Attachment 1

SAIC-91/1251

TECHNICAL EVALUATION REPORT

SAN ONOFRE NUCLEAR GENERATING STATION
UNITS 2 AND 3

STATION BLACKOUT EVALUATION

TAC Nos. M68599 and M68600

Science Applications International Corporation

An Employee-Owned Company

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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 an... ...ncluded 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 (10) by the NRC staff 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 (11) 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, ventilation system for equipment operability, containment isolation valves for providing 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.

This preliminary SBO evaluation is based upon the review of the licensee's submittals dated April 17, 1989 (13), May 1, 1990 (14), September 12, 1991 (15), and the information available in the plant Updated Safety Analysis Report (UFSAR) (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, Southern California Edison (SCE) Company, calculated (13) a minimum acceptable station blackout duration of four hours for the San Onofre 2 and 3 (SONGS 2/3) Plant site. The licensee stated that no modifications are required to attain this 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 "1," and

   d. Estimated frequency of LOOPs due to severe weather (SW) which places the plant in SW Group "1."

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

   The EAC power configuration of the plant is "C." SONGS 2/3 is equipped with two emergency diesel generators per unit. One EAC power supply per unit is necessary to operate safe-shutdown equipment following a loss of offsite power.

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

The licensee has selected target EDG reliability of 0.95 for all SONGS 2/3 EDGs, based on having a nuclear unit average EDG reliability greater than 0.95 for the last 100 demands. EDG reliabilities have been calculated (14) in accordance with Nuclear Safety Analysis Center (NSAC) 108 and were determined to be greater than 0.98 for each individual EDG.

Review of Licensee's Submittal

Factors which affect the estimation of the SBO coping duration are: the estimated frequency of LOOPs due to ESW and SW conditions, the independence of the offsite power system grouping, the expected frequency of grid-related LOOPs, the classification of EAC, and the selection of EDG target reliability.

Using Table 3-2 of NUMARC 87-00, the expected frequency of LOOPs due to ESW conditions places the SONGS 2/3 site in ESW Group "1," which is in agreement with what was stated in the licensee's submittal (13).

Using data from Table 3-3 of NUMARC 87-00, the expected frequency of LOOPs due to SW conditions place the SONGS 2/3 site in SW Group "1," which is in agreement with what was stated in the licensee's submittal (13). This calculation was performed with the condition that there are multiple rights of way among the incoming transmission lines, consistent with UFSAR Figure 2.1-2 (12).

The licensee stated that the independence of the plant offsite power system grouping is "I1/2." A review of the SONGS 2/3 UFSAR (12) shows that:

1. There is a single switchyard for the site;

2. During normal operation, 230-kV power is provided to the essential buses for each unit through the unit reserve auxiliary transformers from a separate offsite transmission line;

3. In the event that one offsite preferred power feeder fails to function, the safety related loads connected to it will automatically transfer to the other offsite power feeder via the companion unit through bus tie circuit breakers.

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."

Establishment of the proper Emergency AC (EAC) Configuration Group is based on the number of available EAC sources and the number of EAC sources required to operate safe shutdown equipment following a LOOP. Each unit has two dedicated EAC sources, one of which is required after a LOOP. We agree with the licensee's assessment which places the plant in EAC Group "C."

The licensee selected (14) the EDG target reliability of 0.95 based upon having an average reliability of 0.98 for each diesel. The licensee added that EDG reliabilities have been calculated in accordance with the method described in NSAC 108. Although this is an acceptable criterion for choosing an EDG target reliability, the guidance of RG 1.155 requires that the EDG statistics for the last 20, 50 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. We are unable to verify the demonstrated start and load-run reliability of the plant EDGs. This information is only available onsite as part of the submittal's supporting documents. Based on the information reported by the licensee in NSAC-108, which gives EDG reliability data at US nuclear power plants, the EDGs at SONGS 2/3 did not experience any failures during the calender years 1984 and 1985. The licensee's selection of the EDG target reliability meets the criteria specified in RG 1.155 and NUMARC 87-00. The licensee stated (14) that SCE will establish a diesel generator reliability program which will be consistent with that clarified in NUMARC 87-00, Appendix D, EDG Reliability Program. This program will be based on NUMARC guidance and will ensure that the 0.95 EDG reliabilities are maintained.

