMPLIANCE WITH THE NATIONAL ENVIRONMENTAL POLICY ACT (NEPA), SECTIONS 102(2)(C) AND (D), AND 10 CFR PART 50, APPENDIX D (NOW 10 CFR PART 51), AND APPENDIX M

58. The Board is required by the Notice of Hearing issued in this proceeding on December 10, 1973 to:

> (a) determine whether the requirements of 102 (2) (C) and (D) of NEPA, 10 CFR Part 50, Appendix D (now 10 CFR Part 51), and 10 CFR Part 50, Appendix M, have been complied with in this proceeding;
>
> (b) independently consider the final balance among conflicting factors contained in the record of the proceeding with a view to determining the appropriate action to be taken; and

(c) determine whether the manufacturing license should be issued, denied, or appropriately conditioned to protect environmental values.

59. Applicant submitted, in accordance with 10 CFR Part 50, Appendix D (now Part 51), and Appendix M a series of Environmental Reports in support of its Application. Applicant's Environmental Report, Part I (ER I), as supplemented, considered the environmental impact of manufacturing activities to be conducted at the Blount Island facility. Applicant's Environmental Report, Part II (ER II), together with Appendices and Supplements, evaluated environmental considerations associated with offshore, estuarine and riverine siting of FNPs.[7]

60. The Staff performed a review and evaluation of the information submitted by the Applicant in its ER. In addition, it performed an independent analysis and environmental evaluation and prepared an Environmental Statement in various parts. The Staff's Final Environmental Statement, Part I (FES I), dated October 1975, considered the environmental impact of the manufacturing activities to be conducted at the Blount Island facility. In September 1976, the

[7] Exhibits OPS-57 through 64. See Appendix A for a listing of the title, date and transcript admission page of these exhibits. The witnesses who sponsored these exhibits were Dr. John A. Nutant and Ms. Cynthia C. Spencer. (Professional Qualifications admitted at Tr. 609 and 6184 respectively.)

Staff published Final Environmental Statement, Part II (FES II) relating to its environmental assessment of the siting of FNPs at various hypothetical locations.[8] In February 1977, after receipt of comments on FES II from the Council on Environmental Quality, the Staff decided to publish an Addendum to FES II to address those comments. The Final Addendum to FES II was published by the Staff in June 1978.[9]

61. While FES II was being prepared the Staff undertook a generic consideration of the comparative risks and consequences between FNPs and land-based nuclear plants concerning a postulated accidental release of radioactive material through the liquid pathway. Consideration of the liquid pathway analysis was included in Part III to the Final Environmental Statement (FES III) which was published in December, 1978.[10]

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[8] FES II was admitted into evidence and incorporated into the record at Tr. 3626. Mr. Fred J. Clark, Jr. was the sponsoring witness. (Professional Qualifications admitted at Tr. 637.)

[9] The Final Addendum to FES II was admitted into evidence and incorporated into the record at Tr. 7014. Messrs. Clifford A. Haupt and Roy E. Toma were the sponsoring witnesses. (Professional qualifications admitted and incorporated into the record at Tr. 7014 and 637 respectively.)

[10] FES III was admitted into evidence by stipulation on April 4, 1979, as Staff Exhibit 3 (Tr. 7264). The Staff's Liquid Pathway Generic Study (NUREG 0440) was also admitted into evidence by stipulation on April 4, 1979 as Staff Exhibit 4 (Tr. 7764). Also on April 4, 1979 the Applicant's Liquid Pathway Generic Study, Topical Report No. 22A60, was admitted into evidence by stipulation as OPS Exhibit 65 (Tr. 7266).

454 036

62. The complete Final Environmental Statement (FES) describes the major systems of the FNP, its manufacturing process, the environmental effects of plant operation at hypothetical sites having characteristics that fall within the postulated site parameters, and postulated design basis accidents. The FES also contains an analysis of alternatives to the FNP. In addition, the FES contains a cost-benefit analysis which considers and balances the environmental effects of the FNP and the alternatives available for reducing or avoiding adverse environmental effects, against the environmental, economic, technical, and other benefits of the facility. The FES concludes that the manufacturing license, subject to certain conditions for the protection of the environment, should be issued. The Staff review has also been supplemented by its evidentiary presentations at the hearing. These are discussed in Section IV., infra.

IV. FINDINGS OF FACT RE: CONTENTIONS ADMITTED AS ISSUES IN CONTROVERSY, BOARD QUESTIONS, AND OTHER MATTERS

63. The Board, in accordance with the Notice of Hearing, has decided the issues in controversy among the parties as set forth in this Section IV of the Initial Decision.

454 037

A. CONTENTION I - EMERGENCY POWER

Brigantine Amended Contention 3:

> "There are insufficient experience and data with respect to the functioning of the high voltage electrical cables which Applicant proposes to be buried in the seabed to transmit electricity from the shore to the facility and the undersea electrical cable that Applicant proposes for connection to the facility to provide adequate confidence that a reliable source of emergency power will be available for safe operation of the facility."[11]

64. On this contention, both Applicant and Staff presented evidence including both written and oral testimony.[12] None of the intervenors presented witnesses, testimony, or other information. Hearing sessions with regard to the contention were held on June 15 and 16, 1976, and the testimony appears at Transcript pages 1044-1157, 1160-1324 respectively.[13]

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[11] Admitted as interpreted by Board Order dated December 29, 1974, p.4.

[12] The Applicant's written testimony, Exhibit No. OPS-22 entitled "Applicant's Testimony Regarding I. Emergency Power," was admitted at Tr. 1052 (6/15/76). The witnesses sponsoring this testimony were Messrs. John W. Wanless, Raymond J. Cooney, P. Blair Haga and Dr. Dee H. Walker. (Professional Qualifications admitted at Tr. 1049, 1047, 1024 respectively). The Staff's written testimony entitled "Supplemental Testimony on Behalf of NRC Staff in Response to Brigantine Amended Contention 3" was admitted at Tr. 1163 (6/15/76). The Staff witness sponsoring this testimony was Mr. Faust Rosa (Professional Qualification admitted at Tr. 1161).

[13] Applicant and Staff witnesses were examined by counsel for City of Brigantine, Atlantic County Citizens Council on Environment, Atlantic County Board of Chosen Freeholders, State of New Jersey, NRC Staff and the Board.

454 038

65. The transmission circuits for emergency power are not within the scope of the FNP design. For FNP's that utilize underwater cable for these transmission circuits the only significant difference between the FNP offsite emergency power and that of land-based plants is the use of buried submarine cables with flexible connections at the plant end to accommodate the motion of the FNP. (Staff's Testimony, Page 3).

66. At present there are two types of high voltage cables with proven experience installed both underground and underwater. These types of cable are known as pipe-type and self-contained type. (Applicant's Testimony, Page 2)

67. For most AC circuits, a pipe-type cable consists of three conductors. Each conductor is insulated with layers of oil impregnated paper tape. The three conductors are installed in a pipe, which is then filled with oil. A protective polyethlene coating is applied to the outside of the pipe. (Tr. 1299).

68. Self-contained cable consists of a hollow conductor surrounded with layers of oil impregnated paper tape insulation. Outside of the paper tape is a layer of lead and surrounding the lead is a polyethylene jacket. Inside the hollow conductor is the oil used in conjunction with the paper tape for the total insulation system. When cables of this type are laid on the bottom unburied, an additional armor is usually applied over the polyethlene jacket for mechanical protection. (Tr. 1300).

454 039

69. The adequacy of the oil-impregnated paper tape insulation system for 345 kV cables was verified by an extensive utility industry testing program at Cornell University from 1957 to 1963 (Tr. 1050). A similar utility-sponsored program in the early 1970's verified the use of the same insulation system for 500 kV cables. Both test programs established that experience data for cables operating at 138 kV and 230 kV is applicab o cables operating at 345 kV. (Applicant's Testimony, Pages 2 and 3).

70. Both pipe-type and self-contained cable systems are designed to completely protect the insulated conductors from moisture. Therefore the same cable is used both underground and underwater. (Applicant's Testimony, Page 3).

71. The environment experienced by a cable installed underground when compared with the environment experienced by an identical cable installed underwater is sufficiently similar that no difference in failure rate would be expected. (Tr. 1182).

72. A tabulation in Applicant's Testimony of several significant high voltage cable installations in various parts of the world illustrates that cables utilizing voltages up to 575 kV are being designed and installed including submarine cables up to 26 miles in length. (Applicant's Testimony, Pages 4, 6 and 7).

454 040

73. A development program for the flexible cable connection for the offsite power circuits of the FNP has established that a standard self-contained 345 kV cable with an aluminum sheath is feasible and can withstand platform motion (PDR, Section 2.10.1.5; see also Staff Testimony, Page 5).

74. At each end of a high voltage oil cable installation there is an oil reservoir with an oil pressurization system and oil pressure alarm. An oil pressure alarm provides a warning that the cable insulation system is deteriorating. Such oil pressure alarms are normally provided on high voltage oil cable installations. (Tr. 1116 - 1117).

75. A Megger test is used to test underwater and underground cable for deterioration of the protective polyethlene coating. This test is in use on underground and underwater cables and is capable of detecting pinholes. (Tr. 1301 - 1302).

76. The general location of a hole in the outer polyethlene coating of an oil/paper cable can be found by applying a potential to the pipe or lead sheath. The route of the cable is traversed by boat with probes immersed several inches in seawater beneath the bottom of the boat. A signal is detected where current leaves the pipe through the hole in the sheath. (Tr. 1301, 1312).

454 041

77. An Edison Electric Institute survey of forced outages of underground transmission circuits, based on a 5-year average for 1,000 miles of cable, reported an outage rate of 0.00068 outages per mile per year. This average annual rate is about 1/5 the outage rate for overhead line and demonstrates the reliability of underground power transmission. (PDR Section 8.2.1).

78. The regulatory requirements for emergency electric power are contained in General Design Criterion 17 which requires that both an on-site electric power system and an off-site electric power system, each redundant in itself, be provided to permit functioning of structures, systems and components important to safety. The on-site source of emergency power for the FNP consists of four diesel generator sets. (Tr. 1155). The plant design is such that on-site power for essential safety systems is adequate even for the case of complete loss of all external power. (Applicant's Testimony, Pages 1 and 2).

79. The Board finds that sufficient experience and data exist to assure adequate confidence that high voltage underwater cable can provide equivalent reliability to overhead transmission lines for emergency offsite power.

80. The Board concludes that an off-site emergency power system for an FNP which utlizies high voltage underwater cable can be designed to meet the requirements of General Design Criterion 17.

454 042

B. CONTENTION II - UNDERWATER ELECTRICAL TRANSMISSION LINES

ACCCE Contention 4b:

> "The Board interprets Contention numbered 4(b) as asserting that the Applicant has not given adequate consideration to prevention of hazards which could be caused by defects in underwater electrical transmission lines. As interpreted, this Contention is hereby admitted as an issue in controversy."[14]

81. On this Contention both Applicant and Staff presented evidence including both written and oral testimony.[15] None of the intervenors presented witnesses, testimony or other information. A hearing session regarding this Contention was held on September 29, 1976 and the testimony appears at Transcript pages 3785-3800.[16]

82. The Applicant and Staff considered possible hazards to people from electric shock, chemical effect of the cable insulation and sudden rupture of the cable. (Applicant's testimony, page 1; Staff's Testimony, page 2.)

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[14] Admitted as interpreted by Board Order dated May 21, 1974, p. 7.

[15] The Applicant's written testimony, Exhibit No. OPS-33 entitled "Applicant's Testimony Regarding II. Underwater Electrical Transmission Lines" was admitted at Tr. 3787 (9/29/76). The witnesses sponsoring this testimony were Messrs. John W. Wanless, Raymond J. Cooney, P. Blair Haga an Dr. Dee H. Walker. (Professional Qualifications admitted at Tr. 1049, 1047, 1024, respectively.) The Staff's written testimony entitled "Supplemental Testimony of NRC Staff in Response to ACCCE Contention 4(b)" was admitted at Tr. 3792 (9/29/76). The Staff witness sponsoring this testimony was Mr. Faust Rosa (Professional Qualifications admitted at Tr. 1161).

[16] Both Applicant and Staff witnesses were examined by the Board.

454 043

83. No shock hazard can exist with the cable metallic housing intact. Under normal operating conditions, a person can touch the metallic housing of the cable while the cable is energized and receive no harmful effects. (Applicant's Testimony, pages 1 and 3).

84. If the cable metallic housing were damaged exposing the conductor, the cable would be deenergized within a small fraction of a second. During this small fraction of a second, most current would flow to this housing and only a very small amount would return to the source through the earth or sea. (Applicant's Testimony, page 2)

85. Regarding chemical effect of the cable insulation, no hazard has been identified. Cable insulation materials are non-toxic. (Applicant's Testimony, pages 3 and 4).

86. The likelihood of sudden rupture of a cable occuring due to salt water coming in contact with an energized conductor is extremely low due to the details of cable construction and the rapid cable deenergization which would result from loss of oil pressure, or from very low levels of current leaking through the insulation. (Applicant's Testimony, page 3.)

87. In response to a Board question, the Applicant advised that it was not aware of any history of ships, boats, or swimmers suffering as a result of contacting high voltage underwater cables. (Transcript, p. 3789.)

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88. In 903 mile years of operation of 345 kilovolt underwater cable, there were no failures experienced along the cable length. (Tr. 3797.)

89. The Staff reviewed the design of underwater/underground transmission cables respecting hazard resulting from defect induced cable failures and concluded that the hazards to the general public are negligible. (Staff's Testimony, page 1.)

90. The Board finds that adequate consideration has been given to the possible hazards that could be caused by defects in underwater cable and concludes that, with available design features, underwater cables and their associated protective systems offer protection against such hazards.

C. CONTENTION III - MARINE ENVIRONMENT

ACCCE Contention 2:

> "The Board interprets ACCCE contention numbered 2 as asserting that the Applicant has not given adequate consideration to the effects of corrosion resulting in adverse changes in mechanical properties due to the effects of both a salt water environment and radioactivity. This contention further asserts that there should be a monitoring system to detect corrosion and other salt water effects. As so interpreted, this contention is hereby admitted as an issue in controversy."[17]

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[17] Admitted as interpreted by Board Order dated May 21, 1974, pp. 4, 5.

454 045

Brigantine Amended Contention 6:

> "There are substantial uncertainties as to the behavior of the reactor and essential safety systems in the marine environment." (Brigantine Proposed Amended Contention 6 from Motion by Intervenor City of Brigantine to Amend and Expand its Contentions, dated October 21, 1975.) "Brigantine's proposed amended contention 6, as interpreted by the Applicant and agreed to by Brigantine and the Staff, is ADMITTED, and it is understood and agreed that the phrase, 'reactor and essential safety systems' is construed to refer solely to Class I safety systems and 'substantial uncertainties' refers to particular unique effects on Class 1 safety systems from the floating platform and marine environment."[18]

91. On these contentions both the Applicant and Staff presented evidence, including material contained in the Plant Design Report (PDR), the Safety Evaluation Report (SER), as supplemented, and written and oral testimony.[19] None of the intervenors presented

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[18] Admitted as interpreted by Board Order dated December 29, 1975, p.5.

[19] The Applicant's written testimony, Exhibit No. OPS-23, entitled "Applicant's Testimony Regarding III. Marine Environment" was admitted at Tr. 1715. The witnesses sponsoring this testimony were Messrs. Joseph B. McAndrew, Clinton Dotson, Raymond J. Cooney, Robert A. Bruce, P. Blair Haga and Dr. D. H. Walker (Professional Qualifications admitted at Tr. 1713, 1712, 1047, and 1024, respectively.) The Staff's testimony, consisting of five separate documents each entitled "Supplemental Testimony of the NRC Staff in Response to Brigantine Amended Contention 6 and ACCCE Contention 2" was admitted at Tr. 1956. The witnesses sponsoring this testimony were Mr. Faust Rosa, Mr. Richard J. Kiessel, Mr. Herbert F. Conrad, Mr. Lauren J. Connery, and CDR. John Deck III, United States Coast Guard (USCG). The testimony sponsored by CDR. Deck was written by LCDR William E. Remley, USCG and LT. Thomas E. Thompson, USCG. CDR. Deck adopted this testimony as his own at Tr. 1955. With the exception of CDR. Deck's written testimony, the Staff testimony follows Tr. 1956. CDR. Deck's written testimony follows Tr. 2028. The Professional Qualifications of Messrs. Rosa, Kiessel, Conrad, Connery, and CDR. Deck were admitted at Tr. 1161 and 1946, respectively.

454 046

witnesses, testimony or other information. Hearing sessions with regard to this contention were held on July 6, 7, and 8, 1976, and the testimony appears at Transcript pages 17061799, 1800-1957, and 1958-2145, respectively.[20]

Protection of Interior Equipment

92. The FNP ventilation systems are designed to prevent the entry of marine air into interior spaces with the exception of the Fuel Building (see paragraph 97 below). Ventilation systems supply air through demisters and filters which remove salt mist and salt particles, respectively. (Applicant's Testimony, p. 1; Staff's Testimony, Rosa, p. 4) Interior spaces are maintained at a pressure slightly higher than the outside environment thus preventing in-leakage of the marine atmosphere (Tr. 1777-1779).

93. Marine demisters which are capable of removing all fog and mist from ventilation system intake air will be utilized on the FNP (Tr. 1980).

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[20] Applicant witnesses were examined by counsel for the City of Brigantine, (Brigantine), Atlantic County Citizens Council on Environment (ACCCE), Atlantic County Board of Chosen Freeholders (Atlantic County), State of New Jersey, NRC Staff and the Board. Staff witnesses were examined by Counsel for Brigantine, ACCCE, Atlantic County, State of New Jersey, Applicant, and the Board.

454 047

94. Salt particle removal filters to be supplied for FNP ventilation systems serving areas housing equipment important to safety will have an efficiency of 99.7 percent for the removal of salt particles larger than two microns (Staff's Testimony, Rosa, p. 3; Tr. 1954, Tr. 1988). These salt particle removal filters meet U.S. Navy Specifications for salt removal in reactor compartment ventilation systems (Tr. 1979, Tr. 1991).

95. Relative humidity within the FNP will be controlled to a maximum of 80 percent (Tr. 1913). The Applicant and Staff agree that under this condition any salt deposition which might occur would be dry salt (Tr. 1913) which is non-corrosive (Staff's Testimony, Rosa, page 4).

96. The deleterious effect of any salt deposition on protection equipment is a long-term process (Tr. 1976) and plant operation could continue in the marine environment for over a year without airborne salt removal (Tr. 1996). However, to provide an additional degree of protection the Applicant will provide a specification for acquisition by the owner of the necessary equipment periodically to measure cumulative salt deposition (if any) (Applicant's Testimony., pages 1 and 2). Although the specific method(s) have not been selected, several possibilities exist, each of which is considered feasible by both the Applicant and the Staff (Tr. 1909, et

454 048

seq.; Tr. 2136, et seq.). The purpose of such monitoring is to detect any potentially significant salt deposition before an equipment problem could develop (Tr. 1976).

97. The fuel building is maintained at a slightly negative pressure with respect to the marine atmosphere to prevent the leakage of radioactivity to the surrounding atmosphere (Tr. 1839, et seq.). Equipment located in the fuel building important to safety will be qualified for operation in the marine atmosphere (Applicant's Testimony, p. 1; Tr. 1871-1873).

98. Ventilation systems are provided with instrumentation to monitor system flow rate, pressure drop across filters and demisters and differential pressure between the ventilated space and the atmosphere outside the plant (Tr. 1779-1780). These monitoring systems provide diverse indication of ventilation system performance and also provide on-line assurance that marine air is not entering ventilated areas (Tr. 1780, Tr. 1904). Continued instrumentation accuracy will be assured by periodic maintenance performed by the owner (Tr. 1781-1782).

99. Intrusion of marine air into interior spaces housing equipment important to safety will be prevented during plant tow by operation of the ventilaltion systems. Other spaces will either be ventilated or closed off to prevent intrusion of marine air. Power for ventilation systems will be provided during tow by the emergency

454 049

diesel generators. (Tr. 1758, Tr. 1771-1773). In the event of diesel generator failure during tow, it is expected that the load would be transferred to another diesel generator within approximately thirty minutes (Tr. 1884).

Protection of Raw Water Systems

100. The Auxiliary Raw Water (ARW) and Essential Raw Water (ERW) systems are the only safety-related systems which are exposed to raw (basin) water. The materials used in these systems were selected for their proven corrosion resistance and strength. (Applicant's Testimony, page 2). Joints between dissimilar metals, such as the carbon steel trim tank-tosystem piping (PDR, p. 9.2-43a), will be protected by a coal-tar epoxy coating (Staff's Testimony, Connery, page 4). The ARW and ERW systems do not come into contact with reactor coolant and are not exposed to neutron radiation (Staff's Testimony, Connery, page 3).

Protection of the Platform Hull

101. Protection of the FNP hull from corrosion is described in detail in Offshore Power Systems Report AD-7100-14A85, "FNP Platform Hull Drydocking Equivalency" (Applicant's Testimony, page 2). The Applicant has divided the exterior of the platform hull into three corrosion control zones: the atmospheric zone, the splash zone and

454 050

the immersed (or submerged) zone (Staff's Testimony, Remley and Thompson, page 2; Tr. 1858-1859).

102. The atmospheric zone is subject to corrosion by minute salt particles carried by the wind. (Staff's Testimony, Remley and Thompson, page 2). Wetting in the atmospheric zone occurs mainly from rain, dew and occasionally, spray (Tr. 1742).

103. The atmospheric zone will be protected from corrosion by a coating system consisting of alkyl silicate inorganic zinc and vinyl copolymer (Staff Testimony, Remley and Thompson, page 2). Protective fenders at the service dock will provide protection against possible damage to the coating from service craft (Tr. 1918). Coating systems such as that proposed for the atmospheric zone have been in service since World War II (Tr. 1743).

104. The splash zone is that area of the platform hull which is continuously wetted with aerated water (Staff's Testimony, Remley and Thompson, page 3). The Applicant has defined the splash zone area as extending from two feet below the waterline to four feet above the waterline based on expected wave action in the basin and investigation of charts of corrosion rates for pilings protected at the waterline (Tr. 1738-1739).

454 050

105. The splash zone will be protected from corrosion by a coating of modified amine-cured epoxy resin filled with inert silicates (Staff's Testimony, Remley and Thompson, page 3). The Applicant has specified a coating thickness of three-sixteenths of an inch based on the coating manufacturer's recommendation (Tr. 1790-1791). Additionally, that part of the splash zone beneath the waterline will be protected from corrosion by the cathodic protection system (Tr. 1807).

106. Coatings of the type proposed for use in the splash zone have been in service for approximately seven years and lifetime predictions are therefore based on limited experience to date as well as general knowledge of the coating chemistry and characteristics (Tr. 1740, 2069-2070). It is reasonable to expect that complete recoating of the splash zone will not be necessary during plant life (Tr. 1740).

107. The Applicant has considered repair or replacement of splash zone coating in OPS Document Number NA-1220-14A80, "Floating Nuclear Plant Platform Hull Corrective Maintenance Plan." Access to areas of defective coating can be obtained by trimming the plant up to 1 degree and through the use of cofferdams where necessary (Staff's Testimony, Remley and Thompson, page 4). The Applicant states that the frequency and extent of splash zone coating maintenance will depend largely on the degree of mechanical damage caused by service vessels and flotsam (Tr. 1803). The Applicant estimates that no more

454 052

than 5 percent of the splash zone coating area will require repair on an annual basis (Tr. 1803, et seq.).

108. The immersed zone will be protected from corrosion by an impressed current cathodic protection system. Corrosion protection is achieved by shifting the normal corrosion potential of the platform hull until it is equal to or more negative than 0.[illegible] volts with respect to a standard copper-copper sulphate reference electrode. At this potential, the corrosion rate of carbon steel in seawater has been shown to be reduced to a negligible value. (SER, p. 59).

109. Each owner will be responsible for providing a suitable cathodic protection system at the operating site (SER, p. 60). Included in the Site Envelope are functional requirements for the on-site cathodic protection system (SER, Supp. 2, page 8). The Applicant will provide platform cathodic protection during plant manufacture while the platform is afloat in the slipway (SER, page 59).

110. During tow from the manufacturing facility to the owner's site, impressed current cathodic protection will not be provided. The Applicant estimates that the duration of tow will be no more than a few weeks and further estimates that, considering additional time out of service for maintenance, the platform hull will be without cathodic protection for a total of less than one year during the forty year life of the plant. (Tr. 1732-1733).

454 053

111. The impressed current cathodic protection system will incorporate automatic control of the rectifier units by hull-mounted reference electrodes (SER, Supp. 2, page 8). The system is therefore self-correcting in that the reference electrodes are used to adjust automatically rectifier current output to compensate for variations from the desired hull potential (Tr. 2026-2027). At monthly intervals during plant life, the cathodic protection rectifier units will be inspected and the voltage and current output of each rectifier will be recorded (Tr. 1719).

112. Impressed current cathodic protection in seawater has been in use at least since 1929. The most extensive experience with these systems probably is with the U. S. Navy reserve fleet where numerous ships have been maintained in excess of twenty years at a reduced corrosion rate. (Staff's Testimony, Remley and Thompson, page 7). The basic difference between the fresh water reserve fleet system and systems used in the ocean is related to the resistivity of the water. The current requirements in the ocean are higher than for fresh water, which has greater resistivity. (Tr. 1876-1877).

113. In addition to protective coatings and the impressed current cathodic protection system, the hull plating thickness has been increased by 0.20 inches beyond that required for platform strength and thickness. This increment is based on a time-averaged corrosion rate for steel in seawater of 0.005 inches per year over the forty year life of the plant. This corrosion rate would be expected

454 054

were no means of corrosion control provided. (PDR, page 3.12-46; Tr. 1733, et. seq.). The assumed annual corrosion rate of 0.005 inches per year does not include non-uniform corrosion in the form of pitting; however, pitting penetration in carbon steel relative to total corrosion diminishes to a minor fraction after long times such as the forty year life of the FNP. Proper selection of welding alloys will prevent pitting problems in the region of welded joints. (PDR, pages 3.12-46, 47; Tr. 1899-1900).

