Attachment

SAIC-91/6659

TECHNICAL EVALUATION REPORT

BROWNS FERRY NUCLEAR PLANT, UNITS 1, 2, AND 3

STATION BLACKOUT EVALUATION

TAC Nos. 68517, 68518, and 68519

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 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 (13) 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 (14) 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.

This SBO evaluation is based upon the review of the licensee's submittals dated April 18, 1989 (10), April 5, 1990 (12), and May 4, 1990 (20), a telephone conversation with the licensee on October 25, 1990, as a result of which the licensee provided a supplemental information package (15), and the information available in the plant Updated Final Safety Analysis Report (UFSAR) (11); 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, Tennessee Valley Authority (TVA), calculated (10 and 12) a minimum acceptable station blackout duration of four hours for the Browns Ferry Nuclear Plant (BFN) site, which consists of three identical units. 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 "2."

2. Emergency AC (EAC) Power Configuration Group

   The EAC power configuration of the plant is "D." BFN is equipped with eight emergency diesel generators, six of which are necessary

to operate safe-shutdown equipment for all three units following a loss of offsite power.

3. Target Emergency Diesel Generator (EDG) Reliability

The licensee has selected a target EDG reliability of 0.975. The selection of this target reliability is based on having an average EDG reliability of greater than 0.95 for the last 100 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. The licensee's estimates of the expected frequency of LOOP due to ESW and SW conditions are consistent with the information provided in NUMARC 87-00.

The licensee stated that the independence of the plant offsite power system grouping is "I1/2." A review of the BFN UFSAR indicates that:

1. The site has a single switchyard;

2. During normal operation, station auxiliary power is taken from the main generator through the unit station service transformer;

3. In the event of a main-generator trip, the generator breaker opens and auxiliary power is supplied from the 500-kV system through the main transformer;

4. Failure of the 500-kV system results in:

a. For Units 1 and 2, the non-safety-related buses are automatically transferred to the two common station service transformers (CSSTs) and the safety-related buses are automatically transferred to the alternate units' unit station service transformers (USSTs);

b. For Unit 3, the 4-kV unit boards and their connected shut-down boards are automatically transferred to the common station service transformers (CSSTs). Upon the CSSTs becoming unavailable, only the safety-related buses are automatically transferred to the cooling tower transformers (CTTs).

Based on these and the criteria stated in Table 5 of RG 1.155, we conclude that the plant independence of offsite power system group is "I2."

The licensee classified the EAC classification of BFN as "D." There are eight EDGs at the site, four for Units 1 and 2, and four for Unit 3. These EDGs are dedicated to their respective units, and also have connectability to support other units. Based on the licensee's statement that six EDGs are required for safe-shutdown loads following a LOOP, the EAC classification of the site is "D."

The licensee selected a target EDG reliability of 0.975 based upon the last 100 demands. The target EDG reliability which the licensee selected (10) and committed to maintain (12) is in conformance with both RG 1.155 and NUMARC 87-00. Since the information supporting the target EDG reliability is only available on site, we are unable to verify the assignment of the target reliability at this time. We did not receive the values for the EDG reliability over the last 20, 50, or 100 demands. The licensee needs to have the analysis showing the EDG reliability statistics for the last 20, 50, and 100 demands in its SBO submittal supporting documents. Although the licensee is committed to maintain the target EDG reliability, it did not state whether the plant has any formal reliability program consistent with the guidance of RG 1.155, Section 1.2, and NUMARC 87-00, Appendix D. Therefore, an audit may be required to ensure compliance.

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 BFN 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 AC power design characteristic of the BFN 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 the required duration of four hours is assessed for each unit based on the following results:

1. Condensate Inventory for Decay-Heat Removal

   Licensee's Submittal

   The licensee's submittal stated that 72,842 gallons of water are required for the decay-heat removal during a 4-hour SBO coping period. The minimum permissible condensate storage tank (CST) level provides 135,000 gallons of water per unit, which exceeds the required quantity for coping with a 4-hour SBO event.

   During the telephone conversation on October 25, 1990, the licensee stated that it will begin to depressurize the reactor at a rate of 100°F/hr 10 minutes after the onset of an SBO event. This is consistent with the plant abnormal operations procedure

AOI-57-2. The licensee also stated that the final reactor pressure will be ~200 psig.

