Attachment 1
SAIC-91/6671

TECHNICAL EVALUATION REPORT

SUSQUEHANNA STEAM ELECTRIC STATION UNITS 1 & 2 STATION BLACKOUT EVALUATION

TAC Nos. 68613, 68614

SAIC

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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 (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 NRCs 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 3.3),

D. Proposed modifications (Section 3.4), 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 preliminary SBO evaluation is based upon the review of the licensee's submittals dated April 17, 1989 (13), April 17, 1990 (14), and February 27, 1991 (15), the licensee's written response (17) to questions discussed at the June 14, 1991 telephone conference, and the information available in the plant Final Safety Analysis Report (FSAR) (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, Pennsylvania Power and Light Company, calculated (13) a minimum acceptable station blackout duration of four hours for the Susquehanna Units 1 and 2. The licensee stated that no modifications were 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 "2," and

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

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

   In its original submittal, the licensee stated (13) that the EAC power configuration group is "D," based on:

   - There are four emergency power supplies not credited as alternate AC sources.

- Three emergency AC power supply are necessary to operate safe shutdown equipment following a loss of offsite power.

However, in a later submittal, the licensee revised its position and stated (15) that only two emergency power supplies are necessary to operate safe shutdown equipment following a loss of offsite power, and thus, the EAC power configuration group is "B."

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

In its original submittal, the licensee selected (13) a target EDG reliability of 0.975. The selection of this target reliability was based on having a nuclear unit average EDG reliability for the last 100 demands greater than 0.95, consistent with NUMARC 87-00, Section 3.2.4.

In a later submittal, however, the licensee revised its position and reduced (15) the minimum required EDG reliability target value from 0.975 to 0.95.

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.

Using Table 3-2 of NUMARC 87-00, the expected frequency of LOOPs due to ESW conditions place the Susquehanna site in ESW Group "3." In response to questions raised in the June 14, 1991 telephone conference, the license stated (17) that it used Thom's method (20) and calculated a 1,000-year return period "fastest mile" wind speed of approximately 110-mph at a height of 30 feet above the ground. Further, the licensee stated that for a 125-mph wind speed the return period would be 1/1,500 years or 6.67E-04.

The calculation performed by the licensee was normalized to a height 30 feet above the ground, while the NRC data listed in NUMARC 87-00 Table 3-2 is based on a normalized height of 30 meters which represents the average distribution line height. A 104-mph wind speed normalized to 10 meters is equivalent to a 125-mph windspeed normalized to 30 meters with each giving a return period of 1/1,000 years or 1E-03. Since the normalized wind speed reported by the licensee at a height of 30 feet exceeds 104 mph, we conclude, based on the licensee's data, that the return period for winds greater than 125-mph normalized to a height of 30 meters is greater than 1E-03 for the Susquehanna site, and thus, the Susquehanna site is in ESW Group "3."

Using data from Table 3-3 of NUMARC 87-00, the expected frequency of LOOPs due to SW conditions place the Susquehanna site in SW Group "2," which is in agreement with what was stated in the licensee's submittal (13). This calculation was performed assuming there were multiple rights-of-way among the incoming transmission lines, consistent with Figure 8.2-1 of the plant FSAR (12).

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

1. There are two electrically connected switchyards for the site;

2. During normal plant operation, each unit's emergency busses are powered from two 230 kV offsite power sources though the start-up transformers (SUTs), as depicted in Figure 1;

3. Each SUT feeds two engineering safeguards transformers (ESTs);

4. Each EST is connectable to four emergency busses in both units, two of which are normally connected;

5. Upon a loss of power from one of the SUTs, the effected emergency busses will automatically be powered by the second SUT from automatic transfers at the 4.16 kV emergency bus level (see Figure 1).