114. The Applicant has provided in OPS Document No. NA-1220-14A79, "Floating Nuclear Plant Platform Surveillance Plan," a program for periodic inspection of the platform hull. In order to assure the continuing effectiveness of corrosion prevention systems the U.S. Coast Guard (USCG) will conduct in-service inspections at four year intervals, or more frequently if deemed necessary by the local USCG Officer in Charge of Marine Inspection. (Staff's Testimony, Remley and Thompson, pages 3, 6 and 7). USCG inspections are required by law (Tr. 2024) and satisfactory resolution of any deficiencies found is required for continued plant operation (Tr. 2100-2101). The Applicant has considered underwater weld repairs of the platform hull and has concluded that such repair is feasible using existing techniques (PDR, pages 3.12-55, et seq.).

454 055

Salt Water - Radiation Synergism

115. With respect to the effects of radiation upon the mechanical properties of metals, experiments have shown that only neutrons have any effect (Staff's Testimony, Conrad, page 2, Tr. 2080-2081).

116. The reactor vessel and its internals are the only FNP components that are subject to significant neutron irradiation (Applicant's Testimony, page 2; Staff's Testimony, Conrad, page 3; Tr. 1950-1951). The reactor vessel is located within containment and is exposed neither to salt water nor to a salt atmosphere (Applicant's Testimony, page 2).

117. Applicant's investigations indicate that radiation levels would have to increase by 8 to 10 orders of magnitude in those areas exposed to salt water before there would even be any potential for synergistic effects (Tr. 1846). No normal or accident condition has been identified which would produce this level of radiation exposure (Tr. 1845-1847).

118. Components of the nuclear steam supply system and associated safety systems will receive inservice inspection under the provisions of Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (Staff's Testimony, Conrad, page 3).

454 056

Plant Motion in the Marine Environment

119. The as-moored accelerations and angular displacements for which the FNP is designed are stated in the Site Envelope (Table 2.1-1) of the PDR. The Commission will require the plant owner to demonstrate that these motions will not be exceeded at the proposed site. (Staff's Testimony, Kiessel, pages 2-4).

120. The Applicant presented analyses of several types of components for motions in excess of the stated design basis limits. The calculated equivalent static accelerations are less than the accelerations for which these components otherwise will be designed to satisfy seismic requirements. (PDR, Appendix B, pages B.9.2-5, 6; Applicant's Testimony, p. 3).

121. It is an acceptable procedure to design FNP systems, components and component supports for loads resulting from wind and wave excitation on the basis of rigid body analyses, appropriate fatigue factors and the specified Site Envelope parameters. (Staff's Testimony, Kiessel, pages 2-4; Tr. 2130, et seq.; SER, page 47).

Conclusions

122. The Board finds that the Applicant has given adequate consideration to the effects of corrosion due to a salt water environment which could result in adverse changes in mechanical properties.

454 057

The Board further finds that the design of the FNP provides adequate protection against corrosion such that plant operation within the marine environment will not pose undue risk to public health and safety.

123. The Board finds that the design of the FNP, in combination with required inservice surveillance, provides adequate monitoring to detect corrosion and other salt water effects and further finds that no additional such monitoring systems are required to detect corrosion and other salt water effects.

124. The Board finds that the Applicant has given adequate consideration to the combined effects of salt water and radioactivity on the mechanical properties of materials. The Board further concludes that there exists reasonable assurance that the combined presence of radiation of the type and intensity necessary to affect the mechanical properties of materials and either salt water or salt air, will not occur in the FNP. The Board finds that the postulated synergistic action of salt water and radiation cannot occur in the FNP and therefore such synergism does not impose an undue risk to public health and safety.

125. The Board finds that the Site Envelope limits on plant motion in the marine environment are reasonable as regards both plant siting and equipment design.

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126. The Board finds on the basis of the foregoing that there are no substantial uncertainties as to the behavior of the reactor and essential safety systems in the marine environment.

D. CONTENTION IV - CENTRAL CONTROL ROOM

ACCCE Contention 9:

> "Applicant has not given adequate consideration to failure or malfunction of control operations because the location of the structure housing the central control operations is in a relatively unprotected position, exposing this structure to severe meteological (sic) conditions and damage or destruction by fire, industrial sabotage, terrorists acts, flying debris or collisions." Further, "the design of the central control operation structure is inadequate to protect it from the hazards mentioned above."[21]

127. On this contention, both Applicant and Staff presented evidence including material contained in the Plant Design Report (PDR), the Safety Evaluation Report as supplemented (SER) and written and oral testimony.[22] None of the intervenors presented witnesses, testimony or other information. Hearing sessions with regard to this contention were held on July 9, 26, 27, 28, 29 and 30, 1976, and the

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[21] Admitted as interpreted by Board Order dated May 24, 1974, p. 10.

[22] The Applicant's written testimony, Exhibit No. OPS-24 entitled "Applicant's Testimony regarding IV. Central Control Room" was admitted at Tr. 2164. The witnesses sponsoring this testimony were Dr. Dee Walker and Messrs. Raymond J. Cooney, P. Blair Haga and Richard S. Orr (Professional Qualifications admitted at Tr. 1024, 1047, 1024, and 1329 respectively). Mr. Charles King was added to the panel for the in-camera sessions (Professional Qualifications admitted at Tr. R-5). The Staff's written testimony entitled "Supplemental Testimony on behalf of NRC Staff in response to ACCCE Contention 9" by Falk Cantor, Kenneth G. Murphy and Ray F. Priebe,

454 059

testimony appears generally at Transcript pages 2163-2869 and R1 - R168.[23]

128. The control room is located on the starboard side of the platform. It is surrounded on three sides by reinforced concrete walls of either one or two foot thickness and on the exterior side by a 1 1/8 inch thick steel plate wall.[24] The roof structure consists of a two foot thick reinforced concrete slab. The floor of the control room consists of metal deck and concrete approximately 3 inches thick. The control room is located approximately 66 feet above the basin water level. (Applicant's Testimony, page 1; Staff's Testimony, page 1; PDR Section 6.5.3.1.2.)

(Footnote 22 Continued)

which follows Tr. 2536, was admitted at Tr. 2536. NRC staff witnesses sponsoring this testimony were Messrs. Murphy and Priebe together with Drs. John A. O'Brien and Jacques B. J. Read (Professional Qualifications of Messrs. Murphy, and Priebe and Drs. O'Brien and Read were admitted at Tr. 2534). Messrs. Phillip Mathews and Charles Long were added to the panel at Tr. 2798 (Professional Qualifications were admitted at Tr. 2803)

[23] Applicant witnesses were examined by counsel for Atlantic County Citizens Council on Environment (ACCCE), City of Brigantine (Brigantine), Atlantic County Board of Chosen Freeholders (Atlantic County), State of New Jersey, NRC Staff and the Board. Staff witnesses were examined by counsel for ACCCE, Brigantine, State of New Jersey, Applicant and by the Board.

[24] The Applicant's written testimony stated that the exterior wall of the control room was 3/4 inch thick steel plate. The thickness of the steel plate was subsequently changed to 1 1/8 inch. The 1 1/8 inch thickness is provided for radiation shielding. (Applicant's Testimony, Page 3, and PDR Section 12.1.2.5).

129. The location of the control room in relation to the other structures, systems, and equipment on the FNP and in relation to the exposure of the control room to the environment is comparable to the location of control rooms on land-based nuclear plants which have been licensed by the Commission (Staff's Testimony, Page 2, and Tr. 2382 and 2567).

130. The primary criteria used in locating the control room were to minimize the length of low level signal cables and to place the control room at an elevation above the maximum water level assumed for the postulated sinking emergency (Tr. 2384 and 2516 and PDR Section 15.6).

131. The control room is a structure important to plant safety and is designed to meet the design criteria and standards established for safety related structures. It is designed to withstand severe meteorological conditions (Applicant's Testimony, page 2; Staff's Testimony, page 2).

132. The control room is designed to withstand the spectrum of missiles assumed to be generated by the design basis tornado.[25]

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[25] A test performed for the Applicant subsequent to the hearings on this contention resulted in penetration of a 3/4 inch steel plate by one of the specified tornado missiles (letter of November 18, 1976 from T. M. Daugherty to the Board). As indicated in Paragraph 2 and footnote 3, supra, the exterior control room wall is now 1 1/8 inch thick. The final design of the exterior control room wall will withstand all specified tornado missiles (Tr. 5243).

454 060

These missiles are more energetic and therefore more potentially damaging than any other missiles or flying debris which could be postulated to occur as the result of other severe meteorological phenomena or potential accidents (Staff's Testimony, page 4; PDR Sections 3.5.3 and 3.5.7; SER Section 3.5.2).

133. The control room is designed to withstand the crash of a passenger carrying helicopter (PDR Section 3.5.5, SER Section 3.5 and Tr. 2237). Potential collisions with the FNP are additionally discussed in the Findings of Fact on Ship Collision and Aircraft, infra.

134. The plant design provides the capability for effecting and maintaining a safe shutdown condition from outside the control room in the unlikely event that conditions necessitate evacuation of the control room (Staff's Testimony, Page 6).

135. The control room is protected against floating fires external to the plant by its location which is well above the basin water level (Staff's Testimony, Page 3). The site envelope requires that an owner provide site features which will prevent an oil spill outside the site structure from approaching within 100 feet of the plant (PDR Table 2.1-1, SER Table 1.2 (Revised), and Staff's Testimony, Page 3.) The FNP external fire protection system is designed to control and/or extinguish floating fires within 100 feet of the plant. In addition, for those sites at which the risk from radiant heat flux from exposure fires more than 100 feet from the plant is significant,

454 062

a falling water film system is provided as an option to protect the exterior walls of the plant, including the control room. (PDR Section 9.5.1.2, SER Section 9.5.1, and Staff's Testimony, Page 3.) The control room ventilation system is designed to protect the control room operators from the effects of smoke and other combustion products (Staff's Testimony, Page 3, and PDR Section 9.4.1).

136. The design of the FNP will enable an owner to meet the industrial security requirements of 10 CFR 73 and Regulatory Guide 1.17 (Protection of Nuclear Power Plants against Industrial Sabotage). (Applicant's Testimony, Page 3).

137. The inherent structural characteristics of the FNP result in a well protected, blast and penetration resistant structure, and provide a facility at which intentional damage would be extremely difficult. Furthermore, the location of the control room, three floors above the boardingplatform and approximately 66 feet above the basin water level, substantially reduces the susceptibility of the control room to credible external threats from a potential adversary. (Staff's Testimony, Page 1 and 5).

138. The owner of each FNP will be required to provide a comprehensive security program for the protection of the plant against external threats. The principal elements of such a program will include physical protection features to prevent or deter surreptitious entry, administrative measures to control access, a trained security

454 063

force for plant surveillance, and a response capability by armed guards supplemented by arrangements with offsite law enforcement authorities. (Staff's Testimony, Page 6).

139. The Board concludes that the design and location of the central control room is adequate to protect the central control operation from hazards due to meteorological conditions, fire, industrial sabotage, terrorist acts, flying debris or collisions.

E. CONTENTION V - TRANSPORTATION

ACCCE Contention 5:

> "The Applicant has not given adequate attention to provisions for preventing accidents in the handling and transportation of radioactive materials to and from the ocean site in the following areas:
>
> a. Provisions to prevent damage to platforms, mooring systems, reactor buildings and breakwater in event of barge collision and possible resultant flying debris, all resulting from rapid onset of severe, unforeseen, extreme meteorological conditions.
>
> b. Provisions to safeguard reactor plant and platform in event of fire aboard a nuclear fuel-transporting barge while barge is within breakwater, entering or leaving breakwater, or in close proximity to the offshore plant.
>
> c. Provisions to deal with a collision of a vessel with a barge or breakwater resulting in dispersal of hazardous cargo on or around the breakwater or on the floating plant."[26]

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[26] Admitted as interpreted by Board Order dated May 21, 1974, p. 7.

454 064

Atlantic County Contention 3:

> "Intervenor contests the adequacy of procedures for safe transfer of spent fuel and radioactive waste from the floating nuclear plant to the ship, to account for the peculiar characteristics of floating nuclear power plants."[27]

Walton Contention:

> "Adequate consideration has not been given by the Applicant to accidents, that could occur during transportation of radioactive materials between the facility and the shore."[28]

140. These three related contentions were considered by the Board together. On these contentions, both Applicant and Staff presented evidence, including material contained in the Plant Design Report (PDR), the Final Environmental Statement (FES), as supplemented, the Safety Evaluation Report (SER), written and oral testimony, and an affidavit. None of the intervenors presented witnesses, testimony, or other information.[29] The Hearing sessions with regard to

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[27] Admitted as interpreted by Board Order dated April 15, 1974,pp.9,10.

[28] Admitted as interpreted by Board Order dated May 21, 1974, pp.2,3.

[29] The Applicant's written testimony, Exhibit No. OPS-34, entitled "Applicant's Testimony Regarding V. Transportation," was admitted at Tr. 3864. The witnesses sponsoring this testimony were Dr. Dee Walker, Mr. P. Blair Haga, and Miss Mary Ann Capo (Professional Qualifications admitted at Tr. 1024, 1024, and 3831, respectively). The Staff's written testimony entitled "Supplemental Testimony of NRC Staff in Response to the Pertinent Portion of ACCCE Contention 5, Atlantic County Contention 3 and Brigantine Original Contention and Walton Contention" by Joseph R. Levine, John A. O'Brien, Edward B. Tomlinson and Robert F. Barker, was admitted at Tr. 3915 (Professional Qualifications of Mr. Levine, Dr. O'Brien, and Messrs. Tomlinson and Barker were admitted at Tr. 1476, 2534, and 3911, respectively). Applicant's Exhibit No. OPS-104, entitled "Affidavit of Dee H. Walker," containing information requested by the Board at Tr. 3900, was filed on March 29, 1977.

these contentions were held on November 3 and 4, 1976, and the testimony appears at Transcript pages 3866 - 3905, 3916 - 3929, 3933 - 3989.[30]

141. A crane will be provided for the Floating Nuclear Plant (FNP) to transfer a spent fuel cask from the plant to a barge (or other form of transportation) alongside the plant (Applicant's Testimony, page 2). The cask handling crane is designed for loads in excess of 200 tons (the largest spent fuel shipping cask proposed for licensing under 10 CFR 71 is only 125 tons) (Applicant's Testimony, page 2). The FNP cask handling crane will be designed to ANSI B30.6 standard (Staff's Testimony, Page 12 and Tr. 3961). The cask handling crane can be designed for the FNP to meet criteria for the health and safety of the public (Tr. 3958).

142. It is the responsibility of the utility owner to perform the radioactive material transfer operations (Applicant's Testimony, page 2). The method for transporting nuclear fuels will be included in the utility owner's application for an operating license (Staff's Testimony, page 9).

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[30] Applicant witnesses were examined by Mr. Walton, by counsel for Atlantic County Citizens Council on Environment (ACCCE), and by the Board. The Staff witnesses were examined by Mr. Walton, by counsel for ACCCE, by counsel for the State of New Jersey, and by the Board.

Shipping Container Design

143. The specific shipping package and the shipping method to be employed in transporting radioactive material from the Floating Nuclear Plant are the responsibility of the utility owner. Design and testing requirements for radioactive material shipping packages and requirements governing their transport have been issued by the Nuclear Regulatory Commission (10 CFR 71), by the Department of Transportation (14 CFR 103, 46 CFR 146, and 49 CFR parts 170-189), and by the U.S. Postal Service (Postal Service Manual, Section 124). These regulations require that radioactive materials, including spent fuel, be packaged for shipping in containers of special design. In the case of spent fuel, the cask must be designed and licensed in accordance with the requirements of 10 CFR 71. This part of the regulations requires that the cask design be such that the contents of the container will not be released in the event of severe hypothetical accidents. (Applicant's Testimony, pages 2 and 3).

Postulated Accidents During Transfer

144. An accident involving transfer of spent fuel would result in more severe radiological consequences than an accident involving transfer of low-level waste containers. Thus, detailed analyses of postulated accidents during transfer were limited to those involving spent fuel casks. (Staff's Testimony, page 9; Applicant's Testimony, page 2.)

454 067

145. Six spent fuel cask drop scenarios during the transfer operation from the FNP to a transport vessel (barge) are analyzed in the PDR Section 15.4.7 (Applicant's Testimony, page 3). These cask drop scenarios are the worst which can be developed using existing design parameters and procedural controls (Staff's Testimony, page 10). The cases analyzed include a drop from the maximum height to which the crane will lift the cask above the basin water surface into the maximum depth of water acceptable for a site (Applicant's Testimony, page 3). In these analyses no credit is taken for the safety features and conservatism in the design of cask handling system components (Staff's Testimony, page 9). The analyses in the PDR show that none of the cases considered would lead to rupture of the shipping cask or release of any radioactivity (Applicant's Testimony, page 3).

146. If a shipping cask should drop onto the ocean floor, the retrieval of the cask would be the responsibilty of the utility owner, including the postulated case of a cask rolling beneath the FNP (Tr. 3868). The device to retrieve the cask may consist of a portable barge-mounted crane (Tr. 3868). The cask retrieval could be accomplished in a reasonable amount of time before appreciable corrosion could occur (Tr. 3869). Even if the radioactivity were released due to corrosion, it would be a very small amount and would be below maximum permissible concentrations (Tr. 3877).

454 068

Radiological Consequences of a Cask Rupture Accident

147. Although the analyses in the PDR show that a cask rupture will not occur, the radiological consequences of a cask rupture were analyzed and reported in PDR Section 15.4.7 (Applicant's Testimony, page 3). Dose analysis was performed for the released radioactivity which passes through the sea water, is vented to the atmosphere, and carried away from the site by atmospheric conditions (Tr. 3881). The resulting hypothetical offsite dose (using conservative meteorological conditions) would meet the dose criteria of 10 CFR 100; namely, 300 rem thyroid and 25 rem whole body (Applicant's Testimony, page 3, and Staff's Testimony, page 11). The isotopes considered in this dose analysis are iodine-131 and krypton-85 (Tr. 3885).

148. Bounding calculations were also performed to estimate the concentrations downstream from a dropped and ruptured cask if the iodine-131 available in the void space of the fuel elements in the cask was released approximately 100 days after the fuel was removed from the reactor. Those calculations indicated that for a distance about five to eight miles in the drift direction away from the dropped cask the concentrations would be three orders of magnitude below Maximum Permissible Concentrations (Tr. 3873).

149. In addition to the analysis required by Regulatory Guide 1.25 and Regulatory Guide 4.2 for a postulated cask drop accident, the

454 069

applicant calculated the dose to the maximally exposed individual as a function of distance from the cask drop location. Although 25 isotopes (fission products) were considered in the calculation, only Cs-137 and Nb-95 contribute significantly to the dose. The results of the analysis show that at a distance of 2 kilometers from the postulated cask drop the swimmer is exposed over a two year period to a whole body dose of only 1.5 mrem and a skin dose of only 3.5 mrem. (Applicant's Exhibit OPS-104; Tr. 3894.)

Explosion or Fire on a Fuel - Resupply Barge

150. The FNP has been designed to withstand damage from flying debris resulting from an explosion of a fuel-resupply barge without jeopardizing plant safety functions (Staff Testimony, page 7). The fire suppression system(s) on the FNP can adequately cope with the diesel fuel barge fire (Staff's Testimony, page 8, and Tr. 2828). It can be concluded that the same fire suppression systems could easily cope with a fire on a nuclear fuel transporting barge and simultaneously, the tug (Staff's Testimony, page 8).

Meteorological Conditions

151. With respect to stormy weather, the transportation of nuclear fuel or waste can be delayed or advanced a sufficient number of days to avoid storms. Also, the time at which the movement takes

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place can be adjusted to avoid heavy traffic or conditions not suitable for safe movement (fog, low tide, etc.) (FES II, page 6-87.)

152. The design of the FNP is such that the plant can withstand collisions or flying debris that might occur during the rapid onset of severe, unforeseen meteorological conditions while nuclear fuel is being handled or transported. The floating nuclear plant is designed to resist the effect of any of the following: (1) a 25 ton tornado borne boat impacting the plant at its water line with a velocity of 29.3 feet per second and a kinetic energy of .67 million foot-pounds. This impact is in addition to the usual spectrum of tornado borne missiles and debris required by the Staff for land-based plants. The tornado borne boat of 25 tons is assumed to strike the platform while the tornado wind and pressure drop are at their most severe combination, so that a super-position of loads occurs; (2) a 3500 ton service vessel striking the plant without tornado effects; and (3) a helicopter weighing 19,000 pounds traveling at 30 miles per hour and having a kinetic energy of .57 million foot-pounds striking any critical part of the plant. (Staff Testimony, page 4.)

Conclusions

153. The Board finds that the Floating Nuclear Plant has been designed so that spent fuel can be safety transferred to a barge (or other form of transportation) alongside the plant.

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154. The Board finds that accidents in the transportation of spent nuclear fuel radioactive waste which could release radioactive materials from the cask or package and thereby produce radiological consequences have been thoroughly considered and adequately treated on a generic basis.

155. The Board finds that the FNP has been designed such that the plant can withstand collisions or flying debris that might occur during rapid onset of severe, unforeseen meteorological conditions while nuclear fuel is being handled or transported.

156. The Board finds that the analyses of fuel cask drop accidents show that the cask would not rupture, but even if it should rupture, the resulting calculated radiological consequences are well below the guidelines set forth in 10 CFR 100.

157. The Board finds that adequate consideration has been given to the prevention of accidents in the handling and transportation of radioactive materials to and from the FNP, and that adequate consideration also has been given to accidents which could occur during such transportation. The Board further finds that such consideration adequately accounts for the characteristics of the FNP.

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F. CONTENTION VI - SITE ENVELOPE DATA

Brigantine Amended Contention I:

> "The postulated site parameters (10 CFR Part 50, Appendix M, para. 2) relating to climatic, meteorology, tidal, or other particular natural conditions have not been properly selected and justified."[31]

158. On this contention both Applicant and Staff presented evidence, including material contained in the Plant Design Report (PDR), the Safety Evaluation Report (SER), as supplemented, and written and oral testimony.[32] None of the intervenors presented witnesses, testimony or other information. Hearing sessions with regard to this contention were held on June 16, 17 and 18, 1976, and

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[31] Admitted as interpreted by Board Order dated December 29, 1975, p.4.

[32] The Applicant's written testimony, Exhibit No. OPS-25, entitled "Applicant's Testimony Regarding VI. Site Envelope Data", was admitted at Tr. 1331 (6/16/76). The witnesses sponsoring this testimony were Dr. Dee Walker and Messrs. P. Blair Haga, Richard S. Orr and Robert C. Beebe (Professional Qualifications admitted at Tr. 1024, 1024, 1329 and 1327 respectively). The Staff's written testimony entitled "Supplemental Testimony on Behalf of NRC Staff in Response To Brigantine Amended Contention I" by Edward F. Hawkins, Gale P. Turi, Joseph R. Levine, Earl H. Markee, Jr.; and "Supplemental Testimony On Behalf Of NRC Staff In Response To Brigantine Amended Contention I" by Renner B. Hoffman, which follows Tr. 1483, was admitted at Tr. 1483 (6/17/76). (Professional Qualifications of Messrs. Hawkins, Levine, Markee and Hofmann and Ms. Turi were admitted at Tr. 1476; on June 18, 1976 Mr. Lewis G. Hulman substituted for Staff witness Hawkins. Mr. Hulman's Professional Qualifications were admitted at Tr. 1520).

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the testimony appears at Transcript pages 1326-1353, 1354-1510, and 1511-1701, respectively.[33]

159. Paragraph 2 of Appendix M to 10 CFR Part 50 requires that the applicant for a manufacturing license provide an envelope of postulated site parameters. Paragraph 5 of Appendix M to 10 CFR Part 50 authorizes the Commission to issue a license for one or more nuclear power reactors to be operated at sites not identified in the license application if the Commission finds that *inter alia* (1) "The applicant has described the proposed design of and the site parameters postulated for the reactor(s)...." The criteria for the design of nuclear power plants for protection against natural phenomena are stated in Criterion 2 of Appendix A to 10 CFR Part 50 and Appendix A to 10 CFR, Part 100.

160. Applicant's envelope of postulated site parameters including those pertaining to climatic, meteorological, tidal and other natural conditions associated with the marine enviornment (and combinations of these phenomena) are summarized in the PDR at Table 2.1-1 and in the SER, Supplement No. 2, in Table 1.2 (Revised).

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[33] Applicant witnesses were examined by counsel for City of Brigantine (Brigantine), Atlantic County Citizens Council on Environment (ACCCE), Atlantic County Board of Chosen Freeholders (Atlantic County), State of New Jersey, NRC Staff and the Board. Staff witnesses were examined by Counsel for Brigantine, ACCCE, Atlantic County, State of New Jersey and the Board.

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Hurricane

161. Hurricane is a windstorm which produces surge (or drawdown) and wave activity. Hurricane winds create pressure loading on FNP structures, while wind and wave together create plant motion (Applicant's Testimony, pp. 2-3; PDR, Section 3.3.1). Surge (or drawdown) combine with astronomical tide to produce the still-water depth (Applicant's Testimony, p. 4). Hurricane is therefore an event of interest in each of the following site envelope parameters: maximum water depth, minimum water depth, plant motion and wind speed (pressure loading) (PDR Table 2.1-1).

162. The Applicant has specified two levels of hurricane intensity in the site envelope, the Hundred Year Storm (HYS) and the Probable Maximum Hurricane (PMH) (PDR Table 2.1-1). The HYS is defined by its recurrence interval or equivalently by a probability of occurrence per year of 0.01 (Transcript, Page 1336). The PMH is a hypothetical hurricane having a combination of characteristics which make it the most severe hurricane that can probably occur in the particular region involved. PMH parameters have been developed by the Weather Bureau, now the National Oceanographic and Atmospheric Administration (NOAA) for the Atlantic and Gulf coastal regions from maximization of hurricane parameters based on historical data (SER, Section 2.2).

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163. The Applicant postulates the occurrence of a hurricane not exceeding HYS intensity subsequent to the postulated sinking emergency and while the plant remains in the sunken condition (PDR, Section 2.3.2). The Staff concurs with the Applicant that this event combination is adequately conservative (SER, Section 2.3.2). Site water depth at mean low water (MLW), the reference condition, must be such that the sum of MLW depth, astronomical tide, storm surge and wave height adjacent to the plant vital structures does not exceed 76 feet, the height above the bottom of the platform to which plant areas housing equipment necessary for safe shutdown are designed to be watertight. (PDR Table 2.1-1; Transcript, Page 1333).

