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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of	)	
	)	
FLORIDA POWER & LIGHT COMPANY	)	Docket No. 50-389
	)	
(St. Lucie Nuclear Power Plant, Unit 2)	)	

NRC STAFF RESPONSE TO BOARD QUESTIONS AND BRIEF OF ISSUES RELATED TO LOSS OF ALL AC POWER

William D. Paton
Counsel for NRC Staff

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I. Introduction

Since 1977 this Board has conducted an exhaustive investigation into the adequacy of electric power systems for St. Lucie, Unit No. 2. In April 1979, the Board determined that further formal proceedings were necessary and directed Florida Power and Light Company (FPL) and the Staff to respond to certain questions.[1/] The two principal questions were whether the electric power systems complied with General Design Criterion 17 (GDC 17)[2/] and whether the loss of all AC power should be taken into account in the design of the plant.

After receiving written responses from the Staff and FPL, the Board ordered an evidentiary hearing to be held commencing December 11, 1979.[3/]

Before the evidentiary hearing commenced, the Staff notified the Board and parties of the status of its efforts with regard to Task A-44 - "Station Blackout."[4/] That task involves the issue of whether loss of all AC power

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1/ Florida Power and Light Company (St. Lucie Nuclear Power Plant, Unit No. 2), ALAB-537, 9 NRC 407 (1979).

2/ The relevant portion of GDC 17 is set out on p. 11.

3/ Memorandum and Order dated November 7, 1979.

4/ Task A-44 was reported to Congress as an unresolved safety issue pursuant to Section 210 of the Energy Reorganization Act of 1974, as amended, in SECY-78-626 - "Reporting the Progress of Resolution of 'Unresolved Safety Issues' in the NRC Annual Report."

should be a design basis event. The Staff advised the Board that Staff efforts with respect to this unresolved safety issue have only recently begun and are expected to take several years. (Baranowsky, Fol. Tr. 760, pp. 2-3) However, the Staff identified a number of design and procedural improvements that have the potential to minimize the risks of loss of all AC power. (Baranowsky, Fol. Tr. 760, pp. 5-6) The record developed during the December, 1979 evidentiary hearings demonstrated that FPL has either already incorporated these improvements or can do so prior to facility operation.

As developed in this brief, evidence of record supports the conclusion that there is compliance with GDC 17 and that if it is determined that loss of all AC power is an event that should be taken into account in the design of St. Lucie, Unit No. 2, appropriate design and procedural improvements can be made prior to operation. It is therefore the Staff's position that the Board should make affirmative findings on the remaining issues in this proceeding and affirm issuance of the construction permit for St. Lucie, Unit No 2.

II. Statement of the Case

In October 1977, Robert D. Pollard, a former AEC employee, made allegations of improper AEC employee behavior with respect to the investigation of the

Florida grid as it affected the St. Lucie site.[1/] Staff counsel sent copies of Mr. Pollard's letter to the Commission, to the Appeal Board and to the parties. Later in October, the Appeal Board assumed jurisdiction over the matters in Mr. Pollard's letter.[2/]

One week before the date of Mr. Pollard's letter, the Appeal Board had affirmed the Licensing Board's authorization of a construction permit,[3/] but had retained jurisdiction for further examination of steam generator tube integrity.

The Commission took jurisdiction specifically over the allegations of employee misbehavior and directed its office of inspector and auditor to investigate those allegations.[4/] The Appeal Board retained jurisdiction over questions involving the stability of the Florida grid.[5/]

When the Staff sent the Pollard letter to the Appeal Board and the Commission, two staff reports were referenced which discussed the generic aspects of the

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1/ Specifically, Mr. Pollard alleged that the AEC Staff attempted to limit a Staff investigation of the Florida grid to the Turkey Point nuclear plants because they were concerned that the investigation, if it extended to St. Lucie, could affect "the upcoming contested hearings on the St. Lucie plants." Letter from Robert D. Pollard to Attorney General Griffin Bell (October 13, 1977).

2/ Order dated October 28, 1977.

3/ ALAB-435, 6 NRC 541 (1977).

4/ CLI-77-28, 6 NRC 717 (November 8, 1977).

5/ Memorandum and Order dated November 25, 1977.

adequacy of off-site electrical power system reliability.[1/] These two NUREGs had been previously sent by the Staff to the Licensing Board. The Staff also enclosed a copy of Task Action Plan A-35 - "Adequacy of Offsite Power Systems." Later in October the Staff furnished the Appeal Board further technical information in the form of a report prepared by the Staff entitled "A Further Evaluation of the Florida Power and Light Company Electric Power Systems."[2/]

The Appeal Board reviewed the material available to it and indicated that it had raised a number of questions.[3/] The Board directed FPL to answer certain questions and directed the parties to file responses to those answers.[4/] The Board prefaced its specific questions by observing that the grid in Florida was less reliable than other grids and that there was no indication on the record that the reliability of the onsite power system had been designed to compensate for that factor.[5/] The questions were:

1/ NUREG-0138, "Staff Discussion of Fifteen Technical Issues Listed in Attachment to November 3, 1976 Memorandum from Director, NRR to NRR Staff," which was published in November 1976 and NUREG-0153, "Staff Discussion of Twelve Additional Technical Issues Raised by Responses to November 3, 1976 Memorandum from Director, NRR to NRR Staff which was published in December 1976.

2/ Letter from the NRC Staff to the Appeal Board (October 25, 1977).

3/ Order dated March 10, 1978.

4/ *Id.*

5/ *Id.*

(1) whether the overall assurance of electric power was less than at other plants, (2) what were the consequences of loss of offsite power combined with failure of the diesels to start, and (3) whether, in light of a grid disturbance which occurred on May 16, 1977, St. Lucie complied with GDC 17. FPL's answers were submitted on March 31, 1978.[1/]

FPL forwarded to the Board and parties a report dated February 1, 1978 entitled "Florida Public Service Commission Engineering Department Final Report on Southeast Florida's Susceptibility to Blackouts."[2/] The Staff sent the Board and parties a "Report on the Generic Aspects of the Florida Power and Light Company System Disturbance" prepared by the Oak Ridge National Laboratory.[3/]

FPL advised the Board and parties that offsite power to St. Lucie had been interrupted on May 14, 1978. An initial report was submitted.[4/] Later in May 1978, FPL forwarded to the Board and parties a lengthy report entitled "Report on System Disturbance, May 14, 1978."[5/] This event was summarized

1/ Letter from FPL's counsel to the Appeal Board (March 31, 1978).

2/ Letter from FPL's counsel to the Appeal Board (April 10, 1978).

3/ Letter from the NRC Staff to the Appeal Board (April 21, 1978).

4/ Letter from FPL's counsel to the Appeal Board (May 17, 1978).

5/ Letter from FPL's counsel to NRC Staff counsel with copies to the Board and other party (May 25, 1978).

in FPL's direct testimony.[1/] It became known to the Board and parties as the "Midway event" and played a prominent role in the evidentiary hearing in December 1979.

In June 1978, the Staff replied to the Applicant's answers to the Board questions of March 10, 1978. Part of the Staff's reply was the affidavit of Robert G. Fitzpatrick which included the statement that there was less overall assurance that St. Lucie would have electric power available from the grid than the general population of non-peninsular nuclear plants and that the geographical aspects of the Florida grid provided an inherent vulnerability that is greater than that faced by non-peninsular systems.[2/] Mr. Fitzpatrick also stated that the onsite emergency power system for Unit 2 had not been augmented by any additional equipment or design features to compensate for any real or perceived inadequacies in the offsite power system.[3/]

1/ First, the Ranch to Pratt & Whitney 240 kV line was out of service for testing. Second, a switching error at Pratt & Whitney substation resulted in the failure of a lightening arrestor, which in turn produced a fault on the Midway-Ranch 240 kV line. Although the Ranch end relayed correctly, the third event, an improperly connected polarizing circuit at Midway, caused the Midway relays looking north to erroneously see the fault and kept the appropriate relay from tripping the Midway and Ranch 240 kV line. The result was to erroneously trip the two Midway-Malabar 240 kV lines, as well as the Midway-Plumosus 138 kV line. The two lines remaining at this time were rated at 69 kV. They then tripped, isolating the Midway substation from all sources of offsite power for eight minutes, sixteen and one-half seconds. Following this outage, the polarizing circuit was corrected and new procedures were established for testing this relay scheme. (Armand, Bivans and Coe, p. 5, n. 8 (Fol. Tr. 45).)

2/ P. 5 of the "Affidavit of Robert G. Fitzpatrick" which was attached to a Staff filing dated June 12, 1978 entitled "NRC Staff Response to Applicants Submittal of April 3, 1978."

3/ Id., p. 6.

In October 1978, the Commission found that no further action was warranted regarding the allegation of Staff misconduct and instructed the Appeal Board to proceed with other aspects of its review.[1/]

On April 5, 1979, the Board framed the questions to be addressed by the parties at the evidentiary hearing which was ultimately held in December 1979.[2/]

In a Memorandum and Order dated November 7, 1979, the Board set the hearing for Tuesday, December 11, 1979, and indicated its intent to tour FPL's System Control Center and to observe its Dispatcher Training Simulator.

One month before the evidentiary hearing, the Staff notified the Board and parties of the status of its efforts with respect to Task A-44 - "Station Blackout." The Staff advised that Task A-44 had been designated an unresolved safety issue which was among the issues being addressed by the Board. It was submitted because of its relevance to the Board questions.

In a Memorandum and Order dated November 29, 1979, the Board stated that the Applicant and the Staff should be prepared to elaborate on their direct testimony by identifying and discussing which, if any, of the generic "design and procedural improvements" mentioned in the Staff's prepared testimony (Baranowsky, Fol. Tr. 760, pp. 5-6) have been or are being adopted at St.

1/ Order dated October 20, 1978.

2/ ALAB-537, 9 NRC 407 (1979). The principal questions are set out verbatim, *infra*, in Sections V and VI. The remaining questions are summarized and discussed in Section VII.

Lucie, Unit No. 2. The evidentiary hearing was held at the University of Miami Law School in Coral Gables, Florida between December 11, 1979 and December 14, 1979.

There were no significant conflicts in the testimony by the Staff and FPL responsive to Board questions. Intervenors participated but submitted no direct testimony.

III. Reference to Rulings

On April 19, 1977, the St. Lucie 2 Licensing Board filed an initial decision authorizing the issuance of a construction permit (LBP-77-27, 5 NRC 1038). The Appeal Board affirmed LBP-77-27 subject to the outcome of further examination into the issue of steam generator tube integrity over which it retained jurisdiction. (ALAB-435, 6 NRC 541, October 7, 1977, affirmed 589 F.2d 1115 (1978), certiorari denied 100 S. ct. 55 (1979)). Later in October the Appeal Board amended ALAB-435 to reflect retention of jurisdiction over allegations of improper AEC employee behavior with respect to the investigation of the Florida grid raised by Robert D. Pollard in a letter dated October 13, 1977 to the Attorney General of the United States. (Order dated October 28, 1977).

On October 20, 1978, the Commission, following an investigation by its office of Inspector and Auditor, ordered that no further action was warranted regarding the allegation of staff misconduct during the St. Lucie proceeding and instructed the Appeal Board to proceed with the merits of the grid stability problem.

This Board determined that further formal proceedings were necessary to address its questions concerning electrical grid stability and emergency power systems. (ALAB-537, 9 NRC 407, April, 1979). Jurisdiction over the issue of steam generator tube integrity retained in ALAB-435 was terminated and the parties were directed to file prepared testimony. Id.

In a Memorandum and Order dated November 7, 1979, this Board set the evidentiary hearing to begin at 9:30 a.m. on Tuesday, December 11, 1979.

IV. Statement of Issues

1. Whether the configuration of the St. Lucie circuits meets the requirements of GDC 17.

2. Whether the St. Lucie 2 design adequately accommodates a loss of all offsite power.

V. Compliance With General Design Criterion 17

A. Introduction

The question concerning whether the circuits that connect the grid to the St. Lucie site meet the requirements of GDC 17 arose in the context of the loss of offsite power which occurred on May 14, 1978 (the "Midway event").[1/] As a result of that loss, there was no power on the circuits. As will be more fully discussed in the next section (VI: Loss of All AC Power as a Design Basis Event), loss of offsite power is an event which the General Design Criteria identify as an anticipated operational occurrence. The circuits are part of the offsite system. The purpose of the circuits is to bring offsite power to the site with the same degree of overall reliability as would obtain if the grid were tied directly to the site. Various circuit configurations will, of course, have differing reactions to different grid disturbances depending on the portion of the grid affected and the geographic location of a particular disturbance. (Tr. 634-35) The overall reliability of the circuits should to the extent practical equal that of the grid. This is the essence of the GDC 17 requirement to design and locate the circuits so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions. The Staff position is that the St. Lucie circuits comply with these requirements.

1/ Offsite power to the St. Lucie site had also been interrupted on May 16, 1977. FPL describes the event in footnote 7, p. 5 of the testimony of Armand, Bivans and Coe, Fol. Tr. 45 as follows:

> The first changeover to onsite power was the result of a voltage transient lasting only a few cycles; i.e., a fraction of a second. Although it is important to note that none of the three St. Lucie-Midway lines lost power, the instantaneous dip in voltage was enough to actuate the automatic throwover scheme at the plant starting the diesels immediately. The plant operator chose to remain on diesel power for several minutes although offsite power was available. The second shift to onsite power occurred later in the day, when the Andytown Orange River 500 kV line relayed incorrectly at a time when the system had not been fully restored from the earlier disturbance and multiple outages of major equipment still existed. Although this interruption lasted 17 minutes, the diesels started immediately, supplying onsite power.

Board Question A.1.

A. General Design Criterion (GDC) 17

1. This criterion, entitled "Electric Power Systems," requires in its third paragraph (Emphasis added):

> Electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions. A switchyard common to both circuits is acceptable. [footnote omitted]

All three transmission lines connecting the St. Lucie station to the applicant's grid originate at the Midway Substation. The May 14, 1978 incident, in which all power at that substation was lost despite redundant incoming sources, demonstrates that these circuits are indeed susceptible to simultaneous failure. [footnote omitted] The testimony should address whether the St. Lucie station nonetheless meets this GDC-17 requirement.

The Board's concerns focused on the fact that the circuits supplying offsite power to St. Lucie all connect to the grid at one point - the Midway substation. (Tr. 226-27). Having all three circuits terminate at a common substation did not seem to the Board to carry out the idea of physical separation. (Tr. 228 and 644). A similar Board concern was that GDC 17 requirements with respect to circuits were being interpreted to extend to the precise point where the circuits connected to the grid and no further. (Tr. 705-706).

The Board indicated that it did not require further responses to its question A.2. (Tr. 875). However, in light of the seeming inconsistency between treating loss of offsite power as an anticipated operational occurrence and the provisions of GDC 17 which are directed to the safety functions of the offsite electrical power system, it should be noted that the Staff's review does include an analysis of the offsite power system although not pursuant to a single-failure criterion. (Fitzpatrick, Fol. Tr. 624 p. 12). The Staff requires transient and steady-state stability studies to demonstrate the ability of the offsite power system to withstand system perturbations. (Id.).