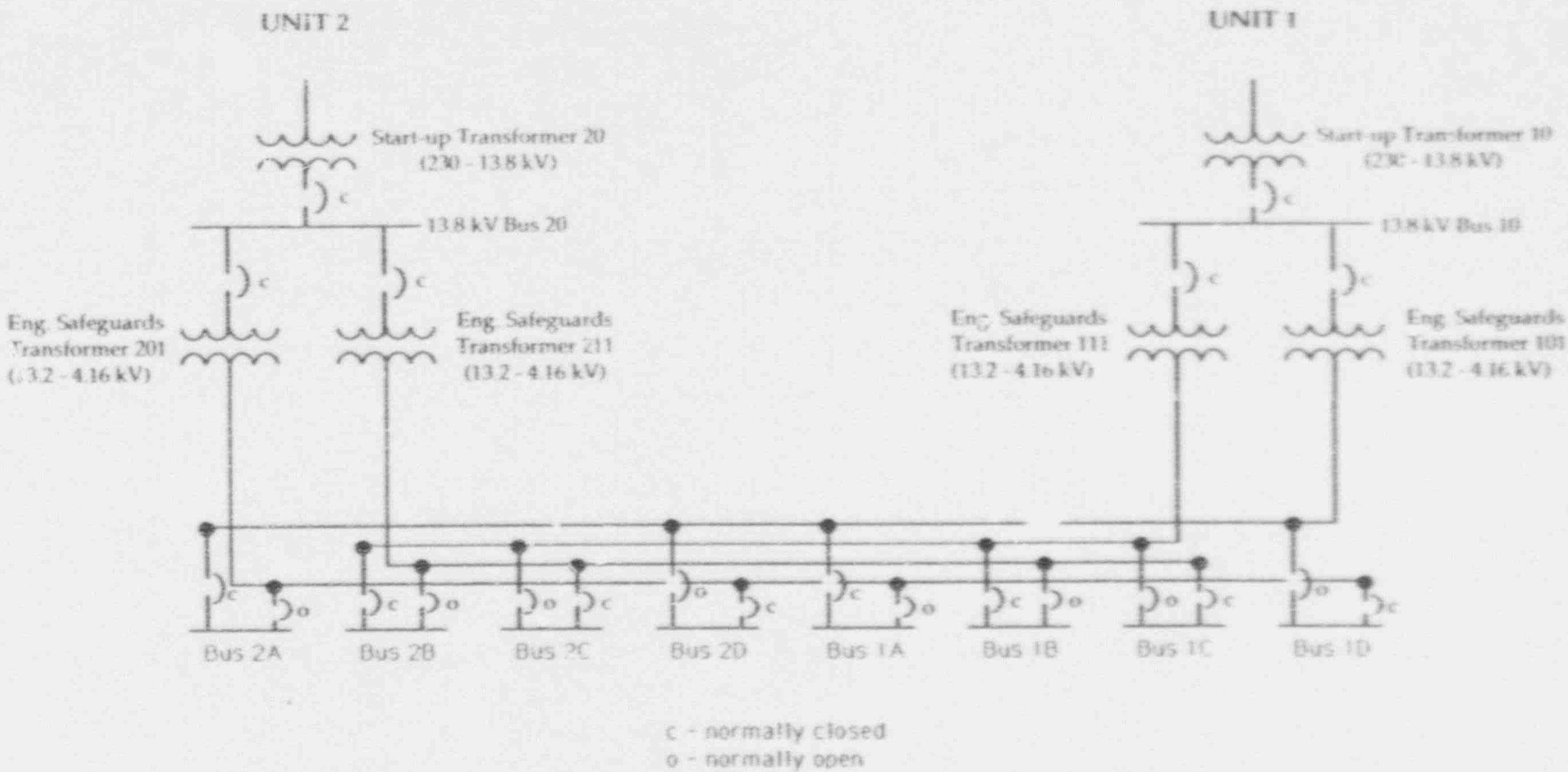

Figure 1: Susquhanna Units 1 and 2 Electrical Schematic

Based on the above, the plant independence of offsite power system group is "I2." This determination is based on the guidance of Table 5 of RG 1.155.

With regard to EAC classification, the current position of the licensee is that Susquehanna is in group "B," based on the assertion that two-out-of-four available EDGs are required to achieve and maintain a safe shutdown for both units.

We have reviewed the applicability of the above claim by considering both EDG capability and connectability as detailed below.

Capability:

Based on the EDG load list provided in FSAR Table 8.3-2, the total load requirement to bring both units to a safe shutdown following a LOOP is estimated at approximately 7913 kW. For two EDGs each needs to carry 3957 kW. According to the plant FSAR, each of the diesels are rated at 4000 kW for continuous operation and 4700 kW for 2000 hours of operation, thus, it appears that the licensee's assertion that two EDGs are required to maintain a safe shutdown following a LOOP is valid.

Connectability:

The licensee stated (17) that manual actions will be required if only two of four EDG are used to cool down both reactors simultaneously following a LOOP. There are six unique combinations of two EDGs that can be used to bring the units to a safe shutdown condition. For four of the combinations (A&B, A&D, B&C, C&D) one RHR pump will be available in each unit for cooldown, however, remote manual operation of one of the RHR-SPC valves will be required in each unit. For the remaining two combinations of EDGs (A&C, B&D) only one RHR pump is effectively available to cooldown both units, since only one division of ESW is available in each case. However, the RHR pump powered by the available EDGs in each case requires both divisions of ESW pumps for cooling. The licensee stated that a single RHR pump is sufficient to bring both units to cold shutdown through "staggered operation" of the RHR pumps in which cooling is manually shifted between the units.