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 SONGS 2/3 experienced three LOOP events during the years 1973-1980. The report concluded that none of the events were symptomatic of grid-related failures. In the absence of any adverse information, we agree with the licensee's statement.

Based on the above, we agree with the licensee's claim that the offsite power design characteristic of the SONGS 2/3 site is "P1" with a minimum required SBO coping duration of four hours.

3.2 Station Blackout Coping Capability

The plant coping capability with an SBO event for a required duration of four hours is assessed with the following results:

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

Licensee's Submittal

Using the methodology described in NUMARC 87-00, the licensee stated (15) that 74,987 gallons of water would be required to remove decay heat during a four-hour SBO event. This estimate is based on the maximum licensed core thermal rating of 3590 MWt for each unit. No cooldown was assumed, as the SONGS 2 and 3 SBO procedure does not require accelerated primary system cooldown to minimize reactor coolant pump leakage.

The licensee stated (13) that the minimum permissible condensate storage tank (CST) level per technical specifications provides 424,000 gallons of water. In a later submittal, the licensee stated (15) that the minimum permissible CST level per technical specifications provides 144,000 gallons of water.

Review of Licensee's Submittal

Using the expression provided in NUMARC 87-00, we estimated that 74,987 gallons of water would be required to remove decay heat during a four-hour SBO event, assuming that no primary system cooldown is attempted. This estimate is based on the maximum licensed core thermal rating of 3590 MWt listed in the SONGS 2/3 UFSAR (12). In its calculation of reactor coolant system inventory at the end of a four hour SBO event, the licensee assumed (15) a cooldown of approximately 30°F. Although we didn't repeat the licensee's calculations, we concur with the licensee that, based on a minimum condensate level of 144,000 gallons, the site has sufficient condensate to cope with a four hour SBO event.

2. Class-1E Battery Capacity

Licensee's Submittal

In its original submittal, the licensee stated (13) that the class-1E batteries were determined to have insufficient capacity to meet SBO loads for four hours. The licensee proposed the following modifications to provide the additional capacity to meet the the proposed SBO duration:

(1) Install cable and conduit between DC Buses A and C and DC Buses B and D (but do not connect);

(2) Modify Station procedures to require that during an SBO event, load group A is connected to battery C and load group B is connected to battery D with the installed cable after approximately 3 hours into the SBO event (exact cross connect time window to be determined by analysts later).

The licensee later revised its position and stated (14) that it had determined that with the design margin removed, the existing batteries have sufficient capacity to support the SBO loads for four hours. As a

result, the licensee stated that the battery load group cross connect modification identified above is no longer required to satisfy the SBO rule.

In a later submittal, the licensee provided (15) a copy of the original battery capacity calculations and load profiles, as well as the new SBO calculation package. The original battery sizing calculations were based on the LOVS/SIAS loading conditions with a 25% aging margin and 11% temperature margin corresponding to the minimum technical specification temperature of 60°F. The battery loading conditions under LOVS/SIAS are as follows:

Subsystem	0 - 1	Minutes 1 - 90	Random		Design Margin
A	484.39	177.59	30.59		8.56%
B	411.96	185.16	34.67		26.43%
	0 - 1	1 - 30	30 - 480	Random	
C	121.99	118.19	79.89	76.97	17.06%
D	105.50	101.70	69.70	60.00	28.79%

The licensee stated that the SBO load profiles are different from the LOVS/SAIS load profiles because of the following:

- Operator action to strip the NSSS protection cabinet loads prior to 30 minutes

- Reduction of the average current drawn by the inverters due to voltage averaging

- The Shutdown Cooling System valves are not required to operate during the first four hours (60 amp reduction for channels C and D)

- Start the EDGs at the end of 260 and 270 minutes for channels A and B respectively

- Non-operation of the EDG fuel priming pumps after the first minute

For the SBO sizing calculations the licensee assumed the same 25% aging margin and 11% temperature margin as for LOVS/SIAS. Although no design margin is used, a 5 amp load has been added to all load profiles to accommodate future design modifications. In addition, the battery load profiles for each channel are extended to determine the maximum duration that the existing batteries can support the required SBO loads. The battery loading conditions under SBO are as follows:

Subsystem	0 - 1	1 - 30	30 - 260	260-261	Random
A	483.10	163.70	130.60	206.20	30.59
	0 - 1	**1 - 30**	**30 - 270**	**270-271**	**Random**
B	409.90	170.50	130.20	205.80	34.67
	0 - 1	**1 - 30**	**30-751**		**Random**
C	114.30	110.10	69.40		16.97
	0 - 1	**1 - 30**	**30-860**		**Random**
D	98.60	94.70	60.90		0

Based on the loading conditions identified above, the licensee concluded that the each of the existing batteries has sufficient capacity to support the required SBO loads for four hours.

Review of Licensee's Submittal

We reviewed the battery sizing calculation provided by the licensee. We found the licensee to have properly identified and clearly stated all

of the assumptions and limitations associated with the analysis. The calculations assumed an aging factor of 1.25, a temperature factor of 1.10 (or 60°F electrolyte temperature) and a design margin of 1.0. The analysis is based on the actual connected load values and as such does not allow for any future load growth. There are four 125 VDC battery channels in each unit. The licensee's calculations show that all batteries marginally meet the four hour SBO loads.

According to the UFSAR (12), battery channels A and B are sized for 1.5 hours of operation, while subsystems C and D are sized for 8 hours. No battery load profiles were provided in the UFSAR. It is our understanding that the LOVS/SIAS battery load profiles and capacity calculations contained in the licensee's submittal dated September 12, 1991 are represented in the UFSAR.

Based on a review of the licensee's battery capacity calculations for SBO loads, we conclude the following:

- We found the assumption of zero percent design margin to be inconsistent with IEEE Std-485 guidance, which states a 10% to 15% design margin needs to be considered. We performed a sizing calculation of batteries channels A, B, C and D with a minimum voltage per cell of 1.81 (which is less conservative than the 1.84 volts per cell used by the licensee) and found that only batteries C and D will have sufficient design margin to conform with the guidance of IEEE Std-485.

- The licensee used a reduced vital bus inverter current due to averaging the initial battery open circuit voltage with the end of duty cycle voltage. This use of a reduced inverter current is non-conservative. The licensee needs to consider the inverter current need associated with the end of duty cycle voltage.

- The licensee needs to clearly state what functions/instrumentation will be lost by shedding the proposed loads, and why the loss of this

information will not affect the operators ability to monitor the status of the plant during the four hour coping period.

3. **Compressed Air**

Licensee's Submittal

The licensee stated (13) that air-operated valves relied upon to cope with an SBO for four hours can either be operated manually or have sufficient backup sources independent of the preferred and class-1E power supply. The licensee added that valves requiring manual operation or that need backup sources for operation are already identified in plant procedures.

In a later submittal, the licensee stated (15) that an existing handswitch in the control room will be used to control operation of the atmospheric dump valves (ADVs), and as such, local operation of these valves is not required. Pressurized gas is supplied to each power operated atmospheric dump valve (ADV) in the form of bottled nitrogen which, upon a loss of pressure in the normal instrument air supply to the ADVs, automatically supplies nitrogen to the dump valves. Each accumulator is required to maintain sufficient nitrogen gas for each ADV to have at least 8 hours of pneumatic operation. If manual operation were required, however, the emergency lighting (powered by its own separate 8-hour battery pack) in the ADV area is sufficient to perform ADV operation via a handwheel during an SBO event.

Review of Licensee's Submittal

According to the UFSAR (12), the auxiliary feedwater lines in the turbine driven auxiliary feedwater pump train are equipped with DC motor-operated control and isolation valves.

With regard to steam relief to the atmosphere, the licensee stated that it will be accomplished remotely from an existing handswitch and hand-

indicating controller in the control room. Bottled nitrogen tanks with an eight hour capacity will automatically supply nitrogen to the ADVs upon a loss of power. In addition, the capability exists for local manual operation of the ADVs. Based on these facts, we agree with the licensee's assertion that the ADVs can be operated successfully during an SBO event, therefore the plant does not require additional backup compressed air during an SBO event.