The licensee initially assumed a maximum of 25 gpm of reactor coolant system leakage in its calculation. After the telephone conversation on October 25, 1990, the licensee amended its condensate calculation, modified its assumed leak rate from 25 gpm to 36 gpm (18 gpm per pump), and determined that 81,482 gallons of water would be required to cope with a 4-hour SBO event.

Review of Licensee's Submittal

Using the expression provided in NUMARC 87-00, we have estimated that the water required for removing decay heat during the four-hour SBO would be 74,300 gallons. This estimate is based on 102% of a maximum licensed core thermal rating of 3293 MWt. In addition, condensate has to be provided to account for an assumed leak rate of 61 gpm (18 gpm per pump plus the maximum allowed technical specifications leakage of 25 gpm). We estimated that 14,600 gallons were needed to make up for the assumed leakage. Without any cooldown, the total necessary condensate inventory is ~89,000 gallons. Since the minimum CST level corresponds to 135,000 gallons of water, there will be 46,000 gallons of water for cooldown. Therefore, there is an adequate amount of water to cope with a 4-hour SBO event. However, the licensee needs to ensure that the minimum CST water level will be available at all times during normal plant operation.

2. Class-1E Battery Capacity

Licensee's Submittal

The licensee stated (10) that the class-1E batteries are currently inadequate to meet SBO loads for four hours. The licensee modified procedure 0-AOI-57-2 to include battery load shedding in

order to provide the necessary 4-hour capacity. The licensee stated that since the non-class-1E station battery No. 4 is inadequate, a manual action would be needed to transfer the loads for switchyard breaker closure to the No. 2 unit battery. This action can be accomplished from the main control room.

In response to the questions raised during the telephone conversation on October 25, 1990, the licensee provided (15) its revised battery sizing calculations for the BFN site. In this calculation, the emergency lighting was not considered, and the licensee stated that the emergency lighting will be provided by battery packs which are sized for eight-hour operation as required by 10 CFR 50 Appendix R analysis. The licensee also provided the results of two sets of battery sizing calculations, one with only Unit 2 operational (Units 1 and 3 in cold shutdown), and one with all three units operational. In the case where only Unit 2 is operational, the licensee provided the results of three analyses. In each analysis, a different unit battery in conjunction with the station battery was assumed to be supporting the Unit 2 SBO loads.

In the case where all three units are operational, the licensee's calculations indicate that the following changes/modifications may be necessary:

1) The 120-VAC RCIC controls are the only required loads on the Unit Preferred MG sets, which will be stripped. These controls need to be relocated to another power source;

2) The existing LCUN-29 batteries (14 positive plates) on Units 2 and 3 need to be replaced with LCUN-33 batteries (16 positive plates), similar to that supporting Unit 1;

3) The present ±5% in the accuracy of the ammeters results in 60 Amperes (A) more load shedding. Installation of more

accurate ammeters, i.e. digital meters with ±0.5% in accuracy, is recommended; and

4) The minimum voltage required at 250-V RMOV Boards 1B, 2B, and 3B for the RCIC electric governor controls to be operational is in excess of that supplied by the batteries for multi-unit operation. Therefore, circuit modifications are required.

The supplemental information package also indicates that procedure 0-AOI-57-2 requires the operator to commence load shedding at 30 minutes into the event. The operator is required to load shed each unit battery until a current of 180 A is reached. The procedure mandates that this be accomplished within 60 minutes after the onset of the SBO event.

The licensee acknowledged (15) that the return of Units 1 and 3 to service will require additional calculations and modifications. If the loads on the batteries for Units 1 and/or 3 should change by modification beyond that specified in the present calculation, the BFN commitment to comply with the SBO rule would automatically necessitate revision of the calculations to ensure conformance of the plant design with regulatory requirements.

Review of Licensee's Submittal

At BFN, there are four 250-VDC batteries, three class-1E unit batteries and one, non-class-1E station battery, all of which are shared between the units. The manner in which the station battery (non-class-1E battery) will be used during an SBO event is not clear. The licensee did not provide any information concerning the loads on this battery.

The licensee provided (15) an analysis on its class-1E battery calculation as a result of the telephone conversation on October

25, 1990. This analysis considers that only Unit 2 is in operation. (The return of Units 1 and 3 to service will require additional information and modifications to be provided later.) This analysis contains the SBO loads on the batteries for six cases, along with the assumptions and justifications used by the licensee. We reviewed the licensee's assumptions and the loads which will be carried by the batteries. We did not, however, review the specific voltages or currents required for the various loads due to the fact that we did not have access to several of the cited references. Our evaluation assumed that the battery loads provided by the licensee are correct.

