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GUIDELINES AND TECHNICAL BASES FOR NUMARC INITIATIVES ADDRESSING STATION BLACKOUT AT LIGHT WATER REACTORS

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GUIDELINES AND TECHNICAL BASES

FOR NUMARC INITIATIVES ADDRESSING

STATION BLACKOUT AT LIGHT WATER REACTORS

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1. INTRODUCTION

1.1 GUIDANCE AND DOCUMENT STRUCTURE

The objective of this document is to provide guidance and methodologies for implementing the Nuclear Management and Resources Council (NUMARC) station blackout initiatives. Section 1 provides an introduction and discussion of the initiatives.

Section 2 provides a set of baseline assumptions concerning the course and nature of a station blackout. Each assumption is accompanied by a basis discussion. These assumptions define the major topics concerning station blackout which the initiatives are intended to address.

Section 3 provides guidance for determining the required coping duration category consistent with the NRC Staff's draft Regulatory Guide 1.155.

Section 4 provides guidelines for assuring plant specific procedures adequately address station blackout response.

Section 5 describes industry's attention to reduce cold starts of diesel generators during testing of emergency standby diesel generators.

Section 6 describes industry's EDG unavailability monitoring program.

Section 7 provides a simplified methodology for reviewing basic plant coping features.

The appendices provide additional information concerning various topics:

Appendix A provides definitions.
Appendix B provides Alternate AC power criteria.
Appendix C provides sample AAC configurations.
Appendix D discusses an EDG performance program.
Appendix E analyzes the effects of loss of ventilation.
Appendix F describes methods for assuring equipment operability under station blackout conditions.
Appendix G provides references.

1.2 NUMARC INITIATIVES

Late in 1985, NUMARC Committee established a working group on station blackout to address USI A-44. The Nuclear Utility Group on Station Blackout (NUGSBO) has provided the major portion of the technical support for the NUMARC station blackout working group. NUMARC determined that many of the concerns related to station blackout could be alleviated through industry initiatives to reduce overall station blackout risk.

In light of these considerations, on June 10, 1986, the NUMARC Executive Committee approved four industry initiatives to address the more important contributors to station blackout risk. These initiatives were described to the Commission by letter dated June 23, 1986 which also forwarded comments concerning the proposed station blackout rule. On October 22, 1987, the NUMARC Board of Directors approved one additional initiative and a modification to one of the original initiatives. The initiatives are:

(1) Initiative 1A --- RISK REDUCTION

Each utility will review their site(s) against the criteria specified in NRC's revised draft Station Blackout Regulatory Guide, and if the site(s) fall into the category of an eight-hour or sixteen-hour site after utilizing all power sources available, the utility will take actions to reduce the site(s) contribution to the overall risk of station blackout. Non-hardware changes will be made within one year. Hardware changes will be made within a reasonable time thereafter.

This initiative was changed by the October 22, 1987 NUMARC vote to reflect changes in NRC's criteria from those in NUREG-1109 which were incorporated in the original Initiative 1.

(2) Initiative 2 --- PROCEDURES

Each utility will implement procedures at each of its site(s) for:

(a) coping with a station blackout;

(b) restoration of AC power following a station blackout event; and,

(c) preparing the plant for severe weather conditions (e.g., hurricanes) to reduce the likelihood and consequences of a loss of off-site power and to reduce the overall risk of a station blackout event.

(3) Initiative 3 --- COLD STARTS

Each utility will, if applicable, reduce or eliminate cold fast-starts of emergency diesel generators through changes to technical specifications or other appropriate means.

(4) Initiative 4 --- AC POWER AVAILABILITY

Each utility will monitor emergency AC power unavailability, utilizing data provided to INPO on a regular basis.

(5) Initiative 5 --- COPING ASSESSMENT

Each utility will assess the ability of its plant(s) to cope with a station blackout. Plants utilizing alternate AC power for station blackout response which can be shown by test to be available to power the shutdown busses within 10 minutes of the onset of station blackout do not need to perform any coping assessment. Remaining alternate AC plants will assess their ability to cope for one-hour. Plants not utilizing an alternate AC source will assess their ability to cope for four-hours. Factors identified which prevent demonstrating the capability to cope for the appropriate duration will be addressed through hardware and/or procedural changes so that successful demonstration is possible.

1.3 SUPPORTING INFORMATION

Utilities are expected to ensure that the baseline assumptions are applicable to their plants. Further, utilities are expected to ensure that analyses and related information are available for review.

2. GENERAL CRITERIA AND BASELINE ASSUMPTIONS

This section contains general criteria and a listing of the base line assumptions, a brief description of their bases, and appropriate references to source material. The topics in this section are:

Section 2.1 --- general criteria
Section 2.2 --- initial plant conditions
Section 2.3 --- the initiating event
Section 2.4 --- station blackout transient
Section 2.5 --- reactor coolant pump inventory loss
Section 2.6 --- operator action
Section 2.7 --- effects of the loss of ventilation
Section 2.8 --- system cross-tie capability
Section 2.9 --- instrumentation and controls
Section 2.10 --- containment isolation valves
Section 2.11 --- hurricane preparations.

2.1 GENERAL CRITERIA

Procedures and equipment in light water reactors relied upon in a station blackout should ensure that satisfactory performance of necessary decay heat removal systems is maintained for the required station blackout coping duration. For a PWR, an additional requirement is to keep the core covered. For a BWR, no more than a momentary core uncovery is allowed. For both BWRs and PWRs, appropriate containment integrity should also be provided in a station blackout to the extent that isolation valves perform their intended function without AC power.

2.2 INITIAL PLANT CONDITIONS

2.2.1 Assumptions

(1) The station blackout event occurs while the reactor is operating at 100% rated thermal power and has been at this power level for at least 100 days.

(2) Immediately prior to the postulated station blackout event, the reactor and supporting systems are within normal operating ranges for pressure, temperature, and water level. All plant equipment is either normally operating or available from the standby state.

2.2.2 *Basis*

(1) The potential for core damage from a station blackout is bounded by events initiated from 100% power due to the presence of substantial decay heat.

(2) Transients initiated from normal operating conditions are considered most probable.

2.3 INITIATING EVENT

2.3.1 Assumptions

(1) The initiating event is assumed to be a loss of off-site power (LOOP) at a plant site resulting from a switchyard-related event due to random faults, or an external event, such as a grid disturbance, or a weather event that affects the off-site power system either throughout the grid or at the plant.

LOOPs caused by fire, flood, or seismic activity are not expected to occur with sufficient frequency to require explicit criteria and are not considered.

(2) The LOOP is assumed to affect all units at a plant site. At a multi-unit site with normally dedicated emergency AC power sources, station blackout is assumed to occur at only one unit. At multi-unit sites with normally shared emergency AC power sources, where the combination of AC sources exceeds the minimum redudancy requirements for normal safe shutdown (non-DBA) of all units, the remaining emergency AC power sources may be used as alternative AC power sources provided they meet the alternate AC power criteria in Appendix B. If there are no remaining emergency AC power sources in excess of the minimum redundancy requirements, station blackout must be assumed to occur at all the units.

(3) Emergency AC (EAC) power sources are assumed to be available as Alternate AC power sources to cope with the station blackout under the following conditions:

(a) For the blacked-out unit, any emergency AC power source(s) in excess of the number necessary to meet minimum redundancy requirements (i.e. single failure) for safe shutdown is assumed to be available and may be designated as an Alternate AC (AAC) power source(s) provided it meets the AAC criteria provided in Appendix B.

(b) For multi-unit sites, EAC sources available from a non-blacked-out unit, after assuming a single failure at the non-blacked-out unit, may be designated as Alternate AC, if they meet the AAC criteria provided in Appendix B and are capable of meeting the necessary shutdown loads of both units.

(4) No design basis accidents or other events are assumed to occur immediately prior to or during the station blackout.

2.3.2 Basis

(1) NRC analysis separates LOOP events into three categories: plant-centered, grid disturbance, and severe weather. Plant-centered events involve hardware failures, design deficiencies, human errors in maintenance and switching, and localized weather-induced faults, such as due to lightning, salt spray, and ice. These plant-centered events reportedly occur at a frequency of 0.056 events per site-year, with a median duration of 0.3 hour. Grid disturbance events have been shown to be of much lesser concern for most plants. Events in this category reportedly have a frequency of 0.020 events per site-year, with a median duration of 0.7 hour. Severe weather events have a lesser experience with 0.011 events and a median duration of 2.6 hours. (Section 3, including Table 3.1, NUREG-1032)

Seismic, fire, and flooding events include accident scenarios for which current licensing requirements specify protective measures. For example, the potential for a fire-induced station blackout is extremely remote due to the effectiveness of current fire protection programs and 10 CFR 50 Appendix R separation requirements imposed on shutdown systems. In fact, some plants installed an alternate or dedicated shutdown capability in response to Appendix R which may also be used to respond to a station blackout event. NRC analysis concludes that fire-induced station blackout is not a generic concern, citing a station blackout frequency of less than $1x10^{-6}$ *per reactor-year for most plants. Consequently, station blackout events that may occur at a particular site involving fire initiators are not likely to occur, and are not addressed in this document.*

The seismic and flooding issues are similar to the fire risk concern regarding the potential for causing station blackout. The Class 1E power system is currently designed to withstand seismic events. Similarly, flooding protection is addressed in the plant's licensing basis. As a result, the potential for seismically-induced or flooding-induced station blackout is on the same order as fire-induced events, and are not addressed in this document.

For these reasons, seismic, flooding, and fire-induced station blackout events are not addressed in these guidelines.

(Appendix J, NUREG/CR-3226)

(2)-(3) *The major contributor to overall station blackout risk is the likelihood of losing off-site power and the duration of power unavailability. A LOOP may occur as a result of a switchyard problem either affecting a single unit, or possibly multiple units at a site. Alternatively, the cause of the LOOP may be a grid or area-wide disturbance associated with severe weather conditions. Although these events are a much smaller fraction of the total number of events (in fact, weather-related events represent on the order of 10% of all LOOPs experienced to date), they can be significant because of the longer time to restore off-site power following such events. To be conservative, the LOOP is assumed to affect all units at a site.*

The next most important contributor to station blackout risk for a given plant is low EDG availability. EDG availability varies among operating sites, based on the number of EDGs on-site, the reliability to start from a standby state, the overall availability of the machine, and the potential for dependent failures. Industry EDG reliability to start from a standby state is typically in the range of 0.98-0.99. It is very unlikely to have average EDG reliability for all machines at a site below 0.95 over a sustained period. Consequently, the contribution of EDG reliability to station blackout risk is well below that of LOOP for most plants.

EDG failures may also occur due to dependent causes (i.e., common cause events). These failures may result from design or operating deficiencies that manifest themselves in a concurrent failure. The potential for these deficiencies affecting all EDGs for multiple unit sites is considered remote since most reactors have staggered operating cycles. Staggered operating cycles also make it less likely that major maintenance activities are scheduled at the same time. Similarly, redundant units are often designed and constructed on independent schedules, with initial commercial operation dates separated by up to several years in time.

Generally high EDG reliability and low dependent failure rates provide a basis for screening EDG configurations. In support of this perspective, NUGSBO analyzed the likelihood of failure on demand for standby systems, such as for typical emergency AC power systems. The potential for simultaneously failing two identical EDGs with each machine at industry average reliability (i.e., approximately 2% average failure rate on demand for each machine) and nominal susceptibility to dependent failure (i.e., 2%) is approximately 7.8×10^{-4}. *The likelihood of three identical EDGs simultaneously failing is even lower, at about* 4.1×10^{-4} *for machines with 0.98 reliability.*

These results suggest that the potential for more than two EDGs failing at a unit is very low. Consequently, assuming failure of EDGs in excess of those required for minimum redundancy is not necessary to assure that the risk of a station blackout is sufficiently low. For multi-unit sites (assuming an EDG single failure at the non-

blacked-out unit), the marginal probability of an additional EDG failure at the non-blacked-out unit is so low that the remaining EDGs are assumed available if they meet the applicable AAC criteria. One-out-of-two shared (1/2S) and two-out-of-three shared (2/3S) configurations do not meet Alternate AC power criteria. At single unit sites with EDGs in excess of the number necessary to meet the minimum redundancy requirements (such as units with 3 or more diesels), these additional EDGs are candidates for Alternate AC. At multi-unit sites, where the combination of emergency AC sources exceeds the minimum redundancy requirements for normal safe shutdown (non-DBA) for all units, the remaining emergency AC power sources may be used as alternate AC power sources provided they meet the AAC power criteria of Appendix B.

The availability of EDGs as an Alternate AC source may be assumed if the machine satisfies the Alternate AC power source criteria provided in Appendix B. This includes criteria designed (1) to minimize the potential for dependent failure events adversely affecting the Alternate AC power source in station blackout scenarios, and (2) to provide requirements for power source availability.

The Staff's stated objective of the proposed station blackout rule is to reduce the core damage frequency due to station blackout to approximately 10^{-5} per year for the average site. As provided in the proposed rule, this objective could be obtained by extending the current nominal two-hour coping capability to four hours. Comparable safety benefits may exist from the utilization of an AAC power source. To investigate these benefits, NUGSBO extended the emergency AC power system model to include the contribution of off-site power system failure frequency and power restoration. A composite LOOP duration distribution was constructed based on the LOOP events reported in NUREG-1032. Assuming a LOOP frequency of 0.1 per year, industry average power restoration distributions, a 1/3 EDG configuration, and failure likelihoods of 2% for each machine and 2% dependent failure, a two-hour coping capability yields a station blackout core damage frequency of well below the 10^{-5} per year. This frequency is below the threshold sought by the Staff in the station blackout rulemaking. (Section 4, NUREG-1032; see also NUREG-1109, page 9 wherein the Staff assumes "... that all plants, as currently designed, can cope with a station blackout for 2 hours, and, with proper procedures and training, plants could cope with a 4-hour station blackout without having to make major modifications.")

(4) The likelihood of a design basis accident or other event coincident with a station blackout is considered remote and is not addressed in this document.

2.4 STATION BLACKOUT TRANSIENT

2.4.1 Assumptions

(1) Following the loss of all off-site power, the reactor automatically trips with sufficient shutdown margin to maintain subcriticality at safe shutdown (i.e. hot standby or hot shutdown as appropriate). The event ends when AC power is restored to shutdown busses from any source, including Alternate AC.

(2) The main steam system valves (such as main steam isolation valves, turbine stops, atmospheric dumps, etc.) necessary to maintain decay heat removal functions operate properly.

(3) Safety/Relief Valves (S/RVs) or Power Operated Relief Valves (PORVs) operate properly. Normal valve reseating is also assumed.

(4) No independent failures, other than those causing the station blackout event, are assumed to occur in the course of the transient. The potential for mechanistic failures resulting from the loss of HVAC in a station blackout event is addressed in Section 7 of this document.

(5) AC power is assumed available to necessary shutdown equipment within four hours from either the off-site or blacked-out unit's Class 1E sources or is available within one hour from an Alternate AC source.

2.4.2 Basis

(1) - (3) These assumptions outline some of the more important features of the station blackout transient. The basic considerations are a normal LOOP transient, proper unit trip with full reactivity insertion, and MSIV closure as appropriate for the design of the plant. In addition, the likelihood of PORV or S/RV malfunction in a station blackout is on the order of 1-2% (See Section 2, NUREG/CR-1988; Section 2 and 6, NUREG/CR-2182; and NUREG-1032)

(4) Imposing additional independent failures on the station blackout response capability has diminishing safety significance for most power plants. This is because the dominant accident contributors to a station blackout event generally involve off-site power system reliability, the reliability and level of redundancy of the emergency AC power system, and the station blackout coping capability, in that order. Since a number of failures must occur to result in a station blackout event, additional independent failures are of secondary importance. The station blackout response capability also depends on systems that are highly reliable due to the design and maintenance standards used. Consequently, the potential for random failure in these systems is low. Finally, the safety effects of response

capability loss are of most significance only if they are experienced early in the station blackout transient (i.e., primarily in the first 30 minutes). This potential has been addressed in NRC Staff analysis which estimates the probability of decay heat removal system failure early in a station blackout event to range from 0.001 for High Pressure Core Spray (HPCS)/RCIC combinations to 0.04 for a single steam turbine-driven train auxiliary feedwater system (AFW). These results underscore the lower significance of additional non-mechanistic failures in the station blackout scenario. (Appendix C, particularly Table C.2, NUREG-1032)

(5) *Historically, the vast majority of LOOP events are of short duration. NRC Staff analysis reports the median AC power restoration time for all LOOP events to be about 1/2 hour, with off-site power restored in approximately 3 hours for 90% of all events. Consequently, assuming a four hour restoration time addresses the bulk of postulated station blackout events. For AAC systems, one hour is considered an acceptable period of time to lineup the AAC power source and restore power to a shutdown bus. (Off-site power restoration times are taken from Supplementary Information, Proposed Station Blackout Rule, 51 FR 55, at 9830)*

2.5 REACTOR COOLANT INVENTORY LOSS

2.5.1 Assumptions

Sources of expected PWR and BWR reactor coolant inventory loss include (1) normal system leakage, (2) losses from letdown, ~~and~~ (3) losses due to reactor coolant pump seal leakage, and (4) BWR inventory loss due to SRV cycling and ADS actuation. Expected rates of reactor coolant inventory loss under station blackout conditions ~~do not~~ are not expected to result in core uncovering for a PWR or more than momentary core uncovering for BWR in the four hour time period. Therefore, makeup systems in addition to those currently available under blackout conditions are not required. ~~There exists sufficient head to maintain core cooling under natural circulation.~~ As a result, it is expected that sufficient head exists to maintain core cooling under natural circulation (including reflux boiling)

2.5.2 Basis

Normal system leakage is limited by technical specifications to a low rate. These rates are not assumed to increase under station blackout conditions. Emergency operating procedures developed in accordance with NSSS vendor Emergency Procedure Guidelines or individual plant analysis should be used to direct operators to take appropriate action. RCP seal leakage is assumed not to exceed 25 gpm per pump for the duration of the station blackout event. However, this assumption is currently the subject of a resolution program (NRC Generic Issue 23).

If the final resolution of Generic Issue 23 results in higher RCP leakage rates, then the coping duration analysis will need to be reevaluated.

Generic NSSS vendor analyses and studies listed below show that for the assumed leakage rates core uncovery does not occur in the four hour time period. These studies also show that sufficient head exists to maintain core cooling under natural circulation for a PWR, and that decay heat removal capability is maintained for a BWR.

(1) *Analyses submitted in response to the TMI accident and emergency procedure guidelines, including IEB 79-05, NUREG-0578, NUREG-0660, and NUREG-0737;*

(2) *Analyses submitted in response to NRC Generic Letter 81-04 concerning station blackout response procedures;*

(3) *C. D. Fletcher, "A Revised Summary of PWR Loss of Offsite Power Calculations", EGG-CAAD-5553, EG&G Idaho, September 1981;*

(4) *D. H. Cook, et. al., "Station Blackout at Browns Ferry Unit One - Accident Sequence Analysis", NUREG/CR-2182, Oak Ridge National Laboratory, November 1981; and*

(5) *A. M. Kolaczkowski and A. C. Payne, Jr., "Station Blackout Accident Analyses", NUREG/CR-3226, Sandia National Laboratories, May 1983.*

2.6 OPERATOR ACTION

2.6.1 Assumptions

Operator action is assumed to follow the Plant Operating Procedures for the underlying symptoms or identified event scenario associated with a station blackout.

2.6.2 Basis

NRC analyses supporting the proposed station blackout rulemaking assume that a reasonable set of operator actions will occur. The governing document for defining operator actions is the plant's procedures. (Appendix H, NUREG/CR-3226)

2.7 EFFECTS OF LOSS OF VENTILATION

2.7.1 Assumptions

(1) Equipment Operability Inside Containment

Temperatures resulting from the loss of ventilation are enveloped by the loss of coolant accident (LOCA) and high energy line break environmental profiles.

(2) Equipment Operability Outside Containment

(a) Areas containing equipment required to cope with a station blackout need only be evaluated if (a) the area is a dominant area of concern, and (b) the dominant area of concern has not been previously evaluated as a harsh environment due to a high or moderate energy line break. The dominant areas of concern are:

(i)	HPCI/HPCS and RCIC rooms (BWR only)	—	decay heat removal equipment
(ii)	Steam driven AFW pump room (PWR only)	—	decay heat removal equipment
(iii)	Main steam tunnel (BWR only)	—	high temperature cutout for decay heat removal equipment.