B. Applicable Law and Practices

Fundamental to this discussion is a recognition of the components of the electric power systems described in GDC 17. Onsite and offsite electric power systems are required. Each is to perform its safety function on the assumption that the other system is not functioning. The onsite system is subject to the single failure criterion.[1/] The offsite system is not.

Although application of the single failure criterion represents a significant difference in GDC 17 requirements for the onsite and offsite systems, the Staff does not dwell on this distinction. Strict application of the literal

1/ Single failure is defined in the introductory portion of 10 C.F.R. Part 50, Appendix A:

> A single failure means an occurrence which results in the loss of capability of a component to perform its intended safety functions. Multiple failures resulting from a single occurrence are considered to be a single failure. Fluid and electric systems are considered to be designed against an assumed single failure if neither (1) a single failure of any active component (assuming passive components function properly) nor (2) a single failure of a passive component (assuming active components function properly), results in a loss of the capability of the system to perform its safety functions. [footnote omitted].

meaning of this criterion may only result in a determination that the minimum requirements have been met.[1/] It is clear that additional criteria may be needed in the circumstances of a particular case.[2/] Similarly, in the Staff's testimony relative to Task A-44, Station Blackout is discussed even though ". . .it was clear that this issue extended beyond the single failure criterion." (Baranowsky, Fol. Tr. 760 p. 2).

The Board focused its inquiry concerning compliance with GDC-17 on the portion of the offsite system which connects the "transmission network" (frequently referred to in the hearing as the grid) to the onsite electric distribution system. This connection is to be made by "two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of

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1/ On April 13, 1979, FPL filed a motion for reconsideration of ALAB-537 based ". . .almost entirely on its understanding of the so called single failure standard." (ALAB-543, 9 NRC 626, 627 (May 3, 1979)). In denying the motion, the Board stated:

> "[T]he single failure standard appears in Commission criteria which, according to their own introductory terms, (1) are incompletely developed, (2) establish only minimum requirements, and (3) reflect the expectation that "additional or different criteria" will have to be "identified and satisfied in the interest of public safety" in "unusual" situations. (ftnt. - See 10 C.F.R. (1978 rev.) at 349.) In addition to what we said above, the peninsular configuration of the South Florida electrical grid--and the attendant system power failures which have therefore been encountered--seem to us to present an "unusual" situation precisely within the explicit contemplation of the regulation itself.

2/ Id.

their simultaneous failure under operating and postulated accident and environmental conditions."[1/]

GDC 17 provides an engineering goal[2/] for two physically independent circuits which are to be designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure. It addresses the failure of the circuits rather than the failure of the grid. What is to be minimized is "their [circuits] simultaneous failure" (GDC 17).

1/ The Atomic Energy Commission published an amendment to 10 C.F.R. Part 50 which added an Appendix A - "General Design Criteria for Nuclear Power Plants" (36 Fed. Reg. 3255, February 20, 1971). On first publication, a portion of General Design Criterion 17 read as follows:

> Electrical power from the transmission network to the switchyard shall be supplied by two physically independent transmission lines (not necessarily on separate rights of way) designed and located so as to suitably minimize the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions. [Emphasis added.]

On July 7, 1971, after the comment period, the Commission published amendments to Appendix A which were said to clarify the intent of the Commission with respect to several of the criteria (36 Fed. Reg. 12733). The sentence quoted above was changed to read as follows:

> Electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions [Emphasis added.]

The difference in language does not appear to have significant impact on the issue under discussion.

2/ "General design criteria (GDC), as their name implies, are 'intended to provide engineering goals rather than precise tests or methodologies by which reactor safety [can] be fully and satisfactorily gauged' Nader v. NRC, 513 F.2d 1045, 1052 (1975)," Petition for Emergency and Remedial Action, CLI-78-6, 7 NRC 400, 406 (1978).

Board question A.1. infers that the circuits may be said to have failed simultaneously on May 14, 1978 because they were simultaneously unable to supply power to the St. Lucie site. The circuits were not able to supply power to the St. Lucie site because the grid had failed. (Tr. 695-6) The portion of the transmission system between the grid and the onsite electric distribution system had not failed. (Fitzpatrick, Fol. Tr. 624, p. 3)

The question is whether the quoted portion of GDC 17 requires that the circuits be located so as to minimize the likelihood of loss of offsite power because of failures of the grid. There is nothing on the face of GDC 17 or in applicable caselaw to indicate that that was intended.

The Board has discussed GDC 17 requirements for circuits briefly in two previous opinions. In The Detroit Edison Company (Greenwood Energy Center, Units 2 and 3), ALAB-247, 8 AEC 936 (1974), the Board affirmed a decision that in a construction permit proceeding, the Licensing Board had jurisdiction to (1) consider the environmental effects of offsite transmission lines associated with a nuclear power plant, and (2) impose conditions concerning the routing, design and construction of such lines.[1/] The Appeal Board found nothing in the statutory or regulatory definitions cited by the Applicant which precluded the Commission from imposing construction permit conditions which relate to transmission lines associated with the facility. Greenwood, p. 941.

1/ The "offsite transmission lines" discussed in Greenwood were "circuits" as discussed in GDC 17. Their purpose was to connect the new facilities with the existing power grid. They traversed a 90 mile common right-of-way. Greenwood, p. 937.

In its decision in Greenwood (id. at 942), the Appeal Board addressed the portion of the regulation of concern here, stating that GDC 17 required that offsite power:

> ... be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions.

The Board then interpreted that requirement:

> In other words, to ensure that power is available from outside sources to operate the reactors safety devices in an emergency the Commission requires electricity to be transmitted to the site on two separate power lines. Before the facility will be approved, the Commission must be satisfied that those lines are located sufficiently far apart so that if one is felled the other will not be. In short, the Commission now conditions construction permits on the acceptable location of power lines outside the immediate facility site. Were we to accept Applicant's reading of the Atomic Energy Act, however, the Commission could no longer impose the safety requirement. An Applicant could then, if it so chose, run both power lines to the site on a single set of poles. We can see no justification for reading into the authority conferred on the Commission by the Atomic Energy Act a geographic "onsite" limitation which would allow a significant safety regulation to be thus undercut. Greenwood, p. 942.

Since Greenwood is an environmental decision it cannot be viewed as definitively resolving the safety question presented here, viz whether the circuits are to be located so as to minimize the likelihood of loss of offsite power because of failures of the grid. However, the decision does seem to represent the technical assumptions within the agency that the quoted portion of GDC 17 applies to the circuits leading to connection with the grid rather than the grid itself.

In Northeast Nuclear Energy Company (The Millstone Nuclear Power Station, Unit No. 3) ALAB-234, 8 AEC 643, 644 (1974), the Appeal Board stated:

> [Q]uestions concerning offsite power raised by the ACRS and the Licensing Board were resolved by the Applicant to the satisfaction of the Staff and the Board. While GDC 17 and and 18 will be met, we note that the former permits a common switchyard for two otherwise independent sources of offsite power. Unless there is adequate separation of the components of the two circuits, such a design opens the possibility of a common incident disabling both outside power circuits, thereby making the reactor dependent upon its onsite diesel generators for electric power.

The Millstone decision addresses the separation of the components of the two circuits along a common right-of-way to preclude a common incident disabling the circuits. If the term "located" within GDC 17 was understood to require more than the physical separation of the circuits, there was no mention of that additional requirement.

Clearly, the regulation requires the likelihood of the simultaneous failure of the circuits to be minimized. However, if the regulation requires the circuits to be located so as to minimize the likelihood of loss of offsite power from a range of potential grid failure events, it is not apparent on its face.

The Board was concerned that GDC 17 requirements for circuits went to the grid and stopped suddenly. (Tr. 704-706). The discussion was that if the grid failed on the grid side of the grid-circuit connection, GDC 17 was not violated, but if the circuits failed on the circuit side of the grid circuit

connection, GDC 17 was violated. (Tr. 704-06). The Board questioned whether GDC 17 was that "fined-tuned." (Tr. 705). While the circuits are part of the offsite system, GDC 17 expressly imposes requirements on the circuits that it does not impose on the grid. The purpose of those requirements is to assure that in performing their function of reliably bringing power from the grid to the site, the circuits do not impose any degradation on the reliability that otherwise exists on the grid. Nothing in GDC 17 imposes similar requirements on the grid as a whole--the requirements are imposed on the circuits, not on the grid. Thus they end at the grid.

C. Compliance with GDC 17

The uncontradicted evidence is that the present configuration of the circuits between the St. Lucie site and the Midway substation meets the requirements of GDC 17.[1/] The circuits are separated so that they cannot physically interfere with each other (Armand, Bivans and Coe, Fol. Tr. 45, p. 7). The three circuits enter the Midway substation in separate bays about 35 or 40 feet apart. (Armand, Tr. 668.) In fact, in some regards the St. Lucie design exceeds those requirements. GDC 17 requires two circuits where three now exist. Two sources of offsite power are immediately accessible to the onsite distribution system - GDC 17 requires only one. (Fitzpatrick, Fol. Tr. 624, p. 3-4; Fitzpatrick, Tr. 627; Armand, Bivans and Coe, Fol. Tr. 45, p. 8; and Bivans, Tr. 227-8 and 626-7.)

1/ In response to the Chairman's question, Mr. Fitzpatrick testified that two other reviewers, two branch chiefs and several Assistant Directors had reviewed and agreed with his conclusions with respect to GDC 17. (Tr. 656-57).

The most important consideration for the required minimum of two offsite power circuits is that they not be the weak reliability link in the offsite power supply system. As long as these offsite power circuits have a reliability equal to or greater than the offsite power system to which they connect, where they connect to the system is of secondary concern. (Fitzpatrick, Fol. Tr. 624, p. 5) The availability of offsite power to the nuclear unit can be no more than the lesser of the availabilities of the offsite power system or the connecting offsite power circuits. In other words, no matter how many circuits connect a nuclear power generating station to the grid, and no matter how well they are designed and protected from postulated failures, a grid failure renders them all useless. GDC-17 uses the words "to the extent practical" in recognition of these considerations of availability. The St. Lucie design meets the physical configuration requirements of GDC-17. (Fitzpatrick, Fol. Tr. 624, p. 5)

The Board was concerned that the May 14, 1978 "Midway event" demonstrated that the Midway to St. Lucie circuits were susceptible to simultaneous failure (ALAB 537, 9 NRC 407, 414). Since 1965, when the Midway substation went into service, simultaneous events have occurred to interrupt power to St. Lucie only twice. The first interruption (for 17 minutes) occurred on May 16, 1977. The diesels started immediately, supplying onsite power. (Armand, Bivans and Coe, Fol. Tr. 45, p. 5.) The second interruption (for 8 minutes) was the May 14, 1978 event at the Midway substation (Armand, Bivans and Coe, p. 5, ftnt. 8 (Fol. Tr. 45)). The diesels also started on this occasion. (Tr. 126).

The May 14, 1978 event at Midway was a loss of offsite power. (Fitzpatrick, Fol. Tr. 624, p. 3, and Tr. 695-6.) None of the three independent circuits could transmit electricity to St. Lucie because the grid had failed. (Fitzpatrick, p. 3, and Tr. 695-6.) The event is not one that the regulations are designed to prevent. In fact, as discussed in VI. "Loss of All AC Power as a Design Basis Event," the event (a loss of all offsite power) is anticipated by the General Design Criteria.

The Board was nevertheless concerned with the configuration of the circuits--specifically with the fact that all three circuits met at a common point on the grid. The question was whether a different configuration of the circuits might increase the reliability of offsite power. (Tr. 226-8, Tr. 269, and Tr. 644.) There was, in fact, testimony that if one of the circuits lead to the "right" substation, the Midway event would not have occurred (Fitzpatrick, Tr. 634-35, and Armand, Tr. 70-71.) In response to a specific Board question, however, as to "overall" reliability, the Staff stated that alternatives to the present configuration would be "about the same." (Tr. 716-17.) In response to a Board question, Staff witness Fitzpatrick testified he did not believe GDC 17 was intended to require the circuits to connect to the grid at separate points. (Tr. 635)

Although the uncontradicted evidence is that St. Lucie 2 meets GDC 17, the record contains considerable discussion of possible remedies or alternatives to what the Board perceived to be a possible inadequacy in the offsite power supply. (Fitzpatrick, Fol. Tr. 624, pp. 7-8; Armand, Fol. Tr. 147, pp. 2-3; Armand, Bivans and Coe, Fol. Tr. 45, p. 8; "Attachment B" Fol. Tr. 147; Tr. 73-77; Tr. 223-226; Tr. 239-246; Tr. 250; Tr. 253-256; Tr. 262-264; and Tr. 293.) FPL has not fully evaluated these alternatives (Bivans, Tr. 264 and 292) and would need six months to do so if it became necessary. (Bivans, Tr. 294).

D. Conclusion

The uncontradicted evidence is that St. Lucie 2 complies with GDC 17. In fact, the configuration of the circuits exceeds the requirements of GDC 17. The May 14, 1978 event at the Midway substation does not demonstrate non-compliance: The Midway event resulted from a failure of the grid - not a failure of the circuits that connect St. Lucie 2 to the grid. Although the record contains considerable discussion of possible remedies or alternatives to a possible inadequacy in availability of offsite power, FPL has not fully evaluated these alternatives.

VI. Loss of All AC Power as a Design Basis Event

A. Introduction

The issue here is whether loss of all AC power should be a design basis event. The Board's concern is that the risk resulting from a loss of offsite power combined with a failure of the onsite diesel generators to start may be greater than the risk found acceptable by the Staff in section 2.2.3 of its Standard Review Plan.

Key to this issue is an understanding of the difference in the regulatory requirements imposed on the two components of the electric power systems. The offsite electric power system (the grid) is expected to fail. Loss of offsite power is listed as an example of an anticipated operational occurrence. In this event, the onsite diesel generators are expected to perform their safety function despite a single failure.

As discussed below, the Staff has given increasing attention to loss of all AC power, but has not, to date, designated it as a design basis event. The Staff has recognized that only limited reduction of risk would result from improving the reliability of the offsite grid. As a result, Staff efforts have been directed toward improving diesel generator performance and increasing the AC power independence of heat removal systems.

In response to Board question B.1., the Staff and FPL analyzed the accident scenario postulated by the Board. Both concluded that the risk of violating the guidelines of 10 C.F.R. Part 100 was less than 10^{-7}. The Staff, however, made its conclusion subject to a confirmatory test of a reactor coolant pump seal assembly.

The Board set out its specific concerns in Board question B.1.:

B. Failure of Offsite Power with Simultaneous Onsite Power Failure

In our order of March 10, 1978 (p. 5), we directed the applicant to discuss the consequences of the following sequence: (1) failure of offsite power (and a presumption of resulting loss of the power generated by the station) followed by and combined with (2) failure of onsite power sources (i.e., the emergency diesel generators) to start on demand. The focus was to be on safety related events that might occur between the loss of all AC power and the eventual restoration of an electric power source.

Both the applicant and staff responded that this sequence, which supposes the simultaneous failure of two onsite emergency power sources, is not a "design basis event" and thus had not been studied in detail. Nevertheless, both briefly discussed its consequences.[24/]

[[24/] Applicant suggests that the first safety related failure encountered would be excessive core heating due to the loss of water from the condensate storage tank, and that this would occur about 16 hours after the loss of AC power (Flugger Affidavit of March 31, 1978, p. 3). The Staff's judgment is that the first failure would be that of a primary pump seal, at about one hour after the loss of AC power - resulting in a small loss of coolant accident (Fitzpatrick Affidavit of June 12, 1978, p. 11).]

