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TECHNICAL EVALUATION REPORT

KEWAUNEE NUCLEAR POWER PLANT

STATION BLACKOUT EVALUATION

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Post Office Box 1303, 1710 Goodridge Drive, McLean, Virginia 22102 (703) 821-4300

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1.0 BACKGROUND

On July 21, 1988, the Nuclear Regulatory Commission (NRC) amended its regulations in 10 CFR Part 50 by adding a new section, 50.63, "Loss of All Alternating Current Power" (1). The objective of this requirement is to assure that all nuclear power plants are capable of withstanding a station blackout (SBO) and maintaining adequate reactor core cooling and appropriate containment integrity for a required duration. This requirement is based on information developed under the commission study of Unresolved Safety Issue A-44, "Station Blackout" (2-6).

The staff issued Regulatory Guide (RG) 1.155, "Station Blackout," to provide guidance for meeting the requirements of 10 CFR 50.63 (7). Concurrent with the development of this regulatory guide, the Nuclear Utility Management and Resource Council (NUMARC) developed a document entitled, "Guidelines and Technical Basis for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," NUMARC 87-00 (8). This document provides detailed guidelines and procedures on how to assess each plant's capabilities to comply with the SBO rule. The NRC staff reviewed the guidelines and analysis methodology in NUMARC 87-00 and concluded that the NUMARC document provides an acceptable guidance for addressing the 10 CFR 50.63 requirements. The application of this method results in selecting a minimum acceptable SBO duration capability from two to sixteen hours depending on the plant's characteristics and vulnerabilities to the risk from station blackout. The plant's characteristics affecting the required coping capability are: the redundancy of the onsite emergency AC power sources, the reliability of onsite emergency power sources, the frequency of loss of offsite power (LOOP), and the probable time to restore offsite power.

In order to achieve a consistent systematic response from licensees to the SBO rule and to expedite the staff review process, NUMARC developed two generic response documents. These documents were reviewed and endorsed by the NRC staff (14) for the purposes of plant specific submittals. The documents are titled:

1. "Generic Response to Station Blackout Rule for Plants Using Alternate AC Power," and

2. "Generic Response to Station Blackout Rule for Plants Using AC Independent Station Blackout Response Power."

A plant-specific submittal, using one of the above generic formats, provides only a summary of results of the analysis of the plant's station blackout coping capability. Licensees are expected to ensure that the baseline assumptions used in NUMARC 87-00 are applicable to their plants and to verify the accuracy of the stated results. Compliance with the SBO rule requirements is verified by review and evaluation of the licensee's submittal and audit review of the supporting documents as necessary. Follow up NRC inspections assure that the licensee has implemented the necessary changes as required to meet the SBO rule.

In 1989, a joint NRC/SAIC team headed by an NRC staff member performed audit reviews of the methodology and documentation that support the licensees' submittals for several plants. These audits revealed several deficiencies which were not apparent from the review of the licensees' submittals using the agreed upon generic response format. These deficiencies raised a generic question regarding the degree of licensees' conformance to the requirements of the SBO rule. To resolve this question, on January 4, 1990, NUMARC issued additional guidance as NUMARC 87-00 Supplemental Questions/Answers (15) addressing the NRC's concerns regarding the deficiencies. NUMARC requested that the licensees send their supplemental responses to the NRC addressing these concerns by March 30, 1990.

2.0 REVIEW PROCESS

The review of the licensee's submittal is focused on the following areas consistent with the positions of RG 1.155:

A. Minimum acceptable SBO duration (Section 3.1),

B. SBO coping capability (Section 3.2),

C. Procedures and training for SBO (Section 3.4),

D. Proposed modifications (Section 3.3), and

E. Quality assurance and technical specifications for SBO equipment (Section 3.5).

For the determination of the proposed minimum acceptable SBO duration, the following factors in the licensee's submittal are reviewed: a) offsite power design characteristics, b) emergency AC power system configuration, c) determination of the emergency diesel generator (EDG) reliability consistent with NSAC-108 criteria (9), and d) determination of the accepted EDG target reliability. Once these factors are known, Table 3-8 of NUMARC 87-00 or Table 2 of RG 1.155 provides a matrix for determining the required coping duration.