Assumptions concerning the potential for thermal-induced equipment failure in a station blackout for the dominant areas of concern are separated into three distinct conditions based on bulk air temperatures:

Condition 1

Equipment located in Condition 1 rooms are considered to be of low concern with respect to elevated temperature effects and will likely require no special actions to assure operability for a 4-hour station blackout. This condition is defined by a steady state temperature of 120° F.

Condition 2

Equipment located in Condition 2 rooms generally require no forced cooling in order to assure operability for a 4-hour station blackout. If additional cooling is needed, such actions as opening doors may be sufficient to support equipment operation to mitigate a station blackout event. This condition is defined by a steady-state temperature of 150° F.

Condition 3

Equipment located in Condition 3 rooms require plant-specific treatment of the potential for thermal-induced failure. Such treatment may include (1) further plant-specific analysis, (2) providing forced cooling, and (3) replacement by equipment designed or qualified for the environment.

NOTE: Plant procedures need to reflect the operator actions necessary to enhance cooling for rooms in above conditions.

The control room complex (i.e., area(s) containing instrument indications and associated logic cabinets which the control room operator relies upon to cope with a station blackout) is considered to be in Condition 1. By opening cabinet doors, adequate air mixing is achieved to maintain internal cabinet temperatures in equilibrium with the control room temperature. Therefore, cabinets containing instrumentation and controls required for achieving and maintaining safe shutdown in a station blackout are considered to be in Condition 1. As such, additional cooling may be provided in a station blackout by opening cabinet doors within 30 minutes of the event's onset.

For multi-unit control room complexes (i.e., area(s) containing instrument indications and associated logic cabinets which the control room operator relies upon to cope with a station blackout) where a portion of the HVAC is powered from the non-blacked-out unit, no significant temperature rise above normal operating conditions is expected. For this situation, the effects of loss of ventilation need not be considered further.

(b) Loss of heating in the battery room does not result in a decrease in battery electrolyte temperature sufficient to warrant battery capacity concern for a four-hour period.

(3) Control Room Habitability

Loss of cooling in the control room for a four hour period does not prevent the operators from performing necessary actions.

2.7.2 Basis

(1) Equipment Operability Inside Containment

No design basis accidents (DBAs) (i.e., LOCAs or steam line breaks) or beyond DBAs (i.e., resulting in core damage) are assumed coincident with a station blackout. Therefore, environmental concerns inside containment are limited to (1) loss of cooling water, and (2) loss of ventilation systems. In both cases, no sudden onset of extreme temperature conditions or humidity is expected. Station blackout results in a slow heatup of containment due to loss of ventilation. Absent DBA conditions, temperatures in a four-hour station blackout are expected to be bounded by thermal profiles considered for the high energy line break events.

The response of a large, dry containment to a station blackout was previously analyzed in the course of preparing Emergency Procedure Guidelines (see Westinghouse ECA-0.0). For two, three, and four loop plants, assuming 50 gpm per pump RCP seal leakage, containment temperature rises less than 15° F from the initial temperature.

Other PWR containments can be expected to perform within an acceptable thermal range, based on the relative volume of other containments to the large dry containment. For example, ice condensers offer a somewhat smaller amount of free volume, combined with several million pounds-mass of ice. Even ignoring the cooling capacity of the ice baskets, containment heating is not expected to result in excess temperatures substantially greater than 50-60° F above normal operating conditions. These temperature increases are well below the thermal profiles *established for ice condenser containments.*

For BWRs, analyses indicate that conditions inside containment under station blackout conditions will be within typical thermal limits established for equipment qualification for pressure suppression containments (e.g., see letter from Mr. N. W. Curtis (Pennsylvania Power and Light Company) to Mr. A. Schwencer (NRC), dated June 15, 1982).

(2) *Equipment Operability Outside Containment*

(a) *As with inside containment, the temperature rise in a station blackout outside containment over a four-hour period is not expected to exceed conditions associated with a high or moderate energy line break. With reactor shutdown and station blackout initiation, a significant amount of equipment is de-energized with a resultant reduction in heat load. Process piping and other high temperature surfaces do not efficiently transfer heat to air, particularly when forced ventilation is not present. Consequently, the potential for significant heatup is negligible in a four-hour period.*

Under station blackout conditions, the effects of the loss of ventilation are less severe due to the associated loss of lighting and AC powered equipment heat loads. The potential for mechanistic failures of systems and components due to loss of ventilation is dependent on the time required for temperatures to rise in closed rooms and cabinets. Temperature buildup in a compartment is a slow process due to the normally large thermal lag associated with natural convection and the loss of AC-supplied heat sources. This large thermal lag allows sufficient time for operator actions to supplement cooling in order to limit the thermal buildup. NUGSBO has analyzed the potential for temperature buildup in closed rooms over a four hour period. The results show that opening doors early in a station blackout (i.e., within approximately 30 minutes) significantly limits any temperature rise due to loss of forced ventilation.

Occasionally, supplemental cooling measures (such as opening doors to increase natural circulation and ventilation) may conflict with other safety or administrative considerations. For example, procedural requirements may exist for keeping fire or flooding doors closed. Despite these procedural considerations, opening doors would be acceptable during a station blackout to increase natural circulation for necessary shutdown instrumentation. Other techniques, such as using permanently mounted small battery-operated fans inside cabinets, could also be considered (Section 5 and Appendix I, NUREG/CR-3226).

Condition 1

Condition 1 rooms are assumed to have a relatively small potential for thermally-induced failure *during a four hour station blackout. This assumption is based on operating experiences and studies concerning the operability of various classes of equipment exposed to elevated temperatures.*

In a station blackout, forced cooling will be lost to most plant areas and the potential exists in Condition 1 areas for bulk air temperatures to rise up to 120° F. For most mechanical and electrical equipment and instrumentation found in Condition 1 dominant areas, temperature rises up to 120° F would likely not adversely affect operability.

Condition 2

Condition 2 rooms are likely to include a relatively substantial heat generation source and a small room geometry. These conditions are more typical of rooms containing steam-driven makeup pumps, such as RCICS and AFWS which are generally qualified or designed to operate in elevated temperatures.

The NRC has considered equipment operability during station blackout conditions (see Jacobus [1987]). One of the conclusions of this review is that certain classes of components (e.g., relays and switches) will likely remain operable in thermal environments of 150° F to 300° F for up to eight hours. While the Jacobus study was not extensive, the general assumption of equipment operability for Condition 2 thermal environments is considered valid because (1) only a four hour station blackout event is considered, and (2) in practice, less than the full four hours would be involved since there would be a period of thermal buildup during the front-end of the station blackout transient.

Condition 3

Condition 3 rooms represent classes of thermal environments where plant-specific consideration may be appropriate.

Appendix F provides a method for assessing the operability of equipment exposed to Condition 1, 2, and 3 environments.

The operability of a representative set of control room complex (i.e., area(s) containing instrument indications and associated logic cabinets which the control room operator relies upon to cope with a station blackout) cabinet equipment was established with actual experience involving loss of control room ventilation for several hours (see Chiramal [1986]). During this extended loss of ventilation event at McGuire, there was negligible operability effects

~~on equipment or instrumentation.~~

(b) *Battery capacity is reduced if the electrolyte temperature drops significantly below design temperatures. Class 1E batteries are housed in seismic Category 1 structures, and are not typically subjected to the direct effects of the external environment. Therefore, the temperature decrease in the battery room is not significant over a four-hour period. Also, the mass of battery electrolyte is sufficient to resist significant temperature drops over a four-hour period due to lower battery room temperatures since battery cell materials are not efficient thermal conductors. Therefore, a decrease in battery capacity due to temperature decreases in electrolyte under station blackout conditions does not warrant further consideration.*

(3) *Control Room Habitability*

Control room habitability is not an important contributor to station blackout risk, particularly for events of 4-hour durations. NUREG-1032 points out that the dominant accident sequences involve either an early core cooling failure or a subsequent loss of core cooling (see Appendix C, NUREG-1032 for a more complete discussion of station blackout accident sequences). Both sequences are dominated by the failure of automatic equipment to properly function on demand. Even these events have failure probabilities of less than 1% per event, reflecting the exceptionally high reliability of these systems and components. With respect to human error, such as due to habitability concerns, NUREG-1032 states: "The potential effect of operator error causing loss of decay heat removal has not been found to be a large contributor to core damage frequency, if adequate training and procedures exist." (draft NUREG-1032, page C-15). Since NUMARC Initiative 2, as provided in Section 4 guidelines, assures adequate training and procedures will exist, the concern regarding operators' ability to perform cognitive tasks is insignificant.

~~*As to the expected environment within the control room, it has been shown that temperatures are not likely to exceed 110° F should a station blackout event actually occur (Chiramal [1986]). In the McGuire event discussed by Chiramal, habitability was never an issue.*~~ *Studies suggest that long term occupancy in higher temperature environments does not prevent performance of tasks of various difficulties (see Eichna [1945] and Humphries and Imalis [1946] for military applications). Such studies have been the basis of guidance in the heating and ventilating industry handbooks (e.g., ASHVE [1950] and ASHRAE [1985]). ASHRAE, in particular, correlates temperature, humidity, and pressure and concludes that light work at 110° F and relative humidities up to 50% would not be intolerable.*

Before the station blackout event, it is assumed that the control room is at 78° F and about 35% relative humidity. Although temperature increases may be expected due to loss of HVAC, the relative humidity actually decreases to approximately 30%. Guidance provided for military applications may establish a technical basis for defining *habitability standards for power plants in a station blackout. The operative standard, MIL-STD-1472C, concludes that a dry bulb temperature of 110°F is tolerable for light work for a four hour period while dressed in conventional clothing assuming the relative humidity is approximately 30%. Loss of HVAC would impose a slow heatup on the control room. It is expected that steady-state control room air temperatures will be well below 110° F for most plants under loss of HVAC conditions. For the conservative case when it is assumed that a control room is initially at 78° F and experiences an exponential temperature rise to a steady-state 110° F should HVAC be lost in a station blackout, the bulk air temperature at the end of the first hour would be approximately 97° F. At the end of the second hour, the air temperature would be approximately 104° F. At the end of the third hour, it would be approximately 108° F. Since it would take some time for a control room to heatup once HVAC is lost, the operator is not exposed to the thermal limit for the duration of the event. Therefore, it is not expected that operator actions would be impacted significantly by projected temperature and humidity conditions and, further, that a dry bulb temperature of 110° F appears to be a conservative limit for control room habitability.*

Additionally, it is expected that operators would act within the first hour to establish a stable independent decay heat removal mode which is significant factor in the plants ability to cope with a station blackout.

2.8 SYSTEM CROSS-TIE CAPABILITY

2.8.1 Assumptions

Under station blackout conditions it is assumed that multiunit sites with fluid or DC electrical system cross-tie capability will be able to achieve and maintain safe shutdown in the affected unit by procedurally utilizing the unaffected unit's cross-tied systems. Systems of the unaffected unit must be electrically independent of the blacked-out unit as appropriate in order to credit their availability to bring the affected unit to safe shutdown.

2.8.2 Basis

NRC analyses supporting other rulemakings (i.e., 10 CFR 50 Appendix R) permit multiunit sites to rely on cross-tie capability of fluid systems to bring the affected unit to safe shutdown conditions.

2.9 INSTRUMENTATION AND CONTROLS

2.9.1 Assumptions

Actions specified in Emergency Procedure Guidelines for station blackout are predicated on use of instrumentation and controls powered by vital buses supplied by station batteries. Appropriate actions will be taken by operations personnel to assess plant status in the event of erratic performance or failure of shutdown instrumentation.

2.9.2 Basis

NSSS emergency procedure guidelines identify instrumentation and controls requirements to achieve and maintain safe shutdown. Operator training includes the use of backup instrumentation and methods for identifying erratic performance.

2.10 CONTAINMENT ISOLATION VALVES

2.10.1 Assumptions

Containment isolation valves either fail in the safe condition in accordance with the design bases of the plant or can be manually closed.

2.10.2 Bases

10 CFR 50 General Design Criteria (GDC) 55 through 57 specify requirements for isolating piping systems penetrating containment, including reactor coolant pressure boundaries. These requirements call for combinations of redundant locked closed and automatic isolation valves for reactor coolant pressure boundaries and any containment penetration line directly connected to the containment atmosphere. In cases where automatic isolation valves are used, the GDC specifies that the valves fail upon loss of power in a position which provides greater safety. All other containment penetration valves must meet the requirements of the GDC by being automatic, or locked closed, or capable of remote manual operation.

Most containment isolation valves are in the normally closed or failed closed position during power operation. These valves can also be closed manually. Loss of AC does not affect the design bases for these valves. Some valves, such as MSIVs, charging and letdown lines, and reactor water cleanup lines, are normally open. Typically, these valves are air-operated, failed closed valves and do not need AC power to close. A few DC operated containment isolation valves exist, such as valves in the shutdown cooling or residual heat removal systems. These DC operated valves are normally closed during power operations, and generally are locked or have DC breaker control power removed by racking out the circuit breaker for the valve operator. The position of these DC operated valves is not affected by the station blackout.

2.11 HURRICANE PREPARATIONS

2.11.1 Assumptions

Procedural actions taken in anticipation of the effects of a hurricane provide significant safety benefits and reduce the risk of a station blackout. Plants which are impacted in their "extremely severe weather" grouping primarily due to the effects of a hurricane have a basis for classifying their "off-site power design characteristic group" (P2*, or P3*) in a lower group.

2.11.2 Bases

NUMARC Guidelines in Section 4.2.3 specify actions to be taken to prepare a plant to cope with a station blackout due to an anticipated hurricane-induced LOOP. These actions can be separated into two groups: (1) actions taken in the 24-hour period prior to anticipated hurricane arrival, and (2) a commitment to be in safe shutdown two hours before the anticipated hurricane arrival at the site. These actions result in a coping categorization consistent with Section 3.2.1, Part 1E(B) and Section 3.2.5 of these guidelines.

The following actions are important for achieving an enhanced coping capability under hurricane conditions:

(1) Plant in safe shutdown at least two hours before the anticipated hurricane arrival at the site (i.e., sustained winds in excess of 73 m.p.h.) so that major decay heat loads can be dissipated using non-emergency plant equipment prior to the occurrence of a LOOP;

(2) Enhancement and verification of EDG reliability by prewarming, prelubricating, starting and load-testing (see, Section 4.2.3);

(3) Topping off condensate storage tank inventory and placing battery systems on charge; and,

(4) Expediting the restoration of important plant systems and components needed to cope with a hurricane-induced LOOP;

and other actions as detailed in Sections 4.2.3 and 4.3.3. Such actions have the capability to enhance the coping capacity for the reasons discussed below.

The timing of anticipatory actions is tied to hurricane tracking performed by both utilities and the National Weather Service. Hurricane tracking normally begins when tropical depressions are first detected far out in the Atlantic Ocean. Forward motion does not normally accelerate until the hurricane approaches the Eastern seaboard or Gulf coast. Even at landfall, hurricane forward speeds are generally below 35 knots-speeds that permit adequate tracking and warning.

Continuous position information for hurricanes is provided to the National Hurricane Center by reconnaissance aircraft and geostationary satellites, and are updated at six hour intervals. This tracking permits National Weather Service analysts to project the time and location of landfalls and to issue hurricane watches and warnings for affected areas (see NWS [1987]). Hurricane watches are issued for an area 36 hours prior to the expectation of hurricane conditions. Hurricane warnings are issued for an area 24 hours prior to the expectation of wind speeds in excess of 73 mph. With the institution of a hurricane warning, plant operators will have sufficient time to take action prior to hurricane arrival.

During the 24-hour period prior to hurricane arrival, NUMARC station blackout initiatives direct plant operators to take actions to enhance the normal EDG reliability and coping capability. These actions include reviewing procedures, restoring systems and components to service, warming, lubricating, starting and load testing EDGs, increasing CST levels, and charging batteries. The safety benefits offered by these actions result from increased EAC availability, above-normal available coping resources (and extended coping times), and lower potential for operator error for hurricane events.

With EDG testing in advance of hurricane arrival, the average EDG will realize a reduction in EDG failures up to 50% depending on mode of failure (i.e., stress versus demand), based on industry EDG failure data reported in NUREG-1032 following reactor shutdown*. This data suggests that approximately 50% of failures can be repaired within four hours in non-emergency situations with normal staffing. With 24-hours available, Figure 4.6 of NUREG-1032 indicates up to 75% of EDG failures may be repairable under normal conditions. Enhancement and verification of high EDG reliabilities is one of two major improvements that can reduce the risk of a station blackout. The other is plant safe shutdown in sufficient advance of an anticipated hurricane-induced LOOP to dump a significant portion of the decay heat load.*

The relative amount of decay heat removed in a two hour period by the main condenser is approximately 60% of the energy generated in the first four hours following shutdown. By removing this energy through the main condenser, the station blackout coping resources normally reserved for processing this decay heat would be preserved, permitting longer coping times for a four hour water supply.

During the hurricane warning period, "topping-off" water supplies can also extend a normal four hour water supply by several hours. For example, increasing the condensate available for coping above a technical specification level of 65% to 100% available capacity can add several hours of coping time to a rated four hour capability. Topping off the condensate storage tank and placing the plant in a safe shutdown several hours before the hurricane induced LOOP reduces the likelihood of core damage from a subsequent station blackout event.

Actions are also available to extend the time to battery depletion in order to support enhanced coping. Analysis demonstrates that for a typical plant, pre-hurricane actions can effectively support enhanced coping capability for hurricane events. With the plant in an early shutdown, certain loads would not be needed should a station blackout subsequently occur as a result of a hurricane-induced LOOP. Further, other loads could reasonably be stripped after initiation of a LOOP in order to extend the effectiveness of the available charge.

During early shutdown, many air-operated valve operations necessary for decay heat removal following shutdown would *also be accomplished while air compressors are available. These operations would result in fewer air-operated valve operations in a station blackout and longer coping capability involving this resource. In any event, air-operated valves necessary for shutdown can be manually operated or are equipped with backup means for ensuring proper positioning in a station blackout.*

The combined effects of these actions (i.e., implementation of plant specific pre-hurricane shutdown requirements and procedures) provide an eight-hour enhanced coping capability under anticipated hurricane conditions.

3. REQUIRED COPING DURATION CATEGORY

3.1 PROCEDURE OVERVIEW

This section provides a methodology for determining the required station blackout coping duration.

3.2 PROCEDURE

Five steps are provided for determining the required coping duration category:

Step 1 Determine the Off-site Power Design Characteristic Group
Plant weather, grid, and switchyard features are grouped into three categories of susceptibility to losing off-site power labeled P1, P2, and P3.

Step 2 Classify the EAC Power Supply System Configuration
The redundancy of the emergency AC power system is evaluated and classified among four available groups labeled A, B, C, and D.

Step 3 Determine the Calculated EDG Reliability
The current EDG reliability is determined consistent with NSAC-108 criteria.

Step 4 Determine the Allowed EDG Target Reliability
Based on current EAC reliability, a method is provided for determining an acceptable EAC target reliability.

Step 5 Determine Coping Duration Requirement
Based on the allowed EDG target reliability determined in Step 4, a coping duration category is calculated.

3.2.1 Step One: Determine The Off-site Power Design Characteristic Group

The objective of this first step is to distinguish between sites having particular susceptibilities to losing off-site power due to plant-centered, grid-related, and weather-related events. Three off-site power design groups are provided:

P1 - Sites characterized by redundant and independent power sources that are considered less susceptible to loss as a result of plant-centered and weather-initiated events;

P2 - Sites whose off-site power sources are less redundant or independent, or that are more susceptible to extended off-site power losses due to weather-initiated events or more frequent losses due to plant-centered events; and,

P3 - Sites whose off-site power sources are (1) least redundant or independent combined with moderate severe weather potential, (2) most susceptible to extended off-site power losses due to weather-initiated or grid-related events, or (3) susceptible to grid-related events.

These categories are provided by the Staff in the draft station blackout regulatory guide and are designed to be mutually exclusive. Further discussion concerning independence of offsite sources is provided in Section 3.3.4.