1. As we see it, the likelihood of loss of all AC power at St. Lucie may be expressed as the product of two factors: (1) the probability that there will be an offsite power failure involving the FPL network generally or the Midway substation in particularly and a resulting loss of station power--which probability seems, based on historical events, to lie in the range 1.0-0.1 per year; and (2) the probability that neither of the two onsite AC power systems (diesel generators) will start. The probability that any one diesel generator will fail to start on demand is taken by the staff to be one per hundred demands, i.e., 10^{-2}.[25/]

[[25/] Fitzpatrick Affidavit of June 12, 1978, p. 4. Also see Regulatory Guide 1.108, Section B.]

If these figures are accurate, then the combined probability for the "loss of all AC power" scenario is in the range of 10^{-4}-10^{-5} per year.[26/]

[[26/] This conclusion further assumes that the failure of two diesel generators to start would be statistically independent events, an assumption which leads to the lowest likelihood of combined failure, and which might be nonconservative if there exists the potential for common failure modes for the onsite systems.]

In this regard, the staff's Standard Review Plan for Nuclear Power Plants set forth numerical guidelines for determining whether an event "resulting from the presence of hazardous materials or activities in the vicinity of the plant" should be considered in designing the plant (i.e., whether it is a "design basis" event).[27/]

[[27/] NUREG 75/087, Section 2.2.3, paragraph II.] Under these guidelines, events with a realistically calculated probability value of at least 10^{-7} per year (or 10^{-6} per year for a conservative calculation) must be so considered.]

The "loss of all AC power" sequence is not precisely within the category of events contemplated by the Standard Review Plan. However, its ultimate result--assuming that power is not timely restored--is an unprotected loss of coolant accident, the consequences of which are likely to exceed the guidelines of 10 CFR Part 100. We do not understand why this sequence of events (i.e., loss of offsite power combined with failure of diesels to start), which appears to have a probability well above the guideline values, should not be taken into consideration in the design of the plant.[28/]

[[28/] We have accepted the Standard Review Plan guideline values as reasonable in another case. Public Service Electric and Gas Company (Hope Creek Units 1 and 2), ALAB-429, 6 NRC 229, 234 (1977).]

The parties are to address this point, setting forth their reasons for adhering (if they do) to a contrary position.

After the parties had submitted written direct testimony in response to Board questions, the staff forwarded to the Board and parties the testimony of Patrick W. Baranowsky concerning the status of recent staff work on the unresolved safety issue designated Task A-44 - "Station Blackout." As stated on page 1 of Mr. Baranowsky's testimony (Fol. Tr. 760), the issue addressed by Task A-44 is whether or not the loss of all AC power should be considered in the design basis of nuclear power plants and, if so, what the design criteria should be.

B. Loss of All Offsite Power

Loss of all offsite power is expected to occur. It is an anticipated operational occurrence.[1/] Loss of all offsite power is the external event which the design of the unit must accommodate.

The evidence was uncontradicted that reducing the probability of loss of all offsite power would not be a significant contributor to reduction of risk. Staff witness Baer stated that because the Florida grid is on a peninsula, the most that could be expected in terms of improvement in reduction of risk would be a factor of 2 - from .4 per year to .2 per year - and being very optimistic perhaps to .1 per year (Tr. 773). He also concluded that that degree of improvement is small in assessing reduction of risk (Tr. 773). FPL witness Flugger had testified to the same effect (Tr. 527-8). Staff

1/ 10 CFR Part 50, Appendix A - General Design Criteria for Nuclear Power Plants - contains the following definition:

> Anticipated operational occurrences mean those conditions of normal operation which are expected to occur one or more times during the life of the nuclear power unit and include but are not limited to loss of power to all recirculation pumps, tripping of the turbine generator set, isolation of the main condenser and loss of all offsite power. (Emphasis supplied.)

witness Baranowsky agreed and added that making the auxiliary feedwater system independent of AC power and diesel generator improvements can involve increases in the reliability of a nuclear power plant to withstand a loss of all offsite AC power by one or two orders of magnitude (Tr. 776 and 815-16).1/

Since loss of all offsite AC power is assumed to occur, the real question is whether the plant's design is adequate to accommodate this event. As discussed below, the staff has historically relied on diesel generator performance, making heat removal systems independent of AC power or combinations of these two for accommodating this event.

C. Staff's Historic Approach to Station Blackout

The Board asked Staff witness Robert L. Baer whether Station Blackout was a design basis event (Tr. 766). Mr. Baer is Chief of Light Water Reactors Branch No. 2, Division of Project Management, Office of Nuclear Reactor Regulation. He stated that the staff had not previously designated Station Blackout as a design basis event, but that for a number of years the staff has been concerned with the problem (Tr. 766).

1/ The testimony of Edward J. Fowlkes of the Federal Energy Regulatory Commission's Office of Power Regulation (Fol. Tr. 314) addresssed the stability of the grid as affected by line failures. In light of the uncontradicted evidence, discussed above, that reducing the probability of loss of offsite power would not make a substantial contribution to reducing risks involved with loss of all AC power, this testimony became less significant in the overall assessment of risks from loss of all AC power.

The station blackout scenario is of concern if the probable consequences of the event include core damage and releases in excess of 10 C.F.R. Part 100 limitations. The three major factors necessary to create such consequences are: (1) prolonged loss of offsite power, (2) loss of diesel generators, and (3) lack of AC power independence of critical safety equipment such as the auxiliary feedwater system. (Tr. 773). Mr. Baer also testified that reducing the probability of loss of all offsite power would not be a significant contributor to reduction of risk from station blackout. (Tr. 773). For greater improvements in reduction of risk, the staff has been considering improvement in diesel generator reliability and has sought to insure the AC independence of critical equipment such as the auxiliary feedwater system. (Tr. 773).

Mr. Baer advised that a number of years ago a staff position required new applications to have an auxiliary feedwater system with a power source diverse from AC power (Tr. 766). The intent was to eliminate one AC power dependent failure so that the plant could better survive a loss of all AC power (Tr. 766). It then became evident that to eliminate AC power dependent failures was not so simple since auxiliaries like lube oil systems also required AC power. The staff had not addressed auxiliaries in its review to that point. (Tr. 767). Other matters which the staff realized should be considered were seal failures and access for the operator if manual operation was anticipated (Tr. 767).

Although the staff's approach has been evolving towards consideration of station blackout as part of its licensing review for a number of years, loss of all AC power has not been designated as a design basis event to date. (Tr. 767-68). The recently designated Task A-44 has as its purpose addressing the question of whether the loss of all AC power should be considered in the design of nuclear power plants.

D. Task A-44

After the testimony of the parties had been submitted, the staff advised the Board and parties of the status of Task A-44 - "Station Blackout" (Baranowsky, Fol. Tr. 760). The issue addressed by Task A-44 is whether the loss of all AC power should be considered in the design of nuclear power plants and if so what the design criteria should be (Baranowsky, Fol. Tr. 760, p. 1). This issue has been designated by the Commission as an unresolved safety issue (Baranowsky, Fol. Tr. 760, p. 2).[1/]

In October 1979, a simple survey analysis was begun to make a rough estimate of the failure probability for all AC power and the loss of shutdown heat removal capability at current operating PWRs. The intent of the work was to provide a screening mechanism to identify operating plants most likely to suffer core damage due to station blackout at the outset of the program and

1/ Mr. Baranowsky testified that he had hoped to publish a plan for the resolution of Task A-44 within a few weeks after the evidentiary hearing. (Tr. 764.) The plan has not been published. In fact, on February 15, 1980, a draft Task Action Plan was distributed to appropriate members of the Staff and is now under review. The Staff will advise the Board promptly if the draft Task Action Plan is approved.

to identify appropriate short term actions which could be taken to improve station blackout vulnerability while a more intensive program was undertaken. (Baranowsky, Fol. Tr. 760, p. 2-3) The longer term and more extensive effort for Task A-44 has not yet been fully scoped. One approach being considered is to incorporate all or part of this effort in the Integrated Reliability Evaluation Program (IREP) which will be conducted by the Probabilistic Analysis Staff over the next three years to provide safety reliability and accident probability estimates at all operating nuclear power plants (Baranowsky, Fol. Tr. 760, pp. 2 and 3).

One sequence considered in the survey analysis was the independent failure of offsite AC power followed by the failure of onsite (emergency) AC power (which may result from a common cause failure of the emergency diesel generators) and the dependent or independent failure of the emergency feedwater system (shutdown cooling). (Baranowsky, Fol. Tr. 760, p. 3). The dependent failure would typically involve reliance on AC power within or by supporting systems of the emergency feedwater system. For this sequence the time interval following station blackout in which the restoration of AC power must occur to avoid core damage is on the order of one to two hours. (Baranowsky, Fol. Tr. 760, p. 3). For plants in which the emergency feedwater system is highly reliable under station blackout conditions, the overall core damage probability for station blackout events should be low, however, other sequences involving reactor coolant system integrity or longer term cooling requirements could be significant. (Baranowsky, Fol. Tr. 760, p. 4).

The survey analysis results, which are subject to large uncertainties indicate that the frequency of a station blackout lasting about one hour may be higher than 10^{-5} per year at some plants. Diesel generator reliability appears to have the largest affect on this estimate. (Baranowsky, Fol. Tr. 760, p. 4) As a point of reference, the Reactor Safety Study (RSS) estimated a station blackout frequency of $4x10^{-4}$ per year. This evaluation included the common mode failure of the emergency diesel generators. The RSS also showed that the most likely sequence resulting in core damage following a station blackout involved the failure of the steam turbine driven train of the emergency feedwater system. And, that the cumulative core damage frequency for station blackout was estimated at approximately $6x10^{-6}$ per year. (Baranowsky, Fol. Tr. 760, p. 4).

A useful result stemming from the early work performed on the Station Blackout issue is the identification of several design and procedural improvements which have the potential for minimizing the accident probability for Station Blackout sequences. These are identified by Mr. Baranowsky as: (1) preoperational and periodic testing requirements of Regulatory Guide 1.108 for emergency diesel generators should be implemented, (2) a shutdown heat removal system (emergency feedwater system) should be provided with at least one train independent of AC power, (3) the limiting conditions of operation should be amended to limit the time that power generation can continue for combinations of offsite power circuits, AC independent shutdown cooling trains, and emergency (onsite) AC power supplies out of service and (4) emergency procedures should be made available to operators, plant maintenance personnel, and offsite personnel identifying the functions for coping with a Station Blackout and restoring offsite and onsite (emergency) AC power supplies. (Baranowsky, Fol. Tr. 760, pp. 5-6)

In a Memorandum and Order dated November 29, 1979, the Board stated that the Applicant and the Staff should be prepared to elaborate on their direct testimony by identifying and discussing which, if any, of the generic "design and procedural improvements" mentioned in the Staff's prepared testimony (Baranowsky, Fol. Tr. 760, pp. 5-6) have been or are being adopted at St. Lucie 2.

With respect to the first recommendation, Staff witness Fitzpatrick stated that Regulatory Guide 1.108 will be implemented at St. Lucie 2 (Tr. 734). FPL witness Liebler stated that it was FPL's intent to comply with Regulatory Guide 1.108 (Tr. 406).

FPL witness Flugger responded to the second Baranoswky recommendation that plants should have at least one train of auxiliary feedwater totally independent of AC power by stating that FPL's steam driven train is designed to be totally independent of AC power (Flugger, Fol. Tr. 483, p. 4, Tr. 484 and 507). Mr. Flugger described the totally AC power independent feedwater train in the St. Lucie design. There are three auxiliary feedwater system pumps, one of which is steam driven (Tr. 484). The controller at the pump is DC power operated and all the valves from the pump that have to open and close to align the pump to the steam generator are DC power operated (Tr. 487). The lube oil system is AC power independent as is the lube oil cooler (Tr. 487). All of the valves in the system can be opened manually in the event that something goes wrong with the controller (Tr. 488). Mr. Flugger stated that FPL has committed to review the design specifically with regard to recovery from Station Blackout and make sure that whatever is needed will be provided (Tr. 488).

The Board inquired whether the status of construction would affect the time available to make any changes resulting from the Baranowsky recommendations (Tr. 489). Mr. Flugger stated there would be no time problem in making the changes. (Tr. 489). Although it is not clear whether Mr. Flugger's response was limited to changes with respect to the AC power independent heat removal system or referred to all four improvements, this recommendation is the only one which would require substantial time to implement.

Mr. Baranowsky explained his third recommendation concerning limiting conditions of operation. By minimizing the time in which a diesel generator and an AC power independent shutdown train are simultaneously out of operation, one reduces the probability that loss of offsite power will adversely affect station safety. (Tr. 833-4) Mr. Flugger stated that limiting conditions of operation will be specifically designed for St. Lucie 2, based on the safety analysis and evaluation of the plant and that they will be consistent with NRC requirements (Tr. 507-8). Mr. Flugger understood this recommendation as intending a cross correlation between the auxiliary feedwater system and the AC power supply limiting conditions of operation. He did not see that as a major change and agreed that it appeared prudent (Tr. 509-10).

With respect to the fourth recommendation concerning emergency procedures, FPL witness Coe responded that the system dispatcher has specific procedures to follow to restore power to each nuclear power plant. (Tr. 36) Mr. Coe referenced the emergency manual procedures which is attachment 9 to the joint testimony of Armand, Bivans and Coe (Tr. 36).

FPL witness Liebler stated that procedures for dealing with Station Blackout will be developed and made available to plant personnel prior to operation of St. Lucie 2. They will be based on a review of the final as-built design of the plant and will include directions for restoration of AC power sources (Tr. 403). In response to Dr. Johnson's question, Mr. Liebler stated that the St. Lucie 2 emergency procedures for Station Blackout will emphasize restoration of AC power and maintenance of the plant in a safe condition (Tr. 435-36). Implementation of these procedures will include specific training for operators in simulated loss of offsite power conditions (Tr. 436).

Gulf States Utilities Company (River Bend Station, Units 1 and 2), 6 NRC 760, 775 (1977) requires, in a construction permit proceeding, that the Board be informed as to the Staff's perception of the nature and extent of the relationship between significant unresolved generic safety questions and the eventual operation of the reactor under scrutiny. This information will help the Board determine whether (1) the problem has already been resolved for the reactor under study; (2) there is a reasonable basis for concluding that a satisfactory solution will be obtained before the reactor is put in operation; or (3) the problem would have no safety implications until after several years of reactor operation and, should it not be resolved by then, alternative means will be available to insure that continued operation (if permitted at all) would not pose an undue risk to the public.

Should it be determined as a result of Task A-44 that station blackout should be specifically analyzed as a design basis event, there is a reasonable basis for concluding that a satisfactory solution to the issue will be obtained before the reactor is put in operation. Mr. Baranowsky has suggested four design and procedural improvements which have the potential for minimizing the accident probability for Station Blackout sequences (Baranowsky, pp. 5-6). These improvements were discussed at length on the record. The Staff will require compliance with Regulatory Guide 1.108 (Tr. 734) and FPL has stated their intent to comply (Tr. 406). The facility design already provides a shutdown heat removal system with one train independent of AC power (Tr. 484 and 507). FPL agrees that the suggested changes in limiting conditions of operation are prudent (Tr. 509-10). FPL has already established emergency procedures to cope with loss of offsite power (Tr. 36) and testified that procedures to cope with loss of all AC power will be developed and made available to plant personnel prior to operation of St. Lucie 2 (Tr. 403).