164. The HYS is the operating basis event with respect to wind pressure loading on plant structures and with respect to plant motions resulting from wind and wave (Applicant's Testimony, Page 2).

165. HYS wind speed was bounded originally by the Applicant at 130 mph for the Atlantic and Gulf Coasts. This magnitude was increased subsequently to 160 mph based on the recommendation of NOAA (SER Section 1.10, Appendix C; SER Supp. 1, Section 1.10, PDR Table 2.1-1).

166. Each owner will be required to evaluate surge height for the HYS (SER, Section 2.3.2). The Applicant expects that each owner will determine a site specific HYS wind speed because a lower magnitude than the generic bound established by the Applicant would be

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expected (Applicant's Testimony, Page 3). Plant motions resulting from the HYS will be evaluated by the owner through model testing (SER, Section 3.7.2).

167. The Applicant postulates the occurrence of a hurricane no more intense than the PMH with the plant in the normal, floating condition (PDR Table 2.1-1). The Staff concurs with the Applicant that the PMH is an adequately conservative maximum hurricane (Staff's Testimony, Hawkins, et.al., Page 2; Tr. 1544 and 1661). The Site Envelope requires that plant motions not result in platform contact with the basin floor during the passage of a PMH (PDR Table 2.1-1). Thus the minimum acceptable basin water depth at MLW is equal to the algebraic sum of plant draft, astronomical tide, hurricane surge (or drawdown) and maximum plant motion (downward corner displacement) produced by the PMH (PDR Table 2.1-1).

168. The PMH is one of the design basis events with respect to wind pressure loading on plant structures (see our discussion of Tornado, below) and is the design basis event with respect to plant motions resulting from wind and wave (Applicant's Testimony, Page 2; PDR Table 2.1-1).

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169. The Applicant has based the FNP design on the maximum wind speed stated in HUR 7-97[34] for the Atlantic and Gulf Coasts (PDR, Section 3.3.1.1). The maximum ten-minute wind speed of 163 mph from HUR 7-97 is stated in the site envelope as an equivalent fastest mile wind speed of 204 mph (PDR Tables 2.1-1 and 3.3-2).

170. Each owner will be required to evaluate storm surge and drawdown for the PMH (Staff's Testimony, Hawkins, et.al., Page 3). Each owner may determine a site-specific PMH wind speed because a lower magnitude than the generic bound established by the Applicant would be expected at most sites (Applicant's Testimony, Page 2). Plant motions resulting from the PMH will be evaluated by the owner through model testing (SER, Section 3.7.2).

Tornado

171. Tornado is a windstorm which produces direct loading on FNP structures resulting from wind and pressure drop forces. Those forces in turn produce plant motion (Applicant's Testimony, Page 5). Tornado is therefore an event of interest in the following site envelope parameters: minimum basin water depth, plant motion and wind speed (pressure loading) (PDR Table 2.1-1).

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[34] U.S. Department of Commerce, Environmental Services Administration, Weather Bureau (Now NOAA), Memorandum HUR 7-97, "Interim Report Meterological Characteristics of the Probable Maximum Hurricane, Atlantic and Gulf Coasts of the United States", May 7, 1968.

172. The Site Envelope requires that basin water depth be sufficient to prevent contact between the platform and the basin floor during the passage of the design basis tornado (PDR, Section 2.3.1). The site envelope requires that basin water depth at MLW be at least equal to the sum of plant draft plus the maximum downward motion produced by the design basis tornado (PDR Table 2.1-1).

173. The design basis tornado is one of the design basis events with respect to pressure loading on plant structures and is one of the design basis events for plant motions resulting from extreme winds (see our discussion of Hurricane, above) (Applicant's Testimony, Page 3; PDR Table 2.1-1).

174. The tornado characteristics defined in Regulatory Guide 1.76 were used by the Applicant to design the FNP (PDR Section 3.3.2). The basis for these tornado characteristics is discussed in detail in "Technical Basis for Interim Regional Tornado Criteria", WASH-1300, May, 1974. The Tornado characteristics used by the Applicant are bounding for all areas alonr the Atlantic and Gulf Coats (Staff's Testimony, Hawkins, et.al., Page 7 and 8).

175. The principal parameters of the Applicant's design basis tornado are: rotational wind speed 290 mph, maximum forward speed 70 mph and a pressure drop of 3 psi (PDR Table 2.1-1). These magnitudes represent conservative upper bounds. (Staff's Testimony, Hawkins, et.al., Page 8).

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176. The tornado characteristics developed in WASH-1300 resulted mainly from data collected over land. The Applicant and the Staff agree that it is reasonable and conservative to extend data collected over land to the region of adjacent coastal waters for the purpose of predicting tornado characteristics (Tr. 1698-1699).

177. The owner will be required to analyze plant motions resulting from the design basis tornado and to demonstrate that neither platform contact with the basin floor nor acceleration and/or angular displacements in excess of site envelope limits occur. No further evaluation of tornado intensity parameters is required of an owner unless the owner wishes to postulate a less severe design basis tornado for design of site features for the specific site (Applicant's Testimony, Page 5).

178. Waterspouts are small regions of intense rotational winds which develop over water and draw water into the rotating fluid. Their potential effects upon an FNP are similar to those produced by tornado; however, the maximum wind force and pressure drop are approximately 30% of those of the design basis tornado. The Applicant and Staff agree that the large margin between waterspout and tornado forces assures that waterspout loadings will not be limiting for either plant design or siting (PDR, Section 2.7.5; PDR, Appendix 2D; SER, Section 2.8.1.1).

454 080

Tsunami

179. Tsunami are long period sea waves caused by underwater disturbances such as earthquake, volcanic eruption or landslide (PDR, Section 2.3.1; SER, Section 2.8.4). As tsunami waves approach land, bottom friction causes wave amplification, and a significant series of alternating surges and drawdowns may occur (Staff's Testimony, Hawkins, et.al., Page 3; PDR, Section 2.3.1). Tsunami is therefore an event of interest in the site envelope limitations for maximum and minimum basin water depth (PDR Table 2.1-1). The Applicant has not included tsunami as an event for which plant accelerations and angular displacements are compared to site envelope limits, because the response of the plant is expected to be a gentle rise and fall analagous to the response to tidal fluctuations (PDR, Section 2.3.1).

180. The Applicant postulated the occurrence of a tsunami coincident with the ten percent exceedance high spring tide subsequent to the hypothetical sinking emergency and while the plant remains in the sunken condition. The sum of MLW depth plus astronomical tide plus tsunami surge height plus wave height adjacent to the plant vital structures is required to be less than 76 feet, the maximum water depth for which systems necessary for safe shutdown are protected from flooding. (PDR Table 2.1-1).

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181. The Applicant postulates the occurrence of a tsunami coincident with the ten percent exceedance low spring tide with the plant in the normal, floating condition. Basin water depth at MLW is required to be be equal to or greater than the sum of plant draft plus astronomical tide plus tsunami drawdown. Satisfaction of this limit assures that the platform will not contact the basin floor (PDR Table 2.1-1).

182. Global records of tsunami indicate that the Pacific is the most active region while tsunami along the Atlantic and Gulf coasts have been both rare and of small magnitude. It is expected that the magnitude of tsunami wave heights would be less than hurricane-induced wave heights. (Staff's Testimony, Hawkins, et.al, Page 4; Applicant's Testimony, Page 3).

183. Each owner will be required to estimate tsunami magnitudes based on evaluation of potential initiating mechanisms, both local and distant (SER, Section 2.8.4).

Astronomical Tide

184. Site Envelope limits for both maximum and minimum water depth account for astronomical tide as a component of still water level (PDR Table 2.1-1; Applicant's Testimony, Page 4). The HYS, PMH and tsunami are each postulated to occur in coincidence with ten percent exceedance tide levels (PDR Table 2.1-1). The ten percent

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exceedance tide levels (high and low) are those predicted tidal maxima and minima which are exceeded by only ten percent of the predicted monthly maxima and minima over a continuous 19 year period. The Applicant postulated the occurrence of the design basis tornado at a water depth equal to or greater than MLW (PDR Table 2.1-1). MLW is the average water depth during low water conditions. The design basis tornado event is not combined with the ten percent exceedance low tide because the combined probability is small. (Tr. 1340; PDR, Section 2.3.1, 2.13).

Earthquake

185. Earthquakes required to be postulated for the design of nuclear power plants are defined in 10 CFR Part 100, Appendix A, in terms of probability of occurrence and magnitude. Appendix A is supplemented by Regulatory Guide 1.60. (Applicant's Testimony, Page 4).

186. The Applicant postulated a safe shutdown earthquake (SSE) having maximum accelerations at the basin floor of 0.3g (horizontal) and 0.2g (vertical) (PDR Table 2.1-1). The Applicant testified and the Staff concurred that the postulated SSE acceleration will meet or exceed the requirements of 10 CFR, Part 100, Appendix A for most locations along the Atlantic and Gulf coasts (Applicant's Testimony, Page 4; Staff's Testimony, Hoffman, Page 5; SER, Page 33; PDR, Section 2.5.3).

 454 083

187. The Site Envelope parameter limits for horizontal SSE acceleration are derived from the maximum ground acceleration of 0.3g (Tr. 1442, 1462); the site envelope parameter limit for SSE vertical motion is the Regulatory Guide 1.60 ground response spectrum corresponding to a maximum vertical ground acceleration of 0.2g (PDR Table 2.1-1; Section 2.5.2.2).

Seiche

188. Earthquakes, landslides and windstorm can produce standing wave oscillations of a large enclosed or semi-enclosed water body known as seiche. Seiche will be evaluated for the environmental phenomena specific to each site in order to assure that the maximum water level produced by each environmental phenomenon is used in site evaluation (Staff's Testimony, Hawkins, et. al., Page 7).

Precipitation

189. Precipitation produces structural loadings from the accumulation of water on plant roof surfaces. The Site Envelope requires that the expected rainfall rate at an FNP site not exceed 13 inches per hour (PDR Table 2.1-1). The Applicant and Staff agree that the precipitation rate for all Atlantic and Gulf coastal locations is less than 13 inches per hour (Applicant's Testimony, Page 5; Staff's Testimony, Hawkins, et.al, Page 5). The Staff's estimate of precipitation rate at sites along the Atlantic and Gulf coasts is based on

the Probable Maximum Precipitation (PMP) defined in Hydro-Meteorological Report 33[35] of the U.S. Department of Commerce. PMP is defined by the U.S. Department of Commerce (NOAA) as "the theoretically greatest depth of precipitation for a given duration that is meteorologically possible over the applicable drainage area that would produce flows of which there is virtually no risk of being exceeded". (Staff's Testimony, Hawkins, et.al, Page 5).

Minimum Air Temperature

190. The platform hull is designed for a minimum service temperature (in air) of -15°F (PDR Sections 3.12.4.2, 3), although a lower service temeprature can be accomodated by using a different hull steel (PDR, Section 3.12.4.3). The Applicant has included in the Site Envelope the requirement that the minimum air temperature, at 0 to 5 meters above the basin surface, be no lower than -15°F (PDR, Table 2.1-1). Based on data reported in PDR Appendix 2D, the Applicant concluded that sites exist along the Atlantic and Gulf coasts which will satisfy this limit (PDR Appendix 2D; Section 2.7.2). The Staff concluded that the Applicant's original limit of -5°F was sufficient for all of the East and Gulf coasts except for the northern portions of the coast of Maine (SER, Section 2.8.1.1).

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[35] U.S. Department of Commerce, U.S. Weather Bureau (Now U.S. Weather Service, NOAA), "Seasonal Variation of Probable Maximum Precipitation, United States East of 105th Meridian for Areas 10 to 1,000 Square Miles", Washington, D.C., 1956.

454 085

Maximum Water Temperature

191. Plant cooling water systems required for safe shutdown are designed to transfer their maximum heat load at a maximum heat sink temperature of 95°F (Applicant's Testimony, Page 6). The Site Envelope requires that basin water temperature not exceed 95°F (PDR Table 2.1-1). Based on data reported in PDR Appendix 2D (Section 2D.5), the Applicant concluded that sites along both the Atlantic and Gulf coasts will satisfy this limit. The Staff concluded, based on the Applicant's original limit of 85°F, that there are many areas along the Atlantic and Gulf coasts where maximum water temperature will not exceed 85°F (SER, Page 36).

Minimum Water Temperature

192. Platform hull material toughness testing requirements are based on minimum service temperature (PDR, Page 3.12-27a). The Applicant requires that the Nil-Ductility Transition Temperature (NDTT) of platform exterior plating be -30°F or lower. This temperature (-30°F) results from the basic requirement that the NDTT of platform exterior plating be approximately 60°F below the minimum service temperature of the bottom shell (PDR, Page 3.12-27f). The Site Envelope requires a minimum basin water temperature of 28.6°F (PDR Table 2.1-1). This temperature is the freezing point of sea water of average salinity and was the minimum water temperature measured during the trans-artic cruise of the ice breaker Manhattan (PDR, Pages 2.7-5,

454 086

2.7-6). Slightly lower temperatures resulting from localized high salinity would not be of any significance (Applicant's Testimony, Page 6).

Conclusion

193. There is adequate knowledge regarding climatic, meteorological, tidal and other natural conditions at ocean and inshore locations at which FNP's could be sited. (Tr 1382-83, 1503-04). The depth of knowledge regarding climatic, meteorological, tidal and other natural conditions at riverine, estuarine and coastal locations is documented in numerous Commission dockets including, inter alia, Calvert Cliffs, Pilgrim, Brunswick, St. Lucie, Turkey Point, Oyster Creek, Millstone, San Onofre and Surry.

194. The Site Envelope parameters specified in PDR Table 2.1-1 and in SER, Supplement 2, Table 1.2 (Revised), conservatively account for all reasonably expectable environmental occurrences that could adversely affect an FNP (Tr. 1381, 1453).

195. The Board has reviewed the envelope of site parameters with regard to the climatic, meteorological, tidal and other natural conditions described in PDR Table 2.1-1 and in SER, Supplement No. 2 Table 1.2 (Revised). Included in this review were the site parameters specifically discussed in these findings of fact as well as all other site parameters set forth in those tables. The Board concludes that

454 087

the Applicant, in accordance with the provisions of 10CFR50, Appendix M, Paragraph 5 and 10CFR2.104 (b), has properly selected and justified the site parameters set forth in those tables (SER 1.6, 21.0; Applicant's Testimony, p. 1, Tr. 1397, 1435, 1489).

G. CONTENTION VII - RADIOLOGICAL IMPACT ON SWIMMERS AND BOATERS

ACCCE Contention 3d:

> "Subpart 3d asserts that the Applicant has not given adequate consideration to the radiological impact on humans who may boat or swim in the vicinity of the floating nuclear plant. This contention is hereby admitted as an issue in controversy."[36]

196. On this contention, both Applicant and Staff presented evidence, including material contained in the Plant Design Report (PDR), the Final Environment Statement (FES), as supplemented, and written and oral testimony.[37] None of the intervenors presented witnesses, testimony, or other information. The Hearing session with

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[36] Admitted as interpreted by Board Order dated May 21, 1974, p. 6.

[37] The Applicant's written testimony, Exhibit No. OPS-35, entitled "Applicant's Testimony Regarding VII. Radiological Impact on Swimmers and Boaters", was admitted at Tr. 3333. The witnesses sponsoring this testimony were Dr. Dee Walker, Mr. P. Blair Haga, and Miss Mary Ann Capo (Professional Qualifications admitted at Tr. 1024, 1024, and 3831, respectively). The Staff's written testimony entitled "Supplemental Testimony of NRC Staff in Response to ACCCE Contention 3(d)" by Dr. Reginald L. Gotchy, which follows Tr. 3849, was admitted at Tr. 3848 (Professional Qualifications of Dr. Gotchy were admitted at Tr. 3847).

454 088

regard to this contention was held on November 3, 1976, and the testimony appears at Transcript pages 3833-3857.[38]

197. Applicable parts of Title 10 of the Code of Federal Regulations (10 CFR 20, the Annex to Appendix I of 10 CFR 50, and 10 CFR 100) are the governing regulations relating to radiological impact on humans, including swimmers and boaters. The Floating Nuclear Plant (FNP) is designed to be in compliance with those regulations. (Applicant's Testimony, page 1.)

198. The Staff prepared an independent assessment of the potential radiological impact on routine releases from the FNP on humans, including swimmers and boaters, in the Final Environmental Statement, Part II, Section 11.3, page 11-7.

Normal Operation - Maximum Permissible Concentrations

199. The Maximum Permissible Concentrations of radioactivity in air and water above natural background for unrestricted use are defined in 10 CFR 20, Appendix B, Table II. The estimated yearly quantities of radioactive discharges from an FNP during normal operation are given in Section 12.4 (commencing on page 12.4-1) of the

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[38] Applicant witnesses were examined by counsel for Atlantic County Citizens Council on Environment (ACCCE) and by the Board. The Staff witness was examined by counsel for ACCCE and by the Board.

454 089

Plant Design Report (PDR). The average concentrations in air and surrounding water resulting from these estimated yearly releases during normal plant operation are compared in PDR Section 12.4.3 (commencing on page 12.4-23) with the Maximum Permissible Concentration limits and are below the acceptable limits for all isotopes.

Normal Plant Operation - Airborne Dose

200. Estimates of the annual dose resulting from released airborne radioactivity are presented in PDR Section 12.4-4 (commencing on page 12.4-25) as a function of distance from the plant. In calculating the dose from airborne radioactivity over a period of a year, conservative values for atmospheric disperson conditions given in PDR Section 2.7.1 were used; thus, these doses represent conservative limit values for Atlantic Coast and Gulf Coast sites. These data show that the dose guidelines for released airborne radioactivity set forth in the Annex to Appendix I (10 millirad gamma and 20 millirad beta for all reactors at a site) can be met for continuous occupancy for distances greater than about 200 meters from the plant. The distance of 200 meters corresponds to the distance that is about as close as an individual might be able to approach a typical breakwater in a boat (Tr. 3841). Assuming an occupancy of 100 hours per year at 200 meters, and using the annual doses in PDR Section 12.4.4 from airborne

radioactivity, a swimmer or boater would receive a dose of only 0.16 mrem per year from this source from an FNP.[39]

Normal Plant Operation - Direct Dose

201. Estimates of the additional annual dose resulting from direct radiation are presented in PDR Section 12.4.4 as a function of distance from the plant. Assuming an occupancy of 100 hours per year at 200 meters from the plant, a swimmer or boater would receive a dose of 0.082 mrem per year from this source of radiation from an FNP. The Annex to Appendix I of 10 CFR 50 does not require a consideration of the direct radiation from the plant (Tr. 3843). The direct dose is only a small fraction of that resulting from natural background radiation, approximately 80 mrem per year. (Applicant's Testimony, page 2).

Normal Plant Operation - Dose Due to Liquid Releases

202. Estimated annual doses to swimmers and boaters from liquid releases are presented in PDR Section 2.8 as follows: an individual spending 100 hours per year swimming in the mixing zone of the thermal plume and 100 hours per year boating in the mixing zone of

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[39] Dose value of 0.36 mrem per year in Applicant's Testimony (page 2) was revised in PDR Amendment 24 to the current value of 0.16 mrem per year in compliance with Regulatory Guide 1.112 (issued April, 1976), NUREG-0017 (issued April, 1976), and Regulatory Guide 1.109 (published March, 1976), and Revision 1 (issued October, 1977).

454 090

the thermal plume would receive a dose of 1.2×10^{-4} mrem per year and 4.3×10^{-5} mrem per year, respectively, from an FNP.[40] These doses are only a small fraction of the dose for a submerged individual due to background radiation, approximately 60 mrem per year (Tr. 3855).

Doses for Postulated Accidents

203. In addition to the calculation of doses due to routine releases from the plant, the Applicant is also required under 10 CFR 100 to calculate the doses due to postulated accidents which could result in release of a significant quantity of radioactive fission products. Activity release by isotope for each such postulated accident is set forth in PDR Sections 15.3 (commencing on page 15.3-1f) and 15.4 (commencing on page 15.4-10). Doses were calculated employing these activity releases and the conservative atmospheric dispersion conditions set forth in PDR Section 2.7.1. Plots of these doses as a function of distance from the release point on the plant are presented in PDR Sections 15.3 and 15.4. Evaluation of these dose plots demonstrates that an exclusion distance of 500 meters (0.3 miles) and a low population boundary of 1200 meters (0.75 miles) is

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[40] Dose values of 6.7×10^{-5} and 2.3×10^{-5} mrem per year in Applicant's Testimony (page 2) were revised in PDR Amendment 24 to the current values of 1.2×10^{-4} and 4.3×10^{-5}, respectively, in compliance with Regulatory Guide 1.112 (issued April , 1976), NUREG-0017 (issued April, 1976), and Regulatory Guide 1.109 (published March, 1976), and Revision 1 (issued October, 1977).

454 092

adequate to meet the dose guidelines of 10 CFR 100 for sites along the Atlantic and Gulf Coasts. The actual exclusion distance and low population boundary are site specific and will be calculated by each Owner. (Applicant's Testimony, page 3.)

Conclusions

204. The floating nuclear plant is designed to be in compliance with applicable parts of 10 CFR 20, the Annex to Appendix I of 10 CFR 50, and 10 CFR 100.

205. The Applicant's calculated doses to swimmers and boaters are not significant compared to natural background radiation (Tr. 3844). The Staff concluded that the radiological impact (from FNP routine releases of radioactive effluents) on boaters and swimmers will be insignificant.

206. The Board finds that adequate consideration has been given to the radiological impact on humans who may swim or boat in the vicinity of the FNP. The Board further finds that routine releases of radioactive effluents from the FNP will have no significant effect on humans who may boat and swim in the vicinity of the plant. The Board also finds that the calculated doses for postulated accidents comply with the requirements of 10 CFR 100 for sites along the Atlantic and Gulf coasts.

454 023

H. CONTENTION VIII - AIRCRAFT

Brigantine Amended Contention 4:

> "The probability of aircraft crashing into the facility is understated, since the analysis is based on the frequency of commercial aviation flights without regard to the frequency of other kinds of flights, e.g., military and general aviation."[41]

Atlantic County Contengent 2:

> "With the continuance of air traffic and increases to air traffic along the Atlantic sea coast, we believe that the proposed Floating Nuclear Plants located in said zone should be constructed to withstand the effects of a possible collision with any existing size aircraft that may fly over or in the vicinity of the site and any reasonably foreseeable large size aircraft built during the lifespan of the proposed plants that may operate as above without damage to the reactor core such that dosages of harmful radiation in excess of required limits would occur.
>
> Our basis for this belief is that:
>
> a. The crash probability is sufficiently high.
>
> b. The resultant damage to the proposed plants and attendant effects on radiological safety in the event of a collision is sufficiently great.
>
> c. The combination of the above indicate that the plant should be so designed." [42]

Pertinent Part of ACCCE Contention 6:

> "The applicant has not given adequate consideration to possible accidents resulting ... from an intentional collision by an aircraft as part of industrial sabotage."[43]

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[41]Admitted as interpreted by Board Order dated December 29, 1975, p.4.

[42]Admitted as interpreted by Board Order dated April 15, 1975, p.9.

[43]Admitted as interpreted by Board Order dated May 21, 1974, p.8.

454 094

207. Both Applicant and Staff presented evidence concerning this contention, including material contained in the Plant Design Report (PDR), the Safety Evaluation Report (SER) and written and oral testimony.[44] None of the intervenors presented witnesses, testimony or other information. Hearing sessions with regard to this contention were held on September 23, 24, 28, and 29, 1976, and the testimony appears at Tr. pages 3413-3431, 3432-3504, 3505-3630, and 3631-3770.[45]

208. Standard Review Plan 3.5.1.6, Aircraft Hazards, and Regulatory Guide 1.70, Rev. 2 (NUREG-25/094), Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants, Section 2.2.3.1, set standards for aircraft crash probability with which an owner must comply when siting a nuclear power plant (Staff's Testimony, Page 2 and Applicant's Testimony, Page 1). The PDR, Table 2.1-1, identifies plant-site interface requirements. Table 2.1-1

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[44] The Applicant's written testimony, Exhibit No. OPS-26, entitled "Applicant's Testimony Regarding VIII. Aircraft, "was admitted at Tr. 3421. The witnesses sponsoring this testimony were Dr. Dee H. Walker, Mr. P. Blair Haga, Dr. Douglas H. Shaffer, and Mr. John F. Hanst (Professional Qualifications admitted at Tr. 1024, 1024, 2881, and 3419 respectively). The Staff's written testimony entitled " Supplemental Testimony of NRC Staff in Response to Brigantine Amended Contention 4, Atlantic County Contention 2 and the Pertinent Portion of ACCCE Contention 6," by Jacques B. J. Read, John A. O'Brien, Ray F. Priebe, was admitted at Tr. 3636. Professional Qualifications of Dr. Read, Dr. O'Brien, and Mr. Priebe were admitted at Tr. 2534.

[45] Applicant and Staff witnesses were examined by counsel for intervenor Atlantic County Citizens Council on Environment (ACCCE) and the Board.

454 025

vicinity. The results of the Applicant's analysis demonstrate that although the threat of a military crash at this site is greater than that from commercial aviation, the cumulative threat from all aviation is of the order of 10^{-7}/year or less. (Applicant's Testimony, Page 3.)

215. The FNP, with substantial protection around its safety-related areas to satisfy NRC tornado missile protection requirements, is not vulnerable to the crash of small aircraft. The Applicant has calculated the thickness of steel or concrete required to prevent perforation of missiles resulting from a crash into the plant of aircraft weighing up to 12,500 pounds. In all cases structures protecting safety-related plant areas exceed the required thickness. (Applicant's Testimony, Page 3.)

216. The probability of an aircraft crash into the FNP is determined by four factors, all first power terms such that none is more influential than any of the others. These terms are: 1) number of overflights, 2) accident rate, 3) density function, and 4) effective plant area. (PDR, Appendix 2B.) The Applicant treated these variables as discussed below.