THERE ARE FIVE PARTS IN STEP ONE TO DETERMINING THE OFF-SITE POWER DESIGN CHARACTERISTIC GROUP:

PART 1.A DETERMINE THE SITE SUSCEPTIBILITY TO GRID-RELATED LOSS OF OFFSITE-POWER EVENTS;

PART 1.B ESTIMATED FREQUENCY OF LOSS OF OFF-SITE POWER DUE TO EXTREMELY SEVERE WEATHER (ESW GROUP);

PART 1.C DETERMINE THE ESTIMATED FREQUENCY OF LOSS OF OFF-SITE POWER DUE TO SEVERE WEATHER (SW GROUP);

PART 1.D EVALUATE INDEPENDENCE OF OFF-SITE POWER SYSTEM (I GROUP); AND,

PART 1.E DETERMINE OFF-SITE AC POWER DESIGN CHARACTERISTIC GROUP (P GROUP).

Part 1.A: Determine Site Susceptibility to Grid-Related Loss of Off-site Power Events

Grid-related loss of off-site power events are defined as LOOPs that are strictly associated with the loss of the transmission and distribution system due to insufficient generating capacity, excessive loads, or dynamic instability. Although grid failure may also be caused by other factors, such as severe weather conditions or brush fires, these events are not considered grid-related since they were caused by external events.

The industry average frequency of grid-related events is approximately 0.020 per site-year, with most events isolated to a few systems. According to NUREG-1032, the average occurrence for the majority of systems is about once per 100 site-years. NUREG-1032 notes sites having a frequency of grid-related events at the once per 20 site-year frequency are limited to St. Lucie, Turkey Point, and Indian Point. Accordingly, no other sites are expected to exceed the Once per 20 site-year frequency of grid-related loss of off-site power events.

PLANTS SHOULD BE CLASSIFIED AS P3 SITES IF THE EXPECTED FREQUENCY BASED ON PRIOR EXPERIENCE OF GRID-RELATED EVENTS EXCEEDS ONCE PER 20 YEARS. THIS DOES NOT INCLUDE EVENTS OF LESS THAN 5 MINUTES DURATION. EVENTS OF LONGER DURATION MAY BE EXCLUDED IF THE RESULTS OF ANALYSIS CONCLUDES THE EVENT IS NOT SYMPTOMATIC OF UNDERLYING OR GROWING GRID INSTABILITY.

PLANTS CLASSIFIED AS P3 SITES ON THE BASIS OF GRID EXPERIENCE NEED NOT COMPLETE THE REMAINING PARTS OF THIS STEP IN ORDER TO DETERMINE COPING DURATION REQUIREMENTS.

Part 1.B: Estimated Frequency of Loss of Off-site Power Due to Extremely Severe Weather (ESW Group)

*The estimated frequency of loss of off-site power due to **extremely severe weather** is determined by the annual expectation of storms at the site with **wind velocities greater than or equal to 125 mph**. These events are normally associated with the occurrence of great hurricanes where high windspeeds may cause widespread transmission system unavailability for extended periods. Since electrical distribution systems are not designed for these conditions, it is assumed that the occurrence of such windspeeds will directly result in the loss of off-site power.*

USE METHOD "A" OR "B" BELOW TO DETERMINE THE ESTIMATED FREQUENCY OF LOSS OF OFF-SITE POWER DUE TO EXTREMELY SEVERE WEATHER AT THE SITE AND SELECT AN ESW GROUP:

A. **Site-specific data** provides the most accurate source for calculating the annual frequency of storms with wind velocities greater than or equal to 125 mph, and **can be used in calculating the estimated frequency of loss of off-site power due to extremely severe weather.**

Once the frequency (e) is calculated, use Table 3-1 to assign the site to an ESW Group.

Table 3-1

EXTREMELY SEVERE WEATHER GROUPS (ESW)

ESW GROUP	ANNUAL WINDSPEED EXPECTATION ≥ 125 MPH
1	e < 3.3 x 10-4
2	3.3 x 10-4 ≤ e < 1 x 10-3
3	1 x 10-3 ≤ e < 3.3 x 10-3
4	3.3 x 10-3 ≤ e < 1 x 10-2
5	1 x 10-2 ≤ e

B. If site data is not readily available to perform this calculation, the annual estimated frequency of loss of off-site power due to extremely severe weather may be derived from data recorded at local weather stations. Alternatively, a loss of off-site power frequency estimate for extremely severe weather may be based on data obtained from the National Oceanic and Atmospheric Administration (NOAA). Site-specific NOAA data is summarized in Table 3-2 along with the appropriate ESW Group.

Table 3-2

EXTREMELY SEVERE WEATHER DATA[a]

SITE	STORMS 125 MPH+	ESW GROUP	SITE	STORMS 125 MPH+	ESW GROUP
ARKANSAS NUCLEAR ONE	0.0002	1	MONTICELLO	0.0003	1
ARNOLD	0.0008	2	NINE MILE POINT	0.0001	1
BEAVER VALLEY	0.0001	1	NORTH ANNA	0.0034	4
BELLEFONTE	0.0001	1	OCONEE	0.0011	3
BIG ROCK POINT	0.0001	1	OYSTER CREEK	0.005	4
BRAIDWOOD	0.001	3	PALISADES	0.0006	2
BROWNS FERRY	0.0001	1	PALO VERDE	0.0004	2
BRUNSWICK	0.013	5	PEACH BOTTOM	0.0026	3
BYRON	0.0002	1	PERRY	0.0001	1
CALLAWAY	0.0001	1	PILGRIM	0.0068	4
CALVERT CLIFFS	0.0038	4	POINT BEACH	0.0036	4
CATAWBA	0.0011	3	PRAIRIE ISLAND	0.002	3
CLINTON	0.0002	1	QUAD CITIES	0.0002	1
COMANCHE PEAK	0.0001	1	RANCHO SECO	0.0005	2
COOK	0.0006	2	RIVER BEND	0.0068	4
COOPER	0.0014	3	ROBINSON	0.0036	4
CRYSTAL RIVER	0.006	4	SALEM	0.0038	4
DAVIS-BESSE	0.0004	2	SAN ONOFRE	0.0001	1
DIABLO CANYON	0.0001	1	SEABROOK	0.0038	4
DRESDEN	0.0001	1	SEQUOYAH	0.0007	2
FARLEY	0.002	3	SHOREHAM	0.01	5
FERMI	0.0001	1	SOUTH TEXAS	0.012	5
FITZPATRICK	0.0001	1	ST LUCIE	0.017	5
FORT CALHOUN	0.0014	3	SUMMER	0.0011	3
FORT ST. VRAIN	0.0001	1	SURRY	0.006	4
GINNA	0.0001	1	SUSQUEHANNA	0.0018	3
GRAND GULF	0.004	4	THREE MILE ISLAND	0.002	3
HADDAM NECK	0.01	5	TROJAN	0.0011	3
HARRIS	0.01	5	TURKEY POINT	0.023	5
HATCH	0.0009	2	VERMONT YANKEE	0.0034	4
HOPE CREEK	0.0038	4	VOGTLE	0.0006	2
INDIAN POINT	0.0079	4	WATERFORD	0.0068	4
KEWAUNEE	0.0036	4	WATTS BAR	0.0001	1
LASALLE	0.0002	1	WNP-2	0.0001	1
LIMERICK	0.002	3	WOLF CREEK	0.0003	1
MAINE YANKEE	0.0028	3	YANKEE ROWE	0.0056	4
MCGUIRE	0.0001	1	ZION	0.0001	1
MILLSTONE	0.012	5			

Note (a): NRC STAFF PROVIDED THE DATA IN TABLE 3-2 USING CLIMATOLOGICAL SOURCES CITED IN THE REFERENCES TO THIS PROCEDURE. NUMARC HAS NOT VERIFIED THE ACCURACY OF THIS DATA.

Part 1C: Determine the Estimated Frequency of Loss of Off-site Power Due to Severe Weather (SW Group)

*Four factors are used to calculate the estimated frequency of loss of off-site power due to **severe weather**:*

(1) *Annual expectation of **snowfall** for the site, in inches [h_1];*

(2) *Annual expectation of **tornadoes of severity f2 or greater** at the site (i.e., windspeeds greater than or equal to 113 miles per hour), in events per square mile [h_2];*

(3) *Annual expectation of **storms** for the site with **wind velocities between 75 and 124 mph** [h_3]; and,*

(4) *Annual expectation of **storms with significant salt spray** for the site [h_4].*

These factors are combined in the following relationship to yield the estimated frequency of loss of off-site power due to severe weather:

$$f = (1.3 \times 10^{-4}) * h_1 + b * h_2 + (1.2 \times 10^{-2})\ h_3 + c * h_4$$

where:

b	=	12.5 for sites with multiple rights of way
b	=	72.3 for sites with a single right of way
c	=	0.78 if site is vulnerable to effects of salt spray
c	=	0 for other sites

Sites which are determined to be susceptible to the effects of salt spray may remedy this situation through design or procedures to minimize the loss of off-site power.

DETERMINE THE ESTIMATED FREQUENCY OF LOSS OF OFF-SITE POWER DUE TO SEVERE WEATHER AS FOLLOWS:

A. Determine the **total amount of snowfall in inches** which falls on the site in any year. NOAA data for snowfall are provided in Table 3-3. **Label the data used as h_1.**

B. Determine the **expected frequency of "f2+" tornadoes per square mile** for the site using plant-specific data. NSSFC data are also provided in Table 3-3. **Label the data used as h_2.**

C. Determine the **expected frequency of storms with winds between 75 and 124 mph** at the site. NOAA data are also provided in Table 3-3. **Label the data used as h_3.**

D. Determine the **expected frequency of hurricanes and tropical storms with significant salt spray** for the site. NOAA data for sites vulnerable to the effects of salt spray are also provided in Table 3-3. **Label the data used as h_4.**

E. Calculate the **estimated frequency of loss of off-site due to severe weather, *f***, in events per year.

F. Use Table 3-4 to **determine the Severe Weather Group** (SW Group).

Table 3-3

SEVERE WEATHER DATA[b]

SITE	SNOWFALL (h1)	TORNADO (h2)	STORMS (h3)	SALT SPRAY (h4)	SITE	SNOWFALL (h1)	TORNADO (h2)	STORMS (h3)	SALT SPRAY (h4)
ARKANSAS NUCLEAR ONE	6	0.00045	0.067	0	MONTICELLO	46	0.0001218	0.08	0
ARNOLD	33	0.000257	0.25	0	NINE MILE POINT	89	0.0000058	0.06	0
BEAVER VALLEY	45	0.0000692	0.03	0	NORTH ANNA	15	0.0000367	0.08	0
BELLEFONTE	4	0.000253	0.029	0	OCONEE	6	0.000038	0.12	0
BIG ROCK POINT	97	0.0000183	0.006	0	OYSTER CREEK	17	0.0000038	0.063	0
BRAIDWOOD	40	0.000205	0.08	0	PALISADES	48	0.0001845	0.1	0
BROWNS FERRY	4	0.000415	0.029	0	PALO VERDE	0	0.0000018	0.125	0
BRUNSWICK	2	0.000087	0.12	0	PEACH BOTTOM	22	0.0000601	0.026	0
BYRON	35	0.000118	0.01	0	PERRY	38	0.000066	0.08	0
CALLAWAY	24	0.000106	0.05	0	PILGRIM	42	0.000005	0	0.08
CALVERT CLIFFS	9	0.0000077	0.062	0	POINT BEACH	42	0.000035	0.1	0
CATAWBA	6	0.000104	0.12	0	PRAIRIE ISLAND	46	0.0001713	0.08	0
CLINTON	24	0.000305	0.1	0	QUAD CITIES	40	0.000089	0.15	0
COMANCHE PEAK	4	0.000109	0.05	0	RANCHO SECO	0	0.0000006	0.1	0
COOK	48	0.000145	0.1	0	RIVER BEND	0	0.000154	0.09	0
COOPER	30	0.000248	0.5	0	ROBINSON	1	0.000197	0.09	0
CRYSTAL RIVER	0	0.000013	0.1	0	SALEM	22	0.0000275	0.045	0
DAVIS-BESSE	38	0.000083	0.11	0	SAN ONOFRE	0	0.0000153	0.001	0
DIABLO CANYON0		0.0000001	0.07	0	SEABROOK	65	0.0000291	0.045	0
DRESDEN	40	0.000181	0.08	0	SEQUOYAH	4	0.0001499	0.1	0
FARLEY	0	0.000081	0.05	0	SHOREHAM	26	0.0000251	0.08	0
FERMI	32	0.0000939	0.05	0	SOUTH TEXAS	0	0.000031	0.12	0
FITZPATRICK	89	0.0000057	0.06	0	ST LUCIE	0	0.000013	0.15	0
FORT CALHOUN	29	0.000141	0.5	0	SUMMER	2	0.000106	0.12	0
FORT ST. VRAIN	59	0.000013	0.02	0	SURRY	8	0.000044	0.1	0
GINNA	89	0.0000054	0.06	0	SUSQUEHANNA	44	0.0000292	0.028	0
GRAND GULF	1	0.000392	0.03	0	THREE MILE ISLAND	35	0.0000392	0.027	0
HADDAM NECK	27	0.000089	0.08	0	TROJAN	7	0.0000004	0.14	0
HARRIS	8	0.000222	0.13	0	TURKEY POINT	0	0.000012	0.18	0
HATCH	0	0.000029	0.022	0	VERMONT YANKEE	79	0.0000871	0.04	0
HOPE CREEK	22	0.0000275	0.045	0	VOGTLE	2	0.000036	0.022	0
INDIAN POINT	29	0.0000141	0.08	0	WATERFORD	0	0.000032	0.09	0
KEWAUNEE	42	0.000036	0.1	0	WATTS BAR	10	0.0001422	0.1	0
LASALLE	40	0.000221	0.08	0	WNP-2	53	0.0000002	0.03	0
LIMERICK	22	0.0000285	0.027	0	WOLF CREEK	20	0.0003815	0.23	0
MAINE YANKEE	74	0.000001	0.034	0	YANKEE ROWE	79	0.000068	0.063	0
MCGUIRE	6	0.0000302	0.03	0	ZION	40	0.00005	0.01	0
MILLSTONE	27	0.000046	0	0.18					

NOTE (b): NRC STAFF PROVIDED THE DATA IN TABLE 3-3 USING CLIMATOLOGICAL SOURCES CITED IN THE REFERENCES TO THIS PROCEDURE. NUMARC HAS NOT VERIFIED THE ACCURACY OF THIS DATA.

Table 3-4

SEVERE WEATHER GROUPS (SW)

SW GROUP	ESTIMATED FREQUENCY OF LOSS OF OFFSITE POWER
1	f < 0.0033
2	0.0033 ≤ f < 0.0100
3	0.0100 ≤ f < 0.0330
4	0.0330 ≤ f < 0.100
5	0.10 ≤ f

Part 1D: Evaluate Independence of Off-site Power System (I Group)

The potential for long duration loss of off-site power events can have a significant impact on station blackout risk and required coping durations. Long duration LOOP events are associated with grid failures due to severe weather conditions or unique transmission system features. Shorter duration LOOP events tend to be associated with specific switchyard features. Two features, in particular, are of special importance: (1) the independence of the off-site power sources constituting the preferred power supply to the shutdown buses on-site, and (2) the power transfer schemes when the normal source of AC power is lost.

Two plant groupings are specified in this part for classifying the interface of the preferred power supply to the safe shutdown bus: I1/2 and I3. The I1/2 group is characterized by features associated with greater independence and redundancy of sources, and a more desirable transfer scheme. I3 sites have simpler, less desirable off-site power systems and switchyard capabilities. The importance of the site groupings becomes evident when combined with the potential for losing off-site power due to severe and extremely severe weather.

THE OFF-SITE POWER SYSTEM IS IN THE I3 GROUP IF:

(1) A "YES" ANSWER CAN BE ASSIGNED TO CONDITION "A" BELOW,

AND

(2) A "YES" CAN BE ASSIGNED TO EITHER CONDITIONS "B(1)" OR "B(2)", BELOW.

A. All off-site power sources are connected to the unit's safe shutdown buses through (1) one switchyard, or (2) two or more electrically connected switchyards.

B(1) The normal source of AC power is from the unit main generator and there are no automatic transfers and one or more manual transfers of all safe shutdown buses to preferred or alternate off-site sources.

B(2) The normal source of AC power is from the unit main generator and there is one automatic transfer and no manual transfers of all safe shutdown buses to one preferred or one alternate off-site power source.

OTHERWISE THE SITE IS ASSIGNED TO THE I1/2 GROUP.

Part 1E: Determine Off-site AC Power Design Characteristic Group (P Group)

Site susceptibility to loss of off-site power is separated into three basic groups, based on combinations of features. The determining features are: (1) independence of off-site power, (2) severe weather potential, measured either by experience or recurrence intervals, and (3) extremely severe weather potential. The following tables establish the off-site power design characteristic group.

A. REVIEW THE INDEPENDENCE OF OFF-SITE POWER GROUP, SW GROUP AND ESW GROUP, AND

USE THE FOLLOWING TABLES TO DETERMINE THE OFF-SITE POWER DESIGN CHARACTERISTIC GROUP.

OFF-SITE POWER DESIGN CHARACTERISTIC GROUP MATRIX

I1/2 SITES

SW GROUP \ ESW GROUP	1	2	3	4	5
1	P1	P1	P1	P2	P3
2	P1	~~P2~~ P1	P2	P2	P3
3	P2	P2	P2	P3	P3
4	P3	P3	P3	P3	P3
5	P3	P3	P3	P3	P3

Table 3-5a

I3 SITES

SW GROUP \ ESW GROUP	1	2	3	4	5
1	P2	P2	P2	P2	P3
2	P2	P2	P2	P2	P3
3	P2	P2	P3	P3	P3
4	P3	P3	P3	P3	P3
5	P3	P3	P3	P3	P3

Table 3-6a

NOTE: Coastal plants are susceptible to long duration LOOPS as a result of extremely severe weather associated with hurricanes. As a result, plants with otherwise sufficient EDG reliability and configuration and lower susceptibility to severe weather events may be in a higher coping duration category solely due to the probability of a hurricane induced LOOP.

B. IF A PLANT IS SUSCEPTIBLE TO A HURRICANE INDUCED LOOP AND HAS HURRICANE RESPONSE PROCEDURES WHICH MEET THE GUIDELINES OF SECTION 4.2.3 OF THIS DOCUMENT, USE THE FOLLOWING TABLES TO DETERMINE THE OFF-SITE POWER DESIGN CHARACTERISTIC GROUP.

OFF-SITE POWER DESIGN CHARACTERISTIC GROUP MATRIX

For Hurricane Exposed Plants

I1/2 SITES

SW GROUP \ ESW GROUP	1	2	3	4	5
1	P1	P1	P1	P2•	P3•
2	P1	~~P2•~~ P1	P2*	P2	P3•
3	P2	P2	P2	P3•	P3
4	P3	P3	P3	P3	P3
5	P3	P3	P3	P3	P3

Table 3-5b

I3 SITES

SW GROUP \ ESW GROUP	1	2	3	4	5
1	P2	P2	P2	P2	(P3•)
2	P2	P2	P2	P2	P3•
3	P2	P2	P3*	P3	P3
4	P3	P3	P3	P3	P3
5	P3	P3	P3	P3	P3

Table 3-6b

•DENOTES SITE UPGRADE ATTRIBUTED TO IMPLEMENTATION OF PLANT SPECIFIC PRE-HURRICANE SHUTDOWN REQUIREMENTS AND PROCEDURES WHICH PROVIDE AN ENHANCED 8-HOUR COPING CAPABILITY UNDER ANTICIPATED HURRICANE CONDITIONS.

3.2.2 Step Two: Classify The Emergency AC Power Configuration

After the likelihood of losing off-site power, the redundancy of the emergency AC power system is the next most important contributor to station blackout risk. With greater EAC system redundancy, the potential for station blackout diminishes, as does the likelihood of core damage. The importance of EAC redundancy is reflected in this procedure through the use of four distinct EAC configuration groups:

A - *Characterized by highly redundant and independent EAC sources to safe shutdown equipment;*

B - *Having better than typical redundant and independent EAC sources to safe shutdown equipment;*

C - *Having typical redundant and independent EAC sources to safe shutdown equipment; and,*

D - *Having the lowest level of independency and redundancy in EAC sources powering safe shutdown equipment.*

Placement in one of the groups listed depends on the number of EAC standby power supplies available and the number required to operate AC-powered decay heat removal equipment necessary to achieve and maintain safe shutdown in a station blackout. Overall, the greater the level of EAC redundancy, the less restrictive are the station blackout coping durations and maximum EDG failure rates before longer coping durations are required, or corrective actions become necessary.