Our review of FSAR Table 8.3-1 reveals that the control building structure cooling, ventilation and heating for both units are powered from the C and D EDGs. Therefore, if A and B are the available EDGs, there will be no HVAC available at the control building structure. Since EAC classification is based on loads which support the safe shutdown operation of the plant for an extended period, as stated in NUMARC 87-00 Supplemental Questions and Answers the combination of the A and B EDGs does not meet the connectability criterion. Further, to provide a full division of AC and DC support, the plant needs to have EDGs A and C or B and D available. In all other combinations, AC power is available for the extended period but a full division of DC power may not be available for the extended period. For the combinations of A and C and B and D, the dependency of the RHR and ESW pumps requires staggering the operation of the RHR pumps between units to achieve a safe shutdown consistent with the guidance. However, this action is not consistent with the staff position which states (18) that any actions that would add to the burden of operators that are already in a high stress environment, such as load switching, are considered to be a degradation of the normal safe shutdown capability for a LOOP. Thus, we conclude that three EDGs are required to power the LOOP shutdown loads for both units. The three-out-of-four EDG requirement results in a site EAC power configuration value of "D."

The licensee initially selected (13) an EDG target reliability of 0.975 based upon having a nuclear unit average EDG reliability greater than 0.95 for the last 100 demands. However, in a later submittal, the licensee revised its position and reduced (15) the minimum required EDG reliability target value from 0.975 to 0.95. Although the information used by the licensee 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 and 50 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. The information in NSAC-108, which gives EDG reliability data at US nuclear power plants for the calender years 1983 to 1985, indicates that the EDGs at Susquehanna experience an average of 90 valid start demands per diesel calender year and have reliability levels of higher than 0.99. Using this data, it appears that the licensee's selection of the EDG target reliability (0.95) is appropriate. Nevertheless, the licensee needs to have an analysis showing the EDG reliability statistics for the last 20, 50 and 100 demands in its SBO submittal supporting documents.

In response to questions regarding EDG reliability program raised at the June 14, 1991 telephone conference, the licensee stated (17) that PP&L is in the process of implementing a reliability program consistent with the elements provided in RG 1.155, Position 1.2, which includes: individual EDG reliability target levels, surveillance testing and reliability monitoring, an EDG maintenance program, an information and data collection system, and a management oversight program.

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 the U.S., indicates that Susquehanna had not experienced any partial or significant losses of offsite power prior to the calender year 1984. In the absence of any contradictory information, we agree with the licensee's statement.

Based on an ESW group "3," SW group "2," and an EAC classification "D," the offsite power design characteristic of the Susquehanna site is "P2" requiring an EDG target reliability of 0.975, with a minimum coping duration of eight hours. This is different from the "P1" offsite power design characteristic and four hour minimum coping duration reported by the licensee. In the following sections, we have reviewed the plant coping capability for a duration of eight hours.

3.2 Station Blackout Coping Capability

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

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

Licensee's Submittal

The licensee stated (13) that 117,626 gallons of water are required for the decay heat removal during the four-hour coping period. The minimum permissible Condensate Storage Tank (CST) level per Technical Specifications provides 135,000 gallons of water, which exceeds the required quantity for coping with a 4-hour SBO event.

In response to questions raised at the June 14, 1991 telephone conference, the licensee provided the contributing elements to its calculation of condensate inventory as follows:

PP&L Method:

Decay Heat =	55,000 gallons
RCP seal leaks =	19,700 gallons
Blowdown =	18,100 gallons
	93,300 gallons required for 4 hours

NUMARC 87-00 Method:

Decay Heat =	72,841 gallons
RCP seal leaks =	22,500 gallons
Blowdown =	22,285 gallons
	117,626 gallons required for 4 hours

In its coping assessment, the licensee stated (19) that it has performed its own in-house analysis which assumed a constant reactor vessel leakage of 100 gpm starting 15 minutes into the SBO event and reactor depressurization to 200 psia using one SRV. Based on these conditions, the licensee concluded that the minimum CST level will provide enough water to maintain the reactor vessel water level constant f[illegible] six hours. Under the same conditions, however, the licensee stated that the manual connection of the RWST to the CST would extend the core cooling capability of the CST to more than 20 hours.

Review of Licensee's Submittal

Using the expression provided in NUMARC 87-00 (assuming no cooldown), we estimated that 122,256 gallons of water per unit would be required to remove decay heat during an eight-hour SBO event. This estimate is based on the maximum licensed core thermal rating of 3439 MWt per unit listed in the Susquehanna FSAR (12). Assuming a reactor coolant system leakage of 61 gpm (18 gpm per reactor recirculation pump and 25 gpm technical specification leakage) would result in an additional 29,280 gallons in losses. In addition, the licensee calculated that an another 22,285 gallons would be required for blowdown. This results in a total condensate requirement of approximately 174,000 gallons which exceeds the minimum permissible Condensate Storage Tank level of 135,000 gallons of water.

