UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

STATION BLACKOUT EVALUATION

ARIZONA PUBLIC SERVICE COMPANY

PALO VERDE, UNITS 1, 2, AND 3

DOCKET NOs. 50-528/529/530

1.0 INTRODUCTION

On July 21, 1988, the Code of Federal Regulations, 10 CFR Part 50, was amended to include a new Section 50.63, entitled "Loss of All Alternating Current Power," (Station Blackout). The Station Blackout (SBO) rule requires that each light-water cooled nuclear power plant be able to withstand and recover from an SBO of a specified duration. The SBO Rule also requires licensees to submit information as defined in Part 50.63 and to provide a plan and schedule for conformance to the SBO Rule. The SBO Rule further requires that the baseline assumptions, analyses, and related information be available for NRC review. Guidance for conformance to the SBO Rule is provided by (1) Regulatory Guide (RG) 1.155, Station Blackout, (2) The Nuclear Management and Resources Council, Inc. (NUMARC) 87-00, Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors, and (3) NUMARC 87-00 Supplemental Questions/Answers and Major Assumptions dated December 27, 1989, (issued to the industry by NUMARC on January 4, 1990).

To facilitate the NRC staff's (hereafter referred to as staff) review of licensee responses to the SBO Rule, the staff endorsed two generic response formats. One response format is for use by plants proposing to use an Alternate AC (AAC) power source and the other format is for use by plants proposing an AC independent response. The generic response formats provide the staff with a summary of the results from the licensee's analysis of the plant's SBO coping capability. The licensees are expected to verify the accuracy of the results and maintain documentation that supports the stated results. Compliance to the SBO Rule is verified by a review of the licensee's submittal, an audit review of the supporting documentation as deemed necessary, and possible follow-up NRC inspections to ensure that the licensee has implemented the appropriate hardware and/or procedure modifications that will be required to comply with the SBO Rule.

The licensee's responses to the SBO Rule were provided by letters from D. B. Karner dated April 14, 1989, and from W. F. Conway dated March 26, 1990, December 11, 1990, and August 31, 1991, to the U.S. Nuclear Regulatory Commission, Document Control Desk. Also, the licensee's responses to NRC questions posed during a teleconference on June 11, 1991, were received as internal correspondence dated June 14, 1991.

The licensee stated that its August 31, 1991, submittal superseded the previous submittals. However, it appears to the staff that the previous submittals were not intended to be completely superseded, and the staff has not entirely disregarded the previous submittals in making this evaluation. Therefore, the licensee should review the safety evaluation (SE) and advise the staff if any of the information used in the SE is no longer valid.

The licensee's responses were reviewed by Science Applications International Corporation (SAIC) under contract to the NRC. The results of the SAIC review are documented by a Technical Evaluation Report (TER) SAIC-91/1250 "PALO VERDE NUCLEAR POWER STATION, STATION BLACKOUT EVALUATION," dated October 24, 1991, (Attachment 1).

2.0 EVALUATION

After reviewing the licensee's submittals and the SAIC TER, the staff concurs with the SAIC analysis and conclusions as identified in the SAIC TER (refer to Attachment 1 for details). The staff findings and recommendations are summarized as follows:

2.1 Station Blackout Duration

The licensee has calculated a minimum acceptable SBO duration of 4 hours based on a plant offsite ac power design characteristic Group "P1," an emergency ac (EAC) power configuration Group "C," and a target Emergency Diesel Generator (EDG) reliability of 0.95. The EAC power configuration Group "C" is based on two EDGs not credited as AAC power sources, with one EDG required to operate safe shutdown equipment following a loss of offsite power. The "P1" grouping is based on an independence of offsite power classification of Group "I 1/2," a severe weather (SW) classification of Group "1," and an extremely severe weather (ESW) classification of Group "2." The target EDG reliability was based on the Palo Verde Station having an average EDG reliability greater than 0.90 for the last 20 demands. The licensee indicated in its previous transmittal that the average EDG reliability was greater than 0.94 and 0.95 for the last 50 and 100 demands, respectively. Any one of these three reliability indicators meets the criteria of RG 1.155.

After reviewing the available information in the licensee's submittal, RG 1.155, NUMARC 87-00, and SAIC's TER, the staff agrees with the licensee's calculation of a 4-hour SBO coping duration.

Recommendation: 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 documentation.

2.2 Alternate AC (AAC) Power Source

The licensee has proposed to use two gas turbine generators as an AAC power source to operate systems necessary for the required coping duration of 4 hours and recovery therefrom.