In the calculations provided, there are several assumptions which we consider to be non-conservative in spite of the licensee's claim of their being conservative:

1) The licensee used an exception to the IEEE Std-485 cell-sizing method in its calculations. In the standard, time is broken into intervals no smaller than one minute. The largest current during the time interval smaller than one minute is assumed to be the continuous current throughout the one-minute interval. The licensee used a less conservative method by breaking the first minute into smaller intervals, some of which are only two seconds in length. This is non-conservative because it results in a smaller net average current over the one-minute interval;

2) For the battery-room temperature, the licensee assumed an initial temperature of 76°F. The licensee needs to ensure that the room ambient air temperature will not drop below this temperature under any circumstances or, if it does, there is an alarm in the control room to alert the operators to take appropriate action;

3) The licensee used a design margin of 1.00 in its battery calculations. This is not consistent with the guidance provided in IEEE-Std 485, which recommends a design margin of 1.10-1.15 be used.

4) The licensee assumed that only two circuit breakers would need to be closed at the end of the SBO event and that each breaker would require 5 A to close each breaker. A review of the plant electrical distribution drawings indicates more circuit breakers need to be operated to connect the emergency buses to the offsite power source.

Although the supplemental information provided by the licensee is detailed, we did not have enough information to thoroughly review the batteries. With regard to the loads on the batteries, we have the following concerns:

1) In the load tables provided by the licensee (15), we found that there were several loads which were not considered to be powered which should be (i.e., the turbine emergency bearing oil pump and the generator emergency seal oil pump). Since no information was provided about the loads that would be on the station (non-class-1E) battery, the licensee needs to establish how these pumps will be powered;

2) No analysis was provided for the 125-VDC EDG batteries. It is not clear how long these batteries will last or how many EDG starts they can support.

From the information provided (15), it appears that the licensee will have to strip more from the batteries than was assumed to be shed for the calculations. Due to the 5% error in the ammeter reading, the licensee indicated that it will have to shed an additional 60 A (5% of the 1200-A full-scale ammeter reading) beyond that which it has assumed will be shed in the battery

calculations. The licensee provided an additional list of loads that need to be shed in order to remain below the maximum continuous current for each unit in operation.

Overall, our review indicates that although the licensee's analysis is non-conservative, the available site battery capacity is sufficient for Unit-2 operation only. The licensee needs to ensure, however, that loads such as the emergency bearing oil pump for the turbine and the generator, are powered for the period required, and to document the source(s) of power.

Before Unit 1 or 3 returns to service, the licensee needs to re-evaluate its battery calculations to verify that each unit has sufficient battery capacity to power the necessary systems for all of the operating units, taking into account the aforementioned non-conservatism.

3. Compressed Air

Licensee's Submittal

The licensee stated (10) that the air-operated valves relied upon to cope with an SBO for four hours have sufficient back-up sources and that there are no valves that require manual operation. The licensee stated (15) that the only valves required to be operable during an SBO event are the main steam relief valves (MSRVs).

Review of Licensee's Submittal

Upon review of the BFN UFSAR Section 4.4, we found that each MSRV has an accumulator. In the supplemental information package (15), the licensee provided calculations showing that each accumulator has sufficient capacity to cycle the valve at least five times, which is sufficient to cope with a four-hour SBO event. During telephone conversation on October 25, 1990, the licensee stated

that the back-up air supplies will not be used beyond the first hour of an SBO event.

4. Effects of Loss of Ventilation

Licensee's Submittal

During an SBO event, BFN will be without any heating, ventilation, and air conditioning (HVAC) systems. Consequently, the licensee performed area heat-up calculations and provided the results for the control rooms, the main steam tunnel, and the HPCI and RCIC rooms in its submittals (10 and 12).