4. **Effects of Loss of Ventilation**

Licensee's Submittal

The licensee stated (15) that time-dependent heat transfer analyses was used to determine room temperature rise in plant compartments following an SBO. This method was based on a specific lumped parameter model and assumes only poured concrete walls as heat sinks. The licensee contends that this model is overly conservative because it predicts only the steady state compartment temperature and does not allow credit for heat which will be dissipated in plaster walls, ceilings and compartment air mass. In addition, as part of the analysis, SBO temperature rise calculations based on NUMARC 87-00 methods were also provided.

The licensee identified the following as dominant areas of concern:

1) AFW Pump Room
2) Distribution (Inverter) Rooms (4 for each unit)
3) Switchgear Rooms (2 for each unit)
4) Control Room Cabinet Area (Common)
5) Control Room (common)

In its room heatup analyses for the Distribution and Switchgear rooms, the licensee only analyzed (15) the rooms with the highest heat load (Switchgear Room #302A and Distribution Room #310B).

The areas that were considered but eliminated as DACs were the battery rooms and the atmospheric dump and steam relief valve areas. The battery rooms were dismissed as DACs because NUMARC 87-00 guidance does not consider battery rooms as DACs. For San Onofre 2 and 3, the atmospheric dump and steam relief valves are located outdoors, and were not considered DACs.

The control room loss of ventilation calculation was only performed for one hour, as it was assumed that after one hour the control room HVAC would be provided by the non blacked-out unit's diesel.

The licensee stated (15) that a containment heatup analysis during an SBO has not been performed. The licensee added that the containment heat loads resulting from a Reactor Coolant System leakage of 11 gpm are well below the heat loads assumed in the LOCA/HELB analysis, and thus, no additional analyses were performed.

The results of the licensee's time dependent room heatup analyses and the and corresponding result using NUMARC 87-00 are summarized in Table 1.

The licensee stated (12) that reasonable assurance of the operability of SBO response equipment in the above DACs has been assessed using Appendix F to NUMARC 87-00 and concluded that no modifications or associated procedures are necessary to provide reasonable assurance of equipment operability during an SBO event.

Review of Licensee's Submittal

We assume that the computer code used by the licensee in its time-dependent heat transfer analyses has already been verified and validated through the licensee's own quality assurance program. As we did not have access to the computer code used by the licensee in its calculations, the assumptions and results of the licensee's calculations were reviewed and compared to the NUMARC 87-00 calculated temperatures. The licensee stated that the Control Room will have

Table 1: Summary of the Room Heatup Analysis Results

Room	Initial Temp. (°F)	Licensee's Time-dependent Analysis Result (°F) 1 hr	4 hrs	NUMARC 87-00 Steady State Temp (°F)
Switchgear Room	95		96.8	101.4
Distribution Room	95		118.5	138.2
Computer Room	72		163.9	192.8
AFW Pump Room	104		107.4	114.2
Control Room Cabinet Area	75	111.1 *		140.6
Control Room Area	75	114.6 *		151.9

* The licensee stated that HVAC would be available to the Control Room within one hour.

HVAC available after one hour. The plant UFSAR states (12) that there is a common control room shared by both units. This room is cooled by a single train of normal HVAC and two 100%-capacity redundant subsystems of emergency HVAC. One emergency subsystem is on emergency power train A and the other is on train B. For the control room to have an emergency HVAC train available during an SBO, each subsystem has to be connectible to the same emergency power supply train from each unit. However, we were unable to confirm this connectability from the information available in the plant UFSAR (12). The licensee needs to verify that such connectability exists.

Our review of the information provided by the licensee reveals the following concerns:

AFW Pump Room:

Upon review of the licensee's heatup analysis for the AFW pump room, we found the assumed heat loads, areas, and calculating assumptions to be reasonable. In addition, the calculated final temperature was consistent with the final calculated temperature using NUMARC 87-00 methodology. Based on the above, we accept the licensee's calculated SBO temperature for the AFW pump room.

Containment:

The licensee concluded that the containment heatup during an SBO was enveloped by the LOCA/HELB analysis, based on the expected heat loads resulting from an assumed RCS leakage of 11 gpm. The licensee's assumption of 11 gpm RCS leakage is non-conservative. The licensee needs to recalculate the expected containment heat loads resulting from an assumed RCS leak rate of 111 gpm, consistent with the guidance, and verify that the expected temperature in the containment is enveloped by the LOCA/HELB temperature profiles.