2.2.1 General staff position on AAC power sources

The definition in 10 CFR 50.2, RG 1.155, and NUMARC 87-00 define AAC power source in terms of four attributes: (1) connections to the offsite or the onsite AC power systems, (2) minimum potential for common cause failure with offsite power or the onsite emergency AC power sources, (3) timely availability, and (4) required capacity and reliability. More specifically, in regard to the fourth attribute, the SBO Rule reads as follows:

> "(4) Has sufficient capacity and reliability for operation of all systems required for coping with station blackout and for the time required to bring and maintain the plant in safe shutdown (non-design basis accident)."

In view of the variety of types, capacities, capabilities of power sources proposed as AAC sources by various licensees, the staff has characterized proposed AAC power sources as being either optimum, fully capable, or partially capable. This characterization, which relates only to the capacity attribute cited above, was necessary in order to facilitate the staff review of licensee responses to the SBO Rule. It does not invalidate or revoke any of the requirements or guidance applicable to AAC power sources.

An optimum AAC power source design is one that is capable of powering simultaneously both safety trains of normal safe shutdown systems and equipment. Such a design, following actuation of the AAC source, would provide completely redundant normal safe shutdown capability during an SBO and recovery therefrom from the main control room.

A fully capable AAC power source design is one that is capable of powering at least one complete safety train of normal safe shutdown systems and equipment. This includes decay heat removal, battery charging, HVAC (heating, ventilation, and air conditioning), emergency lighting, and the associated controls and instrumentation. Thus, although redundant capability is not available, a fully capable AAC source would enable attainment of safe shutdown during an SBO and recovery therefrom from the main control room.

A minimally capable AAC power source design is one that is not capable of powering all (or any) normal safety train related safe shutdown equipment; but it is capable of powering specific equipment that, in conjunction with extensive manual operator actions both inside and outside of the control room, is critical for attaining safe shutdown during an SBO. Appendix R diesels proposed as an AAC source are examples of minimally capable AAC sources. With this design, operability of the main control room could not be assured unless the batteries were sized to operate for the SBO duration, or battery charging capability was provided by the AAC source.

2.2.1.1 Connectability of AAC Power Sources

The basic criteria governing the connectability of an AAC power source are contained in 10 CFR 50.2 (the AAC source should be connectable to but normally

not connected to the offsite or onsite emergency AC power systems), and 10 CFR 50.63 (SBO should not assume a concurrent single failure or design basis accident). Therefore, as a minimum, an AAC source need only be connectable to one set of safe shutdown equipment (for each unit at a multi-unit site), regardless of whether that equipment is part of a safety train or not.

2.2.2 Proposed AC (AAC) Power Source

The Palo Verde Station is a 3-unit site with two dedicated EDGs per unit. The licensee indicated that two non-Class 1E gas turbine generators designated as AAC power sources would be utilized at the Palo Verde Nuclear Generating Station (PVNGS). The licensee also stated that the AAC power sources will be available within 1 hour of the onset of the SBO event and will have sufficient capacity and capability to operate those systems necessary for coping with an SBO of 4-hour duration. The licensee added that each of the two gas turbine generators meets the criteria specified in Appendix B to NUMARC 87-00, and provided a statement on each criterion. The licensee's statement regarding the criterion B.10 was not clear about the 3-month testing requirement of the AAC power sources (see SAIC TER Section 3.2 for details). The staff finds that the AAC power sources meet the "fully capable" classification discussed above in Section 2.2.1 of this SE. The staff agrees with the SAIC TER that the proposed AAC power sources meet the requirements of Appendix B to NUMARC 87-00, pending clarification of the 3-month testing requirement.

Recommendation: The licensee needs to clarify its intent with respect to the 3-month testing requirement.

2.3 Station Blackout Coping Capability

The characteristics of the following plant systems and components were reviewed to assure that the systems have the availability, adequacy, and capability to achieve and maintain a safe shutdown and to recover from an SBO for a 4-hour coping duration.

2.3.1 Condensate Inventory for Decay Heat Removal

Using the guidance described in NUMARC 87-00, the staff's consultant has performed an analysis and determined that the water required to cope with a 4-hour SBO event at the Palo Verde plant would be 156,000 gallons for each unit. The minimum permissible condensate storage tank level per the plant TS will provide 300,000 gallons of water for each unit which exceeds the required amount for coping with a 4-hour SBO event. Based on its review, the staff concludes that there is sufficient water at the Palo Verde plant to cope with a 4-hour SBO event.

2.3.2 Class 1E Battery Capacity

The licensee stated that a battery calculation has been performed to verify the adequacy of the Class 1E battery to support the SBO loads for 2 hours,

which is their current design basis requirement. The licensee also stated that the proposed AAC power source will be available within 1 hour of the onset of an SBO event and will power one division of battery chargers. The staff, therefore, concludes that PVNGS has sufficient battery capacity.