For the SBO coping capability, the licensee's submittal is reviewed to assess the availability, adequacy and capability of the plant systems and components needed to achieve and maintain a safe shutdown condition and recover from an SBO of acceptable duration which is determined above. The review process follows the guidelines given in RG 1.155, Section 3.2, to assure:

a. availability of sufficient condensate inventory for decay heat removal,

b. adequacy of the class 1E battery capacity to support safe shutdown,

c. availability of adequate compressed air for air-operated valves necessary for safe shutdown,

d. adequacy of the ventilation systems in the vital and/or dominant areas that include equipment necessary for safe shutdown of the plant,

e. ability to provide appropriate containment integrity, and

f. ability of the plant to maintain adequate reactor coolant system inventory to ensure core cooling for the required coping duration.

The licensee's submittal is reviewed to verify that required procedures (i.e., revised existing and new) for coping with SBO are identified and that appropriate operator training will be provided.

The licensee's submittal for any proposed modifications to emergency AC sources, battery capacity, condensate capacity, compressed air capacity, appropriate containment integrity and primary coolant make-up capability is reviewed. Technical specifications and quality assurance set forth by the licensee to ensure high reliability of the equipment, specifically added or assigned to meet the requirements of the SBO rule, are assessed for their adequacy.

The licensee's proposed use of an alternate AC power source is reviewed to determine whether it meets the criteria and guidelines of Section 3.3.5 of RG 1.155 and Appendix B of NUMARC 87-00.

This SBO evaluation is based on the review of the licensee's submittals dated April 17, 1989 (10), November 14, 1989 (16), and March 30, 1990 (13), and the information available in the plant Updated Safety Analysis Report (USAR) (12); it does not include a concurrent site audit review of the

supporting documentation. Such an audit may be warranted as an additional confirmatory action. This determination would be made and the audit would be scheduled and performed by the NRC staff at some later date.

3.0 EVALUATION

3.1 Proposed Station Blackout Duration

Licensee's Submittal

The licensee, Wisconsin Public Service Corporation (WPSC), calculated (10, 11, 13, and 16) a minimum acceptable SBO duration of four hours for the Kewaunee Nuclear Power Plant (KNPP) site. The licensee stated that no modifications are required to attain this proposed coping duration.

The plant factors used to estimate the proposed SBO duration are:

1. **Offsite Power Design Characteristics**

   The plant AC power design characteristic group is "P1" based on:

   a. Independence of the plant offsite power system characteristics of "I1/2,"

   b. Expected frequency of grid-related LOOPs of less than one per 20 years,

   c. Estimated frequency of LOOPs due to extremely severe weather (ESW) which places the plant in ESW group "2," and

   d. Estimated frequency of LOOPs due to severe weather (SW) which places the plant in SW group "2."

2. **Emergency AC (EAC) Power Configuration Group**

   The EAC power configuration of the plant is "C." KNPP is equipped with two emergency diesel generators. One EAC power supply is necessary to operate safe shutdown equipment following a loss of offsite power.

3. **Target Emergency Diesel Generator (EDG) Reliability**

The licensee has selected a target EDG reliability of 0.95. The selection of this target reliability is based on having a unit average EDG reliability of greater than 0.94 for the last 50 demands consistent with NUMARC 87-00, Section 3.2.4.

Review of Licensee's Submittal

Factors which affect the estimation of the SBO coping duration are: the independence of the offsite power system grouping, the estimated frequency of LOOPs due to ESW and SW conditions, the expected frequency of grid-related LOOPs, the classification of EAC, and the selection of EDG target reliability. According to Numarc 87-00 the expected frequency of LOOP due to ESW conditions place the KNPP site in ESW group "4." The licensee contested NUMARC's classification, and submitted site-specific weather data (16) to the NRC. The NRC staff concluded that an ESW group "2" was acceptable (11) for KNPP. Using Table 3-3 of NUMARC 87-00, the expected frequency of LOOPs at KNPP due to SW condition is in group "2," regardless of having offsite power transmission lines on one, or two or more rights-of-way.