According to FSAR Table 6.2-1 and 6.2-4, there appears to be a minimum of 960,000 gallons of condensate available in the Suppression pool at a temperature of 90°F at the beginning of the SBO event. However, in its coping analysis, the licensee states (19) that its SBO coping strategy recommends that the HPCI suction transfer from the CST to the suppression pool because the high suppression pool level will be bypassed within the first 75 minutes of the SBO event. If the suction transfer does occur, the HPCI pump may fail on high lube oil temperature or high pump seal water temperature before the end of the eight hour SBO event.

In addition, in its coping assessment the licensee stated (19) that there is a minimum of 270,000 gallons of water in the RWST which can be manually connected to refill the CST during an SBO.

Based upon information provided by the licensee and the results of our review, we conclude that the CST has insufficient capacity to provide adequate core cooling for the entire eight hour coping duration. Thus, the licensee needs to provide for adequate core cooling for the entire eight hour SBO duration either by proceduralizing the manual connection of the CST to the RWST, or by utilizing the cool water available in the Suppression pool at the onset of SBO, to supplement or replace the CST and ensure the availability of the high pressure injection systems.

2. **Class-1E Battery Capacity**

Licensee's Submittal

The licensee stated (13) that a battery capacity calculation has been performed which verifies that the station Class-1E batteries (125V and 250V) have sufficient capacity to meet SBO loads for four hours assuming loads not needed to cope with a SBO are tripped. The licensee further stated that these loads are identified in plant procedures.

In its SBO coping assessment, the licensee stated (19) that the current 125V DC battery cells will be upgraded from nine positive plates to ten positive plates following each unit's refueling outage later this year. Based on these battery modifications, the licensee made the following design assumptions to develop load profiles and calculate battery endurance:

- A temperature correction factor of 1.11 based on a minimum expected electrolyte temperature of 60°F was used.
- An aging factor of 1.25 was used.
- To allow for additional loads, the actual load was increased by two amperes and rounded up to the next integer.

* The following non class-1E loads need to be manually shed from the 250 VDC batteries (1D650 and 1D660) to extend battery capacity to four hours:

  A. Reactor Feedwater Pumps Emergency Lube Oil Pumps
  B. Reactor Recirculation MG Set Emergency Lube Oil Pumps
  C. Turbine Generator Emergency Lube Oil Pump
  D. Turbine Generator Emergency Seal Oil Pump
  E. Computer UPS 656

The battery endurance calculations performed by the licensee are summarized as follows:

Battery	Channel/ Division	Endurance (hrs)	Final Terminal Voltage
1D610	1A/I	6.8	108.3
1D620	1B/II	6.4	108.7
1D630	1C/I	13.2	108.0
1D640	1D/II	12.2	108.2
1D650	I	7.8 *	--
1D660	II	4.3 *	--
2D610	2A/I	6.3	108.8
2D620	2B/II	5.9	109.0
2D630	2C/I	11.3	108.1
2D640	2D/II	10.8	107.9
2D650	I	9.3	--
2D650	II	6.4	--

* Includes Load Shedding

The licensee used the results of the battery endurance calculations to demonstrate that the batteries have sufficient capacity to supply SBO loads for a coping duration of four hours. In addition, the licensee stated (19) that a portable AC generator has been installed which is designed to provide AC power to the "A" and "B" channel battery chargers in the event of an extended SBO. The licensee estimates that the generator can be connected within one to two hours to the plant AC distribution system. Once tied to the battery chargers, the diesel is expected to function for at least forty hours.

In addition, the licensee stated (16) that a plant modification to install a non-class 1E battery to carry all non-class 1E loads, thus permanently shedding these loads from batteries 1D650 and 1D660 ensuring at least four hour capacity, is under evaluation.

In response to questions raised at the June 14, 1991 telephone conference, the licensee provided (17) a copy of its battery capacity calculations for 125 VDC batteries 1D610 and 1D630 for review.

Review of Licensee's Submittal

The batteries should be able to provide the normal plant monitoring and control for the entire SBO duration of eight hours. According to the Susquehanna FSAR, the design basis for battery sizing is four hours.

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

- The licensee's assumed temperature correction factor of 1.11 (based on an electrolyte temperature of 60°F) and aging factor of 1.25 are conservative and consistent with NRC guidance.
- The licensee did not use a design margin in its calculation. This is not consistent with the recommendation of IEEE-Std 485, which states a 10% to 15% design margin needs to be considered.
- The licensee's assumed SBO load profile is consistent with the information contained in the FSAR.