217. Number of Overflights. The number of overflights is determined by "peak day" statistics which represent the heaviest traffic of the year. Yearly rates are obtained by assuming "peak day"

454 096

traffic every day of the year. (Tr. 3610.) This term is therefore conservative.

218. Accident Rate. The long term accident rate trend is downward (Tr. 3477). Therefore, using the present rate is conservative.

219. Density Function. The density function is a mathematical statement that the likelihood of a crash decreases as the distance from the airway increases. The function used by the Applicant was formulated by fitting to a curve offset distances from airways at which serious crashes occurred in the years 1964-1967. (PDR, Appendix 2B, Page 2B-11.) As such, this function is neither conservative nor unconservative.

220. Effective Plant Area. Analysis by the Applicant indicated that the average shadow area is obtained by utilizing a 32° crash angle. The Applicant used a 30° crash angle which [illegible]sults in a slightly greater shadow area. (Tr. 3484.) In additi[illegible]nsions of plant features were increase[illegible]o account for eng[illegible]ation of aircraft (Tr. 3429). The resu[illegible]ant is a conservatively calculated effective plant area.

221. In addition to the conservatism built into the factors making up the probability calculation, another conservatism is the Applicant's simplifying assumption that a crash into the plant by an

aircraft larger than 12,500 pounds is equatable to safety-related consequences. No credit is taken for the structural barriers incorporated into the plant, especially the shield building, which the NRC Staff has estimated could survive a collision of a 70,000 pound F-111B at approximately 100 miles per hour (Tr. 3574-3575, 3747.)

222. Present Nuclear Regulatory Commission regulations do not require inclusion of intentional crash as a design basis event (Staff Testimony, Page 7). While acknowledging the possibility of threat of such a crash by a deranged individual, the Staff considers the execution of such a threat to be incredible (Tr. 3738).

Conclusions

223. The Board concludes that the FNP need not be designed to withstand the consequences of a large aircraft crash since siting restrictions limit the probability of such an event to the order of 10^{-7} or less.

224. The Board concludes that the FNP need not be designed to withstand the consequences of an intentional crash of an aircraft as a part of industrial sabotage.

454 098

225. The Board finds that the Applicant has given adequate consideration to commercial, military and general aviation, and that the Applicant has demonstrated that potential FNP sites exist along the East and Gulf Coasts where the probability of aircraft crash is acceptably low. Evaluation of aircraft crash probability at a specific site is the responsibility of the plant owner.

I. CONTENTION IX - SHIP COLLISION

Brigantine Amended Contention 5:

> "The probability of ship collisions is understated, since inadequate consideration is given to potential changes in the pattern of ship traffic and the character of ships and their cargoes over the 40-year life of the facility."[46]

Pertinent Part of ACCCE Contention 6:

> "... the Applicant has not given adequate consideration to possible accidents resulting from a collosion (sic) of the floating plant with a ship...."[47]

226. On these contentions both Applicant and Staff presented evidence, including material contained in the Plant Design Report (PDR), the Safety Evaluation Report (SER), as supplemented, and

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[46] Admitted as interpreted by Board Order dated December 29, 1975, p.4.

[47] Admitted as interpreted by Board Order dated May 12, 1974, p.8.

454 099

written and oral testimony.[48] None of the intervenors presented witnesses, testimony or other information. Hearing sessions with regard to this contention were held on July 30, September 20, 21, 22, and 23, 1976, and the testimony appears at Tr. 2869-3412.[49]

227. Regulatory Guide 1.70 (NUREG-75/094), Section 2.2.3 and Standard Review Plans 2.2.1 and 2.2.2 require that transportation activities in the vicinity of proposed nuclear power plant sites be evaluated to determine if accidents that could result from these activities need to be design basis events for the plant. Regulatory Guide 1.70, Section 2.2.3.1 and Standard Review Plan 2.2.3 indicate that potential accidents external to the nuclear plant should be considered design basis events if the probability of the accident exceeds on the order of 1×10^{-7} per year and if the consequences may affect the plant to the extent that the requirements of 10 CFR 100 could be exceeded. (Applicant's Testimony, pages 1 and 2). For an

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[48] The Applicant's written testimony, Exhibit No. OPS-27, entitled "Applicant's Testimony Regarding IX. Ship Collision", was admitted at Tr. 2884. The witnesses sponsoring this testimony were Drs. Dee H. Walker, Douglas H. Shaffer and Henry J. Stumpf, Capt. Derek R. King, Ms. Hyla Napadensky and Mr. P. Blair Haga (Professional Qualifications admitted at Tr. 1024, 2881). The Staff's written testimony entitled "Supplemental Testimony of NRC Staff in Response to Brigantine Amended Contention 5 and the Pertinent Portion of ACCCE Contention 6" by Drs. Jacque B. J. Read and John A. O'Brien, which follows Tr. 3284 was admitted at Tr. 3284 (Professional Qualifications of Drs. Read and O'Brien were admitted at Tr. 2534).

[49] Applicant witnesses were examined by Counsel for City of Brigantine (Brigantine), Atlantic County Citizens Council on Environment (ACCCE), State of New Jersey, NRC Staff and the Board. Staff witnesses were examined by Counsel for ACCCE, State of New Jersey, OPS, and the Board.

454 108

Applicant's consideration in determining design basis events, the Staff has identified several accident categories with the categories being based upon the effect that a particular type of accident could have on the plant. The accident categories include explosions, flammable vapor clouds, toxic chemicals and fires. (SER Supplement 2, Appendix C, Section 5).

228. The Applicant examined available data on shipping accidents and then evaluated in more detail those accidents which presented a potential hazard to the plant (Tr. 2895). Seven classes of shipping accidents were identified as presenting a potential hazard to the plant (PDR Appendix 2A). Of these accident classes, three were determined to be design basis events for which there are specific plant design features and/or site requirements (Ship Collision With Plant; Tanker Collision With Breakwater: Fire; Service Ship Accidents). Two accident classes were determined to be of sufficiently low probability to be excluded from the plant design basis (Liquified Natural Gas (LNG) Carrier Accident; Munitions Ship Explosions). The remaining two accident classes were included within the plant design basis up to specific maximum design limits (Tanker Accident: Vapor-Air Explosion; Hazardous Chemical Carrier Accident: Toxic Vapor Cloud). (Applicant's Testimony, pages 2 and 4). Each of the accident classes is discussed infra.

454 100

Ship Collision With Plant

229. Site protective features (such as a breakwater) are required to prevent a large vessel from colliding with the plant (PDR Table 2.1-1). The Applicant has shown that protective barriers can be designed to prevent a ship collision with the plant. Applicant has also shown that a ship collision with the site protective structure, excluding cargo effects, will not result in unacceptable consequences with respect to 10 CFR 100. (PDR Section 2A.2.) Potential hazards arising from the cargo of a ship colliding with the site protective structure are discussed <u>infra</u>.

Tanker Collision With Breakwater: Fire

230. The site protective features are required to be such that they prevent a potential oil spill occurring outside the site structure from reaching a point closer than 100 feet from the plant (Applicant's Testimony, page 3; SER Section 2.10.2). The fire which could result from a collision of a tanker carrying flammable fuel, other than LNG (see paragraph 232), with the site protective structure may be a design basis event at some sites. An adequate external fire protection system is provided for these cases. (PDR Section 9.5.1.2.)

454 102

Service Ship Accidents

231. Potential accidents involving the FNP and service ships are of three types: direct collision with the plant by the service ship; fire resulting from release of diesel fuel oil into the basin surrounding the FNP; explosion on the service ship. Vessels within the basin must be limited in size and speed such that potential impact on the plant will be no greater than that equivalent to a ship of 3150 long tons at 13 knots. (PDR Section 2A.8.1; Applicant's Testimony page 3; SER Section 2.10.2). The aqueous film forming foam system is provided to extinguish a fire within 100 feet of the plant resulting from a spill of flammable liquid. The applicant has evaluated the consequences of an explosion of a fuel-air mixture in a supply barge tank and has determined that preventative actions are possible. The Staff concurs. The owner will be required to: (a) inert the fuel barge tanks during offloading, or (b) maintain sufficient separation between the plant and fuel supply barge, or (c) limit the volume of individual tanks on the fuel supply barge. (PDR Section 2A.8.3.1; Applicant's Testimony, page 4; SER Supplement 1, Section 2.10.2).

Liquified Natural Gas (LNG) Carrier Accident

232. The Site Envelope requires that the probability of a munitions ship explosion, the consequences of which could exceed the plant design basis, be on the order of 1 X 10^{-7} per year or less (PDR Table 2.1-1; SER Supplement 2, Table 1.2 (Revised)). The Applicant has

454 103

concluded and the Staff has concurred that sites can be found such that the probability of an accident involving an LNG accident, the consequences of which could exceed the plant design basis, be on the order of 1 X 10^{-7} per year or less (PDR Table 2.1-1; SER Supplement 2, Table 1.2 (Revised)). The Applicant has concluded and the Staff has concurred that sites can be found such that the probability of an accident involving an LNG carrier affecting the site is on the order of 1 X 10^{-7} per year or less. (PDR Section 2.4.6; Applicant's Testimony page 4; SER Section 2.10.2).

Munitions Ship Explosion

233. The Site Envelope requires that the probability of a munitions ship explosion, the consequences of which could exceed the plant design basis, be on the order of 1 X 10^{-7} per year or less, (PDR Table 2.1-1; SER Supplement 2, Table 1.2 (Revised)). The Applicant has concluded and the Staff has concurred that for East Coast sites well removed from munitions terminals and for Gulf Coast sites the probability that a munitions ship accident with mass detonation sufficiently near the plant to affect it is negligibly low (PDR Section 2A.4; Tr. 3213-3220; SER Section 2.10.2). The owner will be required to demonstrate with an appropriate site specific model that the probability of a munitions ship explosion affecting the plant to the extent that 10 CFR Part 100 dose guidelines could be exceeded is on the order of 1 X 10^{-7} per year or less (SER Section 2.10.2).

454 104

Tanker Accident: Vapor-air Explosion

234. The FNP is designed to withstand explosions which produce a reflected overpressure of no more than 2 psi on the plant's Category I structures (PDR Section 2.9.2). For a site to be suitable, the owner must demonstrate that the probability of an explosion producing reflected overpressure of greater than 2 psi is on the order of 1×10^{-7} per year or less. This can be done by showing that a site possesses protective features which provide adequate separation distance to insure that the plant design blast overpressure criteria will not be exceeded or that the probability of such an event is on the order of 1×10^{-7} per year or less. The Applicant has demonstrated and the Staff has concurred that sites can be found where the probability of an accident involving a petroleum carrier that results in a reflected blast overpressure greater than 2 psi at the Category I structures is on the order of 1×10^{-7} per year or less (PDR Section 2A.5.5; SER Section 2.10.2).

Hazardous Chemical Carrier Accident: Toxic Vapor Cloud

235. A toxic vapor cloud formed as a result of an accident involving a hazardous chemical carrier is included in the plant design basis up to a specified maximum limit (Applicant's Testimony page 4). For control room habitability, the plant design will accommodate concentrations of toxic gases at the Control room ventilation intakes as specified in Table 2.9-1 of the PDR. These limits were determined

by the methods of Regulatory Guide 1.78, "Assumptions for the Evaluation of the Hazards of a Nuclear Power Plant Control Room during a Postulated Hazardous Chemical Release". For a site to be suitable for a FNP the owner must show that the probability of an accident producing concentrations at the control room ventilation system intakes in excess of those specified is on the order of 1×10^{-7} per year or less. (Applicant's Testimony page 5). The Applicant has demonstrated and the Staff has concurred that sites can be found where the probability of an accident involving a hazardous chemical carrier is on the order of 1×10^{-7} per year or less (PDR Appendix 2A; Applicant's Testimony page 6; SER Section 2.10.1).

Future Ship Traffic, Character of Ships and Cargoes

236. The Applicant has evaluated shipping trade flow and traffic patterns with emphasis on the shipping of various hazardous material cargoes (PDR Sect. 2A, 2A.4, 2A.6, 2A.7). Although these evaluations are based on current and immediate past shipping and hazardous cargo traffic, these results can be extended reasonably to the future. Continuing economic pressures indicate that growth in the shipping trades (except for LNG) will be accommodated by fewer overall ships of larger size. (Applicant's Testimony page 6; Tr. 2998, 2999, 3001, 3064, 3109, and 3210). In addition ships of increased draft are less likely to be in shallow waters near an FNP site. Improvements in ship design and stricter safety regulations can also be expected to reduce accident probabilities. Therefore, future trends in shipping

454 106

are expected to reduce the overall likelihood of an accident at an FNP site (Applicant's Testimony page 6; Staff's Testimony page 2; Tr. 3235, 3255, and 3315).

237. Projections of LNG traffic have been made on the basis of proposed LNG projects (PDR Section 2A.6; Applicant's Testimony page 6; Tr. 2994, 2995 and 3001). A study of the routes of LNG ships show that most ships approach the eastern seaboard from well out to sea and do not traverse the coastline; consequently they do not enter the general area of potential FNP sites. Although the present trend is for an increase in LNG traffic from foreign ports there seems to be no evidence to indicate a significant future increase in coastal LNG traffic. (PDR Section 2A.6.2; Applicant's Testimony page 6; Tr. 3051, 3052, 3182 and 3312).

Conclusion

238. The Board finds that the seven classes of shipping accidents discussed in the Plant Design Report Appendix 2A encompass the potential hazards to the FNP from shipping.

239. The Board finds that the probability of ship collision has not been understated and that adequate consideration has been given to potential changes in the pattern of ship traffic and the character of ships and their cargoes over the 40 year life of the facility.

454 108

240. The Board finds that adequate consideration has been given to possible accidents resulting from ship collisions with site structures and from serivce ship collisions with the plant itself.

241. The Board further finds that the combination of FNP design features and site envelope requirements provides reasonable assurance that shipping accidents will not present an undue hazard to the health and safety of the public.

J. CONTENTION X - ICE CONTAINMENT

ACCE Contention 7:

> "The refrigerated ice containment structure system is innovative and therefore should not be permitted without an adequate pre-licensing testing taking into account the effect of roll, pitch, and yaw present on a floating nuclear plant."[50]

242. On this contention both Applicant and Staff presented evidence, including material contained in the Plant Design Report (PDR), the Safety Evaluation Report (SER), as supplemented, and written and oral testimony.[51] None of the intervenors presented

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[50] Admitted as interpreted by Board Order dated May 21, 1974, pp. 8,9.

[51] The Applicant's written testimony, Exhibit No. OPS-42, "Applicant's Testimony Regarding X. Ice Condenser Containment", was admitted at Transcript, page 6009 (5-13-77). The witnesses sponsoring this testimony were Dr. Dee H. Walker and Messrs. P. Blair Haga, Richard S. Orr, and John D. Sutherland (Professional Qualifications admitted

454 108

witnesses, testimony or other information. Hearing sessions with regard to this contention were held on May 13, 16, and 17, 1977, and the testimony appears at Transcript pages 6002-6042, 6043-6117, and 6118-6150 and 6174-6226, respectively.[52]

243. The ice condenser containment has been adopted in the design of nuclear plants by the Indiana and Michigan Electric Co. (D. C. Cook 1 & 2); Duke Power Co. (McGuire 1 & 2, Catawba 1 & 2); and the Tennessee Valley Authority (Sequoyah 1 & 2, Watts Bar 1 & 2). In addition, two units utilizing ice condenser containment are under construction in Japan and two in Finland. (Applicant's Testimony, Page 2; Staff's Testimony, Pages 1-2).

244. The design of the ice condenser containment system is based on an extensive ice condenser development program which began in 1965. This program consisted of comprehensive system testing as well as full scale static and dynamic structural testing of ice condenser

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(Footnote 51 Continued)

at Transcript, pages 1024, 1024, 1039, and 6004). The Staff's written testimony entitled, "Supplemental Testimony of NRC Staff in Response to ACCCE Contention 7" by William C. Milstead, Jr. was admitted at Transcript, page 6085 (5/16/77). (Mr. Milstead's Professional Qualifications were admitted at Transcript, page 6083).

[52] Applicant witnesses were examined by counsel for Atlantic County Citizens Council on Environment (ACCCE), State of New Jersey, NRC Staff and the Board. Staff witnesses were examined by Counsel for ACCCE, State of New Jersey, and the Board.

454 109

components. Structural behavior of ice condenser components was measured during static and dynamic testing and confirmed analytical predictions of their structural adequacy. (Applicant's Testimony, Pages 1-2).

245. Ice condenser heat absorption capability during design basis accident was verified by blowdown tests on a full scale ice condenser section at energy levels of up to 160 percent of those predicted. In these tests, 36 ft. long ice baskets were used instead of 48 ft. ice baskets which are used in the actual ice condenser. This reduced basket length provides a conservative indication of the heat absorption capability of the full length ice condenser section. (Tr. 6097-6098).

246. In the full scale section tests, higher than predicted drain temperatures were observed. These high drain temperatures indicate that ice melt out is delayed in time and long term pressures are lower than predicted. (Tr. 6177-6183).

247. The first ice condenser plant, D. C. Cook 1, achieved initial criticality in January, 1975, and commercial operation in August, 1975. There had been no problems of safety significance associated with the ice condenser and through December 31, 1976, D. C. Cook 1 had generated over eleven billion kilowatt-hours of electricity with a plant availability of greater than 33 percent. (Applicant's Testimony, Page 2; Tr. 6092).

454 110

248. There have been some normal "teething" problems with the ice condenser at D. C. Cook 1 including air handling units, refrigeration system imbalances, air leaks and isolated incidents of ice buildup on the lower inlet doors. In only a single instance did this require a reduction of power, in this case a reduction to 20 percent of power to reclose lower inlet doors. (Tr. 6056-6057 and 6111-6112).

249. The ice condenser for the FNP will have substantially the same geometries, features, and materials of construction as those for land based plants (Applicant's Testimony, Page 1).

250. The FNP ice condenser is exposed to the same type of loading conditions as land based ice condensers. Additionally it is exposed to loads resulting from roll, pitch, and yaw which are transmitted to the ice condenser through plant structures. A load acting on an ice condenser component has an identical effect whether it is caused by roll, pitch, and yaw or by a seismic event. Maximum loads which may occur as a result of roll, pitch and yaw are significantly less than the loads for which adequacy was demonstrated during the static and dynamic structural testing of ice condenser components. (Applicant's Testimony, Page 2)

251. Dynamic tests under simulated seismic loadings showed ice fallout from ice baskets to be less than the allowable limit of one percent. As design basis wind and wave loadings on the FNP are about one-twentieth of the seismic loadings used in the test, it is

454 110

concluded that fallout during this condition will be also less then one percent. (Tr. 6023-6033).

252. To assure that the ice condenser installed on the FNP is able to perform its safety function, a monitoring program will be performed throughout plant life. This program will include weighing of ice baskets, visual inspection of doors and flow passages, testing of opening forces on doors, monitoring of temperatures at various locations within the ice condenser, and checking the chemical composition of the ice. There is also a monitoring system that provides indication that the door panels are all properly closed. This is very similar to the program at D. C. Cook. (PDR, Pages 6.2-117a(f) - 6.2-117c; Tr. 6055-6056).

253. Ice may be replenished in the ice condenser by either adding water of the proper chemical composition at a controlled rate and allowing it to freeze or by melting down the ice bed and completely refilling with fresh flake ice. Tests have shown that fresh flake ice fuses within five weeks of filling to a level which provides adequate retention for high "g" loadings. It is not necessary to partially melt the ice to ensure fusion. (Tr. 6047 and 6210-6211).

254. The Board concludes that the ice condenser containment system, which is being used on a total of fourteen domestic and foreign land based nuclear power plants, is not innovative for the FNP

454 112

and that adequate prelicensing testing has been performed which appropriately takes into account the effect of roll, pitch, and yaw.

K. CONTENTION XI - TURBINE-GENERATOR MATTERS

255. On June 15, 1976, Mr. Ernst J. Effenberger made a limited appearance statement before this Board concerning turbine-generator matters (Tr. 999-1010). The Board requested the Applicant and Staff to address the matters raised by Mr. Effenberger (Tr. 1011). Both Applicant and Staff presented evidence on these matters, including material contained in the Plant Design Report (PDR), the Safety Evaluation Report (SER), as supplemented, and written and oral testimony.[53] Intervenors Atlantic County Citizens Council on Environment (ACCCE) and Atlantic County Board of Chosen Freeholders (Atlantic County) presented written and oral testimony.[54]

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[53]The Applicant's written testimony, Exhibit OPS-38, entitled "Applicant's Testimony Regarding Turbine-Generator Matters," was admitted at Tr. 5095. The witnesses sponsoring this testimony were Drs. Dee H. Walker and Douglas H. Shaffer and Messrs. P. B. Haga, John F. Hanst, John D. Dickinson, Harold C. Kersteen, and Francis S. Maszk (Professional Qualifications admitted at Tr. 1024, 2881, 3419, 5091, 5093, and 5094). The Staff's written testimony entitled "NRC Staff Testimony in Response to Limited Appearance Statement of Ernst Effenberger," was admitted at Tr. 5659, 5660. The witnesses sponsoring this testimony were Drs. Kazimieras M. Campe and John A. O'Brien and Messrs. Ronald F. Naventi, Richard J. Kiessel, Stefan S. Pawlicki and Ralph A. Birkel (Professional Qualifications admitted at Tr. 5658, 2534, 5658, 1946, 5658, and 1038).

[54]The June 15, 1978 limited appearance statement of Mr. Ernst J. Effenberger was withdrawn (Tr. 4016 and 4033) and the written testimony of ACCCE, entitled "Comments on the Safety Evaluation Report, NUREG-75/100 (9/30/75), and Supplement, NUREG-0054 (3/16/76), by the Office of Nuclear Reactor Regulation United States Nuclear Regulatory Commission, Related to the Proposed Manufacturing

454 113

Hearing sessions with regard to the turbine-generator matters were held on December 8, 9, 10, 16 and 17, 1976, February 28, March 1, 2, 3, and 4, May 9, 10, 11, 12, 13 and 17, 1977 and the testimony appears generally at Transcript pages 4004-6001 and 6151-6172.[55]

256. In response to the Board's request at Tr. 5940 and 6377-6378, the Applicant provided additional information with respect to the preliminary design of the turbine-generator spring mounted support and vacuum balanced condenser and the effect of these two

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(Footnote 54 Cont'd)

of Floating Nuclear Power Plants, Offshore Power Systems, Docket No. STN 50-437, Safety Evaluation of Mechanical Equipment, Comments by Ernst J. Effenberger, a Concerned U.S. Citizen," dated June 1976, was admitted into evidence at Tr. 4069. Mr. Effenberger, on behalf of ACCCE, read into the record at Tr. 4021-4026 additional direct testimony. (The Professional Qualifications of Mr. Effenberger were admitted at Tr. 4021.) Atlantic County's written testimony entitled "Testimony of Intervenor Atlantic County in Respect to Turbine-Generator Design & Turbine Missiles," by Dr. George Luchak was admitted at Tr. 4343. (The Professional Qualifications of Dr. Luchak were admitted at Tr. 4336.) Dr. Luchak testified that he was an expert in the areas of systems engineering, applied probability, reliability and cost effectiveness studies (Tr. 5046). Dr. Luchak testified that he is not an expert in the areas of turbine design, turbine supports, valve systems, fracture mechanics, materials, stress corrosion, instrumentation and controls, bearing design, or the design of concrete structures; nor has Dr. Luchak ever designed a structure for dynamic loads or missile impact (Tr. 4398-4412 and Tr. 4763, 4764). Atlantic County's written testimony entitled "Testimony of Intervenor Atlantic County in Respect to Turbine-Generator Design & Turbine Missiles" by Daryl F. Todd, Atlantic County Freeholder, was withdrawn and not offered into evidence (Tr. 5081, 5082).

[55] Applicant witnesses were examined by counsel for Atlantic County, State of New Jersey, ACCCE, NRC Staff, and by the Board. Staff witnesses were examined by counsel for Atlantic County, State of New Jersey, ACCCE and by the Board. ACCCE witness Mr. Effenberger was examined by counsel for Atlantic County, NRC Staff, State of New Jersey, Applicant, and by the Board. Atlantic County witness, Dr. Luchak, was examined by counsel for State of New Jersey, ACCCE, City of Brigantine, NRC Staff, Applicant, and by the Board.

454 114

components on the probability of turbine missile generation.[56] Also in response to the Board's request, and as further clarified in the Board Order of February 28, 1978, the Staff provided an evaluation of the effect of the preliminary design of the turbine-generator support and condenser on the probability of turbine missile generation.[57]

257. The Staff submitted on November 21, 1977, the "Affidavit of John A. O'Brien," which provided two amendments to the oral testimony which Dr. O'Brien gave at the May 13, 1977, hearing session.

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[56] On August 15, 1977, Applicant submitted three affidavits entitled "Preliminary Design of the Floating Nuclear Plant Turbine-Generator Support and Discussion of the Effect of the Preliminary Design of the Turbine-Generator Support and Vacuum Balanced Condenser on the Probability of Missile Generation," "Preliminary Design (Proprietary) of the Floating Nuclear Plant Vacuum Balanced Condenser," and "Preliminary Design (Non-proprietary) of the Floating Nuclear Plant Vacuum Balanced Condenser," each by P. Blair Haga, Richard S. Orr, and Dee H. Walker, and each dated August 12, 1978. These affidavits are hereinafter referred to as "Applicant's Affidavit I, II, or III," respectively. (Professional Qualifications of Richard S. Orr were admitted at Tr. 1329). The Applicant had previously supplied to the Staff a brief description of the spring mounted FNP turbine support and an indication that a condenser was being designed to minimize the vacuum load on the support. This information is contained in Applicant's Exhibit OPS-106, a letter (with attachment) from OPS to the NRC dated September 8, 1976, admitted at Tr. 5641. Exhibit OPS-106 also contains other informati n concerning the FNP turbine.

[57] On March 10, 1978, the Staff submitted a document entitled "Affidavit of Richard J. Kiessel," hereinafter referred to as the "Kiessel Affidavit."

454 115

258. The design and supply of the FNP turbine-generator is performed by the Westinghouse Electric Corporation, a supplier of turbine-generators to industry for over 75 years (Applicant's Testimony, Page 2).