Mr. Baer stated that he expected that by the time St. Lucie 2 is in operation they will have diesel generators tested to appropriate standards and the auxiliary feedwater system will be as independent of AC power as the Staff and FPL can make it (Tr. 774). There is time to work out more precise Staff requirements relating to limiting conditions of operation and emergency procedures. (Tr. 774) Mr. Baer stated that the Staff expects to have two and one-half to three years to address our requirements after we receive FPL's application and Final Safety Analysis Report in the Spring of 1980 (Tr. 774).

E. Seal Failure Scenario

FPL and Staff analyzed the probability of exceeding the guidelines of 10 C.F.R. Part 100 in the event of Station Blackout. No other independent failures were assumed. (Fitzpatrick, Fol. Tr. 624p. 16). However, the Staff identified the dependent failure of the reactor coolant pump seals as an item that must be included in the analysis. A significant loss of primary coolant through the reactor coolant pump seals would lead to a loss of core cooling via natural circulation under station blackout conditions (Fitzpatrick, Fol. Tr. 624, p. 20).

FPL's answer was in terms of the time to restore AC power after Station Blackout. Their calculations show that, on the assumption of loss of offsite power of .1 per year, the probability of having a total loss of AC power lasting 1.2 hours was 10^{-6} and 2.4 hours was 10^{-7}. (Flugger, Fol. Tr. 483, pp. 10-12) Changing the assumption to a frequency of 1 per year

the probability of having a total loss of AC power that lasts 2.4 hours was 10^{-6} and 3.6 hours was 10^{-7}. (Flugger, Fol. Tr. 483, pp. 10-12).

The Staff reviewed FPL's analysis and agreed that if FPL could demonstrate primary system integrity (i.e., natural circulation with no excessive leakage) for four hours of Station Blackout conditions, the probability of core damage is well below the 10^{-7} criteria suggested by the Board. (Fitzpatrick, Fol. Tr. 624, pp. 16-17 and 21). To that end, the Staff is requiring FPL to perform a test on a reactor coolant pump seal assembly to demonstrate its sealing capability versus time under station blackout conditions. (Fitzpatrick, Fol. Tr. 624, p. 21 and Siegel, Fol. Tr. 624, pp. 1-3).

G. Conclusion

The Staff has historically been concerned with loss of all AC power, but has not designated it as a design basis event to be evaluated independently of the required analysis of anticipated operational occurrences, i.e., loss of offsite power. While the regulations are sufficiently flexible to permit evaluation of station blackout within the analysis of loss of offsite power, the station blackout scenario has nonetheless recently been designated as an unresolved safety issue.

The Staff has embarked on an effort to determine whether loss of all AC power should be explicitly considered in the design of nuclear power plants and, if so, what the design criteria should be. In the absence of a conclusion from that study, the Staff is not able to conclude that loss of all AC power is presently required to be considered in the design of St. Lucie 2.

The Staff has identified, however, four design and procedural improvements which have the potential for minimizing the accident probability for loss of all AC power sequences. The record shows that these improvements are either already planned by FPL or can easily be implemented prior to operation. And the Staff review of FPL's application for an operating license will extend for two-and-one-half to three years after the application is received in the Spring of 1980. There is a reasonable basis to conclude that loss of all AC power issues will be resolved before St. Lucie 2 is licensed to operate.

VII. Other Board Questions

Staff and FPL testimony with respect to the remaining Board questions was essentially in agreement. It was prepared and submitted prior to the Staff filing testimony relating to Task A-44.

In question B.2., the Board asked for an analysis of events occurring after the loss of all AC power. FPL testimony analyzed the condition of the reactor coolant pumps during the event and concluded that the seals would remain functional for at least 24 hours. (Flugger, Fol. Tr. 483, pp. 13-20.) The Staff could not fully agree with FPL's testimony because it had insufficient test data on the seal design under expected reactor temperatures and pressures following a station blackout. (Siegel, Fol. Tr. 624, p. 3.)

The parties were also asked to reconcile their differing responses to question B.1(b) of the Boards March 10, 1978 order. Question B.1(b) reads:

(b) As a function of the delay time involved, what are the consequences of a loss of offsite power at St. Lucie 2 combined with failure of onsite power sources to start on demand (i.e., delayed start). No other failure of the system (e.g., LOCA) need be considered in this analysis.

FPL's response concluded that there was a sufficient volume of condensate storage to allow the unit to maintain hot standby conditions for at least 16 hours; the spent fuel storage pool would not require makeup for at least 36 hours; and that power would be restored before any unacceptable consequences would occur (Flugger, Fol. Tr. 483, p. 13). The Staff response to the Board indicated the onset of reactor coolant seal problems within 1 hour after the loss of all AC power. (Fitzpatrick, Fol. Tr. 624, p. 17).

The Staff's conclusion was based on section 9.2.2.3.1 of FPL's PSAR which demonstrates reactor coolant pump seal integrity for 1 hour of operation following loss of component cooling water. (Fitzpatrick, Fol. Tr. 624, p. 18). The static condition (pump not running) which would follow loss of all AC power is much less severe than the dynamic (pump running) condition discussed in Unit 2 PSAR at Section 9.2.2.3.1. (Flugger, Fol. Tr. 483, p. 14). The NRC Staff recognized its conservatism but in the absense of direct test results for the static condition to be encountered the Staff was unwilling to assume reactor coolant pump seal performance for more than an hour. As more fully explained in the testimony of Staff witness Siegel (Fol. Tr. 624) a confirmatory test on at least one of the four seal assemblies is being required to provide the additional verification necessary to determine the adequacy of the reactor coolant pump seal design.

Board question B.3. asked for the time required to start a diesel assuming it failed to respond to the initial, auto-start signal. FPL explained that historic data would be unrealistic because existing technical specifications allow the plant to remain on line for 72 hours after one diesel generator fails to start. (Flugger, Fol. Tr. 483, p. 20.) The Staff responded that it does not have this information but that Regulatory Guide 1.108 "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants" (October 1976) established the requirement to report duration of outages from which mean-time-to-repair can be calculated (Fitzpatrick, Fol. Tr. 624, p. 19). The Board has ordered FPL to submit data related to diesel generator performance by March 14, 1980.[1/]

Board question B.4. requested a review of possible measures to decrease the likelihood of exceeding design limits on the reactor fuel and reactor coolant pressure boundary under the assumption that there is some time available to activate an auxiliary power source subsequent to a total loss of AC power. FPL responded that the potential for exceeding design limits is acceptably low, but that FPL will review procedures prior to issuance of an operating license to assure that operators have the capability to achieve and maintain hot shutdown conditions for the duration of the loss of all AC power event. (Flugger, Fol. Tr. 483, p. 24.) The Staff agreed that the risk was acceptably low subject to confirmation of seal performance assuring four hours of natural circulation. (Fitzpatrick, Fol. Tr. 624, p. 21.) We have also discussed in detail (see VI. "Loss of All AC Power as a Design Basis Event")

1/ Order dated February 19, 1980.

a number of design and procedural improvements suggested by Staff witness Baranowsky in connection with Staff efforts under Task A-44.

The Board asked whether there were measures to increase the reliability of the onsite power systems during an "alert status" period. (Question C.) FPL witness Liebler responded that one way to increase the reliability of the onsite power system during an "alert status" would be to idle start the diesel generators and run them for a short period of time. Because the diesel generators are subject to routine surveillance testing, however, no significant increase in reliability would be gained by idle starting. (Liebler, Fol. Tr. 404, p. 2.) The Staff testified that idle starting diesel generators for every alert state might unnecessarily hamper their performance in a real emergency. (Fitzpatrick, Fol. Tr. 624, p. 22.)

The Board asked for a concise discussion of existing measures and those planned for the near future by which the reliability of FPL's system could be enhanced with particular attention to personnel errors apparently involved in the May 1978 outage and the May 1977 disturbance. (Question D.)

FPL has been and is continuing to upgrade the reliability of the offsite power system in three major areas: (1) strengthening the power system by adding generation and transmission capability, (2) improving power system field personnel training and guidance and (3) installation of a centralized monitoring and control facility (Fitzpatrick, Fol. Tr. 624, p. 23).

The 500 kV system additions addressed by FPL (see Armand, Bivans and Coe, Fol. Tr. 45, pp. 9-12) provide a significant improvement in reliability, capability and performance for the St. Lucie site. (Fitzpatrick, Fol. Tr. 624, p. 23). The Staff testified that the new 230 kV tie to Georgia will be helpful, but that the new Martin Station and the 500 kV line to the south are more significant to the St. Lucie site because they are closer to St. Lucie. (Tr. 845-7).

To reduce personnel errors, field switching personnel and the system dispatcher/operators who monitor and control both the granting of clearances and sequencing of switching are now better equipped to perform their duties. FPL has described the analysis and procedures that must be followed before granting a switching request. (Armand, Bivans and Coe, Fol. Tr. 45, pp. 10-11). The fact that approved written procedures are involved in this process is a change from prior FPL practice and is a major improvement. (Fitzpatrick, Fol. Tr. 624, p. 24).

The third major improvement involves the system dispatch and control center which was visited by the Board and parties on Tuesday, December 11, 1979. The system provides FPL a powerful tool for optimizing operation and, on occasion, for restoration of the power system. FPL has also purchased a training simulator to perform extensive operator training. (Fitzpatrick, Fol. Tr. 624, p. 24). FPL described the years of training and experience required of dispatchers and control room operators. (Tr. 153-156).

VIII. Conclusion

For the reasons set forth, the Atomic Safety and Licensing Appeal Board should make affirmative findings on the remaining issues in this proceeding and affirm issuance of a construction permit for St. Lucie, Unit No. 2.

Respectfully submitted,

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Dated at Bethesda, Maryland
this 29th day of February, 1980

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of	)	
FLORIDA POWER & LIGHT COMPANY	)	Docket No. 50-389
(St. Lucie Nuclear Power Plant, Unit 2)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of "NRC STAFF RESPONSE TO BOARD QUESTIONS AND BRIEF OF ISSUES RELATED TO LOSS OF ALL AC POWER" in the above-captioned proceeding have been served on the following by deposit in the United States mail, first class or, as indicated by an asterisk, through deposit in the Nuclear Regulatory Commission's internal mail system, this 29th day of February, 1980.

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In the matter of FLORIDA POWER & LIGHT COMPANY (St. Lucie Nuclear Power Plant, Unit No. 2)	))))))	Docket No. 50-389

PROPOSED FINDINGS OF FACT
AND CONCLUSIONS OF LAW
SUBMITTED ON BEHALF OF
FLORIDA POWER & LIGHT COMPANY

INTRODUCTION

On December 11 through 14, 1979, the Appeal Board held a hearing in Coral Gables, Florida, relating to the stability of Florida Power & Light Company's (FPL's) electrical grid and the reliability of emergency power systems for St. Lucie Unit No. 2. Some of the background of the proceeding is set forth in ALAB-537 of April 5, 1979, and ALAB-543 of May 3, 1979, as well as in the Appeal Board's orders of October 28, 1977, November 25, 1977, and March 10, 1978.

Both FPL and the NRC Staff submitted material in response to questions and requests for information contained in the March 10, 1978, order. Additional questions and requests for information were contained in ALAB-537 and in the Appeal Board's memorandum and order of November 29, 1979. The evidence received in the December hearings addressed those questions.

Consistent with the directions of the Appeal Board issued at the end of the hearings (Tr. 869-77), FPL's proposed findings of fact and conclusions of law are not submitted in the form of a proposed opinion (Tr. 876-77). Rather, they are set forth below in the form of responses to the questions contained in ALAB-537 with references to the record that has been compiled. The questions relate to General Design Criterion (GDC) 17, failure of both offsite and onsite sources of AC power, onsite AC power system reliability during an alert status and ongoing improvements in FPL's electrical grid.

DISCUSSION

A. General Design Criterion (GDC) 17

1. Part 1 of this question states:

> This criterion, entitled "Electric Power Systems," requires in its third paragraph (emphasis added):
>
> > Electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and

> postulated accident and environmental conditions. A switchyard common to both circuits is acceptable.22/

All three transmission lines connecting the St. Lucie station to the applicant's grid originate at the Midway Substation. The May 14, 1978 incident, in which all power at that substation was lost despite redundant incoming sources, demonstrates that these circuits are indeed susceptible to simultaneous failure.23/ The testimony should address whether the St. Lucie station nonetheless meets this GDC-17 requirement.

22/ As we now view it, subject to being persuaded otherwise, the "common switchyard" provision refers to the switchyard at the site and not to a distant facility (such as, in this instance, the Midway Substation).

23/ See the applicant's May 25, 1978 "Report on System Disturbance, May 14, 1978."

The NRC Staff is satisfied that St. Lucie is in full compliance with the requirements of GDC-17, including the specific provision quoted in the Appeal Board's question. (NRC Staff Testimony of Robert G. Fitzpatrick, follows Tr. 624, p. 3 [hereinafter Fitzpatrick, Fol. Tr. 624, p. ___]; See also Bivans, Tr. 226-28.) In fact, the uncontradicted direct testimony in this proceeding indicates that the termination of three circuits from St. Lucie into two separate busses at Midway, a major strong point in the FPL grid, exceeds the basic requirements of GDC-17. (See, e.g., Joint Testimony of Michel P. Armand, Ernest L. Bivans and Wilfred E. Coe Relating to Questions A1 and D of ALAB-537, follows Tr. 45, p. 8 [hereinafter Armand, et al., Fol. Tr. 45, p. ____]; Bivans, Tr. 626-27.)

In nuclear power plant design, grid unavailability (i.e., loss of offsite power) is recognized as an anticipated operational occurrence. That is, it is an event which is expected to occur one or more times during the life of the nuclear power plant. As a result, the regulations do not require a design which precludes such an event but, rather, require a capability to cope with it if and when it occurs. (Fitzpatrick, Fol. Tr. 624, p. 3.)

In light of the above, the most important consideration for the minimum two offsite power circuits required by GDC-17 is that they not be the weak link in the offsite power supply system. The availability of offsite power to a nuclear unit can be no greater than the lesser of the availabilities of either the offsite system or the circuits connecting the unit to the offsite system. (Fitzpatrick, Fol. Tr. 624, p. 5.)