- The licensee did not assume any diesel generator field flash attempts as part of its first minute random load. The inclusion of a diesel generator field flash load assignment will not change the final result, however.

- The A and B channels for the 125 VDC batteries do not have sufficient capacity to last eight hours. However, if the licensee were to use the portable AC generators to provide charging to these batteries they will have sufficient capacity. This requires that the portable AC generator to be added to the list of SBO equipment and meet the criteria in Appendix B of NUMARC 87-00, except for the one hour time requirement.

- The 250 VDC batteries in Unit 1 and the division II 250 VDC battery in Unit 2 do not have sufficient capacity to last for eight hours. The division I 250 V batteries (in Unit 1 and 2) supports RCIC operation and division II supports HPCI operation. Since the licensee intends to use RCIC to cope during an SBO, then the division I 250 VDC batteries will be examined. The licensee's data indicates that Unit 1 250 VDC (1D650) is insufficient to support the operation of RCIC during the full eight hour SBO duration.

Based on the above, we conclude that, except for the Unit 1 250 VDC (1D650) battery, all other class-1E batteries have sufficient capability or backup charging capability to support the required loads during an eight hour SBO event. The licensee needs to:

1) Add the portable AC generator to the list of SBO equipment and meet the criteria in Appendix B of NUMARC 87-00, except for the one hour time requirement.

2) Provide a higher battery capacity for battery 1D650, or provide charging capability to the existing battery to extend its support beyond the eight hour SBO duration.

3. **Compressed Air**

Licensee's Submittal

The licensee stated (13) that air-operated valves used for decay heat removal to cope with a SBO for four hours have sufficient backup motive sources independent of the preferred and blacked out unit's Class-1E power supply to function for four hours. No valves require manual operation or need backup sources for operation.

In its coping assessment , the licensee stated (19) that its recommended strategy is to depressurize the reactor vessel to approximately 200 psia within the first hour using one SRV.

Review of Licensee's Submittal

Examination of the plant FSAR Sections 7.3.1.1a.1.4.2 and 7.7.1.12 (12) reveals that the nuclear pressure relief system at Susquehanna includes 16 pressure relief valves each operated by a pressure relief solenoid pilot air valve. Six of these valves are part of the automatic depressurization system (ADS). Each ADS valve has its own accumulator which is sized to provide one ADS safety/relief valve actuation at the drywell design pressure of 45 psig or two ADS actuations at 70% drywell design pressure (31.5 psig). Therefore, these valves have sufficient back-up sources of compressed air for their operation during an eight hour SBO event.

4. **Effects of Loss of Ventilation**

Licensee's Submittal

The licensee stated (13) that it has performed a plant-specific analysis to determine the effects of loss of ventilation and concluded that the only dominant areas of concern (DACs) were:

HPCI Room	128°F
RCIC Room	128°F
Main Steam Tunnel	117°F

The control room (which includes four relay rooms) did not exceed 120°F and was not identified as a DAC.

The two relay rooms in Unit 1 were calculated to reach an ambient air temperature of 94°F (lower room) and 105°F (upper room) and were not identified as DACs. The Unit 2 relay rooms were assumed to be identical to those in Unit 1.

In its supplemental submittal, the licensee stated (16) that the plant-specific analysis was carried out using the Compartment Temperature Transient Analysis Program (COTTAB) which was developed in-house for all compartment heat-up calculations. In its analysis of "dominant areas of concern," the licensee identified the Control Structure and Reactor Building (for both units). Three COTTAB calculations were performed; one for the Unit 1 and Unit 2 Reactor Buildings; one for the Control Structure, and one specifically for the HPCI and RCIC rooms. These calculations included the normal lighting and instrument panel heat loads, in addition to the emergency loads powered off of the station batteries.

- Control Room

For the control room compartment, the licensee examined (16) the temperature in the cabinets which house equipment necessary during an SBO. At Susquehanna, the Control Room Complex consists of a common control room to both units, and two separate relay rooms for each unit. The licensee did not analyze each individual heat load to calculate temperature rise in the control room, and as such, the control room was assumed to be at a constant 120°F throughout the SBO event. The initial temperature for the relay rooms was assumed to be 80°F which is the maximum allowable technical specification temperature.

Using COTTAP, the licensee calculated (17) all cabinet temperatures to be less than 180°F, except the fire protection cabinet OC650 which was calculated to be 182°F. The licensee used Appendix F to NUMARC 87-00 to conclude that the equipment inside those cabinets calculated to be less than 180°F would remain operational during an SBO. As there is no equipment required for SBO in the fire protection cabinet OC650, the licensee determined the calculated temperature of 182°F to be acceptable.