The potential for excess EAC power sources to be used as Alternate AC is directly related to the existing level of EAC redundancy. Since EAC redundancy is an important parameter for determining station blackout coping duration categories, EAC power sources relied upon as Alternate AC power sources must not also be considered when assessing the required coping duration.

Accordingly, the following process precludes the use of an EAC power source as both an input to determine the EAC group and an Alternate AC source. This process eliminates the potential for "double counting" the value of an individual EAC power source, both as preventing the station blackout, and in responding to its occurrence.

To illustrate this point, consider a single unit site that has three EAC power sources, and needs only one for safe shutdown. This site can be classified as either a one-out-of-three site (EAC Group A); or a one-out-of-two site (EAC Group C) with the third EAC power source available as a potential Alternate AC power source, if it meets the criteria for Alternate AC specified in Appendix B.

THIS STEP CONSISTS OF THREE PARTS:

PART 2.A	*DETERMINE THE NUMBER OF EAC POWER SUPPLIES NORMALLY AVAILABLE;*
PART 2.B	*DETERMINE THE NUMBER OF NECESSARY EAC STANDBY POWER SUPPLIES; AND,*
PART 2.C	*SELECT THE EAC POWER CONFIGURATION GROUP.*

Part 2.A Determine the Number of EAC Power Supplies Normally Available

A. SINGLE UNIT OR MULTI-UNIT SITES WITH NORMALLY DEDICATED POWER SUPPLIES

Count the total number of standby power supplies (see Appendix A) normally available to the blacked-out unit's safe shutdown equipment that are not being used as an Alternate AC power source.

B. MULTI-UNIT SITES WITH NORMALLY SHARED POWER SUPPLIES

Count the total number of dedicated and shared standby power supplies normally available to safe shutdown equipment at each site that are not being used as an Alternate AC power source.

Part 2.B Determine the Number of Necessary EAC Standby Power Supplies

The number of EAC standby power supplies required for station blackout is based on the AC loads needed at each unit to remove decay heat (including ~~the heat generated by~~ AC-powered decay heat removal systems) in order to achieve and maintain safe shutdown with off-site power unavailable.

The number of EAC standby power sources necessary to operate safe shutdown equipment may be less than that required for LOCA loads.

The number of necessary EAC standby power sources should be determined by accounting for the individual safe shutdown loads, or inferred from the site's design basis for operating Class 1E AC equipment without off-site AC power.

A. SINGLE UNIT OR MULTI-UNIT SITES WITH NORMALLY DEDICATED POWER SUPPLIES

Count the total number of EAC standby power supplies on a per unit basis necessary to operate safe shutdown equipment ~~during a station blackout on a per unit basis.~~ following a loss of offsite power

B. MULTI-UNIT SITES WITH NORMALLY SHARED POWER SUPPLIES

Count the total number of EAC standby power supplies necessary to operate safe shutdown equipment ~~during a station blackout for all units at the site.~~ following a loss of offsite power

---

Part 2.C Select the EAC Power Configuration Group

USE THE TABLE PROVIDED BELOW TO SELECT THE EAC GROUP:

Table 3-7

EAC GROUP	SHARED AND DEDICATED SUPPLIES NECESSARY FOR SAFE SHUTDOWN	SUPPLIES AVAILABLE*
A	1	3 DEDICATED
A	1	4
B	2	5
B	2	4
C	1	2 DEDICATED
C	1	3 SHARED
D	3	4
D	3	5
D	2	3
D	1	2 SHARED

Dedicated -- for EAC standby power supplies not normally shared with other units at a site

Shared -- for EAC standby power supplies in which some number are normally capable of providing AC power to safe shutdown equipment at more than one unit at a site, ~~concurrently.~~

*** If any of the EAC power sources are normally shared among units at a multi-unit site, this is the total number of shared and dedicated sources for those units at the site.**

3.2.3 Step Three: Determine The Calculated EDG Reliability

The unit EDG reliability is used in conjunction with the site's off-site power design characteristics (i.e., P1, P2, or P3), and the EAC configuration (A, B, C, or D) to determine the unit's required station blackout coping duration. The unit EDG reliability is calculated by averaging the individual EDG reliability for the last 20, 50, and 100 demands for each machine. However, if the total number of valid demands is less than 100 (e.g., newly licensed plant, EDGs which have undergone intensive maintenance or a reliability requalification program), the EDG reliability over the last 20, and the last 50 if available, can be averaged and compared to the evaluation criteria in Section 3.2.4. If the unit's EDG reliability over the last 20 demands is > 0.90, or > 0.94 over the last 50 demands, then the unit may select an EDG target reliability of either 0.95 or 0.975 as detailed in Section 3.2.4.

The objective of the three-tier approach to reliability measurement is to provide greater depth of understanding regarding reliability trends. The 20-demand sample set is the most volatile, and offers a very sensitive indication of EDG performance. Since this indicator moves with each incremental failure or success, it is not considered a reliable measure of long-term performance. Similarly, the 100-demand sample set offers a long-term trend indication, while providing limited insight to recent trends due to data smoothing effects. The 50-demand sample set bridges the two indicators while also providing an intermediate level. Taken together, the set of indicators provides a fairly complete picture of EDG reliability.

DETERMINE THE CURRENT UNIT EDG RELIABILITY:

(1) CALCULATE THE MOST RECENT EDG RELIABILITY FOR EACH EDG BASED ON THE LAST 20, 50, AND 100 DEMANDS (USING NSAC-108 DEFINITIONS AND METHODOLOGY CONTAINED IN SECTION 2 OF ~~THAT DOCUMENT~~ OR EQUIVALENT).

(2) CALCULATE THE NUCLEAR UNIT AVERAGE EDG RELIABILITY FOR THE LAST 20 DEMANDS BY AVERAGING THE RESULTS FROM (1), ABOVE.

CALCULATE THE NUCLEAR UNIT AVERAGE EDG RELIABILITY FOR THE LAST 50 DEMANDS BY AVERAGING THE RESULTS FROM (1), ABOVE.

CALCULATE THE NUCLEAR UNIT AVERAGE EDG RELIABILITY FOR THE LAST 100 DEMANDS BY AVERAGING THE RESULTS FROM (1), ABOVE.

3.2.4 Step Four: Determine Allowed EDG Target Reliability

The minimum EDG reliability should be targeted at 0.95 per demand per EDG for plants in EAC Groups A, B, C, and 0.975 per demand per EDG for plants in EAC Group D. These reliability levels should be considered minimum target reliabilities. Each plant should establish an EDG Reliability Program as outlined in Appendix D to this document. Plants which select a target EDG reliability of 0.975 should utilize this target level in their reliability program. If the diesel generator performance falls below the target reliability level specified, action should be taken through an EDG reliability program such as set forth in Appendix D to restore the target reliability level.

The unit EDG reliability for the last 20, 50, and 100 demands calculated in the previous step provides the allowed target reliability used in determining minimum required station blackout coping durations in the next step.

ALLOWED TARGET RELIABILITIES ARE DETERMINED AS FOLLOWS:

(1) COMPARE THE CALCULATED AVERAGE NUCLEAR UNIT EDG RELIABILITY DETERMINED IN SECTION 3.2.3 TO THE CRITERIA BELOW:

Evaluation Criteria

LAST 20 DEMANDS > 0.90 RELIABILITY
LAST 50 DEMANDS > 0.94 RELIABILITY
LAST 100 DEMANDS > 0.95 RELIABILITY

(2) IF THE EAC GROUP IS A, B, OR C, AND ANY OF THE THREE EVALUATION CRITERIA IN SECTION 3.2.4, STEP FOUR, PART (1) ARE MET, THEN THE NUCLEAR UNIT MAY SELECT AN EDG RELIABILITY TARGET OF EITHER 0.95 OR 0.975 FOR DETERMINING THE REQUIRED STATION BLACKOUT COPING DURATION. IF THE EAC GROUP IS D, AND ANY OF THE THREE EVALUATION CRITERIA IN SECTION 3.2.4, STEP FOUR, PART (1) ARE MET, THEN THE ALLOWED EDG RELIABILITY TARGET IS 0.975.

(3) IF THE EAC GROUP IS A, B, OR C, AND NONE OF THE THREE EVALUATION CRITERIA IN SECTION 3.2.4, STEP FOUR, PART (1) ARE MET, THEN 0.95 SHOULD BE USED AS THE RELIABILITY TARGET FOR DETERMINING THE REQUIRED STATION BLACKOUT COPING DURATION.

ADDITIONALLY, IF THE RELIABILITY IS LESS THAN 0.90 BASED ON THE LAST 20 DEMANDS, THEN ACCEPTABILITY OF THE COPING DURATION RESULTING FROM USING 0.95 MAY REQUIRE FURTHER JUSTIFICATION.

IF THE EAC GROUP IS D AND NONE OF THE THREE EVALUATION CRITERIA IN PART (1) ARE MET, THE REQUIRED COPING DURATION CATEGORY CALCULATED IN STEP FIVE, SECTION 3.2.5 SHOULD BE INCREASED TO THE NEXT HIGHEST LEVEL (I.E., FOUR HOURS BECOMES EIGHT HOURS; EIGHT HOURS BECOMES 16 HOURS).

3.2.5 Step Five: Determine Coping Duration Category

USE THE TABLE PROVIDED BELOW TO DETERMINE THE COPING DURATION REQUIREMENT IN HOURS:

Table 3-8

OFFSITE POWER GROUP (From Section 3.2.1)	EAC GROUP (From Section 3.2.2)	ALLOWED EDG TARGET RELIABILITY (Per Demand) (From Section 3.2.4)	REQUIRED COPING DURATION CATEGORY
P1	A	0.950	2
P1	B	0.950	4
P1	C	0.950	4
P1	D	0.975	4
P2	A	0.950	4
P2	B	0.950	4
P2	C	0.975	4
P2	C	0.950	8
P2*	C	0.950	4
P2	D	0.975	8
P2*	D	0.975	4
P3	A	0.975	4
P3	A	0.950	8
P3*	A	0.950	4
P3	B	0.975	4
P3	B	0.950	8
P3*	B	0.950	4
P3	C	0.975	8
P3*	C	0.975	4
P3	C	0.950	16
P3*	C	0.950	8
P3	D	0.975	8
P3*	D	0.975	~~4~~ 8

*** Denotes site upgrade attributable to implementation of plant specific pre-hurricane shutdown requirements and procedures which provide an enhanced coping capability under anticipated hurricane conditions.**

3.2.6 Required Action

Step Five (Section 3.2.5) yields one of the four coping duration categories discussed in the NRC Station Blackout Regulatory Guide 1.155: two hours, four hours, eight hours, or 16-hours. Plants in the eight and 16-hour categories should undertake actions to reduce risk consistent with NUMARC Station Blackout Initiative 1.

THE FOLLOWING COURSES OF ACTION ARE AVAILABLE TO REDUCE THE ASSESSED RISK OF

STATION BLACKOUT:

(1) IMPLEMENT ACTION TO REDUCE THE REQUIRED COPING DURATION TO AT LEAST THE FOUR HOUR CATEGORY BY:

(a) REVIEWING PLANT-SPECIFIC WEATHER DATA;

(b) MODIFYING THE SWITCHYARD TO CHANGE THE I-GROUP; AND/OR,

(c) MODIFYING THE PLANT TO CHANGE THE EDG CONFIGURATION; AND/OR,

(d) IMPROVING EDG RELIABILITY.

(2) INSTALL OR UTILIZE AN EXISTING ALTERNATE AC POWER SOURCE THAT MEETS THE CRITERIA PROVIDED IN APPENDIX B.

4. STATION BLACKOUT RESPONSE PROCEDURES

4.1 OVERVIEW

Most existing plant procedures are based on procedure guidelines generated by NSSS vendors or plant-specific analysis, and provide the operator with substantial direction for responding to a station blackout event. Plant procedures may also address power restoration and severe weather concerns. Actions that may not be addressed in existing procedures, but are important considerations during a station blackout, are addressed below. Utilities should review their plant procedures to assure these considerations are addressed.

As provided by NUMARC Station Blackout Initiative 2, plant staffs should review, and revise as appropriate, their operating procedures using the technical bases and associated guidelines provided in this document. Appropriate plant personnel should be trained on any new or revised procedures resulting from this initiative.

4.2 OPERATING PROCEDURES GUIDELINES

4.2.1 Station Blackout Response Guidelines (NUMARC Station Blackout Initiative 2.a)

This section provides guidance for operator actions to be taken in a station blackout event. Section 4.3.1 contains additional information and bases for the guidelines provided in this section.

These guidelines assume a single path to achieve and maintain safe shutdown conditions in a station blackout. In addition to repeated attempts at restoring AC power to a shutdown bus, the path consists of performing operations designed to stabilize the plant using available equipment. Guideline (1) reflects attempts at AC power restoration which may be made from either the preferred or a standby (Class 1E) power source. If an AAC power source is available, it may also be used to restore power. Guidelines (2) through (13) address items to be considered in stabilizing the plant until AC power is restored.

(1) Plant procedures should identify site-specific actions necessary to restore off-site or standby (Class 1E) AC power sources. If an AAC power source is available, it should be started as soon as possible. Plants relying on AAC power sources should start the AAC power source and commence loading shutdown equipment within the first

hour of a station blackout.

(2) Plant procedures should specify actions necessary to assure that shutdown equipment (including support systems) necessary in a station blackout can operate without AC power.

(3) Plant procedures should recognize the importance of AFWS/HPCIS/HPCS/RCICS during the early stages of the event, and direct the operators to invest appropriate attention to assuring their continued, reliable operation throughout the transient since this ensures decay heat removal.

(4) Plant procedures should identify the sources of potential reactor inventory loss and specify actions to prevent or limit significant loss.

(5) Plant procedures should ensure that a flowpath is promptly established for makeup flow from the CST to the steam generator/nuclear boiler and identify backup water sources to the CST in order of intended use. Additionally, plant procedures should specify clear criteria for transferring to the next preferred source of water.

(6) Plant procedures should identify individual loads that need to be stripped from the plant DC buses (both Class 1E and non-Class 1E) for the purpose of conserving DC power.

(7) Plant procedures should specify actions to permit appropriate containment isolation and safe shutdown valve operations while AC power is unavailable. These actions may include:

(a) providing additional bottled air or nitrogen at the valves;

(b) specifying manual valve operation to maintain shutdown (e.g., manual valve seating to reduce system losses)

(c) ensuring appropriate containment integrity.

(8) Plant procedures should identify the portable lighting necessary for ingress and egress to plant areas containing shutdown or AAC equipment requiring manual operation.

(9) Plant procedures should consider the effects of AC power loss on area access, as well as the need to gain entry to other locked areas where remote equipment operation is necessary.

(10) Plant procedures should consider loss of ventilation effects on specific energized equipment necessary for shutdown (e.g., those containing internal electrical power supplies or other local heat sources that may be

energized or present in a station blackout). These procedures should address:

(a) specific room or cabinet temperatures or symptoms (e.g., alarms or indication of loss of cooling) readily identifiable by the operator, and the response thereto;

(b) methods for providing necessary ventilation and/or supplemental cooling within 30 minutes;

(c) the potential need for operator action to override HPCIS/RCICS steam line isolation on high temperature;

(d) opening cabinet doors containing instrumentation in control rooms necessary for safe shutdown in a station blackout within 30 minutes~~(as required)~~; and,

(e) effects of actuation of fire protection features due to elevated temperature.

(11) Plant procedures should consider habitability requirements at locations where operators will be required to perform manual operations.

(12) Non-Class 1E equipment relied upon to cope for the required station blackout coping duration should be addressed in a maintenance program.

(13) Plant procedures should consider loss of heat tracing effects for equipment necessary to cope with a station blackout. ~~Alternate steps, if needed, should be identified to supplement planned action~~.

4.2.2 AC Power Restoration (NUMARC Station Blackout Initiative 2.b)

This section provides guidance for operations and load dispatcher personnel concerning the proper course of action for restoring AC power in a station blackout. Section 4.3.2 contains additional information and bases for the guidelines provided in this section.

(1) Load dispatchers should give the highest possible priority to restoring power to nuclear units. Procedures and training should consider several potential methods of transmitting power from blackstart capable units to the nuclear plant.

(2) Should incoming transmission lines to a nuclear power plant be damaged, high priority should be assigned to repair and restoration activities to at least one line capable of feeding shutdown equipment.

(3) Repair crews engaging in power restoration activities for nuclear units should be given high priority for manpower, equipment, and materials.

(4) Portable AC generators should be designated as backup sources, if available, and directed to nuclear power plant sites. Procedures should address pre-planned actions and identify required equipment.

(5) Once preferred and/or standby (Class 1E) AC power becomes available, station procedures should specify the sequence of circuit breaker operations required to restore AC power to shutdown equipment. Any additional actions such as pulling or replacing fuses should also be identified.

4.2.3 Severe Weather Guidelines (NUMARC Station Blackout Initiative 2.c)

This section provides guidance for operators to determine the proper course of action due to the onset of severe weather, particularly hurricanes. Section 4.3.3 contains additional information and bases for the guidelines provided in this section.

The characteristics of hurricanes which allow them to be tracked provides advance warning and the opportunity for actions to put the plant into a shutdown condition. These actions can greatly reduce the consequences of a hurricane-induced LOOP with a subsequent station blackout. With sufficient warning, actions may also be taken to enhance the reliability of AC power sources.

Actions for Hurricane

(1) The plant procedures should identify site-specific actions necessary to prepare for the onset of a hurricane. These actions should be initiated when a hurricane warning is issued for the plant site area and should include:

  (a) inspecting the site for potential missiles and reducing this potential;
  (b) reviewing the adequacy of site staff to support operations and repair;
  (c) expediting the restoration of important plant systems and components to service;
  (d) warming and lubricating standby (Class 1E) AC power sources;
  (e) determining the status of Alternate AC sources (if available) and taking necessary actions to ensure their availability;
  (f) increasing CST inventory;
  (g) placing battery chargers in service (if applicable); and,
  (h) start and load test EDGs.

(2) Utility procedures should identify additional plant support staff and the method of contacting them once a hurricane notice has been issued by the National Weather Service.

(3) Plant procedures should specify actions necessary to ensure equipment required for station blackout response is available.

(4) Plant procedures should address the following items prior to a hurricane arrival at a site:

(a) the site-specific indicator should ensure that the plant would be in safe shutdown two hours before the anticipated hurricane arrival at the site (i.e., sustained windspeeds in excess of 73 mph);

(b) operator review of station blackout procedures; and,

(c) operator review of procedures to line up and operate the switchyard spraydown system (if installed).

The actions identified in Items 1-4 above result in a coping categorization consistent with Section 3.2.1, Part 1E(B) and Section 3.2.5 of these guidelines.

Actions for Tornado

Plant procedures should identify site-specific actions necessary to prepare for the onset of a tornado. These actions should include:

(a) inspecting the site for potential missiles and reducing this potential, and

(b) expediting the restoration of important plant systems and components to service.

4.3 SUPPORTING INFORMATION

4.3.1 Station Blackout Response Guidelines

This section provides the bases and related supplemental information for the operating procedure guidelines of Section 4.2.1.

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(1) Plant procedures should identify site-specific actions necessary to restore offsite or standby (Class 1E) AC power sources. If an AAC power source is available it should be started as soon as possible. Plants relying on AAC power sources should start the AAC power source and commence loading shutdown equipment within the first hour of a station blackout.

These actions include:

(a) Early commitment of available staff to restore AC power
This should occur within the first few minutes of a station blackout

(b) Isolating the shutdown bus to be loaded onto the AAC system from the preferred power supply and blacked out unit's Class 1E power sources
This can be achieved by circuit breaker operation, and pulling fuses at the switchgear disabling circuit breaker control power or by manual interlocks.

(c) Starting and/or preparing the AAC source for loading.

(d) Transferring the designated shutdown bus to the AAC system.

---

(2) Plant procedures should specify actions necessary to assure that shutdown equipment (including support systems) necessary in a station blackout can operate without AC power.