To insure a strong connecting link, GDC-17 specifically requires that at least two circuits connect the onsite electric distribution system with the grid and that at least one of these be immediately available (i.e., within a few seconds) to the onsite distribution system. The Staff regards the two circuit requirement to be satisfied if the onsite distribution system is connected to the onsite switchyard by two circuits and that switchyard is attached to the grid by two circuits. The provisions for St. Lucie exceed these requirements. Three connections, instead of the required minimum of two, are provided between the power plant site and the grid connection point at the Midway Substation. In addition, two sources of power are immediately accessible to the onsite distribution system instead of the single source required as a minimum by GDC-17. (Fitzpatrick, Fol. Tr. 624, pp. 3-4; 627; Bivans Tr. 227.) The strength of the St. Lucie-Midway Substation link is further apparent from the fact that there have been no simultaneous circuit failures on the St. Lucie to Midway transmission lines. (Fitzpatrick, Fol. Tr. 624, p. 3)

With regard to circuit separation "so as to minimize to the extent practical the likelihood of their [the offsite power supply circuits] simultaneous failure," the three 240 kV circuits between St. Lucie and Midway are so constructed and separated to assure that none can physically interfere with the others. (Armand, _et al._, Fol. Tr. 45, p. 7.) Where the circuits enter the Midway Substation and join with the grid, they do so at different points, thus maintaining separation. (Bivans Tr. 228; Fitzpatrick Tr. 665-68.) Within the substation itself, the three St. Lucie-Midway circuits are tied to the grid by means of two independent busses through a breaker-and-a-half scheme. Substation components are protected such that disruptions in one will not affect others. Transformers are separated by a distance of about 150 feet and placed in concrete reservoir wells partially filled with gravel so that any oil leakage will not spread throughout the station and, in the event of a fire, it would be confined to the immediate area. The two busses are likewise separated by a distance of about 150 feet. In addition, the characteristics of the breaker-and-a-half scheme are such that, even in the unlikely event of the physical loss of both 240 kV busses at Midway,*/ a path for power flow into St. Lucie over all three connecting lines, from numerous substations outside of Midway, would still remain. (Armand, et al., Fol. Tr. 45, pp. 6-7; Coe, Bivans, Tr. 78-83, 229-31.)

Not only is the St. Lucie plant securely connected to the Midway Substation but the substation itself is heavily tied into the FPL grid. Two 240 kV circuits connect Midway to the Malabar Substation to the north. In addition, two 240 kV circuits connect the Midway Substation to the south, with one

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*/ Substations are designed to code criteria which require, among other things, that all structures withstand hurricane winds; and, in fact, FPL has experienced little such damage. (Bivans, Tr. 274-76.) Environmental problems such as salt spray and dust contamination -- particularly in the case of the Midway-St. Lucie transmission lines -- have been considered and no problems have been experienced even under extreme conditions. (Bivans, Coe, Tr. 98-101, 234, 287-90.) Even assuming a single event which destroyed the entire substation, power could be restored to St. Lucie within a period of about six hours by means of a temporary splice which, for all intents and purposes, could later be strengthened and made permanent. (Bivans, Coe, Tr. 234-38.)

circuit going directly to the Ranch Substation and the other going to Ranch via the Indiantown and Pratt & Whitney Substations. A fifth 240 kV circuit connects Midway with Martin Plant by way of the Sherman Substation. Finally, two 138 kV lines running, north and south, to the Malabar and Plumosus Substations, respectively, further tie the Midway Substation to the grid. (See Armand, et al., Fol. Tr. 45, Attachment #1, pp. 6-7, 9, and Attachment #6.) The strength of these connections*/ is demonstrated by the fact that simultaneous events have occurred to interrupt power to Midway on only two occasions**/ since the substation went into service in November 1965. (Id., p. 5)

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*/ Improvements are continuing as discussed below in connection with Question D.

**/ The first occasion was on May 16, 1977 when the automatic switching scheme at St. Lucie functioned as designed and twice shifted from offsite to onsite diesel power. The first changeover was the result of a voltage transient lasting only a few cycles; i.e., a fraction of a second. Although it is important to note that none of the three St. Lucie-Midway lines lost power, an instantaneous dip in voltage was enough to actuate the automatic throwover scheme at the plant, starting the diesels immediately. The plant operator chose to remain on diesel power for several minutes although offsite power was available. The second shift to onsite power occurred later in the day, when the Andytown-Orange River 500 kV line relayed incorrectly at a time when the system had not been fully restored from the earlier disturbance and multiple outages of major equipment still existed. Although this interruption lasted 17 minutes, the diesels started immediately, supplying onsite power. (Armand, et al., Fol. Tr. 45, p. 5 ftn. 7.)

(continued on following page)

Because the three circuits which connect the St. Lucie onsite switchyard with the grid join the transmission network at a single substation (Midway) the Board was concerned as to whether or not such an arrangement is permissible under GDC-17. (See, e.g., Tr. 226,31, 271-72, 633-45.) Witnesses testifying on the question, however, all took the position that the requirements were met in the case of St. Lucie and, indeed, exceeded. (See, e.g., Fitzpatrick, Fol. Tr. 624, pp. 3-5; Bivans, Fitzpatrick, Tr. 226-31, 627.)

In pertinent part, GDC-17 addresses only that portion of the electrical system "from the transmission network to the onsite electric distribution system." It prescribes only those

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**/ (continued)

The only other occasion on which loss of offsite power to St. Lucie was experienced was on May 14, 1978. At this time, a number of events combined to isolate the Midway Substation from the rest of the FPL grid. First, the Ranch to Pratt & Whitney 240 kV line was out of service for testing. Second, a switching error at the Pratt & Whitney Substation resulted in the failure of a lightning arrestor which, in turn, produced a fault on the Midway-Ranch 240 kV line. Although the Ranch end relayed correctly, the third event, an improperly connected polarizing circuit at Midway, caused the Midway relays looking north to erroneously see the fault and kept the appropriate relay from tripping the Midway to Ranch 240 kV line. The result was to erroneously trip the two Midway-Malabar 240 kV lines, as well as the Midway-Plumosus 138 kV line. The two lines remaining at this time were rated at 69kV. They then tripped, isolating the Midway Substation from all sources of offsite power for eight minutes, sixteen and one-half seconds. Following this outage, the polarizing circuit was corrected and new procedures were established for testing this relay scheme. (Id., p. 5 ftn. 8.)

requirements placed upon the physical configuration of the offsite power system in the close proximity of the nuclear generating unit. Specifically, a minimum of two circuits must be utilized to connect the station switchyard directly to the onsite distribution system; and a minimum of two circuits must connect such a switchyard to the offsite power system. Requirements prescribed by GDC-17, however, extend only to that portion of the offsite power system which forms the link between the onsite electric distribution system and the grid. In particular, there is no NRC requirement concerning how many switchyards out in the grid must be directly connected to a station switchyard. GDC-17 does not deal with grid design, nor how and where circuits from a nuclear power plant are connected to it. (Fitzpatrick, Fol. Tr. 624, pp. 3-4; Tr. 634-37.)

In the case of the St. Lucie configuration the "common switchyard" referred to is the one that is electrically connected to the unit generator and the onsite distribution system. Consistent with the requirements of GDC-17 -- in fact, in excess of them -- there are three separate circuits linking the onsite switchyard with the grid. The Midway Substation, the junction point where the circuits actually connect to the grid, however, is beyond the scope of GDC-17. It is not the "common switchyard" referred to in the criterion. (Fitzpatrick, Fol. Tr. 624, pp. 3-5; Tr. 654, 706.) The NRC Staff also emphasized the view that, with reference to simultaneous failures, the use of the expression "to the extent practical" in GDC-17 was meant to allow for engineering judgment and the imposition of safety requirements in light of known potential hazards. Installations particulary susceptible to simultaneous failures are to be avoided. However, multiple circuits running from a nuclear power plant should be no more susceptible to simultaneous failures as a result of accident or environmental conditions because they tie to the grid at a common substation -- as in the case of St. Lucie -- than if they run along a common right-of-way, which is specifically allowed. (Fitzpatrick, Tr. 643, 649-52, 707-11.)

Although testifying witnesses concluded that the offsite electrical power arrangement for St. Lucie is consistent with GDC-17,*/ additional means of providing electricity to the site were discussed. The possibility of linking St. Lucie to separate portions of the grid by means of alternative circuits was discussed but not considered in detail. In particular, the possibility of connecting one of the three St. Lucie circuits to the grid at the Ranch Substation and other locations was addressed; as well as running additional power supply lines from points on the transmission and distribution systems. (See, e.g., Fitzpatrick, Fol. Tr. 624, pp. 7-8; Armand, et al.,

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*/ According to the primary Staff witness on the subject, this conclusion was also agreed to by all other NRC Staff members who considered the question with him; including a number of Branch Chiefs, Assistant Directors, and the Deputy Director of the Office of Nuclear Reactor Regulation. (Fitzpatrick, Tr. 648, 656-57.)

Fol. Tr. 45, p. 8; Testimony of Michel P. Armand, follows Tr. 147, pp. 2-3 [hereinafter Armand, Fol. Tr. 147, p. ____]; Attachment B to letter to Members of the Board from Harold F. Reis, Sept. 19, 1979, follows Tr. 147 [hereinafter Attachment B, Fol. Tr. 147, p. ____].)

The Board also expressed concern that, with the arrangement utilized for St. Lucie whereby connecting circuits all join the grid at Midway, one single event could interrupt the supply of offsite power. Further, it was noted that power has been lost to the site on one occasion as a result of multiple events which caused the electrical isolation of Midway. Had there been a direct connection of St. Lucie to the grid at an additional point, such a loss of power might have been avoided. (Fitzpatrick, Tr. 634-35, 643-44.) However, such a direct connection could, itself, create reliability problems.

Although detailed evaluations have not been performed, preliminary analyses indicate that connecting one of the exising circuits from St. Lucie to Ranch or Malabar would be inferior to the present arrangement from the standpoint of both reliability and load distribution under single as well as double outage conditions. (Armand, <u>et al.</u>, Fol. Tr. 45, p. 8; Armand, Fol. Tr. 147, p. 3; Attachment B, Fol. Tr. 147; Fitzpatrick, Tr. 627-29, 816-17.)

With respect to providing power to St. Lucie by means of an additional line, a 13 kV circuit -- utilizing either the existing distribution line on Hutchinson Island or a dedicated circuit -- would likely be inadequate or marginal at best. (Armand, Bivans, Flugger, Tr. 73-74, 224-26, 562-65, 611-12.) On the other hand, a 138 kV line would be adequate to supply emergency loads at St. Lucie. However, such a line would require crossing the Indian River and may or may not be feasible. In addition, there are alternatives to the construction of a line for providing additional power at St. Lucie, such as the installation of a peaking unit on site, or additional diesels. In any event, methodical and detailed analyses would be required in order to consider the comparative advantages and disadvantages of different alternatives with respect to a variety of factors, including reliability and economics. (Armand, Fol. Tr. 147, p. 4; Bivans, Armand, Tr. 75-77; 223-24; 240-51; 292-94.)

In sum, the termination of three circuits from St. Lucie into two separate busses at a major strong point of the FPL grid provides a firm connection, with demonstrated reliability, exceeding the requirements of GDC-17. Accordingly, any alternative arrangements providing for connections at additional grid locations are not required by that criterion, and could result in reduced reliability at a substantially increased cost. In any event, a new arrangement would require careful, detailed analysis and, on the basis of the current record, would not be expected to result in a significant improvement in offsite power reliability.

2. Part 2 of this question states:

> For its part, the first paragraph of GDC-17 appears to establish an unattainable set of conditions for electrical power systems generally. It reads as follows (emphasis added):
>
> > An onsite electric power system and an offsite electric power system shall be provided to permit functioning of structures, systems, and components important to safety. The safety function for each system (assuming the other system is not functioning) shall be to provide sufficient capacity and capability to assure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and (2) the core is cooled and other vital functions are maintained in the event of postulated accidents.
>
> This paragraph requires that an assessment of the sufficiency of the offsite power system start with the assumption that the onsite system is not functioning. That assessment must then consider the effect of "anticipated operational occurrences." But loss of the offsite power system itself may reasonably be considered to be such an occurrence. The parties should, therefore, explain how the St. Lucie plant can comply with the literal requirements of this paragraph as written. If it cannot, they should attempt to justify the situation in terms of the purpose of the requirement.

In response, and in accordance with the Board's instructions (Tr. 875-76), FPL references the prepared Testimony of Frederick George Flugger Relating to ASLAB Memorandum and Order of April 5, 1979, on Electrical Grid Stability and Emergency Power Systems (Questions A2, B1, B2, B3, and B4 of ALAB 537), follows Tr. 483, pp. 3-6 [hereinafter Flugger, Fol. Tr. 483, p. _____], and Fitzpatrick, Fol. Tr. 624, pp. 10-14).

B. Failure of Offsite Power with Simultaneous Onsite Power Failure

This question states:

In our order of March 10, 1978 (p. 5), we directed the Applicant to discuss the consequences of the following sequence: (1) failure of offsite power (and a presumption of resulting loss of the power generated by the station) followed by and combined with (2) failure of onsite power sources (i.e., the emergency diesel generators) to start on demand. The focus was to be on safety related events that might occur between the loss of all AC power and the eventual restoration of an electric power source.

Both the applicant and staff responded that this sequence, which supposes the simultaneous failure of two onsite emergency power sources, is not a "design basis event" and thus had not been studied in detail. Nevertheless, both briefly discussed its consequences.24/

1. As we see it, the likelihood of loss of all AC power at St. Lucie may be expressed as the product of two factors: (1) the probability that there will be an offsite power failure involving the FPL network generally or the Midway substation in particular and a resulting loss of station power -- which probability seems, based on historical events, to lie in the range 1.0 to 0.1 per year; and (2) the probability that neither of the two onsite AC power systems (diesel generators) will start. The probability that any one diesel generator will fail to start on demand is taken by the staff to be one per hundred demands, i.e., 10^{-2}.25/ If these figures are accurate, then

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24/ Applicant suggests that the first safety related failure encountered would be excessive core heating due to the loss of water from the condensate storage tank, and that this would occur about 16 hours after the loss of AC power (Flugger Affidavit of March 31, 1978, p. 3). The Staff's judgment is that the first failure would be that of a primary pump seal, at about one hour after loss of AC power -- resulting in a small loss of coolant accident. (Fitzpatrick Affidavit of June 21, 1978, p. 11.)

25/ Fitzpatrick Affidavit of June 12, 1978, p. 4. Also see Regulatory Guide 1.108, Section B.

the combined probability for the "loss of all AC power" scenario is in the range 10^{-4} to 10^{-5} per year.26/ In this regard, the Staff's Standard Review Plan for Nuclear Power Plants sets forth numerical guidelines for determining whether an event "resulting from the presence of hazardous materials or activities in the vicinity of the plant" should be considered in designing the plant (*i.e.*, whether it is a "design basis" event).27/ Under these guidelines, events with a realistically calculated probability value of at least 10^{-7} per year (or 10^{-6} per year for a conservative calculation) must be so considered.

The "loss of all AC power" sequence is not precisely within the category of events contemplated by the Standard Review Plan. However, its ultimate result -- assuming that power is not timely restored -- is an unprotected loss of coolant accident, the consequences of which are likely to exceed the guidelines of 10 CFR Part 100. We do not understand why this sequence of events (*i.e.*, loss of offsite power combined with failure of diesels to start), which appears to have a probability well above the guideline values, should not be taken into consideration in the design of the plant.28/ The parties are to address this point, setting forth their reasons for adhering (if they do) to a contrary position.

26/ This conclusion further assumes that the failure of two diesel generators to start would be statistically independent events, an assumption which leads to the lowest likelihood of combined failure, and which might be nonconservative if there exists the potential for common failure modes for the onsite systems.