Turbine Rotor Deflection

259. Mr. Effenberger made the following allegations relating to rotor stresses due to platform deflection:

> "A standard land based T-G rotor is well over designed. The rotor stresses are in the range of 8 to 10 times the safety factor, because the bearing diameter usually dictates the other dimensions of the rotor. The manufacturer of the FNP turbine assumes a ± 1/2 inch deflection allowance in the operation of the turbine rotors. This in turn will increase the bending stresses in the rotor to an extent where the safety factors in certain areas will be reduced to less than two, which will increase the probability of a rotor failure in the same ratio." (Effenberger's Testimony, Page 3).
>
> * * *
>
> "Reducing the stress safety factors in the shaft from 8-10 down to below 2 is increasing the possibility of a shaft failure and a missile generation." (Effenberger's Testimony, Page 8).

260. A Westinghouse criterion for rotor design, whether the rotor is for a land-based plant or an FNP, is that the stress safety factor will be no less than 2. Based upon long Westinghouse experience with land-based plants and marine propulsion turbines, the stress safety factor of 2 or greater is good engineering practice. Analyses conducted demonstrate that the final design of the FNP turbine rotor

454 116

will meet this criterion, even with turbine-generator foundation deflections of ± 1/2 inch. (Applicant's Testimony, Pages 3 and 4, Tr. 5429 and Applicant's Affidavit I, Pages 45, 46, and 48.) The FNP turbine-rotor meets this criterion, even without the benefit of the vacuum balanced condenser (Tr. 5430 and 5441). The analysis of the FNP turbine rotor conservatively assumed the ± 1/2 inch deflection was imposed on every revolution of the rotor,[58] even though such a deflection is an extreme condition that will seldom occur, if at all (Tr. 5616, 5617, 5931 and 5932).

261. Westinghouse Steam Turbine Division analyses of rotors for land-based turbine generator units similar in design to that of the FNP show that, while there are locations where the ratio of allowable[59] to actual stress is in the range of 8 to 10, there are also locations where the ratio of allowable to actual stress is in the range of 2 to 3 (Applicant's Testimony, Page 3, and Applicant's Affidavit I, Pages 46 and 48). The stress safety factors for the FNP turbine rotor on a spring support and with a vacuum balanced condenser

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[58] The terms "shaft" and "rotor" appear to have been used interchangeably in several portions of the transcript; accordingly, the Board makes no distinction between the two terms.

[59] The allowable stress is the endurance strength of the material which is about 50% of the ultimate strength for the FNP rotor material (Tr. 5628 and 5629).

454 118

are similar to the stress safety factors for a land-based turbine rotor on a typical reinforced concrete support and with a typical condenser (Applicant's Affidavit I, Pages 46 and 48).

262. Utilization of a vacuum balanced condenser reduces the vacuum load and the deflection of the FNP rotor. Also, the FNP rotor will be aligned so that the turbine-generator foundation deflections, given in Section 10.2.4 of the PDR, will cause rotor deflections of equal magnitude in the upward and downward directions, thereby minimizing the effect of these deflections. (Applicant's Testimony, Page 4, and Applicant's Affidavit I, Page 46).

263. The spring mounted turbine support serves to attenuate local platform deflections, an advantage for which no credit was taken in the analysis discussed in the preceeding Paragraph 261 (Applicant's Affidavit I, Pages 11 and 47).

Previous Experience With Rotor Deflections

264. Mr. Effenberger made the following allegations relating to previous experience with rotor deflections:

> "There is no comparison between a land based T-G and a floating T-G. A land based unit is erected and operated on its natural 'sagging line.' The slightest deviation from this line will cause an unrest of the rotor which will show up in excess vibration until the misalignment is corrected. Every T-G in the world operates that way. No other situation is known." (Effenberger's Testimony, Page 2).

454 118

* * *

"As discussed earlier, the smooth operation of a turbine shaft depends on an exact alignment of the whole turbine. Any deviation, experience shows about 15 mils, will induce excessive vibration and therefore increase the possibility of a rotor failure." (Effenberger's Testimony, Page 6).

* * *

"Operating experience has shown all over the world that any deviation from the calculated 'sagging line' will cause excessive vibration. No turbine in the whole world is known to operate under any other condition." (Effenberger's Testimony, Page 6).

* * *

"Bending the shaft during operation is against any experience in history and totally unproven." (Effenberger's Testimony, Page 7).

265. In the following statement, Mr. Effenberger appears to contradict the above allegations:

"Going back to the proposed $\pm$ 1/2 inch deflection of the turbine shaft, history has shown that it is possible to force a rotor to operate away from the natural 'sagging line'. This is strictly a stress problem in the rotor coupling and the shaft ends. Increasing the coupling size and the coupling bolts usually takes care of this condition. The specific bearing pressure will also increase, and this dictates a larger bearing. These changes create no problem since the operation under this arrangement is the same as in any other design. In other words, a turbine rotor can be designed to operate at any different point or line as long as the rotor stresses are being taken care of." (Effenberger's Testimony, Page 6).

266. During cross examination by counsel for the State of New Jersey, Mr. Effenberger clarified his concern as being related to the movement (or flexing) of the rotor across the natural "sagging line"

454 119

rather than the operation of the rotor at some constant deviation from the "sagging line" (Tr. 4082 and 4083).

267. Intervenor witness Dr. Luchak agreed with Mr. Effenberger's comments on the bending of the turbine shaft during operation, changes in bearing pressures, and the effects of hull vibrations on rotor strain, all in the context of the high-tuned mount (Luchak's Testimony, Page 5, as interpreted at Tr. 4648 and 4649, and Page 6, as modified at Tr. 4333). As acknowledged by Dr. Luchak (at Tr. 4649), the FNP turbine foundation is a low-tuned mount, not a high-tuned mount (PDR Section 3.7.2.1.1.8). The Board notes that Dr. Luchak indicated that he would wish to reconsider these opinions with respect to the proposed (low-tuned) FNP turbine foundation design (Tr. 4649). The Board therefore finds the preceding opinions of Dr. Luchak are not relevant to the FNP design under consideration in this proceeding.

268. It is normal for turbine-generators to operate away from the natural "sagging line," including movement back and forth across the "sagging line" (Applicant's Testimony, Page 5, Tr. 5195, 5443, and 5446). Such deflections do not cause any problems unless they become excessive (Applicant's Testimony, Page 5). Based on previous experience and analyses, the deflections of the FNP turbine-generator will not result in unacceptable vibration (Applicant's Testimony, Page 5).[60]

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[60] Refer to the section on Bearings (Paragraphs 276 through 280, infra) for additional information respecting the effect of rotor deflection on bearing oil pressure and vibration.

454

120

Rotor Stresses and Plant Motion

269. Mr. Effenberger made the following allegation relating to rotor stresses induced as a result of plant motion:

> "The increase in disc stresses due to plant motions are discussed, but what about rotor stresses? Since the plant motions are not kept away from the turbine shaft, the rotor will go through its own cyclic stresses, plus all the plant motions.
>
> "To illustrate the plant motions, a wave motion period of 20 seconds is assumed. Over a forty year life span, the rotor will experience over 60 million additional stress cycles. This fact is totally ignored." (Effenberger's Testimony, Page 4).

270. The effect of plant motion on rotor stresses is considered in the analyses of the turbine-generator as discussed in PDR Section 10.2.4. These stresses were included in the Applicant's analyses discussed in the previous section on <u>Turbine Rotor Deflections</u>. The Applicant's calculations show that platform motions contribute a maximum of about 17 percent of the total cyclic stress in the rotor, and at most locations the percentage is much lower. In these calculations, the Applicant conservatively assumed that the rotor is continuously exposed to the maximum plant motion rather than a range of lesser plant motions that would actually be present. The Applicant also conservatively assumed that this maximum motion stress level is applied for each revolution of the rotor, whereas the actual stress would cycle less frequently as the plant moves through its motion cycle. The net result of these assumptions is that more than

454 121

30 billion cycles of the maximum motion stress level are imposed on the rotor in the Applicant's analysis, compared to the 60 million cycles mentioned by Mr. Effenberger. (Applicant's Testimony, Page 6). Accordingly, the Board finds that the effects of plant motion on rotor stresses were not ignored, and in fact the Applicant has conservatively considered such effects.

Rotor Stresses and Hull Vibrations

271. Mr. Effenberger made the following allegation relating to rotor stresses and hull vibrations:

> "Hull vibrations will add to rotor strains and stresses and increase rotor failures and therefore missile generations." (Effenberger's Testimony, Page 8).

272. The design of the FNP provides for isolation between the turbine and the hull, as discussed in PDR Section 3.7.2.1.1.8. Accordingly, the effect of hull vibrations on rotor stress or strain levels and on the possibility of missile generation will be negligible. (Applicant's Testimony, Page 7, and Applicant's Affidavit I, Pages 16 through 19).

273. The Applicant has conducted analyses to determine the dynamic response of the turbine-generator and support system to an unbalanced rotating mass. Analyses were performed for the turbine-generator on the FNP (spring mounted) support as well as for the

454 122

turbine-generator on a typical reinforced concrete support. These analyses demonstrate that the dynamic response of the turbine-generator is not adversely affected by the spring mounted support. Therefore, the dynamic behavior of the turbine support will not add to the probability of turbine missile generation. (Applicant's Affidavit I, Pages 12 through 16 and 47).

Condenser Vacuum Load

274. Mr. Effenberger made the following allegation relating to condenser vacuum loads:

> "It is impossible to compensate life (sic) loads such as vacuum loads by selective alignment. In a conventional design the condenser is fixed, the turbine is on the foundation and between the turbine and condenser is a flexible expansion joint. The full vacuum load is on the turbine. The only way to eliminate the vacuum load is to mount the condenser on springs and eliminate the expansion joint. This arrangement works on a land based plant, not on a floating nuclear power plant, because there is no way to restrain the hanging condenser, which is also exposed to the platform motions." (Effenberger's Testimony, Page 7).

275. As stated previously, a vacuum balanced condenser will be utilized on the FNP to reduce the vacuum load on the turbine-generator. The FNP design does not involve mounting the condenser on springs or eliminating the expansion joint. (It is noted that there has been wide use in the power industry of vacuum balanced condensers including many which do not involve spring mounting or elimination of the expansion joint.) Thus, contrary to Mr. Effenberger's allegation,

454 123

it is possible to compensate for vacuum load on the FNP turbine-generator.[61] (Applicant's Testimony, Page 8, Applicant's Affidavit II, and Tr. 5636).

Bearings

276. Mr. Effenberger made the following allegations relating to the FNP turbine rotor bearings:

> "Changing the bearing pressure during operation will induce vibration and increase the possibility of a shaft failure and missile generation." (Effenberger's Testimony, Page 8).
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> * * *
>
> "The journal bearings of a turbine rotor are very precise. The weight of the rotor dictates the size of the bearing, the thickness of the oil film and the oil pressure. The gap between the bearing and the shaft is filled with oil and well defined. If this gap is too large, the phenomena of an oil whip shows up. If the gap is too small, then the oil will be over-heated and the babbit in the bearing melts. The limitations between these two conditions are very small.
>
> "Any bending of a turbine shaft during operation will change the gap in the bearing, will change the bearing pressure and will cause all the conditions as discussed above." (Effenberger's Testimony, Pages 6 and 7).

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[61] The Board notes that Mr. Effenberger himself submitted to the Applicant in late 1975 an invention disclosure for a condenser joint design that would reduce the vacuum load on the FNP turbine-generator. Mr. Effenberger's proposed design did not involve elimination of the expansion joint or mounting of the condenser on springs. The design proposed by Mr. Effenberger was not selected for use on the FNP because other proposed designs were superior. (Applicant's Testimony, Pages 7 and 8, Applicant's Affidavit II, Page 4, and Tr. 4091).

454 124

277. As indicated in PDR Section 10.2.4, the FNP turbine rotor bearing pressures have been evaluated under FNP loading conditions, and the results indicate that the final design will meet the Westinghouse design criteria applicable to all turbine-generators. Such evaluations included consideration of potential for oil whip and bearing overload. (Applicant's Testimony, Page 9).

278. Oil whip is a vibration of the rotor in a sleeve bearing that is caused by instability of the oil film. It has been studied intensively and is well understood. The potential for oil whip is governed by combinations of such parameters as bearing pressure, rotational speed, oil viscosity, bearing clearance and system flexibility. Analyses of the FNP bearings under the range of FNP bearing pressures indicate that oil whip will not occur. Additionally, Westinghouse experience shows that oil whip is unheard of on 1800 RPM rotors such as that on the FNP. If oil whip were to occur, it would be detected by the vibration sensors that will be on the FNP unit, and the unit could be safely shut down for corrective action without an increase in the probability of missile generation. (Applicant's Testimony, Page 9).

279. Design criteria for determining the maximum pressures under which bearings can operate successfully have been established through experiments conducted by Westinghouse and others and through many years of operating experience with Westinghouse turbines. Analyses of the FNP bearings under the expected range of FNP bearing

pressures indicate that sufficient oil film will exist to carry the load. The FNP will contain redundant temperature sensors that will show if a bearing is overloaded (and hence overheated) so that corrective action can be taken, thus preventing melting of the babbitt due to excessive temperatures. The temperature alarm point is 210°F and the established trip limit is 225°F, which is well below the melting point of the bearing babbit (approximately 450°F). If the babbitt in a bearing were to melt, subsequent to the turbine being tripped, the resulting friction forces created between rotating and stationary parts would cause rapid deceleration of the turbine-generator from operating speed with no effect on the probability of missile generation. (Applicant's Testimony, Pages 9 and 10, and Tr. 5456).

280. Westinghouse field service experience has shown that land-based turbine designs similar to the FNP, which have met the above bearing design criteria, have not experienced "excessive vibrations". It is therefore concluded that the FNP turbine-generator will not experience, as a result of bearing pressure induced vibration, any greater potential for missile generation than a similar land-based turbine-generator. (Applicant's Testimony, Page 10).

Shippingport Failure

281. Mr. Effenberger made the following allegation relating to turbine-generator materials:

454 126

> "The T-G manufacturer claims that no T-G failure in his design has occurred. I would like to point out that Shippingport, a nuclear power plant, failed at operating speed last year, not at design or destructive overspeed; it just fell apart after sixteen years of normal operation. Obviously the integrity of the material is only good for a limited time, definitely not for forty years as this FNP is planned to operate." (Effenberger's Testimony, Pages 4 and 5).

282. In February, 1974, after 16 years service, the Shippingport turbine of Duquesne Light Company experienced a disc failure at the second LP disc. No missiles external to the turbine casing were generated by this incident. (Applicant's Testimony, Page 10). Other turbines with design features similar to the Shippingport turbine have been in operation for more than 40 years. (Applicant's Testimony, Page 11).

283. Metallurgical examination of the failed Shippingport disc revealed that the fracture originated at cracks in the corner of the keyway near the exhaust face of the disc. These cracks formed and slowly propagated during the 16 years of operation, and failure occurred when the cracks enlarged to critical flaw size. Modern disc materials used for the FNP turbine exhibit more than twice the toughness of the material used for the Shippingport turbine. In addition, design changes which have occurred since about 1958 limit the stresses and the likelihood of crack formation. (Applicant's Testimony, Page 11, and Staff's Testimony, Page 30). The Board therefore finds there is no reason to expect the FNP turbine to

454 127

experience a "Shippingport-type" disc failure during its forty year design life.

Overspeed Protection Systems

284. Mr. Effenberger made the following allegations relating to the overspeed protection systems for the FNP turbine-generator:

> "Three overspeed protective systems are provided in this design, but all systems act finally on the same valve spindle, so no matter how many systems are installed for overspeed protection, if the one valve gets stuck then there is little protection and the reasoning for having three systems is not valid.
>
> "The trip systems are part hydraulic and part mechanical. This means that the valves are spring loaded and the springs are kept open by hydraulic pressure. On impulse, the fluid is dumped and the springs are closing the valves. Two systems have the same drain line and any bending or plug-up of this line will make the main steam valves inoperable." (Effenberger's Testimony, Pages 3 and 4).
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> * * *
>
> "All three emergency trip systems depend finally on the reliability of a single valve as shown earlier. Is this really enough?" (Effenberger's Testimony, Page 5).
>
> * * *
>
> "The overspeed protective trip systems are acting on the same valve spindle and therefore not reducing the overspeed possibility. Two of the three emergency trip systems have the same dump lines. Any damage or plug-up of this line will increase the possibility of an overspeed condition and therefore missile generation." (Effenberger's Testimony, Page 8).

454 128

285. The three overspeed protection systems for the FNP turbine are described in PDR Section 10.2.2.4, pages 10.2 - 6b, 6c, and 6d. The three systems are designated Electrical, Mechanical and SCOTS (Single Channel Overspeed Trip System). In response to a Board request at Tr. 4181 and 4315, additional description of the overspeed protection systems was provided in Applicant's Exhibit OPS-104 (admitted at Tr. 5106) and in the testimony of Applicant's witness at Tr. 5107 - 5114.

286. The Staff has received a preliminary design of the FNP turbine overspeed protection system (Tr. 5892). The improvements in the FNP overspeed protection system (the double drain trip block and SCOTS) are not innovative, new or unusual (Tr. 5893 and 5898). The SCOTS system has been previously utilized on land-based nuclear plants (Tr. 5893 and 5894). The overspeed protection system will conform to the requirements of IEEE-279, 1971.[62] Conformance with this standard, specifically with the equipment qualification and periodic testing requirements, should result in an enhanced reliability of the overspeed protection system. (SER Section 7.6.1 and Tr. 5928 through 5931).

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[62] Institute of Electrical and Electronic Engineers Standard 279, 1971, "Criteria for Protection Systems for Nuclear Power Generating Stations" (Tr. 5929). As noted in SER Section 7.6.1, the Staff requires that the overspeed protection system conform to IEEE-279, 1971, except as follows:

454 129

287. All three overspeed protection systems do not depend finally on the functioning of a single valve. In accordance with standard American power industry practice of many years standing, the FNP turbine will be furnished with redundant valve systems for the main steam piping (throttle and governor valves) and redundant valve systems for the reheat piping (reheat stop and interceptor valves). In each steam flow path into the turbine there are two valves in series to protect the turbine against overspeed. These valves are held open against a spring force by fluid pressure. Stainless steel tubes are used to carry the trip fluid. A loss of fluid pressure will cause the valve to close. Blockage of any one drain line will not prevent valve closure. (Applicant's Testimony, Page 12).

(Footnote 62 Cont'd)

> "(a) Section 4.4 of IEEE Std 279-1971 (Equipment Qualification). The equipment of the turbine overspeed protection system shall meet the environmental qualification requirements (including vibration) under all conditions of normal, abnormal, and accident conditions, but excluding seismic qualification. (b) Section 4.17 (Manual Initiation). Manual initiation at the system level in the control room for the turbine overspeed protection system is not required. However, industry practice which provides for a means for manual trip locally at the turbine should be followed." (SER Section 7.6.1).

With respect to item (a), the Staff required

> "The turbine overspeed protection system should be designed and installed (equipment quality, mounting, routing and supporting of associated circuitry and piping) such as to provide a high degree of assurance that it will retain its functional capability during and after earthquake." (SER Section 7.6.1).

454 130

288. In response to a hypothetical question by Applicant's counsel, Mr. Effenberger agreed that, if there are three separate drains for the emergency trip fluid, if there is a separate line for the emergency trip fluid from each dump valve, and if there is a third fully independent auxiliary overspeed protection system known as SCOTS, he no longer would believe that two overspeed protection systems have the same drain line and any bending or plugging of any single line will make the main steam valves inoperable (Tr. 4197 through 4200). The hypothetical question is shown to be based on factual information in the PDR Section 10.2.2.4 (Pages 10.2-6b, 6c, and 6d), Applicant's Exhibit OPS-104 and the oral testimony of the Applicant's witness at Tr. 5107 through 5114.

289. During cross examination, Mr. Effenberger agreed that if one valve fails to function and the other nineteen valves operate, there is still protection from turbine overspeed (Tr. 4210).

290. The Board concludes that failure of any one valve or any one trip fluid line will not prevent tripping of the turbine.

Plant Motion and Valves

291. Mr. Effenberger made the following allegation relating to the effect of plant motion on the steam valves:

454 130

"It has not been investigated what the platform motion could do to a valve spindle clearance. The steam chest which houses the main steam valves is also exposed to the paltform (sic) motions." (Effenberger's Testimony, Page 5).

292. Mr. Effenberger's statement appears to imply that a reduction in main steam valve spindle clearance, due to the forces imposed on the main steam valves by plant motions, may prevent the main steam valves from closing. The main steam valves and steam chest have been analyzed and found to be acceptable for accelerations about ten times the values of acceleration that may be experienced due to plant motion. It is therefore concluded that platform motions will not prevent the main steam valves from closing. (Applicant's Testimony, Page 13).

Valve Testing

293. Mr. Effenberger made the following allegations relating to valve testing:

"Turbine main steam valve stems build up deposits no matter how the feedwater is treated. Practice has shown that even valve testing is not practical because the schedule is never kept by the operator. Only those who have worked in and maintained a power plant know that. If every stuck valve would be reported by the utility industry, the insurance rates would go up to the extent that we would have no power stations in operation." (Effenberger's Testimony, Page 4).

* * *

"Every valve testing makes it necessary to reduce the load of the turbine to the point where the valve can be taken out of service to close. Having twenty main steam valves and numerous non-return valves on a 1200 Megawatt Unit, the

time element involved will be such that the unit will never get above 75 - 30% of full load. This means that the utility owner will resist, and if necessary will come up with his own schedule for valve testing. This will further increase the probability of a valve failure and create a potential possibility for any overspeed condition." (Effenberger's Testimony, Page 5).

294. Valve failures cannot result in unacceptable overspeed excursions unless at least two valves in series in the same steam flow path into the turbine fail to close simultaneously when there is a demand to close (see Paragraph 287, supra). Fr the reasons discussed in PDR Section 3.5.4.4.2, it is unlikely that one valve, let alone two valves in series, will fail. Design features such as spiral grooves in throttle and governor valve stems, backseating of the stems and substantial closing force are provided to minimize the possibility that valves will stick open. (PDR Section 3.5.4.4.2, Applicant's Testimony, Page 14, and Staff's Testimony, Page 16). All-volatile treatment of the feedwater, which is provided in the FNP design, will reduce the particulate content of the steam passing through the valves. This particulate material is the cause of buildup on the valve stems and possible sticking. (PDR Section 10.3.5 and Staff's Testimony, Page 16).

295. The Commission will require an owner of an FNP to include in its Technical Specifications the valve testing and in-service inspection program outlined in PDR Section 10.2.6 (Staff's Testimony, Page 13).

454 133

296. The time required to test the FNP turbine valves amounts to a few minutes per valve, or approximately one hour per week for all turbine valves (Applicant's Testimony, Page 14, and Tr. 5116-5119). Maximum load reduction during test of any valve occurs when testing governor valves and is approximately 10 percent of full load when the turbine is operating at full power (Applicant's Testimony, Page 14). It is not necessary to reduce load on the FNP turbine prior to testing the turbine valves (Tr. 5137). When testing is done at less than full load, the turbine control system acts automatically to maintain load at a constant level. Interference with normal operation of the turbine is usually minimized by scheduling valve tests at off peak hours and by staggering the tests of the various groups of valves over a one week period (the period recommended between valve tests). (Applicant's Testimony, Page 14).

297. Testing of conventional nonreturn valves in the extraction pipes between the turbine and feedwater heaters and in the drain lines between the moisture separator-reheater and feedwater heaters will not cause a significant load change (Applicant's Testimony, Page 15).

298. Dr. Luchak testified that it is reasonable to assume turbine valve testing on the FNP will reduce the FNP capacity factor by five percent. (Luchak's Testimony, Page 10). Dr. Luchak's estimated reduction is based on his observation that such a reduction is within the standard deviation of capacity factors he observed on land-based

454 134

plants and that such a reduction would, therefore, not be unusual (Tr. 4372 and 4373). Dr. Luchak performed further calculations based on two issues of the Commission "green book"[63] which additionally convinced him that a reduction in capacity factor of five percent is possible due to valve testing on the FNP (Tr. 5028 through 5030 and Tr. 5034). The Applicant reviewed the two issues of the Commission "green book" to which Dr. Luchak referred at Tr. 5029 and 5030. These two issues listed only two Westinghouse turbines that have valves functionally the same as the FNP turbine, and only one of these two turbines had a valve test. That one turbine has a restriction which requires that load be reduced to at least 75% during valve testing. Since the FNP has no such restriction, the information on this one turbine is not applicable to the FNP. (Tr. 5597 and 5598).

299. Utilizing Mr. Effenberger's estimates of valve test times (which are about 6 times higher than the times stated by the Applicant) and Mr. Effenberger's estimate of power reduction (25% vs. Applicant's maximum of 10%), the Staff calculated that weekly valve testing on the FNP might reduce the capacity factor by about one-half of one percent. (Tr. 5982, 5983, 5989, and 5990).

[63]"Operating Units Status Report, Licensed Operating Reactors, Data for Decisions," Nuclear Regulatory Commission, November and December, 1975.

454 135

300. The Board finds that Dr. Luchak's estimate of capacity factor reduction due to valve testing on the FNP is not supported by the facts. The available information indicates that weekly valve testing on the FNP will not have a significant impact on the plant load or capacity factor.

Turbine Missiles

301. Mr. Effenberger made the following allegations relating to turbine missiles and applicable regulatory probability criteria:

> "NRC, Bush Report 4/7-1973, Probability of T-G Missiles. This report does collect data on a worldwide basis of T-G failures. Not a single floating T-G is included, just information on land based units. Therefore, this report is totally unacceptable for an evaluation." (Effenberger's Testimony, Page 2).
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> "The conclusion in the Bush Report shows that a probable failure of a T-G is in the range of 10^{-4}. To be on the safe side, the NRC assumed a 10^{-7} failure rate on new land based nuclear power plants is sufficient to guarantee the safety of the public. Ignoring the fact that the operation and environmental conditions of a floating nuclear power plant is totally different from land based plants, this requirement was also imposed on the FNP. The FNP was and is evaluated as any other land based power plant and this is wrong and dangerous, because the probability of a T-G failure on the FNP is greater than on a land based plant." (Effenberger's Testimony, Pages 2 and 3).
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> "Missile generation depends on the reliability of failsafe equipment, like an overspeed protective trip system, reliability of valve system, rotor failures - material

454 136

integrity, disc failures - material integrity, valve testing, just to mention a few. The orientation of the T-G in a power plant should be decided considering all the above conditions." (Effenberger's Testimony, Page 3).