The licensee stated that the independence of the plant offsite power system (Figure 1) grouping is "I1/2." A review of KNPP USAR indicates that:

1. All offsite power sources are connected to the unit through a single switchyard (substation);

2. During normal power operation, the engineered safety features (ESF) buses are powered from the Reserve Auxiliary Transformer (RAT) and the Tertiary Auxiliary Transformer (TAT), (Division B of ESF buses is normally fed through the RAT which is connected to the 138 kV portion of the substation, and Division A is normally fed through the TAT

which is connected by underground line to the 13.8 kV winding of the auto-transformer of the substation);

3. Both RAT and TAT are sized and designed to supply the required load of both ESF Buses; and

4. Upon loss of power to the RAT (or TAT) both 4.16 kV ESF buses will be powered by TAT (or RAT) via an automatic transfer.

Based on the above and the criteria stated in Table 5 of RG 1.155 the plant independence of offsite power system group is classified as "I2."

We agree with the licensee that the EAC classification of KNPP is "C." However, we are unable to verify the assignment of the EDG target reliability at this time. The licensee selected the EDG target reliability of 0.95 based on the EDG reliability data for the last 50 demands. Although this is an acceptable criterion for choosing an EDG target reliability, the guidance in RG 1.155 requires that the EDG reliability statistics for the last 20 and 100 demands also be calculated. Without this information it is difficult to judge how well the EDGs have performed in the past and if there should be any concern. The available information in the NSAC-108, which gives the EDG reliability data at U.S. nuclear power plants for calendar years 1983 to 1985, indicates that the EDGs at KNPP experience an average reliability of 0.981 per diesel per year. Using this data, it appears that the EDG target reliability (0.95) selected by the licensee (10) is appropriate. Nevertheless, the licensee needs to have an analysis showing the EDG reliability statistics for the last 20, 50, and 100 demands in its SBO submittal supporting documents. Also, the licensee's submittals do not document the conformance of the plant's EDG reliability program with the guidance of the RG 1.155, Section 1.2 and NUMARC 87-00, Appendix D.

With regard to the expected frequency of grid-related LOOPs at the site, we can not confirm the stated results. The available information in

NUREG/CR-3992 (3), which gives a compendium of information on the loss of offsite power at nuclear power plants in U.S. indicates that KNPP did not have any symptomatic grid-related LOOP prior to the calendar year 1984. In the absence of any contradictory information, we agree with the licensee's statement.

Based on the above, the offsite power design characteristic of the KNPP site is "P1" with a minimum required SBO coping duration of four hours.

3.2 Alternate AC (AAC) Power Source

Licensee's Submittal

The licensee proposes to install a 2000 kW non-class 1E diesel generator (DG) as an AAC power source, see Figure 1 (13). The licensee stated that the AAC power source will be available within 10 minutes of the onset of an SBO event. This power source will have sufficient capacity and capability to operate systems necessary for coping with an SBO for the required duration of four hours.