In response to questions raised during the telephone conversation, the licensee provided (17 and 18) a summary of its heat-up analysis. The results of the calculations are as follows:

Area	Temperatures (°F)		
	Initial	Final	E.Q.†
HPCI room	85	115.00	117
RCIC room	80	109.81	117
Main Steam Tunnel	NP	166.00	160
Preferred MG Set Room (CB/EL 593)‡	75	104	NA
Main Control room (Units 1 and 2)	76	102.68	104
Main Control room (Unit 3)	76	104	104
Relay Room (between MCR)	76	80.58	104
Auxiliary Instrument Rooms (CB/EL 593)	76	102	104
Battery and Battery Board Room (CB/EL 593)‡	76	104	104
250-V Battery Room (RB/EL 621)	80	93.92	104
Shutdown Board Rooms (1 and 2, RB/EL 621)	80	97.05	104
Shutdown Board Room (1 and 2, RB/EL 593)	80	96.76	104
Shutdown Board Room (Unit 3, RB/EL 621)	80	96.64	104
Shutdown Board Room (Unit 3, RB/EL 593)	80	94.59	104
General Floor (RB/EL 595)	80	<104*	104
480-V Board Room (DGB/EL 583)	75	78.82	104
4-kV Shutdown Board Room (DGB/EL 583)	75	95.43	104
4-kV Shutdown Board Room (DGB/EL 565)	75	92.88	104

† The equipment qualification (EQ) value is the maximum abnormal temperature that could occur as a result of outside temperature excursions. This condition could exist for up to eight hours.
‡ Temperature was calculated using a time-dependent transient method.
* This estimation is based on engineering judgement.
NP Not provided
NA Not applicable

The licensee stated that, unless otherwise noted, the NUMARC methodology was used. The licensee added that the main steam tunnel is not a concern due to the fact that no equipment is required to be operable after the closure of the MSIVs upon loss of power.

The licensee also provided its calculations on drywell heat-up during an SBO event. The analysis followed with a few exceptions the method used by Oak Ridge National Laboratory (ORNL) as part of the NRC-sponsored accident sequence analysis (ASA) program for the BFN Unit 1 SBO event, NUREG/CR-2182 (19). The licensee stated that the calculation was performed to include the changes in the revised emergency procedures, use more applicable data, and verify and document the validity of the ORNL report. The licensee concluded that the ORNL results are correct and consistent with results produced by this calculation. The licensee noted that, if heat loads and heat sinks are more realistically modeled, the drywell temperature would be 299°F at the end of four hours without depressurization. This result differs from that of the ORNL, which predicts a drywell temperature in excess of 320°F after three hours into an SBO event without depressurization. Nevertheless, the licensee plans to depressurize the reactor after 10 minutes at a rate of 100°F/hr. A similar sequence was evaluated in the ORNL report which indicated that the drywell temperature would exceed the design temperature of 281°F for a short period of time (a few minutes), and would then drop below this limit. The licensee stated (15) that the TVA case will be similar to, or bounded by, the ORNL case.

Review of Licensee's Submittal

The licensee's calculations (17 and 18) are based on the methodology outlined in NUMARC 87-00. Our review reveals the following concerns, each of which requires an appropriate response from the licensee:

1) The initial temperatures used by the licensee are non-conservative. Instead of using the normal operating temperature for each area, the licensee should have used the applicable technical specifications maximum allowable operating temperature, or the maximum design temperature. Although some areas (i.e., the two control rooms) may have two trains of 100%-capacity HVAC, there is a small probability that both trains will be inoperative or degraded, and therefore, a higher initial temperature may exist. In areas without HVAC (i.e., HPCI and RCIC rooms, etc.), the licensee needs to justify and document the reasons why a higher initial temperature (i.e., 104°F as recommended in NUMARC 87-00 for areas without air conditioning) was not used.

2) In general, the heat loads used by the licensee are lower than those used in similar plants.

   a) The licensee used a value for heat loads in the control room of 5475 watts (W) per unit (17). Based on our reviews of other plants, this load is about half of what other licensees have assumed for control-room heat loads. Since we did not receive detailed information on what these loads include, we are unable to account for the difference.

   b) For the personnel in the control room, the licensee assumed a heat load of 230 Btu/hr (67.4 W) per person, whereas a load of 240 W per person, as recommended in the ASHRAE handbook (16), should have been used. The use of 240 W per person increases the total estimated control-room heat loads by ~20%.

3) The licensee stated that all TVA insulated piping and equipment is insulated to 135°F surface temperature.

Therefore, when there is no HELB event, the maximum temperature in a room with insulated piping and equipment is 135°F. However, both the HPCI and RCIC rooms, which have insulated steam lines and steam-driven turbines, have an EQ temperature of 117°F for eight hours of operation. If the licensee were to use an initial temperature of 104°F, the steady-state temperature in these areas will be ~135°F. The licensee should assess the equipment operability in these rooms to ascertain if it is capable of withstanding temperatures of at least 135°F.