Cooling functions provided by such systems as auxiliary building cooling water, service water, or component cooling water may be required in order for shutdown systems to perform their safety function. For example, after TMI it was recognized that a steam driven auxiliary feedwater pump might have relied on component cooling or service water to cool the bearing lubricating oil rather than relying on sump cooling provided by pump discharge. Systems potentially supplemented in this manner may include component/auxiliary cooling water, service water, and auxiliary/reactor building cooling water systems.

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(3) Plant procedures should recognize the importance of AFWS/HPCIS/HPCS/RCICS during the early stages of the event and direct the operators to invest appropriate attention to assuring its continued, reliable operation throughout the transient since this ensures decay heat removal.

The risk of core damage due to station blackout can be significantly reduced by assuring the availability of AFWS/HPCIS/HPCS/RCICS, particularly in the first 30 minutes to one hour of the event. A substantial portion of the decay and sensible reactor heat can be removed during this period. AFWS/HPCIS/HPCS/RCICS availability can be assured by providing a reliable supply of condensate, monitoring turbine conditions (particularly lubricating oil flow and temperature), and maintaining nuclear boiler/steam generator water levels. This step helps to ensure that the core remains adequately covered and cooled during a station blackout event.

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(4) Plant procedures should identify the sources of potential reactor inventory loss, and specify actions to prevent or

limit significant loss.

Actions should be linked to clear symptoms of inventory loss (e.g., specific temperature readings provided by sensors in relief valve tail pipes), associated manual or DC motor driven isolation valves, and their location. Procedures should establish the priority for manual valve isolation based on estimated inventory loss rates early in the event. If manual valves are used for leak isolation, they should be accessible, sufficiently lighted for access and use, and equipped with a handwheel, chain, or reachrod. If valves are locked in position, keys or cutters should be available in the control room. Procedures should identify the location of valves, keys, and cutters.

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(5) *Plant procedures should ensure that a flowpath is promptly established for makeup flow from the CST to the steam generator/nuclear boiler and identify backup water sources to the CST in order of intended use. Additionally, plant procedures should specify clear criteria for transferring to the next preferred source of water.*

All stored water sources may be assumed to be available in a station blackout at their nominal capacities, including water stored in non-safety tanks. Alternate water delivery systems can be considered available on a case by case basis. In general, all condensate storage tanks should be used first. The main condenser may be assumed to be available if a pump can be operated and is capable of making up (1) to the AFW/HPCI/HPCS/RCIC pump suction with sufficient head and flow, or (2) directly to a CST (safety or non-safety). After the CSTs are exhausted, demineralized or borated water tanks may be used as appropriate. Heated torus water should be used only if sufficient NPSH can be established. Finally, when all other preferred water sources have been depleted, lower water quality sources may be pumped as makeup flow using available equipment (e.g. a diesel driven fire pump). Procedures should clearly specify the conditions when the operator is expected to resort to increasingly impure water sources.

---

(6) *Plant procedures should identify individual loads that need to be stripped from the plant DC buses (both Class 1E and non-Class 1E) for the purpose of conserving DC power.*

DC power is needed in a station blackout for such loads as shutdown system instrumentation, EDG field flashing, circuit breaker operations, and motor-driven valve operators. Emergency lighting may also be powered by safety-related batteries. However, for many plants, this lighting may have been supplemented by Appendix R and security lights, thereby allowing the emergency lighting load to be eliminated. Station blackout procedures should direct operators to conserve DC power during the event by stripping nonessential loads as soon as practical. Early load stripping can significantly extend the availability of the blacked-out unit's Class 1E batteries. For plants with turning gear loaded on the batteries, stripping this load early in the transient can also significantly extend battery availability. In certain circumstances, AFW/HPCI/HPCS/RCIC operation may be extended by throttling flow to a constant rate, rather than by stroking valves in open-shut cycles.

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(7) *Plant procedures should specify actions to permit appropriate containment isolation and safe shutdown valve operations while AC power is unavailable.*

Compressed air is used to operate (cycle) some valves used for decay heat removal and in reactor auxiliary systems (e.g. identifying letdown valves or reactor water cleanup system valves that need to be closed). Valves requiring manual valve operations are identified in Section 7.2.3. Most containment isolation valves are in the normally closed or failed closed position during power operation. Many other classes of containment isolation valves are not of concern during a station blackout. Section 7.2.5 provides guidance on determining valves of concern which need to be capable of being closed.

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(8) *Plant procedures should identify the portable lighting necessary for ingress and egress to plant areas containing shutdown or AAC equipment requiring manual operation.*

Areas requiring continuous occupancy for instrumentation monitoring or equipment operation may require portable lighting as necessary to perform essential functions. Lighting provided to meet the requirements of Section III.J, 10 CFR 50 Appendix R, for achieving safe shutdown is generally adequate if it is independent of the preferred and emergency AC power system.

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(9) *Plant procedures should consider the effects of AC power loss on area access, as well as the need to gain entry to other locked areas where remote equipment operation is necessary.*

At some plants, the security system may be adversely affected by the loss of the preferred or Class 1E power supplies in a station blackout. In such cases, manual actions specified in station blackout response procedures may require additional actions to obtain access.

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(10) *Plant procedures should consider loss of ventilation effects on specific energized equipment necessary for shutdown (e.g., those containing internal electrical power supplies or other local heat sources that may be energized or present in a station blackout).*

Station blackout procedures should identify specific actions to be taken to ensure that equipment failure does not occur as a result of a loss of forced ventilation. Actions should be tied to either the actual loss of AC power or upon reaching certain temperatures in the plant. Plant areas requiring additional cooling are likely to be locations containing shutdown instrumentation and power supplies, turbine-driven decay heat removal equipment, and in the vicinity of the inverters. These areas include: steam driven AFW pump room, HPCIS/HPCS and RCICS pump rooms, the control room, and logic cabinets. Cooling may be accomplished by opening doors to rooms and electronic and relay cabinets, and/or providing supplemental cooling.

Air temperatures may be monitored during a station blackout event through the use of locally mounted thermometers inside cabinets and in plant areas where cooling may be needed. Alternatively, procedures may direct the operator to take action to provide for alternate cooling in the event normal cooling is lost. Upon loss of these systems, or indication of temperatures outside the maximum normal range of values, the procedures should direct supplemental cooling be provided to the affected cabinet or area, and/or designate alternate means for monitoring system functions.

For the limited cooling requirements of a cabinet containing power supplies for instrumentation, simply opening the back doors is effective. For larger cooling loads, such as HPCIS/HPCS, RCICS, and AFWS pump rooms, portable engine-driven blowers may be considered during the transient to augment the natural circulation provided by opening doors. The necessary rate of air supply to these rooms may be estimated on the basis of rapidly turning over the room's air volume.

Temperatures in the HPCI pump room and/or steam tunnel for a BWR may reach levels which isolate HPCIS or RCICS steam lines to protect against a steam line break. Supplemental cooling or the capability to override the isolation feature may be necessary at some plants. The procedures should identify the corrective action required, if necessary.

Actuation setpoints for fire protection systems are typically at 165 - 180 °F. It is expected that temperature rises due to loss of ventilation during a station blackout will not be sufficiently high to initiate actuation of fire protection systems. If lower fire protection system setpoints are used or temperatures are expected to exceed these temperatures during a station blackout, procedures should identify actions to avoid such inadvertent actuations.

---

(11) Plant procedures should consider habitability requirements at locations where operators will be required to perform manual operations.

Due to elevated temperatures in some locations where manual valve actions are required, procedures should identify the protective clothing or other equipment or actions necessary to protect the operator from high temperatures on valve handwheels or other control equipment as appropriate. Control room habitability is discussed in Section 2.7.2.

---

(12) Non-Class 1E equipment relied upon to cope for the required station blackout duration should be addressed in a maintenance program.

Typical maintenance programs for non-Class 1E equipment consider vendor recommendations or other industry programs for maintenance and surveillance activities as well as procurement for spare parts. Such programs provide assurance of the application of appropriate quality standards providing an acceptable confidence in the availability of equipment.

---

(13) Plant procedures should consider loss of heat tracing effects for equipment required to cope with a station blackout. Alternate steps, if needed, should be identified to supplement planned action.

Heat tracing is used at some plants to ensure cold weather conditions do not result in freezing important piping and instrumentation systems with small diameter piping. Procedures should be reviewed to identify if any heat traced systems are relied upon to cope with a station blackout. For example, additional condensate makeup may be supplied from a system exposed to cold weather where heat tracing is needed to ensure control systems are available. If any such systems are identified, additional backup sources of water not dependent on heat tracing should be identified. Control room habitability is discussed in Section 2.7.

4.3.2 AC Power Restoration Guidelines

This section provides the bases and related supplemental information for the AC power restoration procedure guidelines of Section 4.2.2.

---

(1) Load dispatchers should give the highest possible priority to restoring power to nuclear units. Procedures and training should consider several potential methods of transmitting power from blackstart capable units to the nuclear plant.

During a complete loss of AC power, other power stations may be affected by the initiating event. Grid load dispatchers should give high priority to locating alternate transmission sources in order to restore power to the affected nuclear unit.

---

(2) Should incoming transmission lines to a nuclear power plant be damaged, high priority should be assigned to repair and restoration activities to at least one line capable of feeding shutdown equipment.

Multiple incoming transmission lines to a plant switchyard exist at most nuclear utilities. However, it is not necessary to restore all lines in order to feed the necessary shutdown equipment. Transmission line repair should be prioritized in such a way as to ensure that the most efficient manner of AC power restoration is achieved.

---

(3) Repair crews engaging in power restoration activities for nuclear units should be given high priority for manpower, equipment, and materials.

During severe weather conditions, repair activities will be competing for repair resources and manpower. Procedures should be implemented to ensure that repair crews are assigned on a priority basis to tasks related to power restoration to nuclear units. Manpower, equipment, and materials should also be allocated to these crews on a priority basis.

---

(4) Portable AC generators should be designated as backup sources if available and directed to nuclear power plant sites. Procedures should address pre-planned actions and identify required equipment.

The use of portable generators as backup sources of AC power, whether located on-site or locally contracted, should be considered whenever possible. Procedures should be in place to instruct plant operations personnel concerning:

(a) backup generator location and contact personnel;

(b) means of transporting portable generators from outside the plant (e.g., tractor trailer); and,

(c) location of equipment necessary to connect the backup generator to the plant's electrical system.

---

(5) Once preferred and/or standby (Class 1E) AC power becomes available, station procedures should specify the sequence of circuit breaker operations required to restore AC power to shutdown equipment. Any additional actions such as pulling or replacing fuses should also be identified.

Numerous circuit breaker trips will likely occur in the event of a loss of AC power. Plant procedures should address breaker operation sequencing to facilitate AC power restoration as well as identify any additional operator actions such as pulling or installing fuses.

4.3.3 Severe Weather Guidelines

This section provides the bases and related supplemental information for the operating procedure guidelines of Section 4.2.3.

Actions For Hurricane

---

(1) *The plant procedures should identify site-specific actions necessary to prepare for the onset of a hurricane. These actions should be initiated when a hurricane warning is issued for the plant site area.*

The likelihood of core damage due to station blackout can be significantly reduced by taking actions in anticipation of a hurricane. The National Weather Service issues hurricane warnings approximately 24 hours prior to the expected onset of hurricane conditions. This provides ample time for verifying the availability of the Class 1E and Alternate AC power sources and can reduce the potential for a station blackout should a hurricane cause the loss of off-site power. If diesels are load tested, procedures should specify that they should be load-tested more than 2 hours before ~~sufficiently prior to~~ the anticipated hurricane arrival at the site to preclude the possibility of common cause failure (resulting from potential storm effects) involving the diesel generator and the preferred power supply. Similarly, enhancing the ability to respond to a station blackout event can further reduce the likelihood of core damage. ~~Note that if the EDGs are load tested within a few hours of the expected hurricane arrival at the site, they should not be run in parallel with offsite power to preclude the potential for EDG loss upon the LOOP.~~

---

(2) *Utility procedures should identify additional plant staff to be recalled in order to support the present staff and the means to contact them once a hurricane notice has been issued by the National Weather Service.*

The normal plant operations staff may not be adequate to deal with the added activities necessary to mitigate the effects of a hurricane. Utility procedures should be responsive to the need to recall additional personnel.

---

(3) *Plant procedures should specify actions necessary to ensure equipment required for a possible station blackout is available.*

With the onset of a severe weather conditions, the potential for a LOOP increases. It is, therefore, necessary to verify the availability and operability of equipment necessary for responding to a station blackout. Any equipment testing in progress should be completed as soon as practical and no unnecessary testing (i.e., testing not associated with surveillance requirements) started until the severe weather warning has been lifted.

Equipment important to station blackout response should include but not be limited to:

(a) *Emergency diesel generators* - EDGs should be kept in a warm standby condition with circulating water and lubricating oil, if possible. Pre-lubricating should also be accomplished if such means are provided.

(b) *Station batteries* - Station batteries should be checked to verify they are charged.

(c) *Decay Heat Removal Systems* - The status of systems supplied from DC or emergency AC power should be determined and appropriate actions should be taken to ensure the availability of such systems.

---

(4) Plant procedures should address the following items prior to a hurricane arrival at a site:

(a) the site-specific indicator should ensure that the plant would be in safe shutdown two hours before the anticipated hurricane arrival at the site (i.e., sustained winspeeds in excess of 73 mph);

(b) operator review of station blackout procedures; and,

(c) operator review of procedures to line up and operate the switchyard spraydown system (if installed).

The possibility of sustaining core damage from a station blackout can be greatly reduced if the plant has been placed in safe shutdown before the anticipated hurricane arrival at the site. Prior to the hurricane-induced LOOP, decay heat is removed by means of the feedwater pump supplying water to either the steam generator (PWR) or directly to the reactor (BWR) and then condensing the steam that has been subsequently generated through the main condenser.

Section 7 of these guidelines provides a methodology for determining the resources needed to cope with a 4-hour station blackout assuming the blackout occurred with the plant operating at 100% power. Removing decay heat prior to the anticipated hurricane-induced LOOP can ~~significantly~~ extend these resources beyond four hours. A plant that is in a coping duration category in excess of four hours because of extremely severe weather associated with a hurricane can provide risk reduction equivalent to the enhanced coping duration periods by undertaking the actions noted in Section 4.2.3 to achieve an enhanced coping capability.

The time to the anticipated hurricane arrival at the site can be estimated to allow sufficient time to extend the nominal 4-hour coping capability to the enhanced eight hour duration. For example, if an off-site power system's transmission towers are designed for hurricane force winds, the LOOP would not be expected prior to exceeding hurricane conditions. The expected arrival of hurricane conditions at a site can be estimated knowing the hurricane's location, the radius of hurricane force winds about the center, the forward speed of the storm, and its likely path. This knowledge can be used to develop a site-specific indicator.

During a station blackout it would be necessary to commence plant shutdown independent of AC power. All personnel involved in the operation of the plant should review the appropriate procedures dealing with an AC independent shutdown. Specific duties, such as manual valve and breaker operations, should be assigned to eliminate confusion or duplication of tasks.

Some utilities have installed spraydown systems to reduce salt spray accumulation on switchyard equipment during severe weather. The alignment and operation of these systems should be reviewed by the appropriate plant personnel.

Actions For Tornado

Plant procedures should identify site-specific actions necessary to prepare for the onset of a tornado. These actions should include:

- *(a) inspecting the site for potential missiles and reducing this potential, and*
- *(b) expediting the restoration of important plant systems and components to service.*

The warning associated with impending tornadoes may not be of sufficient duration to allow extensive actions. However, the above mentioned activities should be undertaken as a minimum as well as any additional actions that may be deemed prudent by plant personnel.

5. COLD STARTS

5.1 DISCUSSION

NUMARC Station Blackout Initiative 3 was structured to provide utility attention toward reducing, as much as possible, cold starting of emergency diesel generators during test conditions. This initiative was prompted by the NRC Staff attention to this issue in NRC Generic Letter 84-15.

For this review, a cold start is considered to be an attempt to start an emergency diesel generator from ambient conditions without the presence of pre-warmed circulating water or pre-lubrication. A continuously pre-warmed and pre-lubed machine would not be considered to have cold starts.

5.2 ACTION

Each plant should ensure that emergency diesel generator tests are performed in a pre-warmed and pre-lubed condition except during an actual demand test required approximately once each scheduled refueling outage unless the emergency diesel generator is normally pre-warmed and pre-lubricated. Plants with EDG cold starts more frequently than once each scheduled refueling outage should either reduce the cold fast start frequency or provide justification for necessary cold starts. Manufacturer recommendations, operational requirements, or regulatory requirements are examples of acceptable justifications. If more frequent testing is currently required by technical specifications, consideration should be given to applying for technical specification relief.

6. EMERGENCY AC POWER AVAILABILITY

6.1 DISCUSSION

NUMARC Station Blackout Initiative 4 calls for monitoring of plant emergency generator unavailability. Further attention to a more comprehensive diesel generator reliability program is addressed in Appendix D of this document.

6.2 ACTION

Each plant, through participation in the industry-wide Plant Performance Indicator program that is managed by INPO, provides regular reports of diesel generator unavailability data. This "other indicator" in the Plant Performance Indicator Program is trended and provided to each plant semiannually. Through this Program each plant monitors plant specific diesel generator unavailability and can compare its performance to an Industry average.

7. COPING WITH A STATION BLACKOUT EVENT

7.1 OVERVIEW

This section provides an overview of a simplified assessment procedure for coping with a station blackout. There are five steps to the procedure, addressing the following topics:

(1) Condensate inventory for decay heat removal;
(2) Assessing the Class 1E battery capacity;
(3) Compressed air;
(4) Effects of loss of ventilation; and,
(5) Containment isolation.

The procedure is structured to utilize information readily available from licensing documents (e.g., FSAR, licensing submittals), existing calculations, purchase specifications, and drawings. For most units, no additional computation or analysis is anticipated. Plant specific analysis may be relied upon as supplemental to or in lieu of the coping assessment in Section 7.2 for the topics listed above.

7.1.1 Coping Methods

For purposes of this assessment, coping methods are separated into two different approaches. The first is referred to as the "AC-Independent" approach. In this approach, plants rely on available process steam, DC power, and compressed air to operate equipment necessary to achieve safe shutdown conditions (i.e., Hot Standby or Hot Shutdown, as appropriate) until off-site or emergency AC power is restored. A second approach is called the "Alternate AC" approach. This method is named for its use of equipment that is capable of being electrically isolated from the preferred off-site and emergency on-site AC power sources. Station blackout coping using the Alternate AC power approach would entail a short period of time in an AC-Independent state (up to one hour) while the operators initiate power from the backup source. Once power is available, the plant would transition to the Alternate AC state and provide decay heat removal until off-site or emergency AC-power becomes available. The AC power sources used in the Alternate AC power approach would be subject to the Appendix B criteria including electrical isolation requirements in order to assure their availability in the event of a station blackout.

Appendix A provides a definition of Alternate AC power sources. Appendix B provides detailed acceptance criteria for an

Alternate AC power source.

7.1.2 Coping Duration

AC-Independent plants must meet the requirements of this methodology for at least four hours (or at least two hours for plants in both emergency AC group A and off-site power group P1). Plants using an Alternate AC power source must assess their ability to cope for one hour. However, if an Alternate AC power source can be shown by test to be available within 10 minutes of the onset of station blackout, then no coping assessment is required. Available within 10 minutes means that circuit breakers necessary to bring power to safe shutdown buses are capable of being actuated in the control room within that period.

7.2 COPING ASSESSMENT

7.2.1 Condensate Inventory for Decay Heat Removal

Discussion

The purpose of this procedure is to ensure that each plant has adequate condensate inventory for decay heat removal during a station blackout for the ~~required duration.~~ coping duration required in Section 3.2.5.

The necessary condensate inventory is assessed by a bounding analysis. If this quantity is less than the Technical Specification minimum requirement for the condensate storage tank (CST), then the plant's current condensate inventory is adequate. If not, other sources of water that can be aligned and transferred under station blackout conditions are identified and considered.

Procedure

Step 1: **Plant Rating**

Record in A the unit's licensed reactor output in megawatts thermal (Mwt) from the unit's operating license. A = ________

for the coping durations required in Section 3.2.5

Step 2: Required Condensate

Determine the number of gallons of water required for decay heat removal as follows: B = ______

$$B = A^*(~~22.12\ GAL/MWt~~)(X\ GAL/MWt) + C$$

where X = 13.14 for 2 hrs
= 22.12 for 4 hrs
= 35.55 for 8 hrs
= 62.90 for 16 hrs

For plants using the one-hour AAC approach, the amount of water that needs to be provided independent of AC power in the first hour of their total required coping duration is determined by the following formula:

$$B = A^*(7.77\ GAL/MWt) + C$$

If emergency operating procedures do not require a primary system cooldown to minimize reactor coolant pump leakage or to maintain decay heat removal capability, then C = zero.