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"The NRC in its wisdom decided in a last year's ruling to locate the main T-G radial to the containment in any future nuclear power plants. The main reason was the probability of turbine missiles hitting the containment and all the shortcomings discussed earlier. The rest of the world has done this for many years, and this makes sense. A special exception was made for Offshore Power Systems. Why? Since the probabilities of turbine failures on a FNP are greater than on land based plants, it is an absolute necessity, for our protection, to relocate the most dangerous equipment and largest missile producer, so as to reduce the probability of missiles." (Effenberger's Testimony, Pages 5 and 6).

* * *

"If the T-G should go on the destructive overspeed then the largest piece ejecting the turbine casing will have a kinetic energy of 32 million ft. lbs. There is nothing on the present FNP which could contain or stop these missiles which in turn would penetrate all the structures, the shield building, the containment and the reactor vessel itself and in addition would puncture the hull and sink the plant. What happens then, I will leave to your imagination." (Effenberger's Testimony, Page 1).

302. Based on the discussion in the preceding paragraphs, the Board finds that Mr. Effenberger's allegations regarding turbine rotor deflection, previous experience with rotor deflections, rotor stresses and plant motion, rotor stresses and hull vibrations, condenser vacuum load, bearings, the Shippingport failure, overspeed protection systems, plant motion and valves, and valve testing are not supported by the evidence. Therefore, there is no basis for expecting that the probability of a turbine-missile-producing event is significantly different for land-based nuclear plants and FNPs.

454 137

303. The guideline employed by the Staff in determining whether a postulated event needs to be a design basis event (for which specific additional protection is provided) are those events for which a realistic estimate of the probability of occurrence is greater than the order of 10^{-7}/year and which could lead to potential consequences in excess of 10 CFR Part 100 exposure guidelines. (See Standard Review Plan 2.2.3). Stated another way, turbine missile protection is deemed to be adequate if the probability for unacceptable consequences (consequences in excess of 10 CFR 100 exposure guidelines) is found to be of the order of 10^{-6}/year for conservative evaluations, or of the order of 10^{-7}/year for realistic evaluations. These criteria, utilized in determining whether or not an event needs to be considered a design basis event or whether protection is adequate, are not dependent upon whether the plant is land-based or floating. (Applicant's Testimony, Pages 16 and 17, Staff's Testimony, Pages 2, 10 and 11, and Tr. 5869 through 5872).

304. The FNP has an offset turbine orientation. In response to a Board request at Tr. 4314 and 4315, the Applicant provided in Exhibit OPS-103 an example of the barriers that intervene between the turbine and safety related equipment.[64] Specifically, Exhibit OPS-103

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[64] Applicant's Exhibit OPS-103, admitted at Tr. 5121, consists of three sheets entitled, respectively, "Identification of Section Cuts," "Simplified Drawing Showing Significant Structures Between the Turbine and the Reactor Vessel," and "Simplified Drawing Showing Significant Structures Between the Turbine and Safeguards Area No. 2." Applicant's Exhibit OPS-102, marked for identification at Tr. 4813, was not offered into evidence because Exhibit OPS-103, Sheet 1, provided the same information concerning the FNP turbine orientation vis-a-vis the containment (Tr. 5122 through 5124).

illustrates the material and material thicknesses for barriers that intervene between the turbine and the reactor vessel and the turbine and Safeguards Area No. 2. (Applicant's Exhibit OPS-103 and Staff's Testimony, Page 1).

305. The Applicant evaluated design overspeed turbine missile. This evaluation assumed the probability of generation of a turbine missile at design overspeed is 1×10^{-4} per year, based on a review of the Bush report.[65] (PDR Section 3.5.4.3 and Applicant's Testimony, Page 17). Materials, manufacturing techniques and inspection techniques have all substantially improved relative to those associated with the turbines included in the data base for the Bush report[66] (PDR Section 3.5.4.3 and Applicant's Testimony, Page 18). As an example, the FNP turbine must meet the design, material toughness, and quality assurance provisions of Standard Review Plan 10.2.3, "Turbine Disk Integrity" (Staff's Testimony, Page 30). The Board therefore concludes that the 10^{-4} per year value for the probability of turbine missile generation at design overspeed is conservatively high when applied to the FNP.

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[65] Bush, S. H., Probability of Damage to Nuclear Components to Turbine Failure," Nuclear Safety, Vol. 14, No. 3, May-June, 1973.

[66] The data base in the Bush report includes 70,000 turbine years of operation from turbines manufactured from the early to mid 1900's to approximately 1970 (PDR Section 3.5.4.3 and Applicant's Testimony, Page 18).

306. Considering both high and low trajectory design overspeed turbine missiles, the Applicant computed the probability of a missile, once generated, striking an essential safety system to be on the order of 10^{-3}. This gives an overall probability (the product of 10^{-4} and 10^{-3}), at design overspeed, of generating a missile that strikes an essential safety system on the order of 10^{-7} per year. (PDR Section 3.5.4.3.3 and Applicant's Testimony, Page 17).

Design Overspeed Turbine Missile Evaluation

307. The lower half of each low-pressure turbine on the FNP contains a 4-1/2 inch thick steel missile shield extending the entire bladed length of the rotor (Applicant's Exhibit OPS-103, Sheets 2 and 3, PDR Sections 3.5.4.3.4.2 and 10.2.2.5, and PDR Figure 10.2-1B). The Applicant concludes, based on calculations using the Hagg-Sankey formula (Tr. 5602, 5270, PDR Sections 3.5.8.2.1), that a design overspeed turbine missile cannot perforate the missile shield (Tr. 5128, 5702). The Staff's conclusion was based on application of the BRL formula to the turbine internals and casing. The Staff later advised the Board by letter dated December 15, 1978 that subsequent tests, which do not exactly simulate the real situation for the FNP, have led the Staff to conclude that their use of the BRL formula is not supported by the limited data available and the effectiveness of the 4-1/2 inch turbine missile shield now requires further evaluation. The Staff also concluded that the FNP is adequately protected by the 4-1/2 inch thick steel missile shield against design overspeed turbine

454 140

missiles ejected below the turbine floor (or centerline). The Board finds that a missile shield can and will be provided to effectively protect vital targets and the hull bottom from design overspeed missiles ejected below the turbine centerline (PDR Sections 3.5.4.3.3.3 and 3.5.4.3.4.2 and Staff's Testimony, Page 34).

308. The Staff also evaluated design overspeed turbine missiles (SER Section 3.5.3, Staff's Testimony, Pages 1, 2, and 34 and Kiessel Affidavit). The Board previously has considered protection against design overspeed turbine missiles ejected below the turbine floor (or centerline). For targets above the turbine floor, the Staff concluded that the strike and damage probabilities for design overspeed missiles are less than the strike and damage probabilities for destructive overspeed missiles, the Staff evaluation of which is discussed in Paragraphs 311 and 312, infra. (Staff's Testimony, Page 34).

309. The Board finds that the probability, at design overspeed, of generating a turbine missile that strikes an essential safety system is sufficentlly small to meet the Staff criteria, and that the FNP design with respect to this matter is adequate to protect the public health and safety.

Destructive Overspeed Turbine Missile Evaluation

310. The Applicant evaluated destructive overspeed turbine missile. This evaluation consists of a fault tree analysis of the FNP

454 140

turbine control and overspeed protection system that was used to evaluate the probability of reaching destructive overspeed. Improvements in and increased redundancy of the FNP turbine overspeed protection systems, relative to those associated with the machines included in the data base for the Bush report were considered in the Applicant's fault tree analysis and reduced the probability of destructive overspeed. As discussed in Paragraph 294, supra, the FNP turbine valves incorporate design changes to improve their reliability. The probability of reaching destructive overspeed was calculated by the Applicant to be on the order of 10^{-7}/year for the FNP.[67] Since the probability of even reaching destructive overspeed is on the order of 10^{-7}/year, the Applicant, in accordance with the Staff criteria, has excluded destructive overspeed from the FNP design basis. (PDR Sections 3.5.4 and 3.5.4.4 and Applicant's Testimony, Pages 17 and 18.)

311. The Staff also evaluated destructive overspeed turbine missiles (Staff's Testimony, Pages 1 through 11, and SER Section 3.5.3). Unlike the Applicant, the Staff did not eliminate destructive overspeed from the design basis solely on the grounds of a sufficiently low probability of reaching destructive overspeed. Rather, the Staff utilized a destructive overspeed probability of 4 X 10^{-5}/year for a conservative case and 4 X 10^{-6}/year for a realistic case. The

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[67] The actual value calculated by the Applicant as the probability of reaching destructive overspeed is 6 X 10^{-8} per year (PDR Section 3.5.4.4.2).

Staff then computed the strike and damage probabilities to determine if the overall probability of missile generation, strike and damage met the Staff criteria referred to in Paragraph 303, supra. (Staff's Testimony, Pages 1 through 11.) The conservative value of 4 X 10^{-5}/year is based on the data in the Bush report (Staff's Testimony, Page 36, Tr. 5707, 5708 and 5827). The value of 4 X 10^{-6}/year is obtained by taking a factor of ten reduction in the destructive overspeed probability in view of the improved turbine overspeed protection system on the FNP (Staff's Testimony, Page 10).

312. High trajectory turbine missiles were found by the Staff to be a small contributor to the overall risk from destructive overspeed turbine missiles. Thus the Staff's destructive overspeed missile evaluation was primarily with respect to low trajectory missiles. (Staff's Testimony, Pages 1 and 2.) The Staff's analysis utilized the most penetrating of the possible turbine missile (Staff's Testimony, Pages 3 and 4). The seven foot thick concrete portion of the turbine support (denoted as structure "B" on Applicant's Exhibit OPS-103,Sheet 2, and as structure "BB" on Sheet 3) provides substantial protection to certain safety related areas of the FNP since a destructive overspeed missile cannot penetrate this barrier (Tr. 5128, 5699 and Staff's Testimony, Pages 4 and 8). The Staff concluded that the overall probability of unacceptable damage from a destructive overspeed missile is in the range of 10^{-6} (for the conservative case) to 10^{-7} (for the realistic case), which is within the Staff criteria, Paragraph 51, supra (Staff's Testimony, Page 10 and 11).

454 143

313. The preliminary design of the turbine mount and condenser is set forth in Applicant's Affidavits I and II which were furnished in response to a Board request (See paragraph 256 supra). Information contained in these affidavits did not change the Staff's earlier conclusion concerning the probability of generation of a missile at both design and destructive overspeed (Kiessel Affidavit, Page 7).

314. Atlantic County witness Dr. Luchak asserted that if a large missile occurs in the "in-line"[68] turbine orientation, very little can be done practically to alleviate the possibility of damage. Dr. Luchak estimated, based on his review of the Bush report and a paper by Swan and Meleis,[69] that the probability of missile damage to the containment, given missile generation, is 0.25. (Luchak's Testimony, Page 4, and Page 5 as altered at Tr. 4332). Dr. Luchak's estimate and conclusion regarding missile strike and damage did not take into account the correct orientation of the FNP turbine vis-a-vis the containment. Rather, Dr. Luchak's evaluation was based on a tangential turbine orientation, which is quite different from the FNPs offset turbine orientation as shown in Applicant's Exhibit OPS-103,

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[68] The Board interprets "in line" to mean the turbine orientation depicted in Applicant's Exhibits OPS-100 and 101, which are taken from the Bush report and the Swan-Meleis paper, respectively.

[69] "A Method of Calculating Turbine Missile Strike and Damage Probabilities," by S. W. Swan and M. Meleis, Nuclear Safety, 1975. (Luchak's Testimony, Page 4).

454 144

Sheet 1. (Tr. 4816.) In addition, Dr. Luchak's admitted that in reaching his conclusions, he did not consider the FNP shielding andother protection systems (Tr. 4820-4824). The Board rejects Dr. Luchak's conclusions regarding the probability of turbine missile damage because his evaluation was not based on the FNP turbine orientation and other design features of the FNP.

315. The Board finds that the probability of generating a destructive overspeed turbine missile that strikes an essential safety systems is sufficiently small to meet the Staff criteria, and that the FNP design with respect to this matter is adequate to protect the public health and safety.

Turbine Orientation

316. The Staff requires all plants to be adequately protected against the effects of missiles that might result from equipment failures, in accordance with General Design Criterion 4 of Appendix A to 10 CFR Part 50 (Staff's Testimony, Page 41). Regulatory Guide 1.115 discusses low trajectory turbine missiles. The regulatory position set forth in this guide permits alternate means for providing protection against low trajectory turbine missiles. Turbine orientation, or evaluation of turbine missile strike probabilities for essential safety systems to demonstrate that they are sufficiently low, are each acceptable means for providing protection against low trajectory turbine missiles. (Applicant's Testimony, Page 18, and

454

145

Staff's Testimony, Page 42).The Staff does not have any specific requirements on turbine-generator orientation with respect to the containment (Staff's Testimony, page 41).

317. Recent Commission action has included licensing of land-based plants with non-radial turbine arrangements for which the owners submitted missile probability analyses.[70] (Applicant's Testimony, Page 19). The Board therefore concludes that the FNP design considerations for potential turbine missiles are in consonance with both current Staff criteria and recent licensing actions. Accordingly, there is no basis for Mr. Effenberger's statements that the FNP turbine orientation is unacceptable relative to Staff criteria or that the Commission made a special exception for the FNP design. Further, the Board finds incorrect Mr. Effenberger's assertion (Tr. 4110) that FNP size and turbine orientation were dictated by the graving dock, crane and slipway dimensions at the Applicant's manufacturing facility. Rather, the size of the plant dictated the crane size, the slipway, and the graving dock. (Tr. 5103-5104).

Applicability of the Bush Report Data

318. To some extent, both the Applicant's and Staff's turbine missile analysis utilize the data in the Bush report to estimate the probability of turbine missile generation (PDR Section 3.5.4.3,

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[70] See, for example, Docket Nos. 50-454,455,~~456~~ 54,546 and 547.

146

Applicant's Testimony, Page 17, Staff's Testimony, Page 36, and Tr. 5707, 5708, 5712, and 5827). Atlantic County witness, Dr. Luchak, raised several questions concerning the Bush data which are discussed below:

Turbine Aging Effect

319. Dr. Luchak alledged that the Bush report incorrectly assumes failures occur randomly, claiming that the failure rate would increase with time (with the age of the turbine). Dr. Luchak alleged that, since the Bush data is based solely on turbines 20 years old, or less that the turbine failure rate over the 40 year design life of the FNP cannot be estimated from such data. (Luchak's Testimony, Page 2).

320. The Applicant testified that in Table 3 of the Bush report the average service life of the plants listed was slightly over 18 years and about 43,000 of the total of approximately 70,000 turbine years listed correspond to turbines 20 years old or older (Tr. 4716, 5164 and 5165). On cross examination, Dr. Luchak agreed that approximately 60 percent of the total number of turbine years in Table 3 of the Bush report were data on turbines 20 years old or older (Tr. 4725).

321. Dr. Luchak also claimed that a data point relevant to the variation of the failure rate over time was omitted from a table and graph in the Bush report (Tr. 5038 to 5040). However, the Board

454

147

finds that the data point described by Dr. Luchak as "missing" was, in fact, appropiately included (Applicant's Testimony, 5171 - 5176).

322. Dr. Luchak admitted he had no direct evidence of a statistical nature or no facts related to actual turbine experience to support his contention that the turbine failure rate increases with time (Tr. 4760 and 4761). In response to a hypothetical question, Dr. Luchak testified that if the turbine failure rate is higher in the early years than in later years, then the Bush analysis is conservative (Tr. 4762 to 4763). The Applicant's witnesses then supported the hypothetical by testifying that the turbine failures noted in the Bush report occurred early in the life of the turbines[71] (Tr. 5163 through 5166).

323. The Staff's witnesses testified that it was not necessary to adjust the Bush data for "turbine aging effects" because the Bush report included turbines of various ages and therefore, intrinsically included any such effect (Tr. 5708).

324. The Board therefore finds Dr. Luchak's criticism of the Bush report with respect to "turbine aging effect" to be invalid.

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[71]The Applicant testified that of the turbine failures reported by Bush, one turbine failed at 5 years, 11 months, one failed at 4 years, 4 months, and the remainder, with the exception of one failure for which the Applicant was not able to obtain this information, failed at 2 years or less (Tr. 5163 through 5165).

454 148

Turbine Size Effect

325. Dr. Luchak alleged in his written testimony that the Bush data is predominantly representative of small turbines less than 100 megawatts, thereby making its direct applciation to the much larger FNP turbine questionable, since according Dr. Luchak, larger turbines would have increased stresses, decreased safety factors and increased chance of corrosion failures.

326. Dr. Luchak, on cross examination, admitted that he is not an expert with respect to scaling of turbine size and the relationship between scaling and resultant stresses (Tr. 4520). In contradiction to his written testimony, Dr. Luchak on cross examination admitted that stresses may not increase as the physical size of a turbine increases (Tr. 4522), and in further contradiction stated that for purposes of his testimony he did not assume that stresses increase and safety factors decrease with increasing turbine size (Tr. 5009). Accordingly, Dr. Luchak's assertion that the Bush data are not applicable to the FNP turbine, because such data are based primarily on turbines of less than 100 MW, is not supported by the record and is rejected by the Board. The Board previously has found several aspects of FNP turbine design (see Paragraphs 283, 286, 294, 305 and 310, supra) which make application of the Bush data to the FNP turbine conservative.

454 149

Alleged Bush Report Data Omissions

327. Dr. Luchak originally calculated that the lack of any failures from 1961 to 1969 (as reported by Bush) had odds against it of 20 to 1 (Luchak's Testimony, page 2). The method used by Dr. Luchak in this calculation was incorrect (Tr. 5170). Subsequently, Dr. Luchak performed other calculations, using a revised method, and revised his previously calculated odds to 15 to 1 (Tr. 5035-5036, 5170).[72] Dr. Luchak claimed that those high odds support the hypothesis that not all data were reported by Bush. However, Dr. Luchak's revised calculation, which gave the odds of 15 to 1, improperly utilized ten turbine failures rather than seven missile producing failures. Applicant witness, Dr. Shaffer, stated that if Dr. Luchak's revised test had been properly performed utilizing the seven missile producing failures, the resulting odds would be about 3.5 to 1 (Tr. 5168-5171). Dr. Shaffer also performed an independent calculation and concluded that the correct odds were approximately 3 to 1 (Tr. 5168). Dr. Luchak agreed (Tr. 4751-4752) that odds of 3 to 1 do not support his hypothesis that data were omitted by Bush (Tr. 5168-5171; Exhibits ACCCE 5B and 5C).

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[72] Dr. Luchak's calculation of the 15 to 1 odds is contained in Exhibit ACCCE-5B and 5C, admitted at Tr. 5087.

454

150

328. Dr. Luchak also implied in his direct testimony that the Bush data did not include testpit turbine failures (Luchak's Testimony, Page 3). However, on cross examination, Dr. Luchak admitted that factory test failures were included in the Bush data (Tr. 4801-4807).

329. Further, as part of his testimony concerning test pit failures, Dr. Luchak stated his understanding (although he was not sure) that the FNP turbine would not be factory tested. (Tr. 4537a and 4538). The Applicant, however, testified that the factory testing to be performed by Westinghouse on the FNP will be the same as that which is performed on any land-based turbine (Tr. 5198).

Hinkley Point Failure

330. Dr. Luchak stated that the nuclear plant turbine at Hinkley Point produced a missile.[73] Assuming the Bush estimate of 10^{-4}/year for the probability of turbine missile generation, and

[73] Dr. Luchak's pre-filed testimony stated that at least two nuclear plants experienced turbine failures which produced missiles, Hinkley Point and Shippingport (Luchak's Testimony, Page 3). Dr. Luchak subsequently indicated he really did not know if Shippingport produced a missile (Tr. 4331, 4332, and 4527). The Applicant's Testimony, at Page 10, indicates no external missiles were generated by the Shippingport incident. Dr. Luchak revised his testimony on the assumption that Shippingport did not produce a missile (Tr. 4543 and 4544). Due to an oversight, the odds of 40 to 1 on the 7th line of page 3 of Dr. Luchak's pre-filed testimony were left unchanged. However, it is clear to the Board that, in light of the other changes given by Dr. Luchak at Tr. 4543 and 4544, the 40 to 1 odds must change in a like manner, to 20 to 1.

454 150

considering the nuclear plant turbine subclass, Dr. Luchak calculated the odds against occurrence of the Hinkley Point failure as 20 to 1. Dr. Luchak infered that because of these high odds, the actual probability of missile generation is higher for nucearl turbines than the Bush estimate of 10^{-4}/year. (Luchak's Testimony, Page 3).

331. The Hinkley Point failure was considered in the Bush report but was excluded from the data used by Bush in his estimate of turbine missile probability. Bush excluded the Hinkley Point turbine because improvements have been made in turbine materials which would prevent the type of failure experienced at Hinkley Point from occurring again (Tr. 5179).

332. The Board finds that Dr. Luchak's use of the Hinkley Point failure to test the validity of Bush's 10^{-4}/year turbine missile probability to be improper because the Hinkley Point turbine is atypical of the population of turbines for which Dr. Bush estimated the probability of missile generation.

Luchak's Missile Generation Probability

333. Dr. Luchak calculated, as an alternative favored by him over the Bush probability, a probability of turbine missile generation of 2 X 10^{-3}/year as a "base" value. He then applied a factor of 2 for decreasing reliability with age, a factor of 2 for decreasing reliability with scale, and a factor of 2 for a two unit FNP installation,

454

152

giving a resulting probability of 1.6 X 10^{-2}/year for a two unit FNP site (Luchak's Testimony, Page 3; Tr. 4386, 4543 - 4544).

334. With respect to such applied factors, the invalidity of decreasing realiability with age is addressed in Paragraphs 319 through 324, supra. The absence of support in the record for decreasing reliability with size is addressed in Paragraphs 326 and 327, supra. In addition, Dr. Luchak's application of the "size factor" of 2 to his "base" probability value of 2 X 10^{-3}/year is not proper because the value of 2 X 10^{-3}/year is already based on the subclass of nuclear plant turbines, over half of which are 400 megawatts or larger. (Tr. 5166 - 5167).

335. Dr. Luchak's "base" value of 2 X 10^{-3}/year was obtained by dividing the one nuclear plant turbine missile producing failure (Hinkley Point) by an estimate of 500 nuclear plant turbine years (Tr. 4555). It is not proper to utilize the Hinkley Point failure to predict the probability of FNP turbine failure because current turbines, including the FNP turbine, utilize improved materials to prevent such a failure (Tr. 5179 - 5181).

336. The Board therefore finds that Dr. Luchak's estimate of the probability of turbine missile generation for the FNP turbine is not correct. The Board further finds that the data in the Bush report were properly utilized by the Applicant and Staff in estimating the probability of turbine missile generation for the FNP.

454 153

Conclusions

337. In summary, the Board concludes that the FNP design features with respect to potential turbine missiles are adequate to protect the public health and safety, and the allegations raised by Mr. Effenberger and Dr. Luchak are without merit.

L. CONTENTION XII - EFFECT ON BIOTA

ACCE Contention 3a:

> "Subpart 3a contends that the Applicant has not given adequate consideration to adverse effects on the aquatic biota from the thermal plume, from radioactive liquid discharges, and from entrainment."[74]

338. On this contention, both Applicant and Staff presented oral testimony. No written testimony was presented. None of the intervenors presented witnesses, testimony or other information. A hearing session with regard to this contention was held on April 4, 1979, and the testimony appears at Transcript pages 7269-7277 and 7370-7374.

339. The Environmental Report (ER) and the Final Environmental Statement (FES) extensively discuss and give consideration to

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[74]Admitted as interpreted by Board Order dated May 21, 1974, p. 5.

454 154

adverse effects on the aquatic biota from the thermal plume, from radioactive liquid discharges, and from entrainment and impingement.[75]

340. The Applicant and the Staff testified that adequate consideration was given to the matters raised by this contention. (Tr. 7269-7277 and 7370-7374).

341. The Board finds that adequate consideration has been given to adverse effects on the aquatic biota from the thermal plume, from radioactive liquid discharges, and from entrainment.

M. CONTENTION XIII - DISCHARGE OUTFALL

ACCCE Contention 3b:

> "Subpart 3b asserts that the Applicant has not given adequate consideration to the functional design of the discharge outfall."[76]

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[75]The Applicant submitted "Identification of the Evidence of the Applicant (#9)" on March 23, 1979. The NRC Staff submitted its identification of evidence in a letter to the Board on March 23, 1979. These submittals identify the specific sections of the ER and the FES where these topics are considered.

[76]Admitted as interpreted by Board Order dated May 21, 1974, p. 5.

454 155

342. On this contention, both Applicant and Staff presented written and oral testimony.[77] None of the intervenors presented testimony or other information. Hearing sessions with regard to this contention were held on July 12, 1978 and the testimony appears at Transcript pages 6984-7008 and 7015-7021.[78]

343. The function of the discharge outfall is to disperse the heat of the condenser cooling water. The discharge outfall must be designed for each specific site by the owner, taking into consideration the environmental aspects of that site (Applicant's Testimony, Page 1).

344. A generic evaluation of discharge outfalls and their characteristics was performed by the Applicant and by the Staff. Estimates of expected dilution for different types of submerged and surface single port discharges and multiport discharges were calculated. (Applicant's Testimony, Page 2).

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[77] The Applicant's written testimony, Exhibit No. OPS-47, entitled "Applicant's Testimony Regarding XIII. Functional Design of Discharge Outfall" was admitted at Tr. 6988 (7/12/78). The witnesses sponsoring this testimony were Dr. John Nutant, Mr. P. Blair Haga and Dr. John Edinger (Professional Qualifications admitted at Tr. 609, 1024 and 6986 respectively). The Staff's written testimony entitled "Supplemental Testimony of Staff in Response to ACCCE Contention 3b" by Howard F. Bauman was admitted at Tr. 7018. (Professional Qualifications of Mr. Bauman were admitted at Tr. 7016).