4) The final drywell heat-up temperature analysis is based on the result of the ORNL report. In this report, a leak rate of 4 gpm was assumed. The licensee needs to verify that, with a larger assumed leak rate of 61 gpm (as recommended by NUMARC 87-00), containment integrity will not be jeopardized.

The concerns outlined in our analysis can be best resolved by an onsite audit.

Finally, although the calculated main steam tunnel temperature is above its EQ temperature after four hours, based on the licensee's statement that after the MSIVs close no other equipment needs to be operational in this area, we agree that this area shall not be a concern. However, if the steam tunnel houses other valves that need to be open for an SBO (i.e., RCIC/HPCI turbine steam supply valves), the licensee needs to verify that these valves can be closed, if needed. For the general floor area, the licensee used engineering judgement to determine that this area will remain below 104°F, based on there being a small load in a large area (2350 W and 14,000 ft^2, respectively). Using the NUMARC methodology and the load and room area provided by the licensee, we determined that there would be a temperature rise of less than

3°F, giving a temperature of 83°F at the end of the 4-hour SBO event.

5. Containment Isolation

Licensee's Submittal

The licensee stated that the plant list of containment isolation valves (CIVs) was reviewed and it was determined that all of the valves which must be capable of being closed or operated (cycled) under SBO conditions can be positioned with indication independent of the preferred and blacked-out unit's class-1E power supplies. The licensee concluded that no modifications or procedure changes are necessary to ensure that appropriate containment integrity can be provided under SBO conditions.

Review of Licensee's Submittal

In response to the telephone conversation, the licensee provided an information package which contains list of the SBO equipment. In this package, the licensee included a list of CIVs and its exclusion criteria for these valves. Of these criteria, there are three which are not consistent with the exclusion criteria given in RG 1.155. These criteria are:

1) Non-essential system isolation valves which will automatically isolate upon loss of power;

2) Essential system isolation valves which will not be manually isolated to allow system operation during station blackout; and

3) Valves are normally closed during reactor operation (initial condition prior to SBO) and are prevented from opening by valve interlocks.

Valves excluded by the above criteria need to be incorporated into an appropriate procedure.

In addition, it appears that the licensee used the technical specifications list of CIVs instead of analyzing isolation valves given in the plant UFSAR for each penetration. Upon review of the plant list of CIVs (UFSAR Table 5.2-2), we found that there are several valves [i.e., containment cooling to drywell (RHR), containment cooling to suppression pool, etc.] which do not meet the exclusion criteria outlined in RG 1.155.

The licensee needs to list in an appropriate procedure the CIVs which are either normally closed or open and fail as-is upon loss of AC power and cannot be excluded by the criteria given in RG 1.155, and identify the actions necessary to ensure that these valves are fully closed, if needed. Valve closure needs to be confirmed by position indication (local, mechanical, remote, process information, etc.).

6. Reactor Coolant Inventory

Licensee's Submittal

The licensee stated (10) that a plant-specific analysis was used to assess the ability to maintain adequate reactor coolant system (RCS) inventory to ensure that the core is cooled. The licensee also stated that the appropriate loss of all AC power procedure(s) will be revised to ensure adequate RCS inventory and to identify applicable reactor vessel depressurization requirements. The licensee concluded that the expected rates of RCS inventory loss under SBO conditions do not result in a core uncovery during a 4-hour SBO event and, therefore, no make-up systems other than those available under SBO conditions are necessary to maintain adequate RCS inventory.

Review of Licensee's Submittal

Reactor coolant make-up is necessary to replenish the assumed RCS inventory losses due to the reactor coolant pump seal leakage (18 gpm per pump per NUMARC 87-00 guideline), the technical specifications maximum allowable leakage (estimated to be 25 gpm), and the reactor vessel level shrink due to RCS cool down. The licensee stated (15) that the reactor core isolation cooling (RCIC) pump was modelled to assess its capability to remove decay heat and maintain reactor coolant inventory during an SBO event. The steam-driven RCIC pump has a 600-gpm capacity, which is sufficient to provide condensate for decay-heat removal, RCS cooldown, and to compensate for the RCS inventory losses.

NOTE:

The 18-gpm recirculation pump 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 recirculation pump 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 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 stated that these procedures have been reviewed and the changes necessary to meet NUMARC 87-00 guidelines will be implemented.