If emergency operating procedures require a primary system cooldown to minimize reactor coolant pump seal leakage or to maintain decay heat removal capability, then C is the amount of water required to support the cooldown.

Record the result as **B**.

Step 3: Technical Specification for CST Volume D = ______

Obtain the minimum permissible usable gallons of water in the CST as found in the unit's Technical Specifications. Record this value as **D**.

Step 4: Review for Adequacy --- CST Quantities Alone

Compare the value of **B** with the value of **D**.

(a) If B is less than D, adequate condensate is available

(b) Otherwise, continue to Step 5.

Step 5: Additional Water Sources

In this step, additional water sources are identified as backup condensate makeup sources for decay heat removal. The following are examples of sources of water which may serve in this role:

Hotwell
Adjacent unit water sources
Fire water tanks
Cooling water pond

River or lake water

NOTE: **Plant procedures need to reflect actions and water sources relied upon in responding to a station blackout event.**

The following criteria must be met prior to assuming the availability of any backup water sources:

(a) A physical connection and transfer capability is provided independent of the preferred power supply and blacked-out unit's Class 1E AC power sources and capable of providing a source of water to the CST or the makeup pump suction.

(b) Plant procedures must exist to accomplish this makeup to the CST.

(c) The source must be be able to be connected before the CST is emptied.

(d) After one hour, an AAC source may be used to provide power to pumps and valves if the equipment is powered from the AAC source.

NOTE: **Water relied on from adjacent units at a multiunit site must be capable of being transferred to the blacked-out unit without adversely affecting adequate decay heat removal activities at the non-blacked-out unit.**

Record below the usable volume of each additional source of water satisfying Criteria (a)-(d), above.

Source 1:________________ Amt. Water (gal.)__________

Source 2:________________ Amt. Water (gal.)__________

Source 3:________________ Amt. Water (gal.)__________

Source 4:________________ Amt. Water (gal.)__________

Total the amount of water from Sources 1 to 4 and record this amount after E. E = ________

Step 6: **Condensate Available**

Sum the values of **D** and **E**. Record the result as **F**. **F =** ________

(i.e. F=D+E)

Step 7: **Test for Adequacy --- With Backup Sources**

Compare the value of **F** to the value of **B**

(a) **If B is less than F, adequate condensate is available.**

(b) **If B is greater than F, return to Step 5 and identify additional water sources.**

Supporting Information

This section provides the analytical basis for the thermal normalized condensate requirement presented in the condensate inventory procedure. The analysis determines the amount of water necessary to remove decay heat for a given duration. The amount of water is then normalized with respect to the thermal rating of the the reactor to obtain the thermal normalized condensate requirement.

Analysis

Figure 7-1 represents a PWR steam generator or BWR reactor vessel with decay heat (Q'), an inlet mass flow rate (m_i') from the condensate storage tank (CST), and exit mass flow rate (m_e').

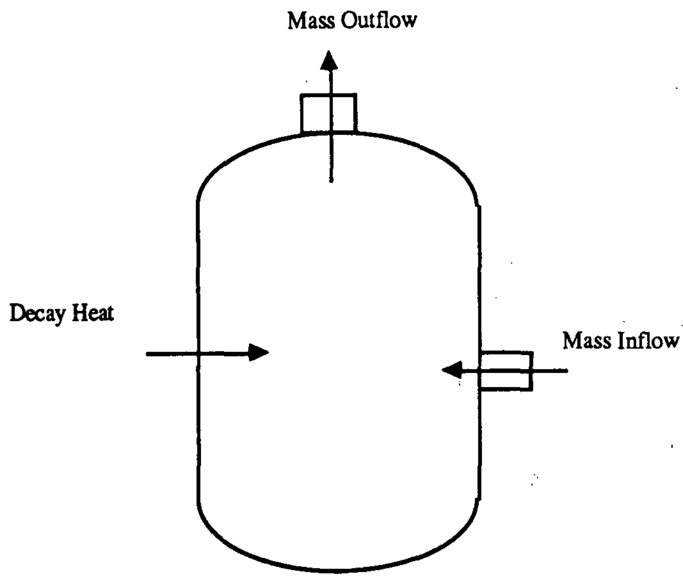


Figure 7-1

Assuming steady state and adiabatic conditions, the equations of mass and energy conservation which describe this system are as follows:

$$m_i' = m_e' = m'$$

$$Q' + m_i'h_i - m_e'h_e = 0$$

These equations can be used to derive an expression for the rate of change of mass in the CST (m_{CST}):

$$Q' = m'(h_e - h_i) = -dm_{CST}/dt\,(h_e - h_i)$$

The amount of condensate necessary to remove decay heat for a given duration (T) is then given by:

$$m_{CST}(0) = \int_0^T Q'/(h_e - h_i)\,dt$$

Results

The right hand side of this equation is evaluated using the following assumptions:

- the reactor has been operating at full power for 100 days
- decay heat is calculated using ANS standard ANS-5.1/N18.6
- there are no stuck open PORVs
- the inlet enthalpy corresponds to the enthalpy of saturated liquid at atmospheric pressure
- the exit enthalpy corresponds to the enthalpy of saturated vapor -- approximately 1200 Btu/lbm for pressures between 100 and 1200 psia

, step 2 formula was developed using 3000 MWt and a 4 hour duration, with sensitivity analyses being performed for a range of 2000 to 4000 MW

A fourth order Runge-Kutta scheme was used to integrate this equation.

7.2.2 Assessing the Class 1E Battery Capacity

Discussion

The purpose of this section is to ensure that each plant has adequate battery capacity to support decay heat removal during a station blackout for the required coping duration.

This procedure offers two analytical methods that can be used to ensure sufficient capacity exits at each unit. IEEE-STD-485, or other design basis battery analysis updated as necessary to reflect current loads, should be used. The two alternatives are outlined below.

(a) Use an existing battery capacity calculation or perform one that verifies sufficient coping capacity under station blackout conditions.

(b) Use an existing battery capacity calculation or perform one that verifies sufficient coping capacity by stripping loads in order to extend the battery life in a station blackout.

NOTE: **All calculations should use the lowest electrolyte temperature anticipated under normal operating conditions.**

Procedure

Battery Capacity Calculation --- No Load Stripping

Step 1: **Review for Battery Adequacy**

Review an existing battery capacity calculation for a station blackout event or perform one for either (a) or (b) below:

(a) **AC-Independent:** **four hours.**

(b) **Alternate AC:** After **one hour.** (assumes battery charger is powered from AAC source)

NOTE: **If an existing battery** capacity **exceeds the above capacity, the rated** battery **capacity should not be reduced solely on the basis of the above station blackout criteria.**

Step 2: **Review for Adequacy - Without Load Stripping**

Compare results of Step 1 to the battery manufacturers capacity curves. If sufficient capacity exists, no further action is required. Otherwise, go to the Load Stripping Case.

Battery Capacity Calculation --- With Load Stripping

Step 1: **List DC Loads to Be Stripped**

List loads on the Class 1E batteries that are not required to cope with a station blackout and can be stripped commencing 30 minutes after the initiation of the station blackout event:

____

____

____

NOTE: **Loads listed above to be stripped must be based on actions reflected in plant procedures and which can be accomplished under station blackout conditions.**

Step 2: **Adjust Duty Cycle Curves**

Delete the loads listed in Step 1 from the unstripped load duty cycle curves in the battery capacity calculation. Recalculate the maximum section size and follow the steps used in the calculation to assess Class 1E battery capacity.

Step 3: Review for Adequacy --- With Load Stripping

Compare results of Step 2 to the battery manufacturer's capacity curves. If sufficient battery capacity exists with load shedding, no further action is required.

Otherwise, battery capacity (IEEE-STD-485, or equivalent) must be extended further to meet the required station blackout coping duration. Acceptable means for extending battery capacity include the addition of batteries or the addition of a battery charging system for the existing batteries provided the source of power for the charging system is independent of both the preferred power source and the blacked out unit's Class 1E power system. Assure that the required additional capacity is achieved.

Supporting Information

The total DC power requirements for a four hour station blackout (one hour for AAC plants) depend on the required loads, their duration of operation, and the capacity of the batteries to hold a charge. The batteries' capacity varies with the rate of discharge, which also varies with the loads. Consequently, the amount of energy recoverable from the batteries depends to a large measure on the rate of discharge associated with the station blackout response loads and initial electrolyte temperature. The battery's ability to discharge stored energy is defined in a series of battery curves provided by the manufacturer. Capacity curves are generally provided for discharge periods ranging from five minutes to upwards of 16 hours.

The capacity of storage batteries varies with electrolyte temperature. This temperature depends on room temperature which may vary in certain circumstances with the season of the year. Calculations should be performed assuming the lowest temperature normally expected for the battery.

The station blackout loads can be estimated from design basis accident loads since they are generally a subset of these loads. They may be classified as being one of three categories: (1) continuous, (2) discontinuous, and (3) momentary loads. Continuous loads are required for the duration of the station blackout event. Inverters and annunciators required for instrumentation and control are common examples of continuous loads. Discontinuous loads are required for short durations throughout the event. Examples of these loads include motor-operated valves and loads necessary to support circuit breaker operations. Momentary loads are of a temporary nature and are required only once or for a limited number of cycles. EDG field flashing is an example of a momentary load that should be considered when determining battery loads.

Knowing the magnitude and timing of loads, it is possible to use the battery capacity curves provided for each plant to determine whether sufficient capacity is available for a four hour station blackout (one hour for AAC plants).

The DC power requirements for a required station blackout may be estimated using the same methodology for which the plant is licensed. The generally accepted methodology is *IEEE Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations* (IEEE-STD-485). IEEE-STD-485 incorporates design margins for aging and temperature correction that are addressed in various other industry standards such as *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Large Stationary Type Power Plant and Substation Lead Storage Batteries* (IEEE-STD-450). This methodology calculates battery load requirements for various sections of time. The magnitude of DC loads for each such section of time is referred to as the section size. Various section sizes are calculated in order to construct a battery duty cycle. The battery is then sized to address the maximum section calculated for the entire duty cycle.

7.2.3 Compressed Air

Discussion

The purpose of this section is to ensure that air operated valves required for decay heat removal have sufficient reserve air or can be manually operated under station blackout conditions for the specified duration.

The loss of instrument air in a station blackout can be minimized through a strategy for operator actions. This procedure provides the requisite information for developing that strategy.

Procedure

Step 1: Identify Air-Operated Valves Necessary for Decay Heat Removal

List below all air-operated valves that are required to be cycled during a station blackout.

____

____

____

____

____

____

____

____

____

____

Step 2: Backup Air Supplies

Review each valve listed and identify the valves that are not supplied with air within design pressure and moisture limits from at least one of the following sources for ~~at least four hours~~ the coping duration required in section 3.2.5 (one hour for AAC plants if the compressor is on the AAC supply, ~~otherwise four hours~~).

(a) **Backup air systems**
(compressors with associated valves, instruments etc.) that are:
- **supplied from the adjacent unit (if it is independent of the preferred and blacked out unit's Class 1E power supply), or**
- **powered from Alternate AC power sources, or**
- **powered by DC power.**

(b) **Backup local sources of compressed air or nitrogen located at the valves.**

Step 3: Criteria for Manual Operation

For all valves not supplied by backup sources, determine whether they meet all of the following criteria for manual operation:

(a) **Procedures specify manual operation for valves in a station blackout;**
(b) **Accessible in a station blackout;**
(c) **Identifiable in a station blackout;**
(d) **Necessary tools, reachrods, or chains are normally present;**
(e) **Appropriate indication and means for communication are provided; and,**
(f) **Sufficient manpower is available onshift to accomplish specified tasks**

Step 4: Review for Adequacy --- Manual Valve Operation

If all air-operated valves required for decay heat removal have backup sources or may be manually operated in a station blackout, no further action is required.

Otherwise, return to Step 2.

NOTE: Plant procedures need to reflect the manual actions and backup air supplies assumed to be relied upon in responding to a station blackout event.

Supporting Information

With the initiation of a station blackout, instrument air systems lose their air compressors and begin to depressurize. As the air headers bleed down, operability of the air-operated valves also degrade ultimately resulting in their unavailability. With prolonged loss of instrument air systems, it is possible that decay heat removal and reactor coolant inventory may be adversely affected.

The amount of air needed for decay heat removal depends on the expected number of valve cycles, the failure mode for air operated valves on the reactor coolant system boundary, and the ability to manually cycle or close air operated valves. Atmospheric dump valves on PWRs generally require air for prolonged operation. In contrast, most other valves, such as feedwater regulator valves, generally fail in the "as-is" position. Similarly, reactor coolant pressure boundary valves generally fail as-is, or closed, in order to limit reactor coolant inventory loss. Valves failing in such a manner do not normally require repositioning in a station blackout.

7.2.4 EFFECTS OF LOSS OF VENTILATION

Discussion

The purpose of this section is to determine the average steady state temperature in dominant areas containing equipment necessary to achieve and maintain safe shutdown during a station blackout. Appendix E provides the basis for the procedure contained in this section. This temperature provides a reference point for reasonably assuring the operability of equipment needed to cope with a station blackout using the methodologies outlined in Appendix F.

Plants utilizing an Alternate AC capability need not complete this review if the Alternate AC source is used to power ESF ventilation systems and is available within 10 minutes (see Section 7.1.2).

in all dominant areas of concern

Procedure

Step 1: **Dominant Area Geometry**

Record in A(1) , A(2), A(3), and A(4), as appropriate, **the estimated total room surface area, excluding floors but including ceilings and walls, *measured in square meters*,** for the following rooms/quadrants (as applicable):

(1) Steam Driven AFW Pump Room (PWRs only)
A(1) = ________

(2) HPCI/HPCS Room (BWRs only)
A(2)=________

(3) RCIC Room (BWRs only)
A(3)=________

(4) Main steam tunnel (BWRs only)
A(4) = ________

Step 2: **Dominant Area Heat Generation Rates**

Record in Q(1), Q(2), Q(3), and Q(4), as appropriate, **the heat generation rates, *measured in Watts*,** for the following rooms/quadrants (as applicable):

(1) Steam Driven AFW Pump Room (PWRs only)
Estimate the heat generation rate for this room/quadrant and enter in Q(1)
Q(1)=____________

(2) HPCI/HPCS Room (BWRs only)
Estimate the heat generation rate for this room/quadrant and enter in Q(2)
Q(2)=____________

(3) RCIC Room (BWRs only)

Estimate the heat generation rate for this room/quadrant and enter in Q(3)

Q(3)=__________

(4) Main steam tunnel (BWRs only)

Estimate the heat generation rate for the tunnel and enter in Q(4). The heat transfer correlation presented in Appendix E is adequate to estimate the heat transfer from hot steam pipes to the surrounding air. Thermal radiation heat transfer may be neglected.

Q(4) = __________

NOTE: **See supporting information for the methodology used ~~information~~ to determine the generation rates (Q) for various equipment configurations.**

Step 3: **Determine the Wall Temperatures:**

Determine **the upper bound for wall temperature, *in* °C,** prior to loss of ventilation. A temperature of 40° C (104° F) may be reasonable for nearly all rooms/quadrants. This temperature is later used as the initial air temperature for the room/quadrant in Steps 4 and 5. A different temperature may be used if it can be justified based on actual measurements.

It is assumed that the wall temperature does not change appreciably throughout the transient as shown in Appendix E ~~(2.5°C)~~ (i.e., an increase of 2.5°C or 4.5°F during a 4-hour period)

(1) Steam Driven AFW Pump Room (PWRs only)

T(1) = __________

(2) HPCI/HPCS Room (BWRs only)

T(2)=__________

(3) RCIC Room (BWRs only)

T(3)=__________

(4) Main steam tunnel (BWRs only)

T(4) = __________

Step 4: Calculate the Steady State Room Temperature Following Loss of Ventilation

Calculate the steady state **ambient air temperature, *in* °C,** using Equation (E-18) for the following rooms/quadrants, assuming no additional cooling or natural circulation to the outside environment:

(1) Steam Driven AFW Pump Room (PWRs only)

$T_f(1) = [Q(1)/A(1)]^{(3/4)} + T(1) =$ ________

(2) HPCI/HPCS Room (BWRs only)

$T_f(2) = [Q(2)/A(2)]^{(3/4)} + T(2) =$ ________

(3) RCIC Room (BWRs only)

$T_f(3) = [Q(3)/A(3)]^{(3/4)} + T(3) =$ ________

(4) Main steam tunnel (BWRs only)

$T_f(4) = [Q(4)/A(4)]^{(3/4)} + T(4) =$ ________

Note that this equation is a simplified form of the complete steady state solution. Heat transfer coefficients and thermal properties have been evaluated in MKS units. Therefore, this dimensionally inconsistent equation is valid only with the units specified in Steps 1, 2, and 3.

Step 5: Calculate the Effect of Opening Area Doors

If it is feasible to open a door during the event to allow removal of heat through natural circulation, perform the following steps to determine the effect of opening the door.

5.1 Record in H(1), H(2), H(3), and H(4), as appropriate, the height of the door, *measured in*

meters.

(1) Steam Driven AFW Pump Room (PWRs only)

H(1) = ________

(2) HPCI/HPCS Room (BWRs only)

H(2)=_________

(3) RCIC Room (BWRs only)

H(3)=_________

(4) Main steam tunnel (BWRs only)

H(4) = ________

5.2 Record in W(1), W(2), W(3), and W(4), as appropriate , the width of the door ***measured in meters.***

(1) Steam Driven AFW Pump Room (PWRs only)

W(1) = ________

(2) HPCI/HPCS Room (BWRs only)

W(2)=_________

(3) RCIC Room (BWRs only)

W(3)=_________

(4) Main steam tunnel (BWRs only)

W(4) = ________

5.3 Calculate the door factor F for the following rooms/ quadrants:

(1) Steam Driven AFW Pump Room (PWRs only)

$F(1) = H(1)^{3/2} W(1)$

(2) HPCI/HPCS Room (BWRs only)

$F(2) = H(2)^{3/2} W(2)$

(3) RCIC Room (BWRs only)

$F(3) = H(3)^{3/2} W(3)$

(4) Main steam tunnel (BWRs only)

$F(4) = H(4)^{3/2} W(4)$

5.4 Calculate the steady-state ambient air temperature, in ° C, using Equation (E-27) for the following rooms/quadrants:

(1) Steam Driven AFW Pump Room (PWRs) only)

$T_f(1) = 4 + T(1) + \left[Q(1)^{3/4} / [A(1)^{3/4} + 16.18F(1)^{0.8653}]\right]$

(2) HPCI/HPCS Room (BWRs only)

$T_f(2) = 4 + T(2) + \left[Q(2)^{3/4} / [A(2)^{3/4} + 16.18F(2)^{0.8653}]\right]$

(3) RCIC Room (BWRs only)

$T_f(3) = 4 + T(3) + \left[Q(3)^{3/4} / [A(3)^{3/4} + 16.18F(3)^{0.8653}]\right]$

(4) Main steam tunnel (BWRs only)

$T_f(4) = 4 + T(4) + \left[Q(4)^{3/4} / [A(4)^{3/4} + 16.18F(4)^{0.8653}]\right]$

Note that this equation is a simplified form of the complete steady state solution. Heat transfer coefficients and thermal properties have been evaluated in MKS units. Therefore, this dimensionally inconsistent equation is valid only with the units specified in Steps 1, 2, and 3.

Step 6: **Reasonable Assurance of Equipment Operability**

Use the methodologies in Appendix F to provide a basis that the equipment relied upon to cope with a station blackout will operate at the steady-state temperatures determined in Steps 4 or 5 for the required duration.

Supporting Information

General Discussion

Since station blackout is not considered to be a design basis event, reasonable assurance of equipment operability need not be provided to the same level of precision and detail required by 10 CFR §50.49 for safety related equipment located in harsh environments. For this reason, a representative analysis approach is provided, with attention concentrated on the few situations where equipment operability is especially important to core cooling in a station blackout.