27/ NUREG 75/087, Section 2.2.3, paragraph II.

28/ We have accepted the Standard Review Plan guideline values as reasonable in another case. *Public Service Electric and Gas Company* (Hope Creek Units 1 and 2), ALAB-429, 6 NRC 229, 234 (1977).

2. In line with the above discussion, the testimony is to analyze events that would occur between the "loss of all AC power" and the violation of either the fuel design limits or the design conditions of the reactor coolant pressure boundary (or any portion thereof). In particular, the parties should, if possible, reconcile their differing responses to question B.1(b) of our March 10, 1978 order,29/ or, if not, point up precisely where the disagreements lie.

3. The testimony should contain a discussion, suported by such data as is available, related to the time that might be required to start a diesel generator assuming it failed to respond to the initial, auto-start signal.

4. Finally, in the light of the discussion of points 2 and 3 above, the parties are to review possible measures for decreasing the likelihood of exceeding design limits on the reactor fuel and pressure boundary under the assumption that there is some time available to activate an auxiliary power source subsequent to a total loss of AC power.

29/ See fn. 24, *supra*.

1. Probability of Loss of all AC power.

As explained in Question B.1, the Board's analysis indicated that the loss of all AC power at St. Lucie Plant appeared to have a probability well above the numerical guideline values set forth in the Staff's Standard Review Plan for Nuclear Power Plants for determining whether an event "resulting from the presence of hazardous materials or activities in the vicinity of the plant" should be considered in designing the plant. Question B.1 therefore asks whether a postulated simultaneous loss of offsite and onsite AC power sources should be included in the design basis for the plant.

In its response, Applicant discussed the concepts of event frequency and engineered safety feature reliability, stressing that the design bases for Unit 2 had been developed by analyzing limiting events to provide reasonable assurance that the facility has adequate capability to accommodate unanalyzed events. (Flugger, Fol. Tr. 483, p. 8). The probability of occurrence of non-design basis initiating events that may produce results more severe than a design basis accident is considered so small that these events are not incorporated into the plant design. The numerical guideline values of $10^{-6}/10^{-7}$ described in Section 2.2.3 of NUREG 75/087 "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition", U.S. Nuclear Regulatory Commission, September 1975, are addressed to "design basis events resulting from the presence of hazardous materials or activities in the vicinity of the plant" and, further, are appropriate only for events that have a potential for yielding offsite exposures that equal or exceed 10 CFR Part 100 guidelines. (Flugger, Fol. Tr. 483, p. 8.)

The use of a single failure criterion in nuclear plant design, which is imposed by Appendix A to 10 CFR Part 50 and is a fundamental premise upon which all nuclear safety related designs are based, has as its objective preventing any single failure from preventing the accomplishment of a safety function. (Flugger, Fol. Tr. 483, p. 9.) In that regard, although increased material and component quality level, testing, and maintenance will improve reliability, above certain levels substantial cost and testing commitments result in minimal increases in reliability. Because of this, the concept of redundancy, upon which the single failure criterion is based, is employed to achieve acceptable reliability levels in nuclear plant designs. (Flugger. Fol. Tr. 483, p. 9.) The loss of offsite electrical AC is protected against in the design of St. Lucie 2 by an onsite AC system that employs, in accordance with GDC-17, redundant and independent diesel-generators. The postulated loss of all AC power following the loss of offsite AC violates the single failure criterion in that it requires the failure of both redundant and independent diesel generators. (Flugger, Fol. Tr. 483, p. 10.)

However, even though the sequence of events postulated by the Board in this question is not a design basis event for St. Lucie 2, or any nuclear plant, Applicant performed an analysis which demonstrated that the postulated loss of all AC event can be accommodated by the St. Lucie 2 design for some period of time. (Flugger, Fol. Tr. 483, p. 10.)

Applicant demonstrated that the appropriate probability for evaluation of the postulated loss of all AC event is the probability during any one year of having a loss of all AC power combined with the probability of not restoring AC power by a certain time "T". Applicant developed an exponential equation to calculate this probability. (Flugger, Fol. Tr. 483, pp. 10-11; Tr. 569). The Applicant's calculations include the assumption that there is no component of common mode failure with respect to loss of the diesel generators. (Flugger, Tr. 577.) Applicant examined historical data from its own system to determine appropriate time constants for restoration of offsite power and repair of diesel generators. (Flugger, Fol. Tr. 483, p. 11.) With respect to the time constant for restoration of offsite power, Applicant performed two studies in parallel. In its engineering department, it plotted grid failure data, and performed an engineering curve fit to this data, which was found to be represented by an exponential curve. Simultaneously, Applicant's System Planning Department performed a statistical analysis, which produced essentially the same results. (Flugger, Tr. 579-80.)*/.

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*/ In the statistical analysis, data involving an event at applicant's Turkey Point Plant in April of 1979, in which all seven transmission circuits failed, but offsite power continued to be supplied to the nuclear units from a unit on site, was not included. However, if that data point was included, it would not greatly affect the result, and the exponential derivation still bounds all data points conservatively. (Flugger, Tr. 582.)

Applicant calculated probability values using both 1.0 per year and 0.1 per year for event frequency of loss of offsite AC power. (Flugger, Fol. Tr. 483, p. 12.) Applicant's analysis resulted in the following table, assuming an event frequency of 0.1 per year for loss of offsite AC power:

DURATION OF LOSS OF AC "T" (HOURS)	PROBABILITY OF HAVING A TOTAL LOSS OF AC POWER THAT LASTS "T" HOURS, P(T).
0	1×10^{-5}
1	2×10^{-6}
1.2	1×10^{-6}
2	2×10^{-7}
2.4	1×10^{-7}
3	3×10^{-8}
4	5×10^{-9}

If an event frequency of 1.0 per year was assumed for loss of offsite AC power, instead of 0.1, Applicant's analysis demonstrated that a value for P(T) of 1×10^{-6} would be reached at 2.4 hours, and 1×10^{-7} at 3.6 hours. (Flugger Fol. Tr. 483, p. 12.)

Based upon these calculations, and application of the $10^{-6}/10^{-7}$ numerical guideline values suggested by the Board Applicant demonstrated that upon the loss of all AC power at St. Lucie 2, the probability of not restoring AC power within one to four hours is within those numerical guideline values. (Flugger, Fol. Tr. 483, p. 12.) In response to Question B.2, discussed in detail below, Applicant then demonstrated that Unit 2 could be safely maintained in a hot shutdown condition until AC power was restored.

The loss of all AC power has recently been identified by the NRC Staff as Task Action A-44. Because this Task Action is in its initial stages of development, no numerical criteria have been established. (Fitzpatrick, Fol Tr. 624, p. 16.)

In its review of Applicant's analysis, the NRC Staff noted that the time constant used by Applicant in the exponential equation, 1.6 $hr.^{-1}$, represented an average duration of 37.5 minutes for loss of all AC power, which was conservative based upon FPL historical data which indicated an average duration of only 26 minutes. (Fitzpatrick, Fol. Tr. 624, p. 16). Applicant conservatively chose to use 37 minutes, because it had a 99.5 per cent statistical confidence that the mean restoration time would not be greater. (Armand, et al, Fol. Tr. 45, p. 13, n. 16). The NRC Staff demonstrated that if the appropriate time constant for 26 minutes of 2.3 $hr.^{-1}$, and conservative estimates of diesel generator unreliability used in the Reactor Safety Study of 3×10^{-2} (instead of 10^{-2} as suggested by the Board) were used in the equation, the 10^{-7} suggested criterion is achieved at 3.5 hours, which is essentially the same figure (3.6 hours) presented by the Applicant. (Fitzpatrick, Fol. Tr. 624, p. 17). Using the $10^{-6}/10^{-7}$

criteria suggested by the Board the NRC Staff agreed that if it could be demonstrated that primary system integrity (i.e., natural circulation with no excessive leakage) could be maintained at St. Lucie 2 for four hours of station blackout conditions, the probability of core damage was well below the 10^{-7}/year criterion for the St. Lucie 2 design. (Fitzpatrick, Fol. Tr. 624, p. 17.)

The analysis performed by the Applicant, and supported by the Staff, as outlined above, does not specifically answer the question posed, which is whether the loss of all AC power should be considered in the design of the plant. However, the NRC Staff provided background information to the Board on an unresolved safety issue, "Station Blackout" (Generic Task A-44) which is relevant to this question. (Testimony of Patrick W. Baranowsky in response to Board Question B.1, follows Tr. 760, p. 1 [hereinafter Baranowsky, Fol. Tr. 760, p. __.])

The definition of Task A-44 is specifically to resolve the issue of whether or not station blackout, i.e. the loss of all AC power, should be considered in the design basis of a nuclear power plant. The task includes a probabilistic evaluation of all aspects related to station blackout. It will be followed by a determination of which of those aspects merit incorporation in the design basis of a plant. (Baranowsky, Tr. 763.)

Witness Baranowsky is the Task Manager for Task A-44. (Baranowsky, Tr. 751.) As of the date of the hearings in December 1979, there was no plan developed under Task A-44 for its resolution. A plan is expected to be developed and published within a matter of weeks. (Baranowsky, Tr. 764.)

The Office of Nuclear Reactor Regulation formally established the issue of station blackout as a generic task in 1977. It was originally designated as Generic Task B-57. However, in November 1978, the Staff's concern regarding the potential risk posed by a station blackout, particularly in older plants not reviewed against current requirements, resulted in a staff proposal (and the Commission agreed) to report this issue to Congress as an "unresolved safety issue" pursuant to Section 210 of the Energy Reorganization Act of 1974, as amended. Accordingly, Task B-57 was elevated in priority and re-designated Task A-44. The responsibiliy for developing and implementing a program to resolve this issue was transferred to the Probabilistic Analysis Staff in the Office of Nuclear Regulatory Research in August 1979. This was partly due to NRR manpower limitations and partly in recognition that the approach to resolving this issue would necessarily have to depend strongly on probabilistic analysis techniques. In particular, it was clear that this issue extended beyond the single failure criterion. (Baranowsky, Fol. Tr. 760, p. 2.)

In October of 1979 a simple survey analysis was begun by the Probabilistic Analysis Staff to make a rough estimate of the failure probability for all AC power and the loss of shutdown heat removal capability at currently operating PWR's. The intent of this work was to provide a screening mechanism to identify operating plants most likely to suffer core damage due to station blackout at the outset of the program, and to identify appropriate short-term actions which could be taken to reduce station blackout vulnerability while a more extensive program was undertaken. (Baranowsky, Fol. Tr. 760, p. 3.)

As noted above, the longer term and more extensive effort for Task A-44 has not yet been fully scoped. One approach being considered is to incorporate all or part of the effort in the integrated reliability evaluation program (IREP) which will be conducted through the Probabilistic Analysis Staff over the next three years to provide safety reliability and accident probability estimates at all operating nuclear power plants. (Baranowsky, Fol. Tr. 760, p. 3.)

Consequently, it appears that the NRC Staff is currently striving to resolve, through a Task Action, the issue of whether the loss of all AC power should be considered in the design basis of a nuclear power plant.

We turn now to the more plant specific questions addressed to the parties concerning the ability of St. Lucie Plant to withstand the postulated loss of all AC power and the expected consequences to be anticipated during the interval before AC power is restored.

2. Analysis of Events Which Could Occur Prior to the Restoration of AC power.

The Board's inquiry here was directed to an analysis of the events that could occur from the time St. Lucie 2 sustained a total loss of all AC power to the time AC power was restored. It wanted to know whether a violation of either the fuel design limits or the design conditions of the reactor coolant pressure boundary would occur. In particular, the Board requested the parties to reconcile, if possible, what appeared to be differing responses to Question B.1(b) of its March 10, 1978 Order concerning the most limiting potential safety related failure. (Slip op., p. 19.)

As noted above, "station blackout", or a loss of all AC power, is not currently a design basis event. (Flugger, Fol. Tr. 483, p. 10; Baranowsky, Fol. Tr. 760, p. 2; Tr. 765; Baer, Tr. 766.) Nevertheless, for a number of years the NRR Staff has been concerned about the loss of all AC power. (Baer, Tr. 766.) About four or five years ago, a Branch Technical Position required new applications to have a design which incorporated an auxiliary feedwater system with a diverse power source and DC controls. The intent was to eliminate at least one dependent failure so that a plant could better survive a loss of all AC power. (Baer, Tr. 766.)

In this regard, Applicant's witness acknowledged that should a station blackout occur, the auxiliary feedwater system is the most critical system for this event. (Flugger, Tr. 533.)

Ongoing Staff analysis of the event led to preliminary consideration of more subtle risks associated with station blackout, such as failure of reactor coolant pump seals. (Baranowsky, Fol. Tr. 760, p. 6; Baer, Tr. 767.) And, more recently, as noted above, Task A-44 has been identified to resolve the question whether or not station blackout should be a design basis event. (Baranowsky, Fol. Tr. 760, p. 1; Tr. 763.)

The preliminary analysis of "station blackout" conducted by the Probabilistic Analysis Staff (PAS) pursuant to TA-44, focused on the loss of shutdown heat removal capability at currently operating PWR's to consider the failure mechanisms within or by supporting systems of the emergency feedwater system. (Baranowsky, Fol. Tr. 760, pp. 2-3.) As a result of this preliminary work conducted in October 1979, at the hearing PAS provided testimony which recommended that, in order to minimize the accident probability for station blackout sequences:

> "(2) A shutdown heat removal system (emergency feedwater system) should be provided with at least one train independent of AC power supplied for activation, motive power, control, and required auxiliary or supporting systems."

(Baranowsky, Fol. Tr. 760, p. 5.)*/

The evidence reflects that the design of St. Lucie Unit No. 2 includes an emergency feedwater system totally independent

*/ The record reflects that PAS made a total of four (4) recommendations. The other three are also discussed below.

of AC power which consists of a 100 per cent capacity steam turbine driven pump, with DC operated valves and DC operated controllers at the pump. The lube oil pump for the steam turbine driven pump is shaft driven and therefore AC independent; the lube oil cooler receives circulation from discharge flow and is AC independent. In short, the St. Lucie 2 design complies with this recommendation. (Flugger, Tr. 484-88.)

The NRC Staff concluded that the limiting event for St. Lucie 2 following station blackout would be loss of natural circulation in the primary coolant system (i.e., loss of core cooling capability) resulting from a significant loss of primary coolant through the reactor coolant pump seals. (Fitzpatrick, Fol. Tr. 624, p. 20; Baer Tr. 767.)

Previously, the Flugger affidavit filed by Applicant in response to the Board's order of March 10, 1978 concluded that there was a sufficient volume of condensate storage to allow the unit to maintain hot standby conditions for at least 16 hours; the spent fuel storage pool would not require makeup for at least 36 hours; and power would be restored before any unacceptable consequences would occur. The Fitzpatrick affidavit filed on behalf of the Staff concurred with FPL's response, but went on to suggest that a failure of a reactor coolant pump (RCP) seal could potentially occur after one hour as a result of the loss of all AC power. (Flugger, Fol. Tr. 483, p. 13.)

Subsequent testimony adduced at the hearing has reconciled this apparent difference and furnished a comprehensive description of events.