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. 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 Modifications

Licensee's Submittal

The licensee initially stated (10) that no modifications are necessary as a result of the coping analysis. As a result of the telephone conversation, the licensee re-evaluated its battery calculations which indicates that several modifications/changes may be necessary (see text pages 11-12) in order for all three units to have sufficient battery capacity to cope with a 4-hour SBO event.

Review of Licensee's Submittal

The licensee needs to confirm and document the need for modifications to ensure sufficient class-1E battery capacity for all three units. No specific commitment has been provided by the licensee with regard to recommendations stated in the BFN battery calculations.

3.5 Quality Assurance and Technical Specifications

The licensee's submittals did not provide any information on how the plant complies with the requirement of RG 1.155, Appendices A and B. In

response to the telephone conversation, the licensee provided a list of SBO equipment. The licensee, however, did not indicate how the equipment on this list conforms to the guidance provided in RG 1.155 Appendix A. The licensee needs to provide an appropriate quality assurance (QA) program consistent with the guidance provided in Appendix A of RG 1.155 for all SBO equipment which are not currently covered under either the Appendix B or the Appendix R QA program. The licensee also needs to prepare a table cross referencing all SBO equipment with its appropriate QA program.

4.0 CONCLUSIONS

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

1. Class-1E Battery Capacity

   Our review indicates that although the licensee's analysis is non-conservative, the available site battery capacity is sufficient for Unit-2 operation only. However, before Unit 1 and Unit 3 return to service, the licensee will need to provide additional information regarding the required changes/modifications (see pages 11-12 of the text) and resolve the following concerns.

   In the calculations provided, there are several assumptions which we consider to be non-conservative in spite of the licensee's claim of their being conservative:

   1) The licensee used an exception to the IEEE Std-485 cell-sizing method in its calculations by breaking the time step size into smaller than one-minute intervals. This results in a smaller net average current and, therefore, is non-conservative;

   2) The assumed initial battery-room temperature is 76°F. The licensee needs to ensure that the room will not drop below this temperature under any circumstances or, if it does, there is an alarm in the control room to alert the operators and appropriate action is taken;

   3) The licensee used a design margin of 1.00 in its battery calculations. This is not consistent with the guidance

provided in IEEE-Std 485, which recommends a design margin of 1.10-1.15 be used.

4) The licensee assumed that only two circuit breakers would need to be closed at the end of the SBO event and that 5 A would be required to close each breaker. A review of the plant electrical distribution drawings indicates more circuit breakers need to be operated to connect the emergency buses to the offsite power source.

With regard to the loads on the batteries, we have the following concerns:

1) In the load tables provided by the licensee (15), we found that there were several loads which were not considered to be powered which should be (i.e., the turbine emergency bearing oil pump and the generator emergency seal oil pump). Since no information was provided about the loads that would be on the station (non-class-1E) battery, the licensee needs to establish how these pumps will be powered;

2) No analysis was provided for the 125-VDC EDG batteries. It is not clear how long these batteries will last or how many EDG starts they can support.

The licensee needs to ensure, however, that loads such as the emergency bearing oil pump for the turbine and the generator, are powered for the period required, and to document the source(s) of power.

2. Effects of Loss of Ventilation

Our review of the licensee's heat-up calculations reveal the following non-conservatism:

1) The initial temperatures used by the licensee are non-conservative. Instead of using the normal operating temperature for each area, the licensee should have used the applicable technical specifications maximum allowable operating temperature or the maximum design temperature. In areas without HVAC (i.e., HPCI and RCIC rooms, etc.), the licensee needs to justify and document the reasons why a higher initial temperature (i.e., 104°F as recommended in NUMARC 87-00 for areas without air conditioning) was not used.

2) In general, the heat loads used by the licensee are lower than those used in similar plants.

   a) The licensee used a value for heat loads in the control room of 5475 watts (W) per unit (17). Based on our reviews of other plants, this load is about half of what other licensees have assumed for control-room heat loads.

   b) For the personnel in the control room, the licensee assumed a heat load of 230 Btu/hr (67.4 W) per person, whereas a load of 240 W per person, as recommended in the ASHRAE handbook (16), should have been used. The use of 240 W per person increases the total estimated control-room heat loads by ~20%.