2.3.3 Compressed Air

The licensee stated that the air-operated valves relied upon to cope with an SBO event of 1-hour duration can either be operated manually or have sufficient backup sources independent of both the offsite and the blacked-out unit's onsite AC power systems. The only valves that require pneumatic energy to ensure proper operation during an SBO event are the atmospheric dump valves (ADVs) and the reactor coolant pump (RCP) seal bleed-off valves. The ADVs have a 13.3-hour dedicated supply of compressed nitrogen gas, given a loss of power to the unit instrument air compressors. With regard to the RCP seal bleed-off valves, the licensee stated that the valves will have nitrogen gas supply as a backup to the compressed-air system to maintain valve closure until the RCS charging system becomes operational when the AAC source is available. Based on its review, the staff concludes that the Palo Verde plant will have a sufficient backup supply of compressed air to cope with an SBO event.

Recommendation: The licensee should provide its plan for the implementation of nitrogen gas supply as a backup to the compressed air for the RCP seal bleed-off valves.

2.3.4 Effects of Loss of Ventilation

The licensee has performed analyses to determine for 1 hour following an SBO event the effects of loss of ventilation in the control room and in the areas containing equipment required to cope with the SBO event. The licensee stated that a plant-specific computer code, which is similar to NUMARC 87-00 methodology, was used to perform the analysis and that a subsequent testing of the computer code against NUMARC 87-00 methodology, provided identical results under steady state conditions. Based on its review, the staff finds that the use of the plant-specific computer code to perform the analyses is acceptable.

The results of the above cited analyses show that: 1) the control room at the Palo Verde plant does not exceed 120°F and, therefore, it is not a dominant area of concern according to the assumption in Section 2.7.1 of NUMARC 87-00, and 2) the temperatures in the areas (AFW pump room, DC equipment room, switchgear room, battery room, charging pump room, and containment building) containing equipment required to cope with an SBO event do not exceed operability limits for the equipment located in these areas. Based on its review, the staff concludes that the effects of loss of ventilation for 1 hour following an SBO event in the control room and the areas containing equipment required to cope with an SBO event at the Palo Verde plant have been properly assessed.

2.3.5 Containment Isolation

The licensee stated that the plant list of containment isolation valves (CIVs) has been reviewed to verify that valves which must be capable of being closed or that must be operated (cycled) under SBO conditions can be positioned with indication independent of the Class 1E power supplies. Therefore, no modifications or associated procedure changes will be required to ensure that appropriate containment integrity can be provided following an SBO event at the Palo Verde plant.

Based on its review, the staff concludes that the CIV design and operation at the Palo Verde plant have met the intent of the guidance described in RG 1.155 and, therefore, are acceptable.

2.3.6 Reactor Coolant Inventory

The licensee stated that the ability to maintain adequate reactor coolant system inventory to ensure that the core is cooled has been assessed for 4 hours. The licensee added that the expected rates of reactor coolant inventory loss under SBO conditions do not result in core uncovery. The licensee added that a plant specific analysis was used for its assessment of the adequacy of reactor coolant inventory.

Based on the above and the results of an independent assessment discussed in the SAIC TER, the staff concludes that sufficient RCS inventory exists to keep the core covered, and natural circulation, through reflux boiling, will keep the core cooled during a 4-hour SBO event.

The reactor coolant inventory evaluation as discussed above was based on the guidance provided in NUMARC 87-00 of 25 gpm per reactor coolant pump (RCP) seal leakage for pressurized water reactors. The 25 gpm value was agreed to between NUMARC and the staff pending resolution of Generic Issue (GI) 23. If the final resolution of GI-23 defines higher RCP leakage rates than assumed for this evaluation, the licensee should be aware of the potential impact of this resolution on their analyses and actions assessing conformance to the SBO Rule.

2.4 Procedures and Training

The licensee stated that plant procedures will be developed to implement the use of AAC in the event of an SBO. The licensee further indicated that plant procedures will be modified to meet the guidelines of NUMARC 87-00, Section 4, in the following areas:

AC power restoration, Severe weather procedures, and SBO response guidelines.

The licensee also stated that the modifications and procedure changes will be completed in accordance with the following schedule:

Unit 1, Fourth Refueling Outage which is scheduled to be completed during November 1993

Unit 3, Fourth Refueling Outage which is scheduled to be completed during April 1994

Unit 2, Fifth Refueling Outage which is scheduled to be completed during November 1994.

The staff did not review the affected procedures or training. The staff expects the licensee to maintain and implement these procedures including any others that may be required to ensure an appropriate response to an SBO event. Although personnel training requirements for an SBO response were not specifically addressed in the licensee's submittals, the staff expects the licensee to implement the appropriate training to ensure an effective response to an SBO. The staff agrees with the licensee's scheduled completion based on the complexity of modification, testing, and extensive procedure changes involved.