This procedure provides the results of representative analyses for such areas to be reviewed against. Plants that do not conform with the acceptance envelopes for thermal conditions may either perform plant specific analysis, provide additional assurance that equipment survivability can be assured, or provide alternative means of cooling in a station blackout.

The representative analysis provided in this section addresses a limited set of plant areas deemed to be potentially susceptible to heatup upon loss of ventilation, such as would occur in a station blackout. These areas are defined by three factors: (1) their containing equipment normally required to function early in a station blackout to remove decay heat, (2) the presence of significant heat generation terms (after AC power is lost) relative to their free volume (i.e., process steam or DC electrical power supplies in small rooms or enclosures), and (3) the absence of heat removal capability in a station blackout without operator action. These areas and their respective equipment consist of:

(1)	HPCI/HPCS and RCIC rooms (BWR only)	-	decay heat removal equipment
(2)	Steam Driven AFW pump rooms (PWR only)	-	decay heat removal equipment
(3)	Main steam tunnel (BWR only)	-	high temperature cutout for decay heat removal equipment

Areas not addressed in this list are viewed as posing a significantly reduced concern for a variety of reasons. Safe shutdown equipment in many plant areas is already qualified to operate in a harsh environment. The containment is one such harsh environment area. The station blackout event is expected to be bounded by analyses previously performed for these areas. Other plant areas will not be exposed to significant heat generation terms since: (1) a station blackout results in the elimination of process steam from most plant areas, or (2) these areas do not contain equipment required for decay heat removal. In addition, the loss of AC power will eliminate AC motors, switchgear, and lighting from the list of heat generation sources. Finally, the equipment needed to function in a station blackout is limited to a turbine driven feedwater makeup system, atmospheric dump or steam relief valves, batteries, and a small set of instrumentation cabinets.

The loss of ventilation concern is significantly reduced for plants using Alternate AC sources, provided these plants also ensure that sufficient forced ventilation is available to safe shutdown equipment. For these plants, the period of ventilation loss would be limited to the time necessary to restore AC power from an Alternate AC source. This period is no greater than 1 hour, and during this time loss of ventilation is not anticipated to cause equipment problems.

Methodology for Determining Heat Generation Rates (Q)

To determine heat generation rates, it is necessary to evaluate electrical and steam equipment.

(1) Electrical Equipment - identify the nameplate rating of the equipment; convert this rating to Watts, for example:

(Nameplate in Horsepower) X (745.7) = watts

(2) Steam-driven Equipment - use standard formula to determine heat generation rates for the applicable configuration, for example:

Pipes

$$Q=\{0.1[0.4 + 15.7(T_s-T_{air})^{1/6} D^{1/2} + 170.3(T_s-T_{air})^{1/3}D](T_s-T_{air}) + 1.4E\text{-}7D(T^4_s - T^4_w)\}L$$

where

Q = the heat generation rate of the pipe in watts

D = the diameter of the pipe in meters

T_s = the surface temperature of the pipe in °K

T_{air} = the air temperature of the room at station blackout onset in°K

L = the length of the pipe in meters

T_W = the surface temperature of the wall in °K "

Pumps $Q = 0.1(2 + 37.0(Ts - Tair)^{1/4} D^{3/4}) D(Ts - Tair) + 1.4E\text{-}7\ D^2 (Ts^4 - Tair^4)$

where

Q = the heat generation rate of the pump in watts

D = the equivalent diameter of the pump in meters

T_s = the surface temperature of the pump in °K

T_{air} = the air temperature of the room at station blackout onset in °K

Note that this equation models a pumps as a sphere. The equivalent diameter of the pump is determined by using the volume of space that is occupied by the pump to calculate the equivalent diameter of a sphere. This is accomplished by the following relationship:

$$D = (6 * V/\pi)^{1/3}$$

where

V = volume occupied by the pump in meters cubed

π = 3.1415927

7.2.5 Containment Isolation

Discussion

The purpose of this procedure is to ensure that appropriate containment integrity can be provided during a station blackout event for the required duration.

Appropriate containment integrity is defined such that the capability for valve position indication and closure of certain containment isolation valves is provided independent of the preferred or Class 1E power supplies. The containment isolation valves requiring this capability are valves ~~identified in technical specifications~~ that may be in the open position at the onset of a station blackout. Acceptable means of position indication includes local mechanical indication, DC-powered indication (including AC-powered indicators powered through inverters), and Alternate AC-powered indication. Acceptable means of closure include manual operation, air-operation (including air-operated valves that are mechanically closed on loss of air), DC-powered operation, and Alternate AC-powered operation.

Procedure

Step 1: Valve Identification

Review the list of containment isolation valves ~~identified in technical specifications~~ and exclude the following valves from consideration:

(1) valves normally locked closed during operation;
(2) valves that fail closed on loss of AC power or air;
(3) check valves;
(4) valves in non-radioactive closed-loop systems not expected to be breached in a station blackout (with the exception of lines that communicate directly with the containment atmosphere); and,
(5) all valves less than 3-inch nominal diameter.

The remaining valves are the containment isolation valves of concern.

Step 2: Containment Isolation Valves Requiring Manual Operation

List valves from Step 1 that are of concern and which need to be operated to cope with a station blackout event for the required duration (i.e., 2 or 4-hours).

Ensure that these valves can be operated independent of the preferred and Class 1E power supplies and have valve position indication (e.g., local mechanical, DC powered, or Alternate AC powered) that is independent of the preferred and blacked-out unit's Class 1E power supplies.

Step 3: Containment Isolation Valves Requiring Closure Capability

List valves from Step 1 not identified in Step 2. Ensure that these valves can be closed independent of the preferred and Class 1E power supplies and have valve position indication (e.g., local mechanical, DC powered, or Alternate AC powered) that is independent of the preferred and blacked-out unit's Class 1E power supplies.

APPENDIX A. DEFINITIONS

Terms defined below were specifically developed for these guidelines and are of special importance to its use.

ALTERNATE AC POWER SOURCE - An alternating current (AC) power source that is available to and located at or nearby a nuclear power plant and meets the following requirements:

(i) is connectable to but not normally connected to the preferred or on-site emergency AC power systems;

(ii) has minimal potential for common cause failure with off-site power or the on-site AC power sources;

(iii) is available in a timely manner after the onset of station blackout;

(iv) has sufficient capacity and reliability for operation of all systems necessary for coping with a station blackout and for the time required to bring and maintain the plant in safe shutdown (Hot Shutdown or Hot Standby, as appropriate); and,

(v) is inspected, maintained, and tested periodically to demonstrate operability and reliability as set forth in Appendix B.

PREFERRED POWER SUPPLY - that power supply from the transmission system to the Class 1E distribution system which is preferred to furnish electric energy under accident or post-accident conditions. *IEEE-STD-765; IEEE-STD-308; and NUREG/CR-3992, page 2.*

REQUIRED COPING DURATION - the time between the onset of station blackout and the restoration of off-site AC power to safe shutdown buses.

SAFE SHUTDOWN - For the purpose of this procedure safe shutdown is the plant conditions defined in plant technical specifications as Hot Standby or Hot Shutdown, as appropriate (plants have the option of maintaining the RCS at normal operating temperatures or at reduced temperatures).

SEVERE WEATHER - the occurrence of annual average snowfall, tornado of F2 severity or greater, hurricane with salt spray potential, and wind speeds in excess of 75 mph. *NUREG-1032.*

HURRICANE INDUCED LOOPS: - for the purpose of this document, is considered to coincide with anticipated hurricane arrival at the site; and the appropriate indicator is sustained wind speeds at the site in excess of 73 mph.

STANDBY POWER SUPPLY - the Class 1E power supply that is selected to furnish electric energy to shutdown equipment when the preferred power supply is not available. *Based on IEEE-STD-308.*

STATION BLACKOUT - means the complete loss of alternating current (AC) electric power to the essential and nonessential switchgear buses in a nuclear power plant (i.e., loss of off-site electric power system concurrent with turbine trip and unavailability of on-site emergency AC power system). Station Blackout does not include the loss of available AC power to buses fed by station batteries through inverters or by Alternate AC power sources as defined in this appendix, nor does it assume a concurrent single failure or a design basis accident. At a multi-unit site with normally dedicated emergency AC power sources, station blackout is assumed to occur in only one unit.

At single unit sites, any emergency AC power source(s) in excess of the number required to meet the minimum redundancy requirements (i.e. single failure) for safe shutdown is assumed to be available and may be designated as an Alternate AC Power Source(s) provided it meets the Alternate AC power criteria in Appendix B.

At multi-unit sites with normally shared emergency AC power sources, where the combination of emergency AC sources exceeds the minimum redundancy requirements for normal safe shutdown (non-DBA) of all units, the remaining emergency AC power sources may be used as alternative AC power sources provided they meet the alternate AC power criteria in Appendix B. If there are no remaining emergency AC power sources in excess of the minimum redundancy requirements, station blackout must be assumed to occur at all the units.

APPENDIX B. ALTERNATE AC POWER CRITERIA

This appendix describes the criteria that must be met by a power supply in order to be classified as an Alternate AC power source. The criteria focus on ensuring that station blackout equipment is not unduly susceptible to dependent failure by establishing independence of the AAC system from the emergency and non-Class 1E AC power systems.

AAC Power Source Criteria

B.1 The AAC system and its components need not be designed to meet Class 1E or safety system requirements. If a Class 1E EDG is used as an Alternate AC power source, this existing Class 1E EDG must continue to meet all applicable safety-related criteria.

B.2 Unless otherwise provided in this criteria, the AAC system need not be protected against the effects of:

(1) failure or misoperation of mechanical equipment, including (i) fire, (ii) pipe whip, (iii) jet impingement, (iv) water spray, (v) flooding from a pipe break, (vi) radiation, pressurization, elevated temperature or humidity caused by high or medium energy pipe break, and (vii) missiles resulting from the failure of rotating equipment or high energy systems; or

(2) seismic events.

B.3 Components and subsystems shall be protected against the effects of likely weather-related events that may initiate the loss of off-site power event. Protection may be provided by enclosing AAC components within structures that conform with the Uniform Building Code, and burying exposed electrical cable run between buildings (i.e., connections between the AAC power source and the shutdown busses).

B.4 Physical separation of AAC components from safety related components or equipment shall conform with the separation criteria applicable for the unit's licensing basis.

Connectability to AC Power Systems

B.5 Failure of AAC components shall not adversely affect Class 1E AC power systems.

B.6 Electrical isolation of AAC power shall be provided through an appropriate isolation device. If the AAC source is connected to Class 1E buses, isolation shall be provided by two circuit breakers in series (one Class 1E breaker at the Class 1E bus and one non-Class 1E breaker to protect the source).

B.7 The AAC power source shall not normally be directly connected to the preferred or on-site emergency AC power system for the unit affected by the blackout. In addition, the AAC system shall not be capable of automatic loading of shutdown equipment from the blacked-out unit unless licensed with such capability.

Minimal Potential for Common Cause Failure

B.8 There shall be minimal potential for common cause failure of the AAC power source(s). The following system features provide assurance that the minimal potential for common cause failure has been adequately addressed.

(a) The AAC power system shall be equipped with a DC power source that is electrically independent from the blacked-out unit's preferred and Class 1E power system.

(b) The AAC power system shall be equipped with an air start system, as applicable, that is independent of the preferred and the blacked-out unit's preferred and Class 1E power supply.

(c) The AAC power system shall be provided with a fuel oil supply, as applicable, that is separate from the fuel oil supply for the onsite emergency AC power system. A separate day tank supplied from a common storage tank is acceptable provided the fuel oil is sampled and analyzed consistent with applicable standards prior to transfer to the day tank.

(d) If the AAC power source is an identical machine to the emergency onsite AC power source, active failures of the emergency AC power source shall be evaluated for applicability and corrective action taken to reduce subsequent failures.

(e) No single point vulnerability shall exist whereby a likely weather-related event or single active failure could disable any portion of the onsite emergency AC power sources or the preferred power sources, and simultaneously fail the AAC power source(s).

(f) The AAC power system shall be capable of operating during and after a station blackout without any support systems powered from the preferred power supply, or the blacked-out unit's Class 1E power sources affected by the event.

(g) The portions of the AAC power system subjected to maintenance activities shall be tested prior to returning the AAC power system to service.

Availability After Onset of Station Blackout

B.9 The AAC power system shall be sized to carry the required shutdown loads for the required coping duration determined in Section 3.2.5, and be capable of maintaining voltage and frequency within limits consistent with established industry standards that will not degrade the performance of any shutdown system or component. At a multi-unit site, except for 1/2 Shared or 2/3 emergency AC power configurations, an adjacent unit's Class 1E power source may be used as an AAC power source for the blacked-out unit if it is capable of powering the required loads at both units.

Capacity and Reliability

B.10 Unless otherwise governed by technical specifications, the AAC power source shall be started and brought to operating conditions that are consistent with its function as an AAC source at intervals not longer than three months, following manufacturer's recommendations or in accordance with plant-developed procedures. Once every refueling outage, a timed start (within the time period specified under blackout conditions) and rated load capacity test shall be performed.

B.11 Unless otherwise governed by technical specifications, surveillance and maintenance procedures for the AAC system shall be implemented considering manufacturer's recommendations or in accordance with plant-developed procedures.

B.12 Unless otherwise governed by technical specifications, the AAC system shall be demonstrated by initial test to be capable of powering required shutdown equipment within one hour of a station blackout event.

B.13 The Non-Class 1E AAC system should attempt to meet the target reliability and availability goals specified below, depending on normal system state. In this context, reliability and availability goals apply to the overall AAC system rather than individual machines, where a system may comprise more than one AAC power source.

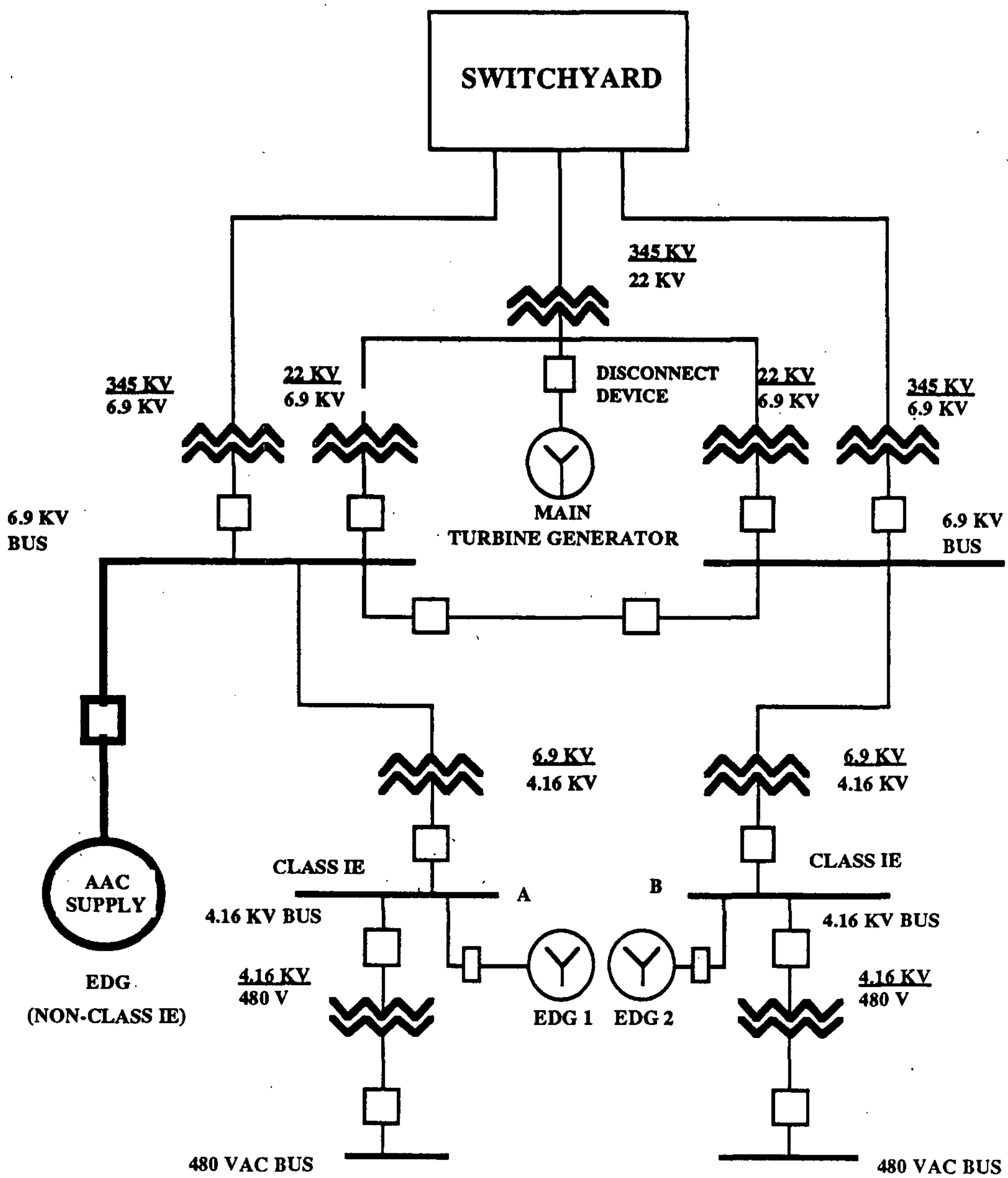
(a) Systems Not Normally Operated (Standby Systems)
System reliability should be maintained at or above 0.95 per demand, as determined in accordance with NSAC-108 methodology (or equivalent).

(b) Systems Normally Operated (Online Systems)

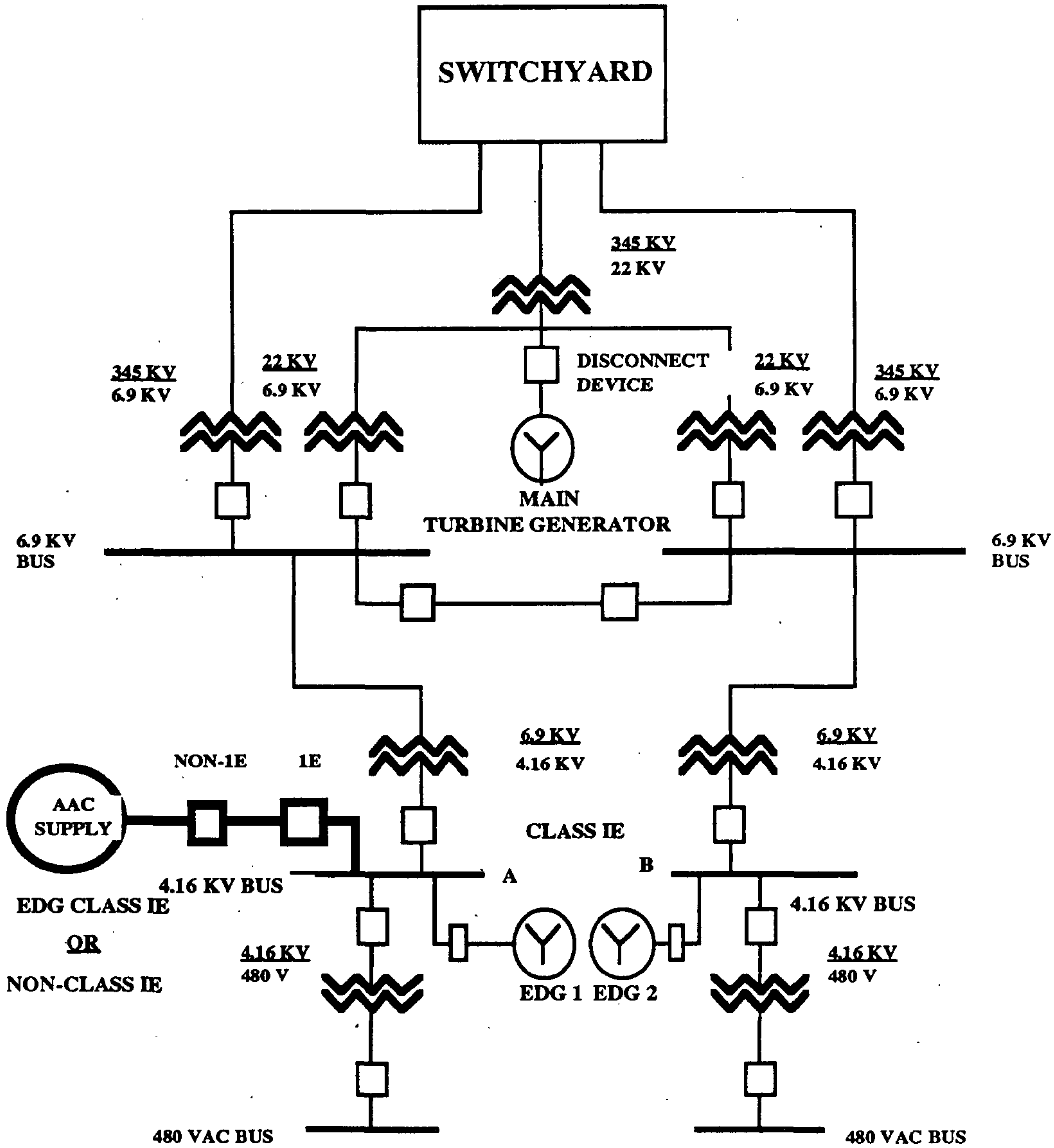
Availability	AAC systems normally online should attempt to be available to its associated unit at least 95% of the time the reactor is operating.
Reliability	No reliability targets or standards are established for online systems.