Control Building Rooms:

(Switchgear Room, Distribution Room, Computer Room, Control Room, Control Room Cabinet Area)

Our review of the remaining rooms evaluated by the licensee, all of which are located in the Control Building, resulted in several concerns with regard to the licensee's methodology and assumptions. Our concerns are as follows:

- The licensee used normal operating design temperatures as the initial temperatures in its room heatup calculations. In many cases these temperatures were non-conservative (i.e. Computer room - 72°F, Control room and control room cabinet area - 75°F). The licensee needs to use as an initial temperature the maximum temperature allowed by technical specifications. The licensee can choose a lower temperature as an initial temperature if it provides administrative controls to ensure that the room temperature will not exceed this temperature under any circumstances during normal plant operation.

- For its heatup calculations, the licensee assumed that the air temperature in the surrounding rooms did not change during the SBO event. The licensee needs to confirm that this is the case, and for those rooms in which the temperature is expected to rise during an SBO event, the licensee needs to use the maximum expected temperature for these rooms.

- Throughout the calculations, the licensee assumes a concrete thermal conductivity of 1.04 (Btu/hr ft °F). This value has previously been considered too high and therefore non-conservative for SBO analysis. A more appropriate and acceptable value of 0.7 needs to be used.

- The licensee assumed non-conservative and inconsistent values for the total volume area which was taken by beams, raised floors,

suspended ceilings, equipment, supports, etc. These values ranged from 2% to 10%. The licensee needs to either measure these areas directly, or use a conservative assumption such as 10% if these areas are not known.

- The licensee needs to provide a technical justification for its assumption of a constant h_{air} of 1.47 BTU/hr-ft^2-°F for all rooms and all heat conducting surfaces. Natural Convection Heat Transfer Coefficients for air are affected by surface orientation (i.e. vertical or horizontal), air properties, system geometry, and air-to-surface temperature difference. Depending on these parameters, the value for h_{air} could range from 0.1 to 10.0 BTU/hr-ft^2-°F. The licensee needs to use a justifiably conservative (i.e. low) value of h_{air} for this analysis if a single constant value is to be used throughout the calculations.

- The use of 3/4 inch and 1 inch thick gypsum plasterboard as being equivalent to one or two foot thick concrete is incorrect for heat transfer calculations. The gypsum plaster does not provide as high a heat capacity as concrete. All of the analyses which credit gypsum as having the heat capacity of concrete need to be reperformed either with the gypsum surface area removed or explicitly accounted for with its own thermal properties and wall thickness.

- The licensee needs to provide a technical justification for the selection of a Δi of one minute and a Δx of one inch (0.0833 feet) in the methodology. A sensitivity study in which these parameters are varied would provide evidence that these particular values of Δi and Δx are suitably conservative for this analysis.

- The licensee assumed four people would occupy the control room during an SBO event with a heat source of 250 Btu/hr person. The heat load assumed by the licensee is non-conservative. A more appropriate value of 250 Watts (853 Btu/hr) needs to be used, as recommended by the ASHRAE handbook. In addition, the licensee needs to justify the assumption that only four persons will occupy

the control room during an SBO. Our experience suggests that a value of ten persons is more appropriate.

Assuming a heat load of 250 Watts per person for ten people results in a total personnel heat source of approximately 8500 Btu/hr, compared to 1000 Btu/hr assumed by the licensee.

- In its control room heatup analysis, the licensee assumed a total heat source of 90,000 Btu/hr consisting of 1000 Btu/hr from personnel, 17,065 Btu/hr from lights and 71755.4 Btu/hr from equipment. Based on our experience with similar two unit sites with shared control rooms, this heat load appears to be too low. Based upon the loads identified (15) by the licensee for each inverter and information contained in the plant UFSAR (12), we conclude that the control room heat load identified by the licensee is non-conservative. Our calculations indicate that the total load is more than a factor of two larger than what was assumed by the licensee. Thus, the licensee needs to provide justification for its assumed control room heat load and perform a new control room heatup analysis, if necessary.