2.5 Proposed Modifications

The installation of two gas turbines as an AAC power source comprise a major hardware modification (see Section 2.2.2). The licensee also mentioned that the modification to improve radio communications to the control room will be installed. Additional modifications to improve the reliability of the control-air supply for the RCP seal bleed-off valves, and move or upgrade the Z to I position transmitters for two trains of ADVs will be implemented.

Recommendation: The licensee should include a full description including the nature and objectives of the required modifications in the documentation that is to be maintained by the licensee in support of the SBO submittals.

2.6 Quality Assurance and Technical Specifications

The licensee stated that the non-safety related equipment added to cope with an SBO condition will meet the quality assurance requirements of Appendices A and B to RG 1.155. However, the licensee's internal correspondence dated June 14, 1991, indicated that all equipment required to cope with an SBO would be Q or QAG and would fall under the normal PVNGS QA program.

The TS for the SBO equipment are currently being considered generically by the NRC in the context of the TS Improvement Program and remains an open item at this time. However, the staff would expect that the plant procedures will reflect the appropriate testing and surveillance requirements to ensure the operability of the necessary SBO equipment. If the staff later determines that TS regarding the SBO equipment is warranted, the licensee will be notified of the implementation requirements.

Recommendation: The licensee should confirm that the non-safety related equipment required to cope with an SBO event will, as a minimum, meet the criteria of Appendix A of RG 1.155.

2.7 EDG Reliability Program

The licensee's submittal dated August 31, 1991, on SBO did not specifically address the commitment to implement an EDG reliability program to conform to the guidance of RG 1.155, Position 1.2. However, the licensee, in its earlier submittal, indicated that it has an EDG reliability program which contains elements consistent with RG 1.155. The licensee added that it recognizes that the program may be modified depending on the resolution of Generic Issue B-56.

Recommendation: The licensee should confirm that its EDG reliability program will meet, as a minimum, the guidelines of RG 1.155.

2.8 Scope of Staff Review

The SBO Rule (10 CFR 50.63) requires licensees to submit a response containing specifically defined information. It also requires utilities "...to have baseline assumptions, analyses, and related information used in their coping evaluations available for NRC review." The staff and its contractor (SAIC) did not perform a detailed review of any proposed hardware and procedural modifications which are scheduled for later implementation. However, based on our review of the licensee's supporting documentation, we have identified the following areas for focus in any follow-up inspection or assessment that may be undertaken by the NRC to verify conformance with the SBO Rule. Additional items may be added as a result of the staff review of the actions taken by the licensee in response to this SE.

a. Hardware and procedural modifications,

b. SBO procedures in accordance with RG 1.155, Position 3.4, and NUMARC 87-00, Section 4,

c. Operator staffing and training to follow the identified actions in the SBO procedures,

d. EDG reliability program meets, as a minimum, the guidelines of RG 1.155,

e. Equipment and components required to cope with an SBO are incorporated in a QA program that meets the guidance of RG 1.155, Appendix A, and

f. Actions taken pertaining to the specific recommendations noted above in the SE.

3.0 SUMMARY AND CONCLUSION

The staff has reviewed the licensee's responses to the SBO Rule (10 CFR 50.63) and the TER prepared by the staff's consultant, SAIC. The licensee provided a coping analysis using an AAC power source which would be available within 1 hour after the onset of an SBO. The staff agrees with the licensee's calculation of a 4-hour SBO coping duration. Based on our review, some actions and confirmations need to be made as described in the recommendations itemized herein. These include (1) clarification of the 3-month testing requirement of the AAC power sources, (2) implementation of backup nitrogen gas supply for the RCP seal bleed-off valves, (3) calculations of the average EDG reliability, (4) confirmation that the non-safety related equipment required to cope with an SBO event will meet the criteria of Appendix A of RG 1.155, (5) confirmation of the EDG reliability program, and (6) maintenance of SBO documentation. The licensee should include the documentation associated with the above actions and confirmations with the other documentation supporting the SBO submittal, and maintain this documentation for further inspection and assessment as may be undertaken by the NRC to further verify conformance with the SBO Rule.

Based on our review of the submittals, the staff finds the licensee's responses and proposed method of dealing with an SBO to be in conformance with the SBO Rule contingent upon receipt of confirmation from the licensee within 30 days that the recommendations documented in the SE will be implemented. The schedule for implementation of the recommendations should also be provided in accordance with 10 CFR 50.63(c)(4).

4.0 ATTACHMENT

SAIC-91/1250 "Technical Evaluation Report, Palo Verde Nuclear Generating Station, Station Blackout Evaluation," October 24, 1991.

Principal Contributor: A. Pal

Date: February 11, 1992

Attachment:
Technical Evaluation Report