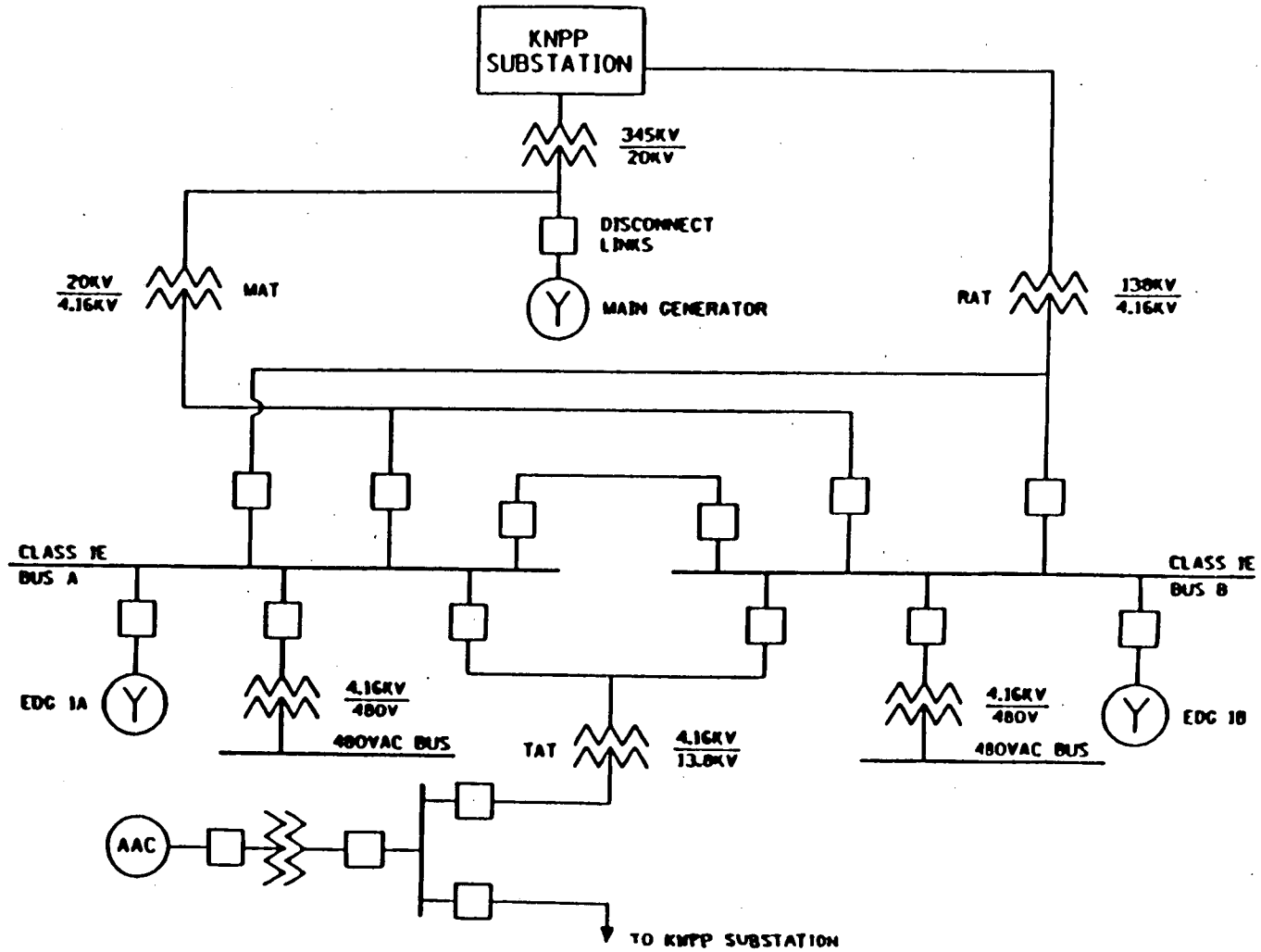
Review of Licensee's Submittal

The licensee's submittals do not directly state that the AAC power source will meet the criteria specified in Appendix B to NUMARC 87-00. However, based on information provided in Attachment A of the licensee's submittal dated April 17, 1989 (10), it appears that once the proposed modification is implemented, the AAC power source will meet the NUMARC criteria. The 2,000 kW diesel generator appears to have sufficient capacity and capability to support the required loads. Our review of the plant USAR indicates that the features needed to operate in support of the licensee's submittal (10) would require a minimum of 1900 kW, which is less than the capacity of the proposed DG.

As stated in the licensee's submittal, a test is required to conform with the criteria stated in Paragraph B.9 of Appendix B to NUMARC 87-00.

FIGURE 1

CONCEPTUAL AAC CONFIGURATION



Although the licensee stated that prior to declaring the system operational, an initial test will be performed to demonstrate the capability of powering the required shutdown equipment, it should be emphasized that this test should demonstrate adequate voltage and frequency regulation under the most severe realistic transient loading condition. Also, this test must demonstrate that the proposed AAC power source is capable of powering the required shutdown equipment within 10 minutes of the onset of an SBO event.