- <u>Reactor Building</u>

The licensee stated (16) that a compartment heat-up analysis was performed for the reactor building (excluding the HPCI and RCIC rooms) which demonstrated that no room which houses necessary equipment reaches a temperature above 130°F.

- <u>HPCI and RCIC Rooms</u>

In its coping analysis, the licensee stated (19) that a COTTAB calculation was performed for the HPCI and RCIC rooms. In its calculation (16), the licensee assumed both HPCI and RCIC to operate continuously for a period of 24 hours. The only electrical loads assumed were from emergency lighting and DC-powered control panels. During the SBO, it was assumed that HPCI and RCIC suction were maintained only by the CST, and therefore, the only hot pipe heat loads are the HPCI and RCIC turbine steam supply exhaust lines. For the bounding case, the licensee calculated a final room temperature of 126.8°F for HPCI and 116.3°F for RCIC. The licensee stated that these temperatures are less than the four hour temperature limit of 180°F presented in NUMARC 87-00 Appendix F guidelines.

In addition, as part of the reactor building heat-up analysis the licensee examined a compartment in each reactor building which houses HPCI and RCIC system piping, as these compartments contain steam leak system isolation instruments which would isolate these systems upon a high room temperature of 167°F. The analysis showed that the HPCI logic circuit would not be powered during SBO, and that for RCIC a maximum temperature of [illegible]°F would be reached during a period of 72 hours. As a result, the licensee has concluded that RCIC system isolation for this reason is not expected.

- <u>Battery Rooms</u>

In its coping assessment, the licensee stated (19) that no specific compartment heat-up analysis was performed for the battery rooms. The licensee stated that the normal temperature of these rooms is between 60°F and 90°F. A lower bound for the temperature at which the battery cells begin to degrade is approximately 160°F according to IEEE-535. Since the battery cells contribute only a small amount of heat into the room, a temperature rise of 70°F to 100°F was considered to be highly unlikely.

Review of Licensee's Submittal

Our review of the licensee's room heatup analyses are summarized as follows:

<u>Methodology:</u>

- The COTTAP computer code that was used extensively by the licensee has not been shown to be adequately qualified for subcompartment analysis. The licensee has not provided any documentation on COTTAP methodology. There has been no evidence of benchmarking or quality assurance of this computer code.

- There is no evidence that any of the calculations have been reviewed or checked by the licensee

- Some COTTAP calculations involve a very large number of rooms which are interconnected via heat conduction pathways and airflow. No justification has been provided to substantiate if this large and complex model can actually calculate a conservative and bounding SBO temperature for each room. With the information that has been provided, it is impossible to determine whether specific selection of individual room thermodynamic conditions, coupled with heat transfer paths is appropriate for every room.

- The calculation for the reactor building heat-up includes transient temperature plots for 105 rooms that were all calculated simultaneously. These plots show different trends of temperature response with time. In some cases, room temperature rapidly rises within the first hour and then asymptotically approaches the steady state value on a much flatter slope. For other rooms, however, this behavior is reversed with the temperature decreasing. Still other rooms experience relatively flat temperature profiles. Finally, in some cases the slope in temperature is more extreme and may even exhibit oscillatory shapes. The licensee needs to provide a detailed technical explanation for this variety of room temperature profiles.

Initial Conditions:

- In its compartment heat-up analyses, the licensee used non-conservative initial room temperatures in many cases (i.e. Switchgear rooms - 93°F, HPCI/RCIC rooms - 100°F). Further, the licensee assumed different and non-conservative values for outside air temperature. These values range from 73.3°F to 95°F.

  The licensee needs to use as an initial temperature the maximum temperature allowed by technical specifications, or for the case of the outside ambient air, a bounding high summer day value. The licensee can choose a lower temperature (i.e. 78°F) as an initial temperature if it provides administrative controls to ensure that the control room temperature will not exceed this temperature under any circumstances during normal plant operation.

- The licensee assumes a variety of values for initial room humidity. A higher concentration of water vapor in a room will reduce the calculated room temperature. Therefore, it is conservative to use low values of humidity. Without sufficient technical justification, the licensee must use the lowest value of humidity for each room.

- Throughout the calculations, the licensee assumes a concrete thermal conductivity of 1.0 (British units). This value has previously been considered too high and therefore non-conservative for SBO analysis. A more appropriate and acceptable value of 0.7 (British units) needs to be used.

- The licensee needs to provide technical justification for making 180°F the maximum allowable temperature inside the control room cabinets.