Section 9.2.2.3.1 of the St. Lucie Unit 2 PSAR was utilized by the NRC Staff to conclude that reactor coolant pump (RCP) seal integrity could be maintained for an hour of operation following the loss of component cooling water. (Fitzpatrick, Fol. Tr. 624, p. 17-18.) However, upon loss of AC power, the reactor will trip, the RCP's will coast down and stop, and cooling water flow to the RCP seals will cease. This static condition (pump not running) is much less severe than the dynamic condition (pump running) discussed in the Unit 2 PSAR at Section 9.2.2.3.1. (Flugger, Fol. Tr. 483, pp. 13-14.)

An analysis of the RCP seal design and construction confirms that a mechanism for development of an appreciable leakage path within the seal cartridge under static conditions does not exist. (Flugger, Fol. Tr. 483, p. 14.) The bases for this conclusion are:

1. All seal components are captured within the seal cartridge assembly and held together by hydraulic and spring forces thereby minimizing the leakage paths.

2. Each of the four seals that comprise the seal assembly are designed to provide sealing against full system pressure.

3. All the components that comprise the seal cartridge assembly, except for the elastomeric U-cups and O-rings, are made of materials that are unaffected by the elevated temperatures, resulting from a loss of coolant to the seals.

4. Confined O-rings made of the elastomeric material used on the U-cups and O-rings have been used on flanged joints of a reactor coolant pump hot test loop where they have been subjected to temperatures of 550° F for in excess of 100 hours. The O-rings maintained their sealing capability although hardening and permanent set of the O-rings, as expected, occurred.

(NRC Staff Testimony of Byron L. Siegel, follows Tr. 624, p. 2 [hereinafter Siegel, Fol. Tr. 624, p. ___]"; Flugger, Fol. Tr. 483, pp. 14-17.)

Operation of a reactor coolant pump after restoration of AC power will likely result in higher than normal seal leak rates due to hardening of the elastomeric materials. Consequently, natural circulation cooldown to cold shutdown conditions would be preferred since it would not require running of a reactor coolant pump. In this regard, in April of 1977 the St. Lucie Unit No. 1 reactor coolant system was borated and the plant was brought to a cold shutdown on natural circulation without the reactor coolant pumps running. (Flugger, Fol. Tr. 483, p. 17.)

Applicant described the procedures for maintenance of reactor coolant system temperature and pressure during natural circulation utilizing the steam turbine driven auxiliary feedwater pump, which is totally independent of AC power, to supply the steam generators and provide removal of decay heat. Applicant also demonstrated that sufficient condensate storage is available, and additional condensate storage makeup is available. Moreover, DC batteries installed at the facility have sufficient capacity to accommodate the postulated transient. (Flugger, Fol. Tr. 483, pp. 18-19.)

The record reflects that the RCP seal cartridge will maintain its low leakage characteristics for the duration of the static loss of all AC event and that the RCP seals are expected to remain functional for a period of at least 24 hours. (Flugger, Fol. Tr. 483, p. 17.)

If the pumps were restarted, upon restoration of AC power, and the elastomeric materials hardened, some increased leakage through the seal would be expected. (Flugger, Tr. 599). Such leakage however would only be in terms of tens of gpm above design value, not hundreds of gpm, and within the capability of the charging system. (Flugger, Tr. 599). No LOCA, even characterized as a small LOCA, would occur. (Flugger, Tr. 599; 10 CFR §50.46(c)(1).)

Applicant also described a procedure for alignment of the Unit 1 diesels to supply AC power to Unit 2 if the need arose. One diesel has the capability to supply the loads required for both units. (Flugger, Tr. 546). Applicant has reviewed the sequence of events and has determined that it would take two men about one hour to align a Unit 1 diesel to Unit 2. (Flugger, Tr. 483, p. 19.)*/

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*/ With respect to alignment of the diesels, the NRC Staff acknowledged that Applicant has not taken any credit for this capability in the analysis of probability versus time for restoration of power. (Fitzpatrick, Fol. Tr. 624, p. 18.) Before any such credit could be assigned, the NRC Staff would require that station blackout at multiunit sites be analyzed in depth, pursuant to Task A-44, prior to determining the criteria for governing reassignment of onsite power sources. However, the Staff feels that the capability of transferring diesel generators between units is a very desirable design feature, especially for the station blackout sequence of events. (Fitzpatrick, Fol. Tr. 624, pp. 18-19.)

The NRC Staff has confirmed the information supplied by the Applicant with information provided by the manufacturer of the reactor coolant pumps for St. Lucie Unit 2, at a meeting held May 16, 1979 between the NRC Staff and the Applicant. (Siegel, Fol. Tr. 624, p. 2.) The NRC Staff agrees that there is a strong basis for acceptance of the conclusion that a significant loss of reactor coolant through the seal cartridge will not occur. However, no test data is available which is specifically related to performance of the elastomeric seals in the geometry utilized in the seal assembly design, at temperatures and pressures anticipated following station blackout. Consequently, the NRC Staff has required the Applicant to perform a confirmatory test on at least one of the four seal assemblies that comprise the seal cartridge under expected blackout conditions of temperature, pressure and time to provide additional verification necessary to determine the adequacy of the reactor coolant pump seal design. The results of this test are required to be included in the FSAR for St. Lucie Plant, Unit No. 2. (Siegel, Fol. Tr. 624, p. 3; letter dated September 17, 1979 signed by Robert L. Baer, follows Tr. 624.)

The NRC Staff has concluded that the analysis provided by the Applicant, supplemented with the forthcoming results from the confirmatory test, which show that the loss of coolant through the reactor coolant pump seals during the duration of station blackout is not sufficient to adversely affect natural circulation, provide adequate assurance that the ability to cool the reactor core will be maintained, and that the fuel design and reactor coolant pressure boundary limits will not be exceeded. (Siegel, Fol. Tr. 524, p. 3.)

Consequently, there is no basis for concluding that an unprotected loss of coolant accident, the consequences of which are likely to exceed the guidelines of 10 CFR Part 100, would occur during the probable time necessary to restore AC power. (Flugger, Fol. Tr. 483, p. 20; Flugger, Tr. 598-600.)

3. Time to Restart Diesel Generator Following Failure to Respond to Initial Auto Start Signal.

Current technical specifications governing repair of diesel generators following failure to start do not place time pressure constraints upon returning the diesel to service. Accordingly, any evaluation of the time to return a diesel to service based upon historical data would likely yield a conservative estimate of the time to return a diesel generator to service. (Flugger, Fol. Tr. 483, p. 20; Fitzpatrick, Fol. Tr. 624, p. 20.)

The NRC Staff does not have an independent data base from which to calculate a mean-time-to-repair (MTTR) for diesel generators in nuclear service. The Licensee Event Reports (LER's) submitted in accordance with the guidelines of Regulatory Guide 1.16 "Reporting of Operating Information -

Appendix A, Technical Specificatons" have not required MTTR data for diesel generator failure reports. Regulatory Guide 1.108 "Periodic Testing of Diesel Generator Units Used as Onsite Electrical Power Systems at Nuclear Power Plants" (October 1976) established a requirement to report duration of outages from which MTTR can be calculated. However, this regulatory guide applies to all construction permit applications following its date of issuance and no operating nuclear plants fall into this category. Although the Regulatory Requirements Review Committee has determined that Regulatory Guide 1.108 should be applied to operating reactors on a case-by-case basis, and some operating plants have been required to meet the requirements of the Guide, the number of plants involved is not sufficient to yield a statistically meaningful data base. (Fitzpatrick, Fol. Tr. 624, pp. 19-20.)

Applicant did submit repair time frequency distribution based upon St. Lucie and Turkey Point experience for diesel generator repairs at those units. This indicated that the median diesel repair time is 111 minutes and the mean is 388 minutes. This data was used to calculate the time constant for restoration of a safety related diesel at an FPL nuclear facility. (Flugger, Fol. Tr. 483, p 22.)

Diesel generator experience at St. Lucie Unit No. 1 has been reflected in the Unit No. 2 design. There have been seven failures to start at St. Lucie of which only two could be categorized as major maintenance items. These two events were associated with turbocharger malfunctions, which involved repair durations of about 60 hours and 173 hours. Four of the remaining five events were corrected in less than two hours. The fifth event involved a sticky solenoid and pluggage of an air starting line for which restoration time was 7-2/3 hours. (Flugger, Fol. Tr. 483, p. 21.) Since the turbocharger failures resulted from a design feature that has been modified in the Unit 2 design, these data points have been omitted from the FPL data base. Similarly, a recent Turkey Point diesel generator voltage regulator transformer problem was resolved by disconnecting a neutral lead, resulting in the elimination of third harmonic current heating effects. Since this problem was unique to the Turkey Point design and does not apply to the St. Lucie diesel generators, this data point was also omitted from the data base. (Flugger, Fol. Tr. 483, pp. 21-22.)

The NRC Staff agreed that it was appropriate to delete data points for failures for which corrective design measures have been made. (Fitzpatrick, Fol. Tr. 624, p. 20.) Inclusion of these data would not alter the conclusions reached with respect to Question B.1 above to the effect that evaluation of a period exceeding about 1 to 4 hours is not required, since the probability of not restoring offsite AC power within that time period is acceptably low. (Flugger, Fol. Tr. 483, p. 22, fn 1.)

4. Measures to Decrease Likelihood of Exceeding Design Limits on Reactor Fuel and Pressure Boundary.

An increase in reliability in terms of the continuity of offsite power would not add materially to the reduction of the likelihood of the loss of all AC power at St. Lucie plant. It would be less than an order of magnitude change in probability. (Flugger, Tr. 527-28; Baer, Tr. 772; Baranowsky, Tr. 776, 816.)

Consequently the inquiry turned to the reliability of the onsite emergency power systems for St. Lucie Plant Unit No. 2. The probability value for diesel reliability, 10^{-2}, appears to be an approximate number. (Flugger, Tr. 525-26.) Applicant's use of that value was confirmed by a 300 start test conducted in the manufacturer's shop for the St. Lucie 1 diesels. That test achieved a 10^{-2} probability of success with a 95% confidence level. This is bounded by the values furnished by WASH 1400 of 3×10^{-2} and the suggested IEEE value of 8×10^{-3} contained in its publication, "Guide to the Collection and Presentation of Electronic and Sensing Component Reliability Data for Nuclear Power Plants". (Flugger, Tr. 516-517.)

However, a test run of starts run in a vendor's shop should not be accepted without reservation as a mark of reliability of a diesel generator. (Baranowsky, Tr. 854.) The

300 start requirement is not for reliability but is for prototype qualification. (Fitzpatrick, Tr. 854-855.)

The St. Lucie Unit 2 design incorporates features to preclude common mode failures of diesel generators, including physical and electrical independence of the "A" and "B" trains. (Flugger, Tr. 539.) Diesel oil is stored in separate tanks. (Flugger Tr. 539). Diesel oil delivered to the site is tested and sampled. (Flugger, Tr. 540.) A sequencer is provided to automatically sequence, with a timer, loads on the diesels to preclude common mode failures from rapid loading of large loads. (Flugger, Tr. 540-541.) The St. Lucie 2 diesels do not operate in a unique environment. (Flugger, Tr. 542.) They are housed in a building designed to withstand hurricanes or other anticipated types of weather conditions. (Fitzpatrick, Tr. 783.) Applicant's witness was unaware of any instance of common mode diesel generator failure in its system, or, after conducting a literature search, for industry. (Flugger, Tr. 577-78.)

The diesel generators for St. Lucie 2 will be required to comply with the Regulatory Guide 1.108 program when they arrive on the site. A level of reliability of 10^{-2} must be maintained during operation, and if necessary, testing must be accelerated until that goal goal is re-established. (Fitzpatrick, Tr. 734; Baer 774.)

As noted above, the NRC Staff voluntarily provided the Board with information with respect to Task A-44, Station Blackout. Early work performed on the station blackout issue has identified several design and procedural improvements which have the potential for minimizing the accident probability for station blackout sequences. (Baranowsky, Fol. Tr. 760, pp. 5-6.) In its Memorandum and Order of November 29, 1979 (unpublished), the Board asked the parties to "... be prepared to elaborate upon their testimony by identifying and discussing which, if any, of the generic 'design and procedural improvements' ... have been or are being adopted at this facility." They are identified as follows:

> 1. The preoperational and periodic testing requirements of Regulatory Guide 1.108 for emergency diesel generators should be implemented in order to demonstrate and maintain a high reliability for these units. The demonstrated reliability should be considered in the establishment of the limiting conditions for operation when one diesel generator is inoperative.

Applicant has committed to compliance with Regulatory Guide 1.108 as implemented in technical specifications for St. Lucie Unit No. 2. (Liebler, Tr. 403, 406.)

> 2. A shutdown heat removal system (emergency feedwater system) should be provided with at least one train independent of AC power supplied for activation, motive power, control, and required auxiliary or supporting systems.

The design of St. Lucie Unit No. 2 includes a steam driven auxiliary feedwater train which is totally independent of AC power. (Flugger, Fol. Tr. 483, p. 3; Tr. 484-487.)

> 3. The limiting conditions of operation should be amended to limit the time that power generation may continue for combinations of offsite power circuits, AC independent shutdown cooling trains, and emergency (onsite) AC power supplies out of service.

Limiting conditions for operation for St. Lucie 2 will be consistent with NRC requirements and will be derived from the Final Safety Analysis Report. (Flugger, Tr. 508.)

Moreover, Applicant agrees that this recommendation is prudent and does not represent a major change from what is presently contemplated. (Flugger, Tr. 510.)

> 4. Emergency procedures should be made available to operators, plant maintenance personnel, and offsite personnel (e.g., grid dispatchers) identifying the functions for coping with a station blackout and restoring offsite and onsite (emergency) AC power supplies.

Applicant has already adopted or has committed to develop such procedures and make them available to plant personnel prior to operation of St. Lucie 2. Applicant currently has in effect procedures which emphasize the desirability of maintaining offsite power to its nuclear plants. It also has specific procedures to restore power to each nuclear plant. (Coe, Tr. 36). Procedures to be developed will be based on a review of the final as-built design of the plant, and will include directions for the restoration of AC power sources. (Liebler, Tr. 403; 435.) Such procedures will include specific training for operators in simulated loss of offsite power blackout conditions. (Liebler, Tr. 435-437.) The operators would be trained to make sure that the auxiliary feedwater system is initiated. (Flugger, Tr. 533.) Applicant will have procedures that identify the need to do so. (Flugger, Tr. 534.)

Applicant has committed to review the detailed actions to stabilize the unit, upon occurrence of the event, prior to issuance of an operating license to insure that the operators have the capability to achieve and maintain hot shutdown conditions for the duration of the loss of all AC power. (Flugger, Fol. Tr. 483, p.24.) In addition, although station blackout is not now a design basis event, Applicant has committed to review plant design specifically with regard to recovery from station blackout. Applicant will provide a design which is workable so that procedures which are useable can be developed. Instrumentation for monitoring critical plant parameters, during a loss of AC power, will be included in the final plant design. Applicant has committed to review the design to make sure the operators will have the instrumentation to cope with the postulated station blackout condition. (Flugger, Tr. 489, 588.)

The FSAR is expected to be submitted during the spring of 1980 and there will be a two and one half to three year review process beyond that time. (Baer, Tr. 774.)