[78] Applicant witnesses were examined by counsel for the State of New Jersey, the Staff and the Board. The Staff witness was examined by the Board.

454 156

345. The temperature rise from the thermal plume at the shoreline for an FNP sited offshore is expected to be less than $1.5^{\circ}F$ (Applicant's Testimony, Page 3). The natural diurnal water temperature change along the coastal regions of the Atlantic and Gulf coasts ranges from less than $2^{\circ}F$ to $9^{\circ}F$ (Applicant's Testimony, page 3).

346. Since the cooling system for a shoreline-sited FNP is indistinguishable from the system for a land-based plant at the same site, there do not appear to be any aspects of shoreline FNP discharge design that would be unique to FNP's or different from the state-of-the-art (Staff's Testimony, Page 3).

347. FES II considered the effects of tidal, wind-driven and littoral currents. The effect of tidal currents is significant only as to the potential for recirculation. Analyses indicate that for most tidal currents there will be no significant recirculation. In addition, net drift due to wind driven or littoral currents would reduce the potential for recirculation. Further, recirculation can be minimized by utilizing a submerged discharge rather than a surface discharge. (Applicant's Testimony, Page 2).

348. The analyses in the ER II, Supplement No. 2 and the FES II indicate that temperature variations that might be caused by an FNP discharge offshore are expected to be lost within the natural diurnal temperature fluctuations of the coastal regions (Applicant's Testimony, Page 4).

454 157

349. The detailed outfall design will be performed by the owner of an FNP (Applicant's Testimony, Page 1). The Board agrees with the finding of the Staff that any of several discharge outfall designs could be used for an offshore-sited FNP (Staff's Testimony, Page 2). The Board also agrees with the judgment of the Staff that, within present technology, an FNP owner would be able to select an adequate cooling water condenser discharge design for a shoreline-sited FNP (Staff's Testimony, Page 3).

350. The Board finds that adequate consideration has been given to the functional design of the discharge outfall.

N. CONTENTION XIV - FOOD CHAIN

ACCCE Contention 3c:

> "Subpart 3c asserts that the Applicant has not given adequate consideration to the cumulative effects of radioactive substances ingested (sic) along the food chain from plankton through humans."[79]

351. On this contention, both Applicant and Staff presented oral testimony. No written testimony was presented. None of the intervenors presented witnesses, testimony or other information. A hearing session with regard to this contention was held on April 4, 1979 and the testimony appears at Transcript pages 7269-7277 and 7370-7374.

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[79] Admitted as interpreted by Board Order dated May 21, 1974, pp. 5, 6.

454 158

352. The Environmental Report (ER), the OPS Topical Report No. 22A60 (Exhibit OPS-65)[80] and the Final Environmental Statement (FES) give consideration to the cumulative effects of radioactive substances ingested along the food chain from plankton through humans.[81]

353. The Applicant and the Staff testified that adequate consideration was given to the matters raised by this contention. (Tr. 7264-7277 and 7370-7374).

354. The Board finds that adequate consideration has been given to the cumulative effects of radioactive substances ingested along the food chain from plankton through humans.

O. CONTENTION XV - DREDGING

ACCCE Contention 3f:

> "Subpart 3f asserts that the Applicant has not given adequate consideration to the impact on the aquatic biota that will be caused by dredging within the breakwater and near its perimeter."[82]

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[80] Exhibit OPS-65 was admitted into evidence at Tr. 7266.

[81] The Applicant submitted "Identification of the Evidence of the Applicant (#9)" on March 23, 2979. The NRC Staff submitted its identification of evidence in a letter to the Board on March 23, 1979. The submittals identify the specific sections of the ER, the OPS Topical Report and the FES where these topics are considered.

[82] Admitted as interpreted by Board Order dated May 21, 1974, p. 6.

355. On this contention, both Applicant and Staff presented written and oral testimony.[83] None of the intervenors presented witnesses, testimony or other information. Hearing sessions with regard to this contention were held on July 12, 1978 and the testimony appears at Transcript pages 7021-7032 and 7033-7041.[84]

356. Consideration of the impact on the aquatic biota that will be caused by dredging within the breakwater and near its perimeter has been given in both the ER II, Section 4.3.1 (Pages 4-7 to 4-11), and Section 5.7 (Page 5-81) and in FES II, Section 5.4.1.3 (Pages 5-9 to 5-12), Section 6.11.2.2 (Page 6-81) and Section 11.3 (Pages 11-4 and 11-5).

357. This contention concerns maintenance dredging since the contention assumes existence of the breakwater (Staff's Testimony, Page 1). Dredging within the breakwater would be undertaken only if

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[83] The Applicant's written testimony, Exhibit No. OPS-48, entitled "Applicant's Testimony Regarding XV. Dredging" was admitted at Tr. 7025 (7/12/78). The witnesses sponsoring this testimony were Dr. John Nutant, Mr. P. Blair Haga, and Dr. Gerald J. Lauer (Professional Qualifications admitted at Tr. 609, 1024 and 7023 respectively). The Staff's written testimony entitled "Supplemental Testimony of NRC Staff in Response to ACCCE Contention 3f" by Dr. Richard B kLean and Dr. S. Marshall Adams was admitted at Tr. 7037. (Professional Qualifications of Dr. McLean and Dr. Marshall were admitted at Tr. 7034 and 7035 respectively.)

[84] Applicant witnesses were examined by the Staff and the Board. The Staff witnesses were examined by the Board.

454 160

significant sedimentation occurs. The dominant parameters that will affect the amount of sediment deposited within the breakwater include the location of the FNP, the amount and type of suspended solids, entrances to the basin and the height of the entrance sills, the volumetric flow of cooling water, and the circulation pattern within and immediately outside the basin. (Applicant's Testimony, Page 2).

358. Dredging within the breakwater may cause destruction of all benthic organisms involved. A total loss of all benthic organisms was assumed and is listed as an environmental cost in the FES II, Table 5.8.1 (Page 5-24) and in the cost-benefit evaluation in Section 11.3 (Pages 11-4 and 11-5). Such loss is considered not to be a significant environmental impact because of the relatively small area affected. (Applicant's Testimony, Page 2).

359. Should dredging near the outer perimeter of the breakwater be required, the area of impact is expected to be less than or of the same order as the site area of approximately 100 acres. The loss of benthic organisms due to such dredging also is considered not to be a significant environmental impact because of the relatively small area affected. (Applicant's Testimony, Page 2).

360. Maintenance dredging is feasible for any breakwater design (Tr. 7031). The impact on aquatic biota from maintenance dredging is not expected to be significant because of the relatively small area affected (Applicant's Testimony, Page 2).

454 160

361. The Board finds that adequate consideration has been given to the impact on the aquatic biota that will be caused by maintenance dredging within the breakwater and near its perimeter.

P. CONTENTION XVI - IMPACT ON RESORT ECONOMICS

Atlantic County Contention 1:

> "This contention asserts that fears of a nuclear accident can have impact on resort economics by frightening vacation and leisure seekers from going to resort areas in proximity to floating nuclear generating stations. This contention does not contest whether these fears might be technically justified but is limited to the effects of these fears, justified or not, on the resort communities."[85]

362. On this contention both Applicant and Staff presented written and oral testimony.[86] Intervenor Atlantic County presented

[85] Admitted as interpreted by Board Order dated April 15, 1974, p.8.

[86] The Applicant's written testimony, Exhibit No. OPS-44, entitled "Applicant's Testimony Regarding XVI. Impact on Resort Economics," was admitted at Tr. 6242. The witnesses sponsoring this testimony were Dr. John A. Nutant and Messrs. P. Blair Haga, K. T. Mao and Dr. Dennis S. Mileti (Professional Qualifications admitted at Tr. 609, 1024, 6230 and 6232, respectively). The Staff's written testimony entitled "Supplemental Testimony of NRC Staff in Response to Atlantic County Contention #1 (concerning impacts on tourism)" by Louis M. Bykoski, Donald P. Cleary, Earl J. Baker and Steven G. West; and "Impact of Offshore Nuclear Generating Stations on Recreational Behavior at Adjacent Coastal Sites" by E. J. Baker, D. J. Moss, S. G. West and J. K. Weyant which follows Tr. 6715, was admitted at Tr. 6715. The Staff's testimony was sponsored by Drs. Baker, West and Bykoski and Mr. Cleary. (Professional Qualifications of Drs. Baker, West and Mr. Cleary were admitted at Tr. 6707. Professional Qualifications of Dr. Bykoski were admitted at Tr. 6710).

written and oral testimony.[87] No other intervenor presented witnesses, testimony or other information. Hearing sessions with regard to this contention were held on May 17, 18, 19 and 20, 1977 and July 10 and 11, 1978. The testimony appears at Transcript pages 6226-6260, 6261-6374, 6375-6529, 6668-6691, 6692-6790 and 6791-6974, respectively.[88]

363. Investigations were made by both the Applicant and the Staff to determine the impact of the presence of nuclear reactors on the resort-oriented economy of coastal communities located near operating nuclear plants (Applicant's Testimony, Page 1 and Staff's Testimony, Page 7).

364. The Applicant investigated economic characteristics of three resort-oriented communities near coastal commercial nuclear power plants in the United States. The Applicant also conducted on a qualitative basis investigations of several coastal resort communities in proximity to coastal nuclear power plants. (Applicant's Testimony, Pages 1, 2 and 7).

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[87] Written testimony of Intervenor, Atlantic County, entitled "Testimony on Behalf of Atlantic County Regarding Atlantic County's Contention #1" by Dr. Marshall E. Levine, was admitted at Tr. 6814. (Professional Qualifications of Dr. Levine were admitted at Tr. 6808).

[88] Applicant witnesses were examined by counsel for Atlantic County Citizens Council on Environment (ACCCE) and Atlantic County. Staff witnesses were examined by Counsel for Atlantic County, the State of New Jersey and the Board. Intervenor witness was examined by counsel for the State of New Jersey, the Applicant and the Staff.

454 163

365. The Staff undertook an investigation to determine if any changes in usage of water-oriented recreational facilities could be attributed to the existence of a nearby operating nuclear power plant. Ten nuclear plants having nearby water-oriented recreational facilities used by tourists were selected for analysis. (Staff's Testimony Pages 8 and 9). Three of these 10 nuclear plants are the same as those investigated by the Applicant (Applicant's Testimony, Pages 1, 7 and 8 and Staff's Testimony, Pages 9 and 10).

366. A study under Commission contract using survey research methods was conducted by Professors Baker and West of Florida State University to estimate the possible reaction of tourists and leisure-seekers to siting of an offshore nuclear generating station near resort areas (Staff's Testimony, Page 2).

367. An investigation by the Applicant also was made to determine the impact of the presence of nuclear weapons testing at the Nevada Test Site on the resort economy of nearby Las Vegas, Nevada. This latter investigation was performed on the basis that the situation in Las Vegas is analogous to other resort communities when considering whether the presence of nearby nuclear operations will adversely impact tourism. (Applicant's Testimony, Page 1).

368. In 1975-76, researchers from Oak Ridge National Laboratory studied the socioeconomic effects of operating reactors on two

454 169

communities:[89] the town of Plymouth near Boston Edison Company's Pilgrim Nuclear Power Station and the town of Waterford near Northeast Utilities' Millstone Nuclear Power Station (Applicant's Testimony, Page 2).

369. The Pilgrim Nuclear Power Station Unit 1 is located in the Commonwealth of Massachusetts, near the town of Plymouth. Unit 1 is a 670-megawatt net electrical output reactor. Unit 1 received its construction permit in 1967 and went into commercial operation in June 1972. At the time the testimony was presented, the proposed Unit 2, an 1180 MWe reactor, was undergoing licensing review for a construction permit. Pilgrim 1 occupies a 517-acre site within the town of Plymouth, Massachusetts on the shores of Cape Cod Bay about 35 miles south of Boston. (Applicant's Testimony, Pages 2 and 3).

370. The Pilgrim Nuclear generating station has been the subject of substantial controversy and publicity. The proposed Unit 2 caused further controversy and continued to draw public attention to the Pilgrim site. (Applicant's Testimony, Page 4).

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[89] "Socioeconomic Effects of Operating Reactors on Two Host Communities: A Case Study of Pilgrim and Millstone", Elizabeth Peelle, presented at Atomic Industrial Forum Symposium, State-of-the-Art of Socioeconomic Impacts Associated with Construction/Operation of Energy Facilities, January 17-18, 1977 (hereinafter referred to as the Oak Ridge Study) (Applicant's Testimony, Page 11).

454 165

371. In the summer months, a large influx of seasonal visitors reside in the Pilgrim area, attracted by its many tourist and recreational facilities. Pilgrim 1 has an overlook where people can view the plant and also has a shore-front area adjacent to the plant where people picnic and fish. This area opened in April 1972, and is open from April through November. The annual average attendance is approximately 75,000 with a peak day attendance of 3,000 visitors. (Applicant's Testimony, Page 3).

372. Population growth is an indicator of growth in tourism in a resort economy (Tr. 6313, 6314, 6318 and 6319).

373. With respect to Plymouth, the economic growth trend as reported in the Oak Ridge study showed that, after growing slowly and steadily during the 1950's and 1960's, Plymouth suddenly underwent explosive growth beginning in 1968 when construction of the Pilgrim I station began. (Applicant's Testimony, Page 3).

374. The Millstone Nuclear Power Station, Units 1 and 2, is located near Waterford, Connecticut. Unit 1 is a 652 and Unit 2 is an 828-megawatt net electrical output reactor. Unit 1 received its construction permit in May 1966 and went into commercial operation in December 1970. Unit 2 received its construction permit in December 1970 and went into commerical operation in October 1975. (Applicant's Testimony, Page 3).

454 166

375. As reported in the Oak Ridge study, Waterford's growth has been relatively gradual. It was noted in the study that this gradual growth was due primarily to restrictive zoning ordinances. However, land values have experienced sharp increases. (Applicant's Testimony, Page 5).

376. There are two resort-oriented communities located in close proximity to the Millstone Nuclear Power Station. New London has beaches and amusement parks. East Lyme, which averages over 250,000 tourists per year, has an unobstructed view of Millstone 1. Three miles east of the plant is the Harkness Memorial State Park with 235 acres available for swimming, boating and fishing. Five miles west is the Rocky Neck State Park with 560 acres available to the general public. Average annual attendance for the two parks is between 500,000 to 600,000 visitors. (Applicant's Testimony, Page 4).

377. As reported in the Final Environmental Statement for Millstone 1, the area around Millstone Point is a favored sport fishing site, and pleasure boating is another major form of recreation in the area. (Applicant's Testimony, Pages 4 and 5).

378. Also reported in the Oak Ridge study were the results of an attitude survey conducted in the summer of 1975 on the residents of Plymouth and Waterford. Those sampled expressed satisfaction with their community in general. The conclusion reached in the survey with respect to tourism was that tourism is little affected by the presence

454 167

of the nuclear power plant in either community. There is no evidence to suggest that the presence of nuclear power plants has had any adverse impact on the resort economy of communities near the Pilgrim and Millstone nuclear plants. In fact, the data show that nearby communities enjoyed sustained economic growth.
(Applicant's Testimony, Page 5).

379. The Applicant also examined certain economic data on communities near the Oyster Creek Nuclear Generating Station. Oyster Creek is a 650-megawatt net electrical output reactor. A construction permit was issued in December 1964. The plant first produced electric power in 1969. Immediately adjacent to the Oyster Creek plant is the site of Forked River Nuclear Power Station, Unit 1, a 1168-megawatt net electrical output reactor. A construction permit was issued for Forked River 1 in July 1973 and the plant is under construction. (Applicant's Testimony, Pages 5 and 6).

380. The site location of Oyster Creek in Ocean County, New Jersey is part of the New Jersey shore area. The area serves as a favorite summer place for vacationers from New Jersey and the surrounding states. Saltwater fishing, boating, waterskiing, and bathing are popular pastimes in the area. (Applicant's Testimony, Page 6).

381. Both the Oyster Creek and Forked River nuclear plants encountered considerable controversy. Extensive anti-nuclear matters

454 168

have been frequently reported and given prominent attention in the local and regional press. (Applicant's Testimony, Page 6).

382. A review of the demographic data of New Jersey discloses that while some areas have lost residents at a high rate, Ocean County leads all other New Jersey counties in population growth and posted the largest migration of people into the area between 1970 and 1975. Large numbers of new housing communities, for summer and permanent living, are continually being established in the County. (Applicant's Testimony, Pages 6 and 7).

383. Based on information concerning the demographic characteristics of the communities near the Oyster Creek plant, there is no evidence to suggest that the presence of this nuclear power plant has had any adverse impact on the resort economy of nearby communities. In fact, the data show that Ocean County has experienced spectacular growth. (Applicant's Testimony, Page 7).

384. The Applicant also conducted investigations on a qualitative basis of other coastal resort communities in proximity to several coastal nuclear power plants. The plants included: Florida Power and Light Company's Turkey Point Plant (Units 3 and 4, commercial operation 1972-73), Maine Yankee Atomic Power Company's Maine Yankee Plant (commercial operation 1972) and Southern California Edison Company's San Onofre Plant (Unit 1, commercial operation 1968). In no case was [illegible] indication that the economy, particularly the

454 169

tourist economy, of nearby communities was adversely affected. (Applicant's Testimony, Pages 7 and 8).

385. In the spring of 1976 the Staff undertook an investigation to determine if any changes in usage of water-oriented recreational facilities could be attributed to the existence of a nearby operating nuclear power plant. Ten locations having water-oriented recreational facilities used by tourists were selected for analysis. Between five and thirteen government (local, state and federal) officials and representatives of local business were interviewed at each location. These individuals were chosen because of their knowledge of local tourism and recreational activities. The interview was structured to: develop information on recreation and tourism activity and trends in the vicinity of the plant; draw out information which might indicate impact, positive or negative, of the plant on tourism and recreation; and finally elicit the respondents' personal opinion concerning plant impacts. This study was updated with followup interviews during May/June 1978. (Staff's Testimony, Pages 8 and 9).

386. The ten nuclear power plant locations investigated by the Staff were Brunswick (Units 1 and 2), Cook (Units 1 and 2), Hadden Neck, Indian Point (Units 1, 2 and 3), Maine Yankee, Millstone (Units 1 and 2), St. Lucie, San Onofre, Three Mile Island (Units 1 and 2) and Zion (Units 1 and 2) (Staff's Testimony, Pages 9 and 10).

454 170

387. Numerous officials interviewed by the Staff at each of the ten plant locations said that the nuclear plant(s) in their areas had no discernible impact on tourism or recreational activity in their vicinity. In most cases there has been a continuing growth in summer populations and tourism in these areas. Many officials interviewed by the Staff felt the nuclear plants' visitor's centers positively influenced their tourism industry. Cook and Maine Yankee, for instance, are advertised in local tourist pamphlets and officials credit them with drawing more visitors to the vicinity. (Staff's Testimony, Pages 10-32).

388. The Staff contracted with the Florida State University for the services of Drs. Earl J. Baker and Stephen G. West, and a research team under their direction, to apply survey research techniques and theory, drawn from several areas of the behavioral sciences, to the question of potential tourist behavior in the vicinity of FNP's (Staff's Testimony, Page 33).

389. Using the estimates of net tourist avoidance developed by the Baker & West study, the Staff computed the impact on the local economy. These computations were made with the assistance of the regional economic and demographic forecasting capability of the U. S. Department of Commerce. Baseline economic forecasts were first adjusted to account for the contribution of plant operation to the local economy. This forecast was then adjusted to account for the loss in tourism activity. The net calculated impact on total earnings

454 170

of each area from siting an FNP at the mid-point along each beach was found by the Staff to be less than one percent. (Staff's Testimony, Page 64).

390. Using what the Staff considers to be very conservative assumptions, the potential impact of an FNP on a local economy was found to be very small and well within the year to year fluctuations in local economic activity as well as within the band of measurement error (Staff's Testimony, Page 64).

391. An investigation was by the Applicant made to determine the impact of the presence of nuclear weapons testing at the Nevada Test Site on the resort economy of nearby Las Vegas, Nevada (Applicant's Testimony, Page 1). The presence of nearby nuclear operations to a resort area make Las Vegas, Nevada analogous to a resort community having a nuclear plant nearby (Tr. 6256 and 6410).

392. Since 1951, the federal government has been conducting nuclear weapons tests at the Nevada Test Site about 65 miles northwest of Las Vegas, Nevada. As of the date of the testimony, a total of 473 announced tests had been conducted and tests are continuing. Prior to 1963, 84 of these tests were surface detonations. The flash from some of these surface detonations was visible in Las Vegas. Since 1963, all tests have been conducted underground. The shock waves from the larger underground tests are felt in Las Vegas. (Applicant's Testimony, Page 8).

454 172

393. Since the inception of nuclear weapons testing in the late 1940's, considerable local and national controversy concerning its hazards has been reported in the media. Between 1966 and 1970, the late Howard Hughes raised serious opposition to conducting nuclear weapons testing near Las Vegas and expended considerable money to wage a campaign against the Nevada Test Site operations. (Applicant's Testimony, Page 9).

394. Despite the presence of nuclear weapons testing near Las Vegas, its resort economy has flourished.[90] (Applicant's Testimony, Pages 9 and 10).

395. Dr. Marshall E. Levine testified on behalf of Intervenor Atlantic County on this Contention. Dr. Levine utilized a newspaper advertisement along with followup personal interviews and letters in an attempt to examine the fears held by the citizens of Atlantic County concerning the proposed siting of an FNP off the coast of

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[90] The number of visitors to Las Vegas increased from about 6.8 million in 1970 to 9.8 million in 1976, at an annual average rate of about one-half million visitors. The number of persons employed in the resort industry increased from about 12,000 in 1958 to about 44,000 in 1974, an average annual growth rate of about 8.5 percent. The number of hotel rooms in Las Vegas increased from about 4,800 in 1954 to about 18,000 in 1974, an average annual growth rate of about 9 percent. The number of motel rooms increased from about 3,700 in 1954 to about 14,000 in 1974, an average annual growth rate of about 5.8 percent. Gross gaming revenues (calculated in 1967 dollars) increased from about $69 million in 1954 to about $465 million in 1974, an average annual growth rate of about 10.8 percent. (Applicant's Testimony, Page 9).

454 173

Brigantine, New Jersey. (Atlantic County's Testimony, Page 1). During cross examination of Dr. Levine, the Applicant established that his study had no external validity and questionable internal validity. (Tr. 6967 and 6969).

396. External validity refers to the extent to which findings can be generalized beyond the particular people studied to a broader group of people (i.e., extrapolated from the sample to the total population) (Tr. 6967). Dr. Levine testified that his survey had no external validity (Tr. 6857). His sample was biased because it only reached members of the county who read the newspaper and because the people who responded to the newspaper advertisement decided if they would be included or excluded in Dr. Levine's study rather than him selecting them (i.e., the sample was self-selected). In addition, Dr. Levine did not know if one person or one group sent in more than one response. (Tr. 6858-6861). Accordingly, the findings in Dr. Levine's study cannot be generalized beyond the particular people who responded to the survey.

397. Internal vallidity refers to the extent that a particular survey provides answers to that which the researcher desires to measure concerning the sample surveyed. If a study lacks internal validity, there is no basis to conclude that what the study is trying to measure has in fact been measured, and no basis to know what has been measured at all. (Tr. 6869-6872 and 6969-6972). Dr. Levine's survey has questionable internal validity (Tr. 6969). Dr. Levine

454 174

admitted that he did not establish internal validity for his study (Tr. 6871). Accordingly the Board concludes that there is no way of knowing that what Dr. Levine was trying to measure with respect to the sample surveyed was in fact measured, and there was no way to know what Dr. Levine measured at all.

398. Dr. Levine also testified that the assumptions drawn in his written testimony, that long time regular vacationers and people from Atlantic County and other communities who are considering moving to or vacationing in Atlantic County would go elsewhere, have no statistical validity and that he could not make a statement that they are true (Tr. 6922 and Atlantic County's Testimony Page 6). In addition, Dr. Levine testified that the sample obtained from his survey has no statistical significance (Tr. 6832).

399. The Board finds that the economy of resort-oriented communities near coastal operating nuclear power plants has not been adversely affected by the presence of nuclear plants. The economy of these areas has had sustained growth and, in some cases, has shown dramatic improvement.

400. The Board finds the potential impact of siting an FNP on a resort economy which is characterized by the presence of tourists and leisure seekers is very small and well within the year to year fluctuations in the local economic activity of the coastal resort area.

454 175

R. CONTENTION XVIII - NET ENERGY YIELD, COST-BENEFIT BALANCE

ACCCE Contention II:

> "The FES Part II cost-benefit analysis underestimates the total direct and indirect cost of the FNP's and grossly overstates the benefits because of (1) the conclusion that FNP's will produce a net energy yield (positive), without regard to the energy impact if less than eight are constructed and sold or if the FNP's, due in part to the unique stresses of the alien marine environment, fail to operate for their planned useful life, (2) the failure to consider cost of decommissioning the breakwater as a potential cost, (3) the failure to compute the cost impact if the FNP's are required to use cooling towers at inshore sites, (4) the failure to consider the various direct and indirect costs resulting from the foreclosure of alternative uses of coastline, and because of (5) the fact that the costs were based upon 1972 costs whereas the benefits are 1988 benefits."[91]

401. On this contention, both Applicant and Staff presented written and oral testimony.[92] None of the intervenors presented witnesses, testimony or other information. Hearing sessions with

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[91] Admitted as interpreted by Board Order dated August 1, 1977, pp.4,5.

[92] The Applicant's written testimony, Exhibit No. OPS-49, entitled "Applicant's Testimony Regarding XVIII. Net Energy Yield, Cost-Benefit Balance" was admitted at Tr. 7069 (7/12/78). The witnesses sponsoring this testimony were Dr. John Nutant, Messrs. P. Blair Haga, William F. Trappen and Thomas A. Mantia (Professional Qualifications admitted at Tr. 609, 1024, 7055 and 609 respectively). The Staff's written testimony entitled "Supplemental Testimony of NRC Staff in ACCCE Contention II," by Dr. Paul C. Fine and Messrs. Fred J. Clark, Norman E. Hinkle and Fred G. Taylor was admitted at Tr. 7110. Mr. Taylor was unavailable for the hearing and was represented by Dr. Glenn W. Suter. (Professional Qualifications of Dr. Fine, Messrs. Clark and Hinkle, and Dr. Suter were admitted at Tr. 7060, 637, 637 and 7106 respectively.)