- In its calculation of the temperature response inside the control room instrumentation cabinets the licensee assumed, as a bounding condition, that the entire control room temperature remained at 120°F for the duration of the four hour SBO event. The licensee needs to provide technical justification for the conservatism of this assumption.

- The licensee needs to provide justification that the COTTAP computer code calculates the maximum hot spot temperature inside the control room instrumentation cabinets, instead of the average cabinet temperature.

Results:

We were unable to verify the licensee's calculations with the information provided, as the heat loads were not clearly identified for each room.

For example, the licensee indicated that the temperature of the Main Steam Tunnel would be 117°F after 72 hours. Upon further review of the licensee's calculations (16), we found that the initial room temperature of the Main Steam Tunnel was assumed to be 130°F and that the temperature decreased during the course of the SBO event. This indicates that either zero or very small heat generation was considered in the licensee's heat-up calculation for this area. The licensee's input parameters for this area were checked and the following heat loads were identified: lighting (9,215 BTU/hr), heat removal (-893,592 BTU/hr) and fans (72,300 BTU/hr). These heat loads will not be applicable during an SBO event. Further review of the licensee's calculation (COTTAP piping data card) did not identify any additional loads for this room. This confirms our concern that no heat loads were considered in the heat-up calculation for this room.

Considering the amount of heat removed from this area during normal plant operation, it is expected that the temperature of this room would rise, not decrease as indicated by the licensee, during an SBO event. This temperature rise would be expected even though the reactor would be depressurized to approximately 200 psia., as this would result in only a modest decrease in the surface temperature of the insulated main steam lines.

Conclusion:

Based on the above, the licensee needs to provide additional information and /or technical justification for several initial conditions and modelling assumptions before we can verify the accuracy of the reported results. If the licensee cannot provide adequate justification, it may need to re-analyze the temperature response for all rooms identified as SBO dominant areas of concern. In order to better understand the calculations, the licensee needs to document the individual heat loads and assumptions for each room separately in a form that can be clearly understood.

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 unit's preferred and Class-1E AC power supplies. The licensee added that no plant modifications and/or associated procedure changes were determined to be required to ensure that appropriate containment integrity can be provided under SBO conditions.

Review of Licensee's Submittal

The available containment isolation system data in the FSAR was examined (Table 6.2-12 and Figures 6.2-44). Upon examination of the available information and applying the containment isolation valve exclusion criteria of NUMARC 87-00 Section 7.2.5., the following valves were identified as requiring valve position indication or closure under the conditions of a SBO:

Penetration:	Description:	Valve Arrangement:
X-203A,B,C,D	RHR Pump Suction	Suppression Pool AC-GT, NO, fail as-is
X-204A,B	RHR Test Line	AC-GT, NC, fail as-is
X-205A,B	Containment Spray	AC-GT, NC, fail as-is
X-206A,B	CS Pump Suction	Suppression Pool AC-GT, NO, fail as-is
X-207A,B	CS Test	Suppression Pool AC-GB, NC, fail as-is
X-208A,B	CS Recirculation	Suppression Pool AC-GT, NO, fail as-is

In response to questions raised at the June 14, 1991 telephone conference, the licensee stated (17) that containment isolation can be assured for each of the penetrations identified above by isolating all "side paths" coming off the main path downstream of the penetration. We were unable to verify that the downstream valves identified by the licensee were part of the penetration boundary or if they were in the immediate vicinity of the penetration. The use of downstream valves does not conform to the guidance.

Thus, the licensee needs to list the valves identified above in an appropriate procedure and identify the actions necessary to ensure that these valves are fully closed, if needed, upon the loss of AC power. The 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 (13) that the ability to maintain adequate reactor coolant system inventory to ensure that the core is cooled has been assessed for four hours using a calculated leakage of 100 gpm.

Review of Licensee's Submittal

The licensee stated (19) that it intends to use both HPCI and RCIC to maintain RCS inventory during an SBO. According to the Susquehanna FSAR, the HPCI pump has a rated flow of 5070 gpm at 1172 psia reactor pressure, while the RCIC pump has a rated flow of 600 gpm. It is our understanding that the RCIC system will be used when the level is established because it is easier to control than HPCI. The injection capability of either system exceeds the amount of water required to remove decay heat and to replenish the assumed RCS leak rate of 61 gpm (18 gpm per pump plus 25 gpm for maximum allowed technical specification leakage). Therefore, Susquehanna has sufficient capability to maintain reactor coolant inventory for the 8-hour SBO event.