- The licensee states (15) that the control room panels face the Control Room Cabinet area. In its heat transfer analyses, the licensee assumed that 50% of the heat loss from the Control Room panels are dissipated to the Control Room cabinet area and that 100% of the heat loss is dissipated to the Control Room area. This assumption is non-conservative. The licensee needs to assume that 100% of the heat loss is dissipated to both the Control Room area and Control Room Cabinet area.

Based on the concerns raised above, the licensee needs to re-assess the temperature rise analyses for all Control Building rooms containing SBO equipment (i.e. Switchgear Room, Distribution Room, Computer Room, Control Room, Control Room Cabinet Area) and verify that there is reasonable assurance of the operability of SBO equipment in these areas.

5. Containment Isolation

Licensee's Submittal

The licensee stated (13) 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 station blackout conditions can be positioned with indication independent of the preferred and blacked-out unit's class-1E power supplies. The licensee stated that no plant modifications and associated procedure changes were determined to be required.

The licensee stated (14) that it has included two additional criteria for exclusion of CIVs, as follows:

(1) Valves which are redundant to an isolation valve which meets the NUMARC exclusion criteria. This is based on NUMARC's response to Question 101 in Enclosure D of their October 27, 1988 letter.

(2) Valves that are "always" or "normally" closed but not "locked closed".

In a later submittal, the licensee provided a list of valves which it had determined could not be excluded using the five exclusion criteria of R.G. 1.155 and an explanation of how these valves would be assured of being closed during an SBO event.

Review of Licensee's Submittal

Using information contained in UFSAR Table 6.2-35 (12) we reviewed the list of plant CIVs to determine those which could not be excluded from consideration using the five criteria of R.G. 1.155. Our review identified the containment sump recirculation line valves outside containment, HV-9302 and HV-9303, as the only valves which could

not be excluded. These penetrations contain a motor-operated butterfly valve which is normally-closed and fails-as-is upon loss of AC power.

In its response to a question, the licensee stated (15) that these valves will not be open during the normal plant operation. The licensee added that the valves are normally closed, they are not tested and their position is monitored during every shift. We consider the licensee's justifications with regard to the exclusion of these valves to be consistent with the intent of RG 1.155.

In addition, the list of valves which the licensee concluded (15) in its September 12, 1991 submittal could not be excluded using the five exclusion criteria of R.G. 1.155 were examined. Our review indicates that with the exception of the containment sump recirculation line valves addressed above all other valves identified by the licensee, either have a fail-closed valve or a check valve in the penetration line which allows exclusion under RG 1.155 guidance.

Thus, we conclude that all valves which must be capable of being closed or that must be operated (cycled) under station blackout conditions can be positioned with indication independent of the preferred and blacked-out unit's class-1E power supplies.

6. **Reactor Coolant Inventory**

Licensee's Submittal

The licensee stated (13) that the ability to maintain adequate reactor coolant system (RCS) inventory to ensure that the core is cooled has been assessed for four hours. The generic analyses listed in Section 2.5.2 of NUMARC 87-00 were used for this assessment. The expected rates of reactor coolant inventory loss under SBO conditions did not result in core uncovery in an SBO of four hours.

In a later submittal, the licensee stated (14) the SONGS 2/3 RCP seals were designed to have no significant degradation as a result of a four

hour SBO event, and as such, RCP seal leakage was assumed not to increase during an SBO event. The licensee stated that the vendor data, including actual test results, demonstrates that the RCP seal leakage will not increase during an SBO event.

In its analysis, the reactor is assumed (15) to be operating at 100% power for 100 days at normal operating conditions at the time of the occurrence of SBO. Normal operating conditions include primary pressure of 2250 psia, RCS cold leg temperature of 557.5°F, RCS hot leg temperature of 608°F and RCS water volume of 82,000 gallons.

The initial RCS leakage assumed by the licensee during SBO is 11 gpm which is reduced during the coping period as RCS pressure decreases. The licensee stated (15) that it has tested the RCP seals and the results indicate that no appreciable seal leakage would exist at the end of a four hour SBO. Therefore, the RCP seal leakage during an SBO will remain within the 11 gpm total RCP seal leakage allowed by technical specifications and no additional RCP seal leakage needs to be assumed.