In the interim, the Staff will work for the resolution of this same question under Task Action A-44. (Baranowsky, Fol. Tr. 760 p. 3)

Station blackout is not a design basis event, nevertheless, Applicant has already adopted or has committed to adopt each of the generic design and procedural improvements at St. Lucie 2 which the NRC Staff believes have the potential for minimizing the accident probability for station blackout accident sequences. Applicant has demonstrated that St. Lucie 2 can accommodate a station blackout and that the potential for exceeding the design limits on the reactor fuel and pressure boundary prior to restoration of AC power is acceptably low. In addition, Applicant has committed to review the St. Lucie 2 design to assure that procedures can be developed and implemented, and instrumentation will be available, to deal with a station blackout should it occur.

Even if it is assumed that Task A-44 will ultimately be resolved by concluding that station blackout should be a design basis event, St. Lucie Unit 2 is so designed that it does not fall into that class of plants for which station blackout is potentially risk significant. The record in this proceeding demonstrates that the loss of all AC power does not have a significant safety impact on such a plant. Accordingly, the Board's conclusions regarding the issuance of a construction permit are unaffected by generic Task A-44. See Gulf States Utilities

Company (River Bend Station, Units 1 and 2), ALAB-444, 6 NRC 760 (1977); Virginia Electric & Power Company (North Anna Nuclear Power Station, Units 1 and 2), ALAB-491, 8 NRC 245 (1978); Tennessee Valley Authority (Yellow Creek Nuclear Plant, Units 1 and 2), LBP 78-39, 8 NRC 602 (1978).

C. System Reliability During Alert Status

This question states:

> According to the staff, the applicant is being required to define conditions in which it will put its power distribution system in an "alert status".30/ At such times, loss of offsite power would presumably be more likely than normal. We wish to be advised as to the existence of measures that might be taken to assure, or at least to increase, the reliability of the onsite power systems during an "alert status" period.

30/ Fitzpatrick Affidavit of June 12, 1978, Enclosure 3.

The entire onsite power system, including the diesels, is routinely subjected to surveillance testing and inspections in order to assure availability. (Testimony of George E. Liebler Relating to Question C of ALAB-557, follows Tr. 404, p.2 [hereinafter Liebler, Fol. Tr. 404, p. __].) In connection with such testing and inspections, FPL will comply with Regulatory Guide 1.108 as it may be effectuated in technical specifications to be developed in the ongoing dialogue with the NRC Staff governing preoperational and periodic testing requirements.*/ (Liebler, Tr. 403, 405-06.)

Consideration has been given to the possibility of running the diesel generators for a short period of time during an "alert status." This would serve to verify the availability of the diesel-start systems, auxiliaries, and the engines themselves by actual operation. (Liebler, Fol. Tr. 404, p.2.) Such a practice, however, could subject the diesel generators to an undue number of challenges. (Fitzpatrick, Fol. Tr. 624, p.22.) In addition, starting and operating the diesel generators under no-load conditions, such as could be done under an "alert" situation,**/ will cause incomplete combustion resulting in the formation of gum and varnish deposits within the engine and the accumulation of unburned fuel in the turbocharger and exhaust system. Thus, consequences of such operation are potential equipment failure due to the formation

*/ Regulatory Guide 1.108 is entitled "Periodic Testing of Diesel Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants." It "describes a method acceptable to the NRC staff for complying with the Commission's regulations with regard to the periodic testing of diesel electric power units to ensure that the diesel electric power systems will meet their availability requirements." (Rev. 1 August 1977, p. 1.)

**/ Under conditions where time is available testing can be performed under load. This is, for example, the type of surveillance conducted during the approach of a hurricane. Loading the diesel generators, however, involves tying them into the grid. Thus, such testing during a period when the grid is subject to disturbance would be unwise since to do so would subject them to whatever disruptions might occur on the grid iteself. (Liebler, Tr. 428-32.)

of deposits and fire in the engine exhaust system. (Liebler, Tr. 425-28; Fitzpatrick, Fol. Tr. 624, p. 22.)

Any improvement in reliability gained from testing in addition to that to be required by the technical specifications implementing Regulatory Guide 1.108 would not be expected to be significant. (Liebler, Fol. Tr. 404, p. 2.) Further, no-load running of the diesel generators for every alert state that the electrical grid might encounter could unnecessarily hamper their performance in a real emergency; not only as a result of the equipment degradation mentioned above, but by requiring the attention of onsite personnel who might otherwise be performing other important functions. (Fitzpatrick, Fol. Tr. 624, pp. 22-23.)

In sum, additional operation of the diesel engines during periods of "alert status" is neither necessary nor desirable, and all witnesses specifically so testified. (Liebler, Fol. Tr. 404, p. 2; Fitzpatrick, Fol. Tr. 624, p. 22; Tr. 414-18, 429-30.)

D. <u>Ongoing Improvement of System Reliability</u>

This question states:

> The testimony should provide a concise, up-to-date discussion of existing measures, or those planned for the near future, by which the reliability of the applicant's system may be enhanced. Particular attention should be paid to the seemingly excessive number of personnel errors which appear to have led to the May 14, 1978 outage and to have contributed to the May 16, 1977 disturbance.

FPL has undertaken a number of projects such that, when they are completed, overall grid reliability should be substantially improved. Further, FPL's system in the Midway area, in particular, will be strengthened so that the probability of a loss of offsite power at this point will be substantially reduced.

Historically, in the event of a major system disturbance within Florida, interconnections to the north -- notably to the Georgia Power Company -- have been designed such that the two systems would separate. Although this, in itself, has not significantly affected the reliability of FPL's grid because it is designed to function independently, reliability could be aided if the two systems remained interconnected. A new 240 kV tie between the peninsular Florida grid and Southern Company was recently established. This tie now connects FPL directly to Georgia Power and should help reduce the instances where separation occurs following large disruptions on the FPL system. (Armand, et al., Fol. Tr. 45, p. 9, Attachment #6; Letter to Members of the Board from Harold F. Reis, Sept. 19, 1979, Attachment A, Fol. Tr. 147; Armand, Bivans, Tr. 136-39, 180-81.)

Another major system improvement consists of additions to the 500 kV portion of FPL's grid. These additions, which are expected to be completed this year, consist of a 16 mile, 500 kV circuit from a new substation at Levee to an existing 500 kV substation at Andytown; two 83 mile, 500 kV circuits from

Andytown to the new fossil plant site at Martin; and a 26 mile, 500 kV circuit from Martin Plant to the Midway Substation. The completion of this network will further strengthen Midway and enhance its ability to provide offsite power to St. Lucie by electrically shortening its ties, via the 500 kV grid, to the rest of the system.*/ Further, when the Martin Plant Unit 1 becomes operational this year it will provide a direct source of offsite power to St. Lucie through the Martin-Midway 500 kV line mentioned above. By the end of 1980 there will be one 500 kV, five 240 kV, and two 138 kV circuits into Midway. (Armand, et al., Fol. Tr. 45, pp. 9-10; Fitzpatrick, Fol. Tr. 624, p. 23.)

Particular attention has also been paid to reducing personnel errors which might result in system disturbances. Field switching personnel and the system dispatcher/operators who monitor and control both the granting of clearances and the sequence of switching are now better equipped to perform their duties. Proposed system configurations are first analyzed under

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*/ During the hearings Intervenors inquired about tying to the "eastern U. S. grid" through Georgia, and the possibility of establishing a 500 kV intertie. (Tr. 26-28.) FPL currently has a project to establish a complete 500 kV network over the north-south length of its system and has been pursuing the project for a number of years. (Bivans, Tr. 178-80.) A 500 kV intertie or system of interties with Georgia now, however, would not provide greater system reliability in the FPL system without the additional trans- mission expansion now underway and planned. (Florida Power & Light Company's Answers to Intervenors' Interrogatories to Florida Power and Light Company, Fol. Tr. 6, #3; Bivans, Coe, Tr. 185, 198-200.)

contingency conditions prior to allowing field switching. A written switching order is then prepared in accordance with specific procedures and guidelines. This order is checked and then, if approved, issued to the party in the field. Finally, the field party checks it prior to proceeding in accordance with specific switching procedures in which it has been trained. (Armand, et al., Fol. Tr. 45, p. 10; Fitzpatrick, Fol. Tr. 624, p. 24.)

During any switching sequence, the system dispatcher/operator can monitor its progress from the new System Control Center, which is now operational, both on a dynamic board which depicts the entire system as well as a specific dynamic CRT display of the substation where the switching is taking place. He may intervene at various points if conditions change due to the outage of another section of the grid. This improved monitoring and control capability is designed to reduce outages which are the result of switching errors. (Armand, et al., Fol. Tr. 45, pp. 10-11.)

In addition, the System Control Center allows dispatcher/operators at a central location to monitor and control the entire grid. The system is displayed on a dynamic map complete with line-flow information and equipment status. Additionally, an operator may display any section, subsection, and status information as well. To assist the operator in monitoring the system, various design limits are programmed into the computer such that alarms are automatically generated when limits are approached for items such as line and transformer thermal ratings, equipment status change, and reserve margins. To aid the operator in testing the impact of anticipated action, he may simulate such action and a Security Analysis Program will quickly alert him to any potential problems that may arise by testing his simulation with up to 500 different contingency conditions. The System Control Center also provides the capability to analyze near-term (present through up to seven days) network conditions, allowing dispatcher/operators to improve their operating strategy. (Armand, et al., Fol. Tr. 45, p. 11.)

Specific procedures have also been adopted to guide the system operator's decisions under potential emergency conditions. Included among the actions to be taken are the reduction of non-essential loads, notification of customers with curtailable load contracts, and other measures designed to reduce load if deemed necessary in order to protect the integrity of the grid. (Id., pp. 11-12, Attachment #7.)

In addition to minimizing the number of outages, it is also important to contain the impact of a fault or malfunction of equipment to that particular component of the grid. The System Control Center further augments existing containment efforts, such as under frequency load shedding schemes and spinning reserves. As described above, the Center, which represents the state-of-the-art, contains a variety of systems which alert the operator to deteriorating conditions and allow him to immediately assess the situation and take corrective action. (Id., p. 12.)

To fully utilize the capability of the System Control Center FPL operators are being trained to respond to crisis situations on a newly installed Dispatcher Training Simulator.*/ With this trainer, an instructor can simulate any major outage on a training console identical to the one at which the operator will normally work. As a result of this training, operators will be able to respond to crisis situations more rapidly, isolating any outage and restoring the critical components of the grid. (Armand, et al., Fol. Tr. 45, p. 12; Fitzpatrick, Fol. Tr. 624, p. 24.)

In sum, FPL has undertaken a program to upgrade the reliability of the offsite power system by: (1) strengthening

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*/ During the hearing the question was raised whether FPL might be substituting technology for experience and, thus, losing valuable dispatcher/operator know-how. (Tr. 150-51.) In response to a request by the Board (Tr. 166-67), tabulations were prepared comparing the ages, education, training, and experience of current operators with those of operators in 1977, prior to installation of the System Control Center. The tabulation, admitted into evidence as Applicant's Exhibit 1, demonstrated the concern expressed in the question to be unfounded. It clearly indicated a high level of experience for operators and that, for example, system operators possess on the order of 30 years' experience as an average. (Coe, Tr. 153-56, 550-54; Applicants Exhibit 1.)

the power system, (2) improving the guidance and training of field personnel, and (3) providing for centralized monitoring and control. This program, which is continuing, should serve to materially upgrade and improve the performance of the off-site power system.

CONCLUSION

The hearing permitted the Appeal Board to take a hard look at problems relating to the reliability of AC power used to operate some of a reactor's safety systems. The Board recognized that its inquiry raised questions going beyond existing NRC design basis events and the general design criteria. (Tr. 592.) The NRC Staff and the Applicant prepared written testimony on the questions addressed by the Board, and the witnesses who testified were subjected to thorough examination both by the Board members and counsel.

The Board focused on obtaining information about the physical features of the Applicant's electrical grid system and the details of certain system occurrences. The Board's inquiry also included a searching examination of the adequacy of the facility's onsite emergency AC power systems.

The information supplied demonstrated that the FPL system had been designed and constructed to function reliably within the unique environment of peninsular Florida (Armand, et al. Fol. Tr. 45, pp. 3-4), and that an ongoing program of system improvement, as described above, will further enhance the reliability of the grid. (Id., pp. 9-13.) The record also reflects an effort by the NRC Staff to require, and a commitment by the Applicant to perform periodic testing of the onsite diesel generator units, pursuant to Regulatory Guide 1.108 as implemented in technical specifications to demonstrate the reliability of the units.

During the course of the hearing, it became apparent that some of the Board's concerns are also concerns of the NRC Staff and are the subject of ongoing inquiry by the Staff; i.e., Task Action A-44. It also became clear that insofar as electrical grid stability and emergency power systems are concerned, St. Lucie Unit No. 2 is in full compliance with existing NRC regulations.

Coming as it did, during the construction permit stage of the licensing for this plant, the Board's inquiry touched upon some design features, operating limitations, and specifications which have not yet been finalized. This is especially so with respect to requirements which may be imposed in consequence of "Three Mile Island Lessons Learned". (Tr. 589-592.) However, the evidence in the record suggests no reason to believe that St. Lucie Unit No. 2 will be unable to meet any such requirements when imposed. (Flugger Tr. 489). Porter County Chapter of the Izaak Walton League of America, Inc. et al v. Nuclear Regulatory Commission, et al, 606 F.2d 1363, 1368-9 (D.C. Cir. 1979). To the contrary, in response to the Board's question relating to a non-design basis event, the Applicant performed an analysis, supported by the Staff, which demonstrated that the facility could safely accommodate a loss of all AC power during the time required to restore AC power.

For the foregoing reasons, the Board's jurisdiction over the issues related to grid stability and emergency power systems, which were the subject matter of the hearing, should be terminated.

Respectfully Submitted,

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By Norman A. Coll
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DATED THIS 14th DAY
OF FEBRUARY 1980.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of	)	
	)	
FLORIDA POWER & LIGHT COMPANY	)	Docket No. 50-389
	)	
(St. Lucie Nuclear Power Plant,	)	
Unit No. 2)	)	
	)	

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that true and correct copies of "Proposed Findings of Fact and Conclusions of Law Submitted on Behalf of Florida Power and Light Company" captioned in the above matter, were served on the following by deposit in the United Stats mail, first class, properly stamped and addressed, on the date shown below:

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
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DOCKETED USNRC FEB 15 1980 Office of the Secretary Docketing & Service Branch

February 14, 1980

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: C. Jean Bishop
Administrative Secretary
ASLAP

RE: FLORIDA POWER & LIGHT COMPANY (St. Lucie Nuclear Power Plant, Unit No. 2) Docket No. 50-389

Pursuant to ALAB-579, the Appeal Board has referred for your consideration under 10 C.F.R. §2.206 intervenors' motion to consider the environmental consequences of Class 9 accidents at the St. Lucie plant. Copies of the relevant documents are attached.

Enclosures:
(1) Intervenors' motion of Dec. 12, 1979
(2) Applicant's response of Jan. 17, 1980
(3) Staff response of Jan. 18, 1980
(4) Intervenors' reply of Feb. 5, 1980
(5) ALAB-579 of Feb. 14, 1980

cc (w/o enclosures):
All parties
Docketing & Service Branch