NOTE:

The 18-gpm reactor 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 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 modified, as necessary, to meet the guidelines of NUMARC 87-00, Section 4 in the following areas:

- AC power restoration, (PP&L Procedure EO-000-031) per NUMARC 87-00, Section 4.2.1 and 4.2.2;
- Battery C[illegible] (PP&L Procedure EO-100-030) per NUMARC 87-00 Section 4.2.1 item [illegible]
- Severe weather, (PP&L Procedure On-000-02) per NUMARC 87-00, Section 4.2.[illegible]

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.

5 Quality Assurance and Technical Specifications

The licensee stated that a quality assurance program will be developed and incorporated unto a plant procedure.

4.0 CONCLUSIONS

Based on our review of the licensee's submittals (13, 14) and the information available in the FSAR for Susquehanna Steam Electric Station Units 1 and 2 (12), 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. **Proposed Station Blackout Duration**

   The licensee proposed an SBO coping duration of four hours, based on ESW group "2," an EAC classification "B," and a proposed EDG target reliability of 0.95. Our review indicates that the Susquehanna site is ESW group "3," with an EAC classification "D," requiring an EDG target reliability of 0.975 and a minimum coping duration of eight hours.

2. **Condensate Inventory**

   Our review indicates that the CST has insufficient capacity to provide adequate core cooling for the entire eight hour coping duration. Thus, the licensee needs to provide for adequate core cooling for the entire eight hour SBO duration either by proceduralizing the manual connection of the CST to the RWST or by utilizing the cool water available in the Suppression pool at the onset of SBO to supplement or replace the CST and ensure the availability of the high pressure injection systems.

3. **Class-1E Battery Capacity**

   We conclude that, except for the Unit 1 250 VDC (1D650) battery, all other class-1E batteries have sufficient capability or backup charging capability to support the required loads during an eight hour SBO event. The licensee needs to:

1) Add the portable AC generator to the list of SBO equipment and meet the criteria in Appendix B of NUMARC 87-00, except for the one hour time requirement.

2) Provide a higher battery capacity for battery 1D650, or provide charging capability to the existing battery to extend its support beyond the eight hour SBO duration.

4. **Effects of Loss of Ventilation**

Our review indicates several concerns with regard to the initial conditions, modelling assumptions and results of the licensee's temperature rise calculations, as discussed in Section 3.2. The licensee needs to provide additional information and /or technical justification for each concern before we can verify the accuracy of the reported results. If the licensee cannot provide adequate justification, it may need to re-analyze the temperature response for all rooms identified as SBO dominant areas of concern. In order to better understand the calculations, the licensee needs to document the individual heat loads and assumptions for each room separately in a form that can be clearly understood.

5. **Containment Isolation**

Our review identified several containment isolation valves (CIVs) which do not meet the CIV exclusion criteria of NUMARC 87-00 Section 7.2.5. The licensee needs to list these valves (identified in Section 3.2) in an appropriate procedure and identify the actions necessary to ensure that these valves are fully closed, if needed, upon the loss of AC power. The valve closure needs to be confirmed by position indication (local, mechanical, remote, process information, etc.).

6. **Quality Assurance and Technical Specifications**

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.

7. **Quality Assurance and Technical Specifications**

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

5.0 REFERENCES

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

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

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

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

5. U.S. Nuclear Regulatory Commission, "Emergency Diesel Generator Operating Experience, 1981-1983," 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. Susquehanna Steam Electric Station Units 1 & 2, Final Safety Analysis Report (FSAR).

13. Keiser H. W., letter to Nuclear Regulatory Regulation, "Susquehanna Steam Electric Station, Station Blackout Rule," Docket No's. 50-387, 388, dated April 17, 1989.

14. Keiser H. W., letter to Nuclear Regulatory Regulation, "Susquehanna Steam Electric Station, Station Blackout," Docket No's. 50-387, 388, dated April 17, 1990.

15. Keiser H. W., letter to Nuclear Regulatory Regulation, "Susquehanna Steam Electric Station, Station Blackout," Docket No's. 50-387, 388, dated February 27, 1991.

16. Maron, D., letter to Nuclear Regulatory Regulation, "Station Blackout Submittal and Emergency Diesel Generators," Docket No's. 50-387, 388, dated May 14, 1991.

17. Maron, A. K., letter to Nuclear Regulatory Regulation, "Response to Follow-Up Questions on Susquehanna SBO Submittal," Docket No's. 50-387, 388, dated August 1, 1991.

18. Russell, W. T., letter to W. Rasin of NUMARC, "Station Blackout," dated June 6, 1990.

19. C. A. Boschetti, "Coping Assessment for the Susquehanna Steam Electric Station During a Station Blackout," PP&L Technical Report No. NPE-89-04, dated April 11, 1989.

20. Thom, H. C. S., 1968. "New Distributions of Extreme Winds in the United States." J. Struc. Div., ASCE 94:1787-1801.