At the end of the coping duration the licensee assumed a primary pressure of 1300 psia, RCS cold leg temperature of 531°F, RCS hot leg temperature of 557.5°F and a reduced RCP seal rate of 6.5 gpm. The licensee stated that during the four hour coping period, the pressurizer level slowly decreases as RCS pressure drops, however, the pressurizer does not empty during the entire four hour coping period. The final RCS water volume, neglecting Safety Injection tank inventory, will be 76,000 gallons. This remaining volume is greater than the volume of water the licensee stated was required to cover the core of 20,000 gallons (2674 ft^3).

The licensee also performed a reactor inventory calculation assuming a 25 gpm leak rate from each RCP seal (100 gpm total). The results of this higher leak rate analysis also demonstrate that the reactor core would remain covered during a four hour SBO event.

Review of Licensee's Submittal

The licensee's use of a generic analysis without specific justification of its applicability to the plant is not acceptable. We performed an independent evaluation of RCS inventory using information available in the plant UFSAR (12) and the licensee's submittals.

The licensee's assumed RCS leakage of 11 gpm in its RCS inventory calculation is non-conservative and inconsistent with the guidance provided in NRC Generic Issue 23. In order to conform to the guidance, the licensee should consider 25 gpm per reactor coolant pump in addition to the 11 gpm technical specification leakage.

Using the information provided by the licensee above and assuming a total leak rate of 111 gpm, we calculated the volume of water remaining in the core at the end of a four hour SBO to be 5717 ft^3. This exceeds the required volume of 2674 ft^3 to cover the core reported by the licensee. Thus, despite our lack of agreement with the licensee's approach, we conclude that the core will not be uncovered during a four hour SBO event.

NOTE:

The 25-gpm RCP seal leak rate was agreed to between NUMARC and the NRC staff pending resolution of Generic Issue (GI) 23. If the final resolution of GI-23 defines higher RCP seal leak rates than assumed for the RCS inventory evaluation, the licensee needs to be aware of the potential impact of this resolution on its analyses and actions addressing conformance to the SBO rule.

3.3 Proposed Procedure and Training

Licensee's Submittal

The licensee stated (13) that plant procedures have been reviewed and that changes necessary to meet NUMARC 87-00 will be implemented in the following areas:

- Station blackout response - SBO response procedure SO23-13.1 will be reviewed and modified as necessary per NUMARC 87-00, Section 4.2.1;

- AC power restoration - procedure SO2/3-13.1, "Station Blackout" will be revised per NUMARC 87-00, Section 4.2.2;

- Severe weather - SCE will develop a severe weather response procedure per NUMARC 87-00, Section 4.2.3;

- Coping Procedures - minor procedure changes will be implemented in the SBO response procedure to ensure that all of the provisions of NUMARC 87-00, Section 7 are included.

The licensee added that procedure changes associated with any modifications required after assessing coping capability per NUMARC 87-00, Section 7, will be completed within two years after the notification provided by the staff in accordance with 10 CFR 50.63 (c)(3).

Review of Licensee's Submittal

We neither received nor reviewed the affected procedures, although several procedure changes have been identified as being required to maintain containment integrity under SBO conditions. We consider these procedures to be plant-specific actions concerning the required activities to cope with an SBO. 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.

3.4 Proposed Modification

Licensee's Submittal

The licensee did not identify any modifications to assure a four hour coping capability as being necessary.

Review of Licensee's Submittal

Our evaluation found several areas where the licensee needs to perform re-evaluations, some of these may result in modifications/changes to the existing equipment.

3.5 Quality Assurance and Technical Specifications

Licensee's Submittal

The licensee stated (15) that when compiling the SBO analysis it compiled a list of all equipment that would be required to operate during the four hour SBO coping duration. The licensee added that the QA classification of each component on this list was reviewed to ensure that the classification was consistent with the provisions of RG 1.155, Regulatory Position 3.5. The licensee concluded that all equipment on the list was identified as Quality Class II and is covered under 10 CFR 50 Appendix B.

Review of Licensee's Submittal

The licensee did not provide any information on this issue for us to review, therefore, we cannot confirm the adequacy of the evaluation. The licensee needs to include its review of QA needs for the SBO equipment as part of the plant SBO supporting documentation for future NRC audit review.