The licensee needs to establish a maintenance and surveillance testing program for the AAC power source in order to provide assurance of high DG reliability and compliance to NUMARC 87-00, Appendix B, Paragraphs B.10, B.11 and B.13.

3.3 Station Blackout Coping Capability

The licensee stated that since the AAC power source will be available within 10 minutes, the coping evaluations for class 1E battery capacity, compressed air, and containment isolation need not to be addressed in accordance with 10 CFR 50.63(c)(2). We consider the licensing statement to mean that the functions needed to cope with an SBO are available, and they are adequately powered from the AAC power source for the required duration. The plant coping capability with an SBO event for the required duration of four hours is assessed based on the following results:

1. Condensate Inventory for Decay Heat Removal

Licensee's Submittal

The licensee's submittal stated that 36,531 gallons of water are required for the decay heat removal during the 4-hour coping period. The minimum permissible condensate storage tank level per technical specifications provides 30,000 gallons of water. The following additional sources of water have been identified as

being available to provide the total amount of condensate for decay heat removal for four hours:

1A Condensate Storage Tank	75,000 gallons
1B Condensate Storage Tank	75,000 gallons

Note: The initial 30,000 gallons required by KNPP Technical Specifications is being supplied by these tanks.

Review of Licensee's Submittal

The licensee stated that 36,531 gallons of water are needed for decay heat removal during a 4-hour SBO event. Using the expression provided in NUMARC 87-00, we have estimated that the water required for removing decay heat would be ~38,100 gallons. This estimate is based on a maximum licensed core thermal rating of 1683 MWt, or 102% of 1650 MWt (Table 14.3-2a of the plant USAR).

Based on above, the site would need ~38,100 gallons of condensate water for the decay heat removal during a 4-hour SBO. The licensee stated that the plant technical specifications requires a minimum condensate level of 30,000 gallons be available in the condensate storage tanks. These tanks have a total capacity of 150,000 gallons. The plant proposes to use the extra capacity in these tanks to supply the balance of the required water. However, to provide assurance that the tanks will contain the required amount of water, the licensee needs to revise the plant's technical specifications minimum condensate storage level to 39,000 gallons.

2. **Class 1E Battery Capacity**

Licensee's Submittal

Since the AAC power source will be available within 10 minutes of the onset of an SBO event, no analysis of class 1E battery capacity calculation is provided.

Review of Licensee's Submittal

According to the plant USAR each of the two station batteries has been sized to carry expected shutdown loads following a plant trip and loss of all AC power for one hour without battery terminal voltage falling below 105 V. The AAC power source will be available and will power one division of the battery charger(s) within 10 minutes. Therefore, the operating station battery will have sufficient capacity to carry the required 4-hour SBO loads.

3. **Compressed Air**

Licensee's Submittal

Since the AAC power source will be available within 10 minutes and power the plant air system, no analysis of the compressed air system is provided.

Review of Licensee's Submittal

A review of the required EDG load after a DBA (USAR Table 8.2-1) indicates that instrument air compressor 1A will be powered. This means that the compressor is connected to an ESF bus and it is, therefore, expected to be available during an SBO event.

4. Effects of Loss of Ventilation

Licensee's Submittal

The licensee stated that the AAC power source provides power to heating, ventilation and air conditioning (HVAC) systems serving the dominant areas of concern. Therefore, consistent with the NUMARC 87-00, Sections 7.2.4 and 7.1.2, the effects of loss of ventilation were not assessed. The licensee added that no modifications and/or procedures are required to provide reasonable assurance for operability of ventilation equipment.

Review of Licensee's Submittal

The licensee's action is consistent with the guidance provided by NUMARC and NRC. Table 8.2-1 of the plant USAR identifies an HVAC load of 480 kW for Shield Building Ventilation & Auxiliary building special ventilation system (zone SV) fans, the containment dome vent fan, and control room vent equipment. The licensee needs to verify that more HVAC is not required to ensure appropriate area cooling. We would like to emphasize that the dominant areas of concern should not be limited to those identified in NUMARC 87-00. The licensee needs to ensure that other areas which have heat generation sources, i.e., operating equipment, are provided with appropriate area cooling.