454 176

regard to this contention were held on July 12 and 13, 1978 and the testimony appears at Transcript pages 7067-7076 and 7103-7130.[93]

Net Energy Yield

402. The Applicant performed an analysis of the net energy yield for the FNP. This analysis was performed on a per-plant basis, assuming the manufacture of both one and four FNPs, taking into account the energy required to build the manufacturing facility as well as an assumed breakwater. Utilizing the methodology employed by the Staff, Applicant's analysis shows that the thermal energy required to build and operate an FNP is approximately 6.1 percent of the thermal energy output for one plant, assuming only one FNP is manufactured and its operating life is 30 years. Assuming four FNPs are manufactured, the corresponding figure is approximately 5.9 percent. (Applicant's Testimony, Page 2). Applicant's results were comparable to the results of the analyses reported by the Staff (FES-II, Section 12.10.4 at page 12-71).

403. Assuming eight FNPs are built, the crossover point at which the positive energy yield begins is at 3.7 months of operating time for an FNP. If only two FNPs are built instead of eight, the

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[93] Applicant and Staff witnesses were examined by the Board.

454 177

crossover point would increase from 3.7 to 3.9 months, an insignificant change compared to the assumed 30 year operating life. (Staff's Testimony, Pages 3 and 4).

Breakwater Decommissioning

404. Decommissioning the breakwater is discussed in Section 9.5.3 (page 9-12, et seq.) of FES II. Additionally, there is a discussion regarding the alteration of the breakwater as a prerequisite to moving the FNPs out of the breakwater enclosure, should that be included in the overall decommissioning plan. There exist a number of alternative methods for decommissioning the breakwater: perpetual care, alternative use, and removal. The FES II contains an adequate discussion of major considerations of cost and benefit for the various decommissioning options. (Staff's Testimony, Page 6).

Cost of Cooling Towers

405. The cost impact for closed-cycle cooling systems for FNPs located at inshore sites is discussed in Section 10.1.1 (Page 10-5) of the FES II. The cost impact is given in Tables 10.1.7 (Page 10-16), 11.2.2 (Page 11-3) and 11.2.3 (Page 11-4).

406. Table 10.1.7 of FES II presents costs for an offshore FNP, inshore FNP with and without cooling towers, and a land-based plant with once-through cooling. Generally, the capital cost of

454 178

inshore-sited FNPs with cooling towers compares favorably with the upper end of the range of costs likely for land-based nuclear stations without cooling towers in the coastal zone of the Atlantic and Gulf coasts (Staff's Testimony, Page 17).

Foreclosure of Alternate Uses of Coastline

407. Sections 9.4 (commencing p. 9-5) and 12.8.1 (commencing p. 12-62) of the FES II discuss conflicting uses of the continental shelf including the coastline. Potential conflicts are site dependent and will be evaluated on a site-specific basis during an owner's construction permit process. However, the effects of such potential conflicts are judged to be of minor significance or avoidable. (Applicant's Testimony, Page 3).

408. FNPs at inshore sites will have no more effect on land use than land-based power stations. Offshore siting will involve even less commitment of land. The small amount of land actually disturbed will be much less than for other types of industrial facilities. (Staff's Testimony, Page 35).

Alleged use of 1972 Cost Estimates and 1988 Benefits

409. The costs for an FNP are discussed in Section 10.1.1 (p. 10-1) and summarized in Section 11.2 (commencing p. 11-3) of the FES

454 179

II. The costs are not "based upon 1972 costs." The costs were calculated using a 1973 base cost. Escalation and interest during construction were then added to arrive at a completed cost in "current" dollars up to the time of commercial operation. Two analyses were performed, assuming commerical operation commencing in 1981 and in 1985, respectively. Operating costs for the entire life of the plant were discounted back to the commercial operation date for each analysis. (Applicant's Testimony, Page 4).

410. The benefits for an FNP are set forth in Section 11.1 (Page 11-1, et seq.) of the FES II. The benefits are not "1988 benefits." The direct benefit from an FNP is the electricity generated. This direct benefit for each plant will begin when the FNP commences operation and is set forth in the FES II in terms of kilowatt-hours of electricity produced. The value of these kilowatt-hours will be dependent upon applicable rates during the period of plant operation. (Applicant's Testimony, Page 4). Indirect benefits, such as taxes and employment, also are discussed in the FES II (Sections 11.1.3 and 11.1.4, commencing Page 11-1).

Conclusions

411. The Board previously has concluded that adequate consideration has been given to the marine environment (See Section C. Contention III - MARINE ENVIRONMENT, <u>supra</u>.). We further find that the net energy yield from an FNP has not been overstated due to the

454 180

failure to consider the unique stresses of the marine environment on the planned operating life of an FNP. In fact, a positive energy yield would occur within four months of initial operation of an FNP.

412. The cost benefit analysis in the FES properly considers the various options for decommissioning and the attendant costs for each op..on.

413. The cost benefit analysis in the FES properly considers the costs associated with cooling towers at inshore FNP sites.

414. Proper consideration is given in the FES to potential foreclosure of alternative uses of the coastal area and shoreline needed for eight FNPs. Such potential foreclosure is judged to be of minor significance and does not alter the overall cost-benefit balance.

415. The costs and benefits in the FES were properly assessed using appropriate time frames for their calculation.

416. Accordingly, the Board finds that the FES II cost-benefit analysis does not underestimate the total direct and indirect costs of the FNPs and does not overstate the benefits.

454 180

S. CONTENTION XIX - SPECIAL ENERGY REQUIREMENTS

Board Retained Issue (Originally Brigantine Contention I.4):

> "Section 12.10.4 of Part II of the FES is inadequate in that it does not take into account the special energy requirements needed to procure breakwater material, to construct the breakwater, to tow plants to the site and to provide shore to barge umbilicals."[94]

417. On this contention, both Applicant and Staff presented written and oral testimony.[95] None of the intervenors presented witnesses, testimony or other information. Hearing sessions with regard to this contention were held on July 12 and 13, 1978, and the testimony appears at Transcript pages 7053-7058, 7059-7067 and 7087-7103.[96]

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[94] Brigantine Contention I.4 was originally admitted by the Board at the May 20, 1977 argument, see Board Order dated August 1, 1977, p.2. Upon the withdrawal of Brigantine as a party the Board retained this contention as an issue (Board Order dated August 1, 1977, pp. 12-13).

[95] The Applicant's written testimony, Exhibit No. OPS-50, entitled "Applicant's Testimony Regarding XIX. Issue Retained by the Board" was admitted at Tr. 7058 (7/12/78). The witnesses sponsoring this testimony were Dr. John A. Nutant, Messrs, P. Blair Haga, Thomas A. Mantia, and William F. Trappen (Professional Qualifications admitted at Tr. 609, 1024, 609 and 7055 respectively). The Staff's written testimony entitled "Staff Testimony in Response to the Issue Retained by the Board Regarding Special Energy Requirements for Floating Nuclear Power Plants" by Dr. Paul C. Fine and Mr. Clifford A. Haupt was admitted at Tr. 7062 (Professional Qualifications of Dr. Fine and Mr. Haupt were admitted at Tr. 7060 and 7011 respectively.)

[96] The Staff witnesses were examined by the Board.

418. Special energy requirements needed to procure breakwater material, to construct the breakwater, to tow FNPs to an owner's site and to provide shore-to-barge umbilicals were calculated (Applicant's Testimony, Page 1).

Breakwater Construction

419 The calculations of the energy requirements for construction of a breakwater were based on the two unit breakwater design described in Section 3.1 (pages 3-1, et seq.) of FES II. (Applicant's Testimony, Page 1).

420. The energy required for quarrying the stone for the breakwater was estimated to be 0.28 trillion BTU. Assuming the stone would be transported 200 miles to the site, the energy required to transport the stone was estimated to be 0.6 trillion BTU. (Applicant's Testimony, Page 2).

421. The energy required to manufacture the cement required for the concrete in the caissons and dolosse was estimated to be 1.7 trillion BTU. The energy required for the other elements in the manufacture of concrete was considered negligible. (Applicant's Testimony, Page 2).

422. The energy required for actual construction of the breakwater was estimated to be 0.7 trillion BTU. (Applicant's Testimony, Page 2).

423. The total energy required for the breakwater was estimated to be 3.3 trillion BTU per FNP. This amount represents less than 0.2 of one percent of the energy generated over a 30 year period of plant operation. (Applicant's Testimony, Page 2).

424. The total energy required for providing materials and for constructing an offshore breakwater was calculated by the Staff to be 8.1 trillion BTU. Since an offshore station was assumed to consist of two FNP units, the energy per unit is about 4.1 trillion BTU (Staff's Testimony, Page 4).

425. The Staff's estimate of energy required for breakwater construction was higher than the Applicant's estimate due to the assumption by the Staff that one-half of the concrete would be reinforced (Tr. 7089). The Staff estimate may be conservative in that reinforcement of the concrete may not be necessary, (Tr. 7095).

Towing

426. Assuming a distance of 2000 miles for tug deployment, including towing distance from the Blount Island manufacturing facility to an owner's site, the energy required for towing one FNP was estimated by the Applicant to be 0.08 trillion BTU (Applicant's Testimony, Page 4). The Staff considered the Applicant estimate to be conservative and adopted it (Staff's Testimony, Page 4).

FNP-to-Shore Circuits

427. Two electrical circuits are required to link an FNP with the owner's power grid (PDR, Page 8.1-1). To calculate the energy required to manufacture the material in the cables and to manufacture the cables, it was assumed that the distance from the shore to the plant is three miles (Applicant's Testimony, Page 3). The energy required was estimated to be 0.46 trillion BTU. The energy to lay the cables was estimated to be 0.6 trillion BTU. Thus the total energy required to provide the FNP-to-shore circuits was estimated to be 1.06 trillion BTU. (Applicant's Testimony, Page 4). The Staff estimated the energy requirement to be 1.2 trillion BTU per FNP (Staff's Testimony, Page 6).

Conclusions

428. The energy requirements needed to procure breakwater material, to construct the breakwater, to tow an FNP to the owner's site and to provide FNP-to-shore circuits represent approximately 0.3 of one percent of the overall expected energy output of an FNP during an assumed 30 years of operation (Tr. 7091). The Board finds that these energy requirements as were taken into account properly in the FES and are insignificant compared to the expected energy output of an FNP during its operating life.

454 185

T. CONTENTION XX - HEAT PUMPS AND SECONDARY AND TERTIARY RECOVERY OF OIL

Board Question:

> The Applicant and the Staff are requested to present evidence on the following Board question: "To what extent, if any, would the consideration of the utilization of heat pumps and of secondary and tertiary recovery from oil wells serve to modify the discussions and/or conclusions reached in Part II of the FES ?"[97]

429. On this Board question, both Applicant and Staff presented written and oral testimony.[98] None of the intervenors presented witnesses, testimony or other information. Hearing sessions with regard to this Board question were held on July 12 and 13, 1978 and the testimony appears at Transcript pages 7078-7083, 7131-7134 and 7134-7137.[99]

Heat Pumps

430. A heat pump is a device which uses an electric motor and fluid systems to bring in ambient low temperature energy from the

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[97] This question was raised by the Board in our Memorandum and Order Re: Motions to Amend and Expand Contentions, dated August 1, 1977, p.10.

[98] The Applicant's written testimony, Exhibit No. OPS-51, entitled "Applicant's Testimony Regarding XX. Board Question," was admitted at Tr. 7080 (7/12/78). The witnesses sponsoring this testimony were Dr. John Nutant and Mr. P. Blair Haga (Professional Qualifications admitted at Tr. 609 and 1024 respectively). The Staff's written testimony entitled "Testimony of NRC Staff in Response to Board Question" by Norman Hinkle was admitted at Tr. 7133. (Professional Qualifications of Mr. Hinkle were admitted at Tr. 637).

[99] Applicant witnesses were examined by the Board.

454 186

natural environment and elevate it to useful temperatures for space heating. By reversing the flow of the working fluid, heat pumps also provide space cooling. Heat pumps can be utilized in new construction and in the replacement of existing heating systems. (Applicant's Testimony, Page 1).

431. Using a heat pump in new construction or as a replacement for existing fossil fuel heating will require additional electric energy generation. Using a heat pump as a substitute for existing electric resistance heating will result in a reduction in electric energy consumption. This will be offset, in part, by newly created demand for summer space cooling in homes currently without space cooling systems (Applicant's Testimony, Page 2).

432. In the Ford Foundation Study reported in A Time to Choose, Final Report by the Energy Policy Project of the Ford Foundation, Ballinger Publishing Co., Cambridge, Mass., 1974, estimates were made of the increase in overall electric energy demand. In the lowest projection case (Zero Energy Growth scenario), it is estimated that electric energy demand will grow by 1.5 Quads (Q) between 1975 and 1985 assuming widespread use of heat pumps in new construction. In this projection, the conversion of one-third of the 7.5 million homes with electric resistance heating in 1975 to heat pump heating by 1985 would result in a reduction in electric energy demand of 0.1 Q. If all of these 7.5 million homes were converted to heat pump heating, a maximum reduction in electric energy demand of 0.2 Q

454

187

would be achieved beyond the reduction already included in the Zero Energy Growth scenario. Thus, even with the maximum possible reduction by conversion to heat pumps, the increase in electric energy demand in the Zero Energy Growth scenario will still be 1.3 Q. This is equivalent to the annual energy output of sixty-two 1000 MWe power plants operating at 70 percent capacity. (Applicant's Testimony, Page 2).

433. More recent studies project an increase in electric energy demand that is significantly greater than the lowest projected demand of the Ford Foundation Study (Applicant's Testimony, Page 3).

434. The use of heat pumps is not expected to reduce the overall growth in electric energy requirements (Applicant's Testimony, Page 5; Staff's Testimony, Page 6).

Secondary And Tertiary Recovery of Oil

435. Since 1970, annual domestic production from existing oil fields has fallen each year, with almost half of the current demand made up by imported oil (Applicant's Testimony, Page 4).

436. Since the total U.S. domestic production of oil by all methods of recovery is estimated to meet only about half of the demand in 1985, secondary and tertiary recovery of oil alone will not be sufficient to eliminate the need for oil imports to make up the shortfall (Applicant's Testimony, Page 4).

454 188

437. Secondary and tertiary methods of recovery of oil are only expected to maintain total overall domestic production and are not expected to significantly reduce the requirements for imported oil. Therefore, oil supplies are not expected to be available to meet the overall projected growth of electric energy demand (Applicant's Testimony, Page 5; Staff's Testimony, Page 4).

Conculsion

438. The Board finds that conclusions reached in the FES are not changed or modified by consideration of heat pumps and secondary and tertiary recovery of oil.

454 189

APPENDIX A

A. Application Documents

Exhibit Number		Title	Date	Admission Into Evidence
1.	20	Application for Manufacturing License and Supplemental Information	May, 1973	Tr. 1031
2.	21	Plant Design Report	January, 1973	Tr. 1031
3.	4	Environmental Report Supplement to Manufacturing License Application	May, 1973	Tr. 614
4.	5	Supplement No. 1 to Environmental Report Supplement to Manufacturing License Application	October 8, 1973	Tr. 614
5.	6	Supplement No. 2 to Environmental Report Supplement to Manufacturing License Application	January, 1974	Tr. 614
6.	7	Supplement No. 3 to Environmental Report Supplement to Manufacturing License Application	June 7, 1974	Tr. 614
7.	8	Supplement No. 4 to Environmental Report Supplement to Manufacturing License Application	August 6, 1974	Tr. 614
8.	9	Supplement No. 5 to Environmental Report Supplement to Manufacturing License Application	January 30, 1975	Tr. 614
9.	10	OPS Letter re Environmental Report to Mr. Gordon K. Dicker of the Staff	January 23, 1975	Tr. 614

454 190

Exhibit Number	Title	Dat	Admission Into Evidence
10. 57	Environmental Report, Part II, Supplement to Manufacturing License Application	June, 197[illegible]	Tr. 6786
11. 58	Environmental Report, Part II, Appendices, Supplement to Manufacturing License Application	June, 1973	Tr. 6790
12. 59	Supplement No. 1 to Environmental Report, Part II, Supplement to Manufacturing License Application	March, 1974	Tr. 6790
13. 60	Supplement No. 2 to Environmental Report, Part II, Supplement to Manufacturing License Application	May, 1974	Tr. 6790
14. 61	Supplement No. 3 to Environmental Report, Part II, Supplement to Manufacturing License Application	December 3,1974	Tr. 6790
15. 62	Supplement No. 4 to Environmental Report, Part II, Supplement to Manufacturing License Application	September 19,1975	Tr. 6790
16. 63	Supplement No. 5 to Environmental Report, Part II, Supplement to Manufacturing License Application	May, 1976	Tr. 6790
17. 64	Supplement No. 6 to Environmental Report, Part II, Supplement to Manufacturing License Application	June, 1977	Tr. 6790

454 190

B. Staff Review Documents

	Title	Publication Number	Date	Admission Into Evidence
1.	Safety Evaluation Report Related to Offshore Power Systems Floating Nuclear Plants (1-8)	NUREG-75/100	9/30/75	Tr. 1043
2.	Supplement No. 1 to Safety Evaluation Report Related to Operation of Offshore Power Systems Floating Nuclear Plants (1-8)	NUREG-0054	3/16/76	Tr. 1043
3.	Supplement No. 2 to Safety Evaluation Report Related to Operation of Offshore Power Systems Floating Nuclear Plants (1-8)	NUREG-0054	10/8/76	----
4.	Final Environmental Statement Related to Manufacture of Floating Nuclear Power Plants by Offshore Power Systems	NUREG-75/091	10/75	Tr. 642
5.	Final Environmental Statement Related to Manufacture of Floating Nuclear Power Plants by Offshore Power Systems, Part II (Staff Exhibit I)	NUREG-0056	9/76	Tr. 3626
6.	Final Addendum to Final Environmental Statement Related to Manufacture of Floating Nuclear Power Plants by Offshore Power Systems, Part II	NUREG-0056	6/78	Tr. 7014

454 192

	Title	Publication Number	Date	Admission Into Evidence
7.	Final Environmental Statement Related to Manufacture of Floating Nuclear Power Plants by Offshore Power Systems, Part III	NUREG-0502	12/78	Tr. 7264

454 193

APPENDIX B

LISTING OF CONTENTIONS ADMITTED AS ISSUES IN CONTROVERSY AND OTHER MATTERS OF BOARD INQUIRY

A. EMERGENCY POWER (CONTENTION I[1])

Brigantine Amended Contention 3

"Motion by Intervenor City of Brigantine to Amend and Expand Its Contentions" (hereinafter "Brigantine Motion") (10/21/75), page 2.

Admitted, "Fourth Prehearing Conference Order and Ruling on Motions" (hereinafter "Fourth Prehearing Conference Order") (12/29/75), page 4.

B. UNDERWATER ELECTRICAL TRANSMISSION LINES (CONTENTION II)

ACCCE Contention 4b

"Atlantic County Citizens Council on Environment's Petition to Intervene in the Above-Cited Matter; Contentions Therefor" (hereinafter "ACCCE Petition") (4/15/74), page 3.

Admitted, as interpreted by the Atomic Safety and Licensing Board, "Second Prehearing Conference Order" (5/21/74), page 7.

C. MARINE ENVIRONMENT (CONTENTION III)

Brigantine Amended Contention 6

Brigantine Motion (10/21/75), page 3.

Admitted, "Fourth Prehearing Conference Order" (12/29/75), page 5.

ACCCE Contention 2

ACCCE Petition (4/15/74), page 2.

Admitted, as interpreted by the Atomic Safety and Licensing Board, "Second Prehearing Conference Order " (5/21/74), page 4.

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[1] This listing reflects the consolidation of related contentions for hearing and utilizes the Roman numeral numbering sequence and subject matter designations employed by Applicant in its various motions to establish schedule.

454 194

D. CENTRAL CONTROL ROOM (CONTENTION IV)

ACCCE Contention 9

ACCCE Petition (4/15/74), page 4.

Admitted, as interpreted by the Atomic Safety and Licensing Board, "Second Prehearing Conference Order" (5/21/74), page 10.

E. TRANSPORTATION (CONTENTION V)

Atlantic County Contention 3

Atlantic County Letter (2/7/74), page 2.

Admitted, "First Prehearing Conference Order" (4/15/74), page 9.

ACCCE Contention 5

ACCCE Petition (4/15/74), page 3.

Admitted, "Second Prehearing Conference Order" (5/21/74), page 2.

Brigantine Original Contention

Kenneth B. Walton Letter (12/13/73)

Admitted, "Second Prehearing Conference Order" (5/21/74), page 2.

Kenneth B. Walton Contention

Kenneth B. Walton Letter (12/13/73)

Admitted, "Memorandum and Order" (5/8/75), page 2.

F. SITE ENVELOPE DATA (CONTENTION VI)

Brigantine Amended Contention 1

Brigantine Motion (10/21/75), page 2.

Admitted, as interpreted by the Atomic Safety and Licensing Board, "Fourth Prehearing Conference Order" (12/29/75), page 4.

G. RADIOLOGICAL IMPACT ON SWIMMERS AND BOATERS (CONTENTION VII)

ACCCE Contention 3d

ACCCE Petition (4/15/74), page 3.

Admitted, "Second Prehearing Conference Order" (5/21/74), page 6.

454 195

H. AIRCRAFT (CONTENTION VIII)

Atlantic County Contention 2

Atlantic County Letter (2/7/74), page 2.

Admitted, as stated by the Atomic Safety and Licensing Board, "First Prehearing Conference Order" (4/15/74), page 9.

Brigantine Amended Contention 4

Brigantine Motion (10/21/75), page 4.

Admitted, "Fourth Prehearing Conference Order" (12/29/75), page 4.

ACCCE Contention 6

ACCCE Petition (4/15/74), page 4.

Admitted, as interpreted by the Atomic Safety and Licensing Board, "Second Prehearing Conference Order" (5/21/74), page 8.

I. SHIP COLLISION (CONTENTION IX)

Brigantine Amended Contention 5

"Motion by Intervenor City of Brigantine to Amend and Expand Its Contentions" (10/21/75), page 4.

Admitted, "Fourth Prehearing Conference Order" (12/29/75), page 4.

ACCCE Contention 6

"Atlantic County Citizens Council on Environment's Petition to Intervene in the Above-Cited Matter; Contentions Therefor" (hereinafter "ACCCE Petition") (4/15/74), page 4.

Admitted, as interpreted by the Atomic Safety and Licensing Board, "Second Prehearing Conference Order" (5/29/74), page 8.

J. ICE CONTAINMENT (CONTENTION X)

ACCCE Contention 7

ACCCE Petition (4/15/74), page 4.

Admitted, as revised by the Atomic Safety and Licensing Board, "Memorandum and Order" (7/10/74).

454 196

K. TURBINE-GENERATOR MATTERS (CONTESTED ISSUE XI[2])

On June 15, 1976, Mr. Ernst J. Effenberger made a limited appearance statement concerning turbine-generator matters (Tr. 999-1010). The Board requested the Applicant and Staff to address the matters raised by Mr. Effenberger (Tr. 1011).

L. EFFECT ON BIOTA (CONTENTION XII)

ACCCE Contention 3a

ACCCE Petition (4/15/74), pages 2-3.

Admitted, "Second Prehearing Conference Order" (5/21/74), page 5.

M. FUNCTIONAL DESIGN OF DISCHARGE OUTFALL (CONTENTION XIII)

ACCCE Contention 3b

ACCCE Petition (4/15/74), page 3.

Admitted, "Second Prehearing Conference Order" (5/21/74), page 5.

N. FOOD CHAIN (CONTENTION XIV)

ACCCE Contention 3c

ACCCE Petition (4/15/74), page 3.

Admitted, "Second Prehearing Conference Order" (5/21/74), pages 5-6.

O. DREDGING (CONTENTION XV)

ACCCE Contention 3f

ACCCE Petition (4/15/74), page 3.

Admitted, "Second Prehearing Conference Order" (5/21/74), page 6

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[2] In the Board's "Second Prehearing Conference Order" (5/21/74) ACCCE Contention 4a pertaining to breakwater stability (ACCCE Petition (4/15/74), page 3) was admitted as an issue in controversy. In the early stages of the hearing this issue was referred to as Contention XI. However, ACCCE Contention 4a was dismissed as an issue in controversy by Board Order dated April 20, 1977.

454 197

P. IMPACT ON RESORT ECONOMICS (CONTENTION XVI)

Atlantic County Contention 1

Atlantic County Letter (2/7/74), pages 1-2.

Admitted, "First Prehearing Conference Order" (4/15/74), page 8

Q. PROGRAMMATIC ENVIRONMENTAL STATEMENT (CONTENTION XVII)

NRDC Contention

"Petition for Leave to Intervene" dated January 9, 1974 and "Amendment of NRDC's Petition for Leave to Intervene" dated February 26, 1974.

Admitted, "First Prehearing Conference Order" (4/15/74), pages 2-3.

R. NET ENERGY YIELD, COST-BENEFIT BALANCE (CONTENTION XVIII)

ACCCE/Atlantic County Contention II

"Motion to Amend and Expand Contentions" dated November 19, 1976.

Admitted, "Memorandum and Order Re: Motions to Amend and Expand Contentions" dated August 1, 1977 (hereinafter "August 1, 1977 Order), pages 4-5.

S. ISSUE RETAINED BY THE BOARD - SPECIAL ENERGY REQUIREMENTS (CONTENTION XIX)

Identified, August 1, 1977 Order, pages 12-13.

T. BOARD QUESTION - HEAT PUMPS, ETC. (CONTESTED ISSUE XX)

Identified, August 1, 1977 Order, page 10.

454 198

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of OFFSHORE POWER SYSTEMS (Manufacturing License for Floating Nuclear Power Plants)	))))))	Docket No. STN 50-437

CERTIFICATE OF SERVICE

I hereby certify that copies of "Applicant's Proposed Partial Findings of Fact in the Form of a Proposed Initial Decision" were served by deposit in the United States Mail (First Class), postage prepaid, upon the persons listed on attachment to this Certificate of Service this 1st day of June 1979.

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454 199

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