With regard to Technical Specifications, the licensee did not state how the plant SBO equipment complies with the guidance of R.G. 1.155, Appendix B.

4.0 CONCLUSIONS

Based on our review of the licensee's submittals and the information available in the UFSAR for San Onofre Unit 2 and 3, 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. **Class-1E Battery Capacity**

   Based on a review of the licensee's battery capacity calculations for SBO loads, we conclude the following:

   - We found the assumption of zero percent design margin to be inconsistent with IEEE Std-485 guidance, which states a 10% to 15% design margin needs to be considered. We performed a sizing calculation of batteries channels A, B, C and D with a minimum voltage per cell of 1.81 (which is less conservative than the 1.84 volts per cell used by the licensee) and found that only batteries C and D will have sufficient design margin to conform with the guidance of IEEE Std-485.

   - The licensee used a reduced vital bus inverter current due to averaging the initial battery open circuit voltage with the end of duty cycle voltage. This use of a reduced inverter current is non-conservative. The licensee needs to consider the inverter current need associated with the end of duty cycle voltage.

   - The licensee needs to clearly state what functions/instrumentation will be lost by shedding the proposed loads, and why the loss of this information will not affect the operators ability to monitor the status of the plant during the four hour coping period.

2. **Effects of Loss of Ventilation**

Our review of the temperature rise calculations provided by the licensee identified several concerns which invalidated the licensee's results for those rooms contained in the Control Building (see Section 3.2). Based on the concerns raised above, the licensee needs to re-assess the temperature rise analyses for all Control Building rooms containing SBO equipment (i.e. Switchgear Room, Distribution Room, Computer Room, Control Room, Control Room Cabinet Area) and verify that there is reasonable assurance of the operability of SBO equipment in these areas.

With regard to the control room and Control Room Cabinet Area, we were unable to confirm this connectability from the information available in the plant UFSAR (12). The licensee needs to verify that such connectability exists.

With regard to the containment, the licensee concluded that the containment heatup during an SBO were enveloped by the LOCA/HELB analysis, based on the expected heat loads resulting from an assumed RCS leakage of 11 gpm. The licensee's assumption of 11 gpm RCS leakage is non-conservative. The licensee needs to recalculate the expected containment heat loads resulting from an assumed RCS leak rate of 111 gpm, consistent with the guidance, and verify that these expected loads are enveloped by the LOCA/HELB analysis.

3. **Proposed Modification**

Our review has identified several areas where the licensee needs to perform re-evaluations, some of which may result in modifications/changes to the existing equipment.

4. Quality Assurance and Technical Specifications

The licensee stated (15) that it has reviewed the QA classification of all required SBO equipment and has concluded that the classification was consistent with the provisions of RG 1.155, Regulatory Position 3.5. The licensee did not provide any information on this issue for us to review, therefore, we cannot confirm the adequacy of the evaluation. The licensee needs to include its review of QA needs for the SBO equipment as part of the plant SBO supporting documentation for future NRC audit review.

With regard to Technical Specifications, the licensee did not state how the plant SBO equipment complies with the guidance of R.G. 1.155, Appendix 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, 1981-1983," 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. Thadani, A. C., Letter to W. H. Rasin of NUMARC, "Approval of NUMARC Documents on Station Blackout (TAC-40577)," dated October 7, 1988.

11. 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).

12. San Onofre Nuclear Generating Station Units 2 and 3 Updated Final Safety Analysis Report (UFSAR).

13. Medford, M. O., letter to NRC Document Control Desk, "Response to 10 CFR 50.63, 'Loss of all Alternating Current Power,' San Onofre Nuclear Generating Station," Docket Nos. 50-361, 50-362, dated April 17, 1989.

14. Nandy, F. R., letter to NRC Document Control Desk, "Supplemental Response to 10 CFR 50.63, 'Loss of all Alternating Current Power,' San Onofre Nuclear Generating Station," Docket Nos. 50-361, 50-362, dated April 17, 1989.

15. R. M. Rosenblum, letter to NRC Document Control Desk, "Station Blackout Analysis for San Onofre Nuclear Generating Station," Docket Nos. 50-361, 50-362, dated September 12, 1991.