3) The licensee stated that all TVA insulated piping and equipment is insulated to 135°F surface temperature. Therefore, when there is no HELB event, the maximum temperature in a room with insulated piping and equipment is 135°F. However, both the HPCI and RCIC rooms, which have insulated steam lines and steam-driven turbines, have an EQ temperature of 117°F for eight hours of operation. If the licensee were to use an initial temperature of 104°F, the

steady-state temperature in these areas will be ~135°F. The licensee should assess the equipment operability in these rooms to ascertain if it is capable of withstanding temperatures of at least 135°F.

4) The final drywell heat-up temperature analysis is based on the result of the ORNL report. In this report, a leak rate of 4 gpm was assumed. The licensee needs to verify that, with a larger assumed leak rate of 61 gpm (as recommended by NUMARC 87-00), containment integrity will not be jeopardized.

If the steam tunnel houses valves, other than the MSIVs, that need to be open for an SBO (i.e., RCIC/HPCI turbine steam supply valves), the licensee needs to verify that these valves can be closed, if needed.

The licensee needs to revise analyses taking into account the above considerations, and document justifications for each assumption made in these analyses.

3. Containment Isolation

In response to the telephone conversation, the licensee provided an information package which contains a list of the SBO equipment. In this package, the licensee included a list of CIVs and its exclusion criteria for these valves. Of these criteria, there are three which are not consistent with the exclusion criteria give in RG 1.155 (see text, page 20).

In addition, it appears that the licensee used the technical specifications list of CIVs instead of analyzing isolation valves given in the plant UFSAR for each penetration. Upon review of the plant list of CIVs (UFSAR Table 5.2-2), we found that there are several valves [i.e., containment cooling to drywell (RHR),

containment cooling to suppression pool, etc.] which do not meet the exclusion criteria outlined in RG 1.155.

The licensee needs to list in an appropriate procedure the CIVs which are either normally closed or open and fail as-is upon loss of AC power and cannot be excluded by the criteria given in RG 1.155, and identify the actions necessary to ensure that these valves are fully closed, if needed. Valve closure needs to be confirmed by position indication (local, mechanical, remote, process information, etc.).

4. Proposed Modifications

Upon re-evaluation of its battery calculations, the licensee determined that several modifications/changes may be necessary (see text, pages 11-12) in order for all three units to have sufficient battery capacity to cope with a 4-hour SBO event. However, no commitment has been provided regarding the extent of these modifications. The licensee needs to confirm and document the need for the required modifications to ensure sufficient battery capacity for all three units.

5. Quality Assurance and Technical Specifications

The licensee's submittals did not provide any information on how the plant complies with the requirement of RG 1.155, Appendices A and B. In response to the telephone conversation, the licensee provided a list of SBO equipment. The licensee, however, did not indicate how the equipment on this list conforms to the guidance provided in RG 1.155 Appendix A. The licensee needs to provide an appropriate quality assurance (QA) program consistent with the guidance provided in Appendix A of RG 1.155 for all SBO equipment which are not currently covered under either the Appendix B or the Appendix R QA program. The licensee also needs to prepare a table

cross referencing all SBO equipment with its appropriate QA program.

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. Fox, C. H., Jr., letter to NRC Document Control Desk, "Response to Station Blackout Rule," Docket Nos. 50-259, 50-260, and 50-296, dated April 18, 1989.

11. Browns Ferry Nuclear Plant Updated Final Safety Analysis Report.

12. Wallace, E. G., letter to NRC Document Control Desk, "Supplemental Response to Station Blackout Rule," Docket Nos. 50-259, 50-260, and 50-296, dated April 5, 1990.

13. Thadani, A. C., Letter to W. H. Rasin of NUMARC, "Approval of NUMARC Documents on Station Blackout (TAC-40577)," dated October 7, 1988.

14. 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).

15. Supplemental information package provided by the licensee as a result of the telephone conversation on October 25, 1990.

16. "ASHRAE Handbook, 1977 Fundamentals," American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., New York, 1977.

17. "Loss of Ventilation During Station Blackout," information provided as a result of the telephone conversation on October 25, 1990, (part of reference 15).

18. "Operability of Station Blackout Response Equipment for BFN," information provided as a result of the telephone conversation on October 25, 1990, (part of reference 15).

19. U.S. Nuclear Regulatory Commission, "Station Blackout at Browns Ferry Unit One - Accident Sequence Analyses," NUREG/CR-2182, November 1981.

20. Wallace, E. G., letter to the NRC Document Control Desk, "Supplemental of SBO Implementation of NUMARC 87-00 Guidance," Docket Nos. 50-259, 50-260, and 50-296, dated May 4, 1990.