5. Containment Isolation

Licensee's Submittal

Since the AAC power source will be available within 10 minutes and powers the containment isolation valves (CIV's) requiring closure capability during an SBO event, no analysis for containment isolation is provided.

Review of Licensee's Submittal

Since the AAC will be available to both divisions of ESF buses, containment isolation valve closure capability is assured.

6. Reactor Coolant Inventory

Licensee's Submittal

The licensee stated that the AAC source powers the necessary make-up systems to maintain adequate reactor coolant system inventory to ensure that the core is cooled for the required coping duration.

Review of Licensee's Submittal

Reactor coolant make-up is necessary to replenish the RCS inventory losses due to the RCP seal leakage (25 gpm per pump per NUMARC 87-00 guideline), and the technical specifications maximum allowable leakage (estimated to be 25 gpm). The make-up, or the charging, system at KNPP has three positive displacement pumps. Each pump has a design flow capacity of 60.5 gpm. Therefore, two-out-of-three charging pumps need to be operational from the onset of an SBO event to maintain the pressurizer level and RCS inventory. Our analysis indicates that with only one pump running and a net RCS loss of 15 gpm, only the pressurizer would be near empty at the end of the four-hour SBO event, provided that no RCS shrinkage occurs. Therefore, we agree with the licensee that the core will not be uncovered during a 4-hour SBO event.

3.4 Proposed Procedures and Training

Licensee's Submittal

The licensee stated that the following plant procedures have been reviewed per guidelines in NUMARC 87-00, Section 4:

1. Station blackout response guidelines,
2. AC power restoration, and
3. Severe weather.

The licensee listed the plant procedures which fall in each of above categories in the plant SBO submittal. The licensee stated that these procedures will be revised, if necessary, to meet NUMARC 87-00 guidelines. The licensee added that additional procedure changes will be implemented as required upon completion of installation of the AAC modifications.

Review of Licensee's Submittal

We neither received nor reviewed the affected SBO procedures. We consider these procedures as plant-specific actions concerning the required activities to cope with an SBO. We believe that it is the licensee's responsibility to revise and implement these procedures, as needed, to mitigate an SBO event and to assure that these procedures are complete and correct, and that the associated training needs are carried out accordingly.

3.5 Proposed Modifications

Licensee's Submittal

The licensee has proposed to install a 2000 kW non-class 1E diesel generator for the use as an AAC power source. The licensee stated that, once modifications are completed, this AAC power source will meet the

criteria specified in Appendix B to NUMARC 87-00. Procedures for operation, maintenance, surveillance, and testing of the AAC power source will be revised or created as necessary.

Review of Licensee's Submittal

The licensee's proposed modification conforms with the requirements of the SBO rule. We believe once the proposed modification is completed KNPP would have a DG of sufficient capacity to be used as an AAC power source. This evidence is dependent upon the conformance of the licensee to its commitment as it appears in Attachment A to its submittal dated April 17, 1989 (10).

3.6 Quality Assurance and Technical Specifications

The licensee's submittals do not document the conformance of the plant's SBO equipment to the guidance of RG 1.155, Appendices A and B.

4.0 CONCLUSIONS

Based on our review of the licensee's submittals and the information available in the USAR for Kewaunee Nuclear Power Plant, we find that the submittal conforms with the requirements of the SBO rule and the guidance of RG 1.155 with the following exceptions:

1. **Emergency Diesel Generator Reliability Program**

   The licensee's submittals do not document the conformance of the plant's EDG reliability program with the guidance of the RG 1.155, Section 1.2 and NUMARC 87-00, Appendix D.

2. **Alternate AC (AAC) Power Source**

   The licensee needs to make a direct commitment to meet the criteria specified in Appendix B of NUMARC 87-00. As part of this commitment, the licensee needs to establish a maintenance and surveillance testing program for the AAC power source in order to provide assurance of maintaining high reliability consistent with the criteria specified in Paragraphs B.10, B.11 and B.13.