APPENDIX C. SAMPLE AAC CONFIGURATIONS

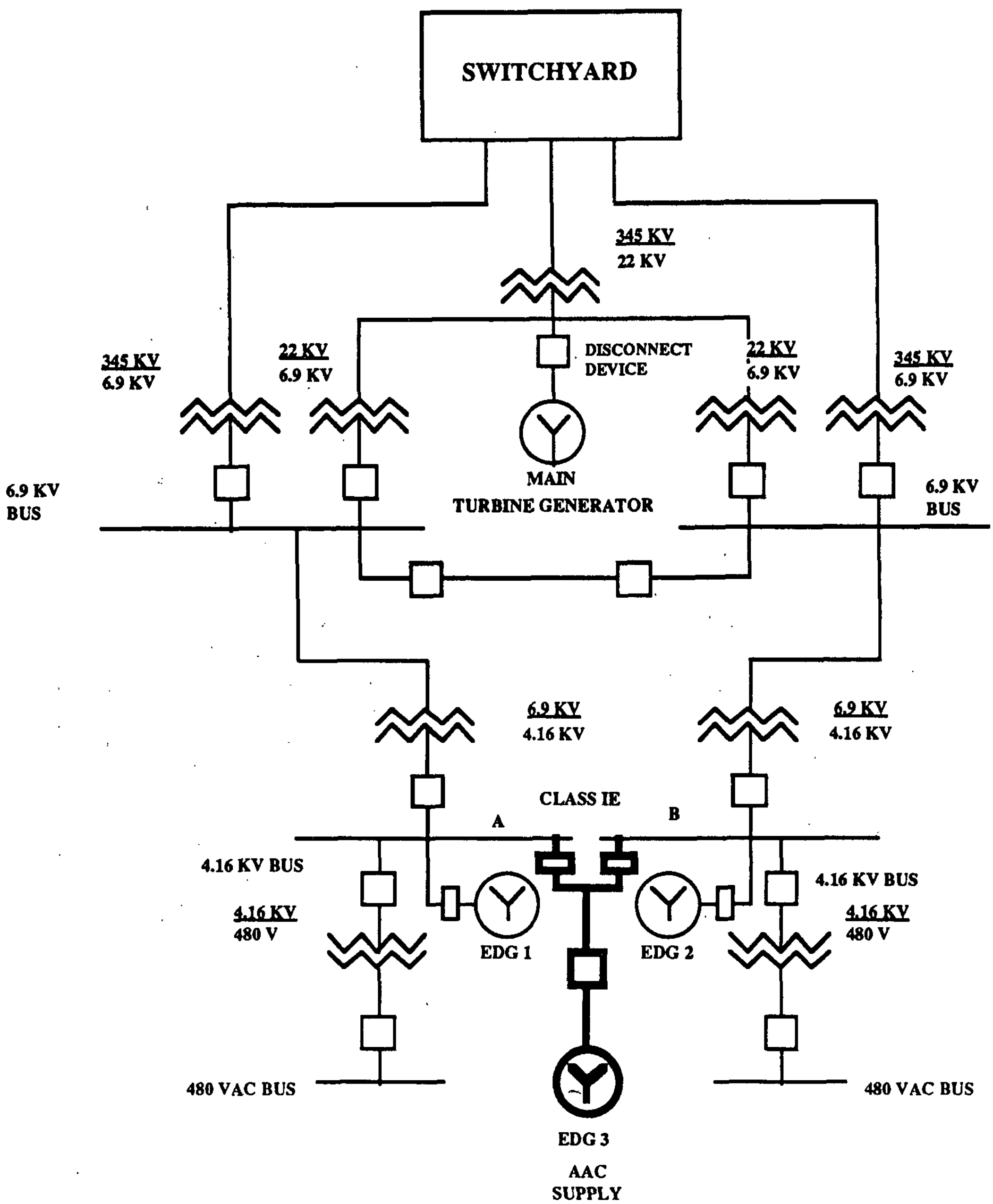
AAC Configuration 1A: Non-Class 1E Power Source



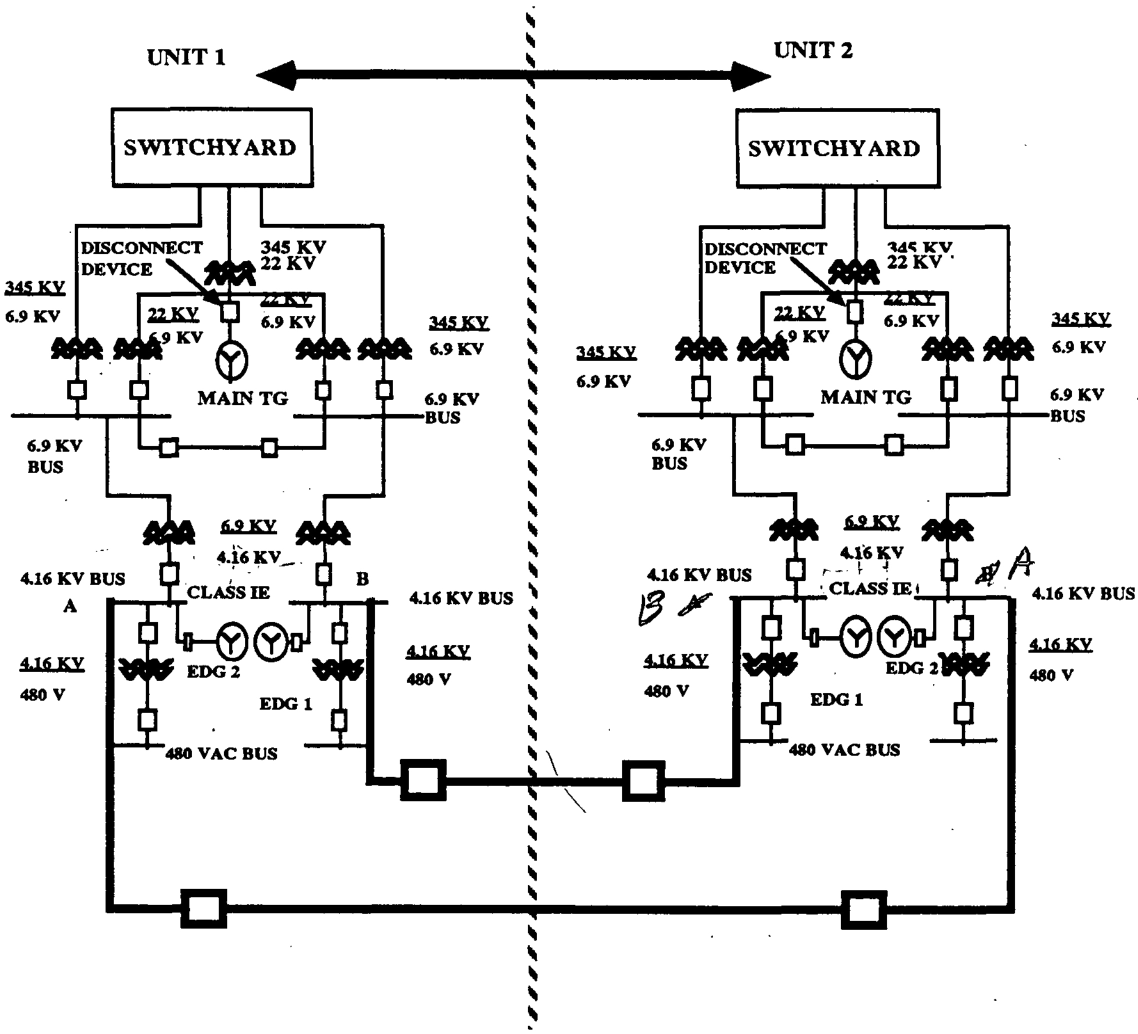
AAC Configuration 1B: DG Class 1E or Non-Class 1E



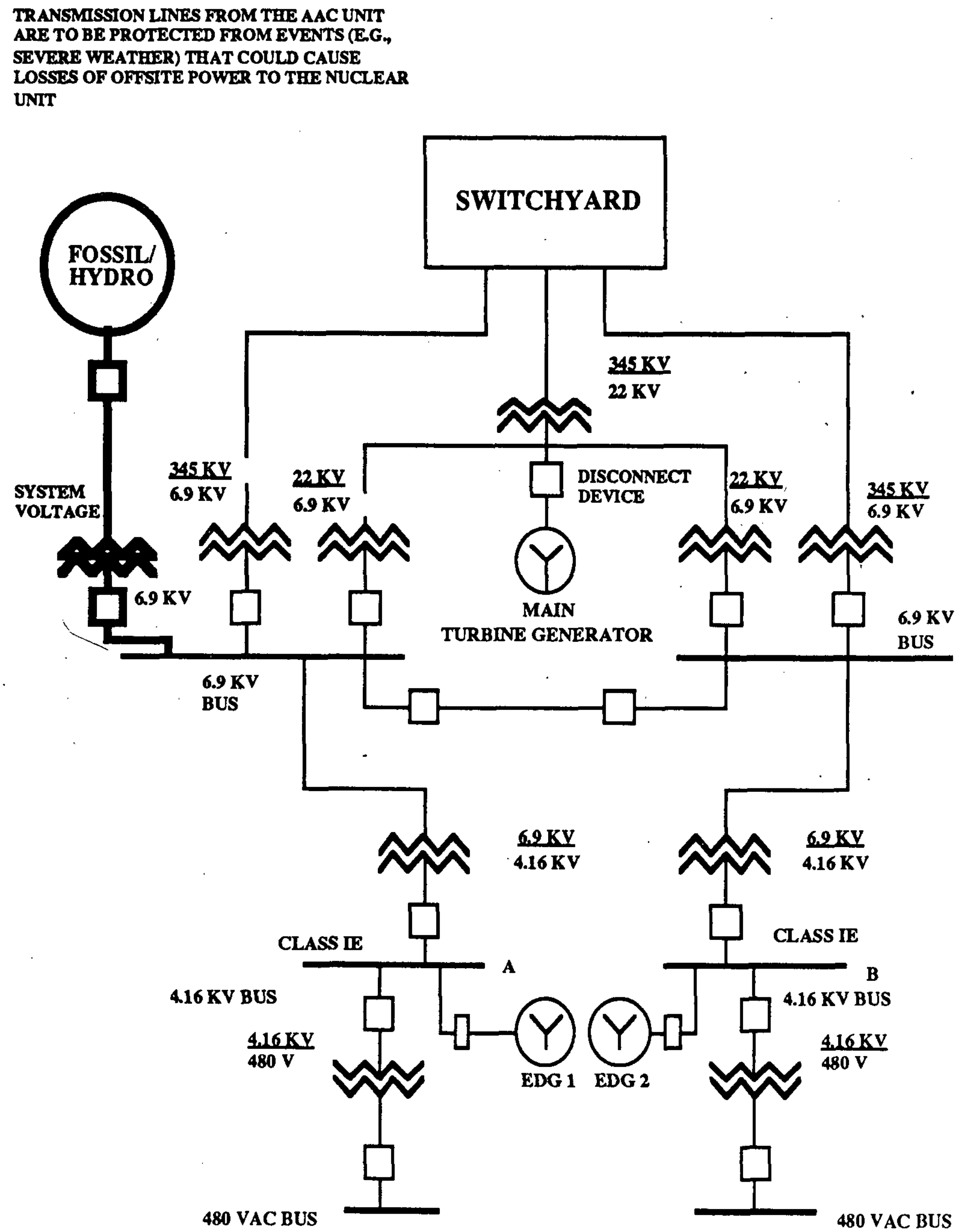
AAC Configuration 2A: Swing Diesel



AAC Configuration 2B: Dedicated Diesels with Cross-tie at Multiunit Site

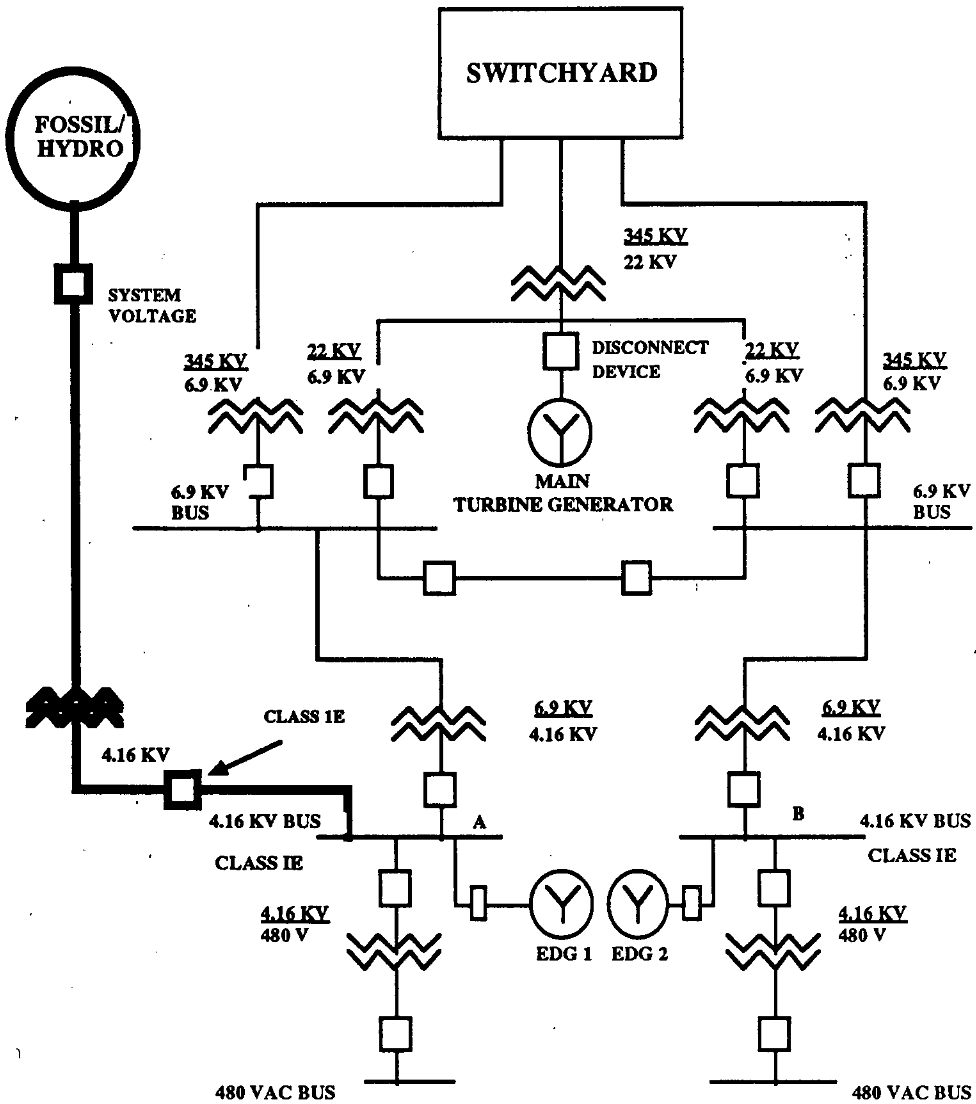


AAC Configuration 3A: Nearby Power Source Connected to Non-Class 1E Bus



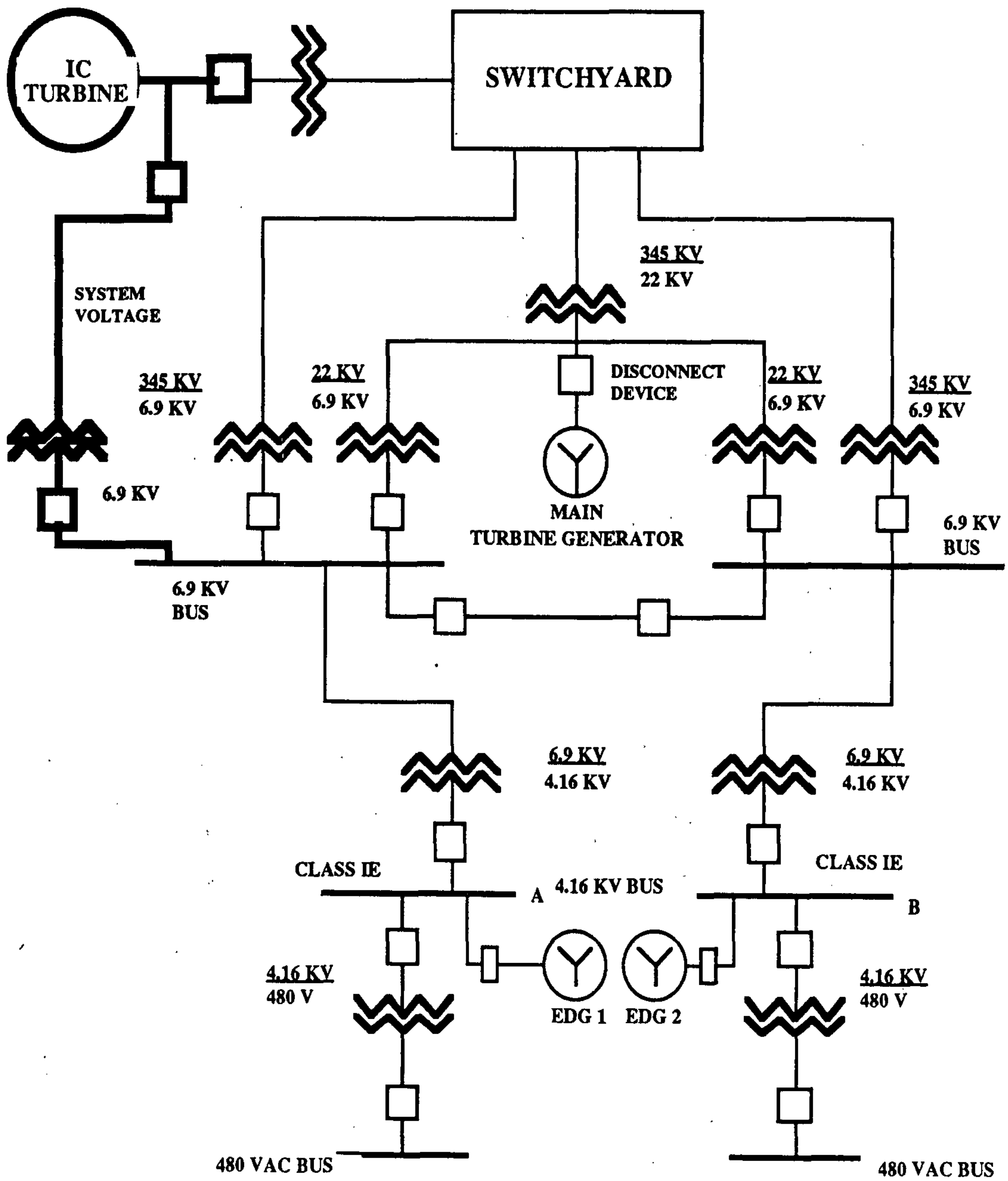
AAC Configuration 3B: Nearby Power Source Connected to a Class 1E Bus

TRANSMISSION LINES FROM THE AAC UNIT ARE TO BE PROTECTED FROM EVENTS (E.G., SEVERE WEATHER) THAT COULD CAUSE LOSSES OF OFFSITE POWER TO THE NUCLEAR UNIT