3. **Condensate Inventory for Decay Heat Removal**

   The plant technical specifications require a minimum condensate level of 30,000 gallons in the condensate storage tanks. The licensee stated that the condensate storage tanks, with a total capacity of 150,000 gallons, can provide the water required for decay heat removal for four hours. The plant needs a minimum of 38,090 gallons to remove decay heat during an SBO event. To provide assurance that the condensate storage tanks contain the required amount of water the technical specifications' minimum condensate level should be increased to 39,000 gallons.

4. Effects of Loss of Ventilation

The licensee states that the AAC power source will be available within 10 minutes and provides power to HVAC systems serving dominant areas of concern. We would like to emphasize that the dominant areas of concern should not be limited to those identified in NUMARC 87-00. The licensee needs to ensure that other areas which house operating systems are provided with appropriate area cooling.

5. Quality Assurance and Technical Specifications

The licensee's submittals do not document the conformance of the plant's SBO equipment with the guidance of RG 1.155, Appendices A, and B.

5.0 REFERENCES

1. The Office of Federal Register, "Code of Federal Regulations Title 10 Part 50.63," 10 CFR 50.63, January 1, 1989.

2. U.S. Nuclear Regulatory Commission, "Evaluation of Station Blackout Accidents at Nuclear Power Plants - Technical Findings Related to Unresolved Safety Issue A-44," NUREG-1032, Baranowsky, P. W., June 1988.

3. U.S. Nuclear Regulatory Commission, "Collection and Evaluation of Complete and Partial Losses of Offsite Power at Nuclear Power Plants," NUREG/CR-3992, February 1985.

4. U.S. Nuclear Regulatory Commission, "Reliability of Emergency AC Power System at Nuclear Power Plants," NUREG/CR-2989, July 1983.

5. U.S. Nuclear Regulatory Commission, "Emergency Diesel Generator Operating Experience, 1981-I983," NUREG/CR-4347, December 1985.

6. U.S. Nuclear Regulatory Commission, "Station Blackout Accident Analyses (Part of NRC Task Action Plan A-44)," NUREG/CR-3226, May 1983.

7. U.S. Nuclear Regulatory Commission Office of Nuclear Regulatory Research, "Regulatory Guide 1.155 Station Blackout," August 1988.

8. Nuclear Management and Resources Council, Inc., "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," NUMARC 87-00, November 1987.

9. Nuclear Safety Analysis Center, "The Reliability of Emergency Diesel Generators at U.S. Nuclear Power Plants," NSAC-108, Wyckoff, H., September 1986.

10. Steinhardt, C.R., letter to Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, "Kewaunee Nuclear Power Plant Docket No. 50-305,

License No. DPR-43, Generic Response to Station Blackout Rule for Plants Using Alternate AC Power," dated April 17, 1989.

11. Davis, Michael J., letter to K. H. Evers, "Evaluation of Station Blackout Due to High Winds at Kewaunee (TAC No. 68558)," dated April 4, 1990.

12. Kewaunee Nuclear Power Plant, Updated Safety Analysis Report.

13. Evers, K. H., letter to document control desk of U. S. Nuclear Regulatory Commission, "Station Blackout (SBO) Supplemental Response," dated March 30, 1990, Docket 50-305, Operating License DPR-43, Kewaunee Nuclear Power Plant.

14. Thadani, A. C., Letter to W. H. Rasin of NUMARC, "Approval of NUMARC Documents on Station Blackout (TAC-40577)," dated October 7, I988.

15. Thadani, A. C., letter to A. Marion of NUMARC, "Publicly-Noticed Meeting December 27, 1989," dated January 3, 1990, (confirming "NUMARC 87-00 Supplemental Questions/Answers," December 27, 1989).

16. Evers, K. H., letter to Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, "Kewaunee Nuclear Power Plant Docket No. 50-305, License No. DPR-43, Station Blackout - Weather Data," dated November 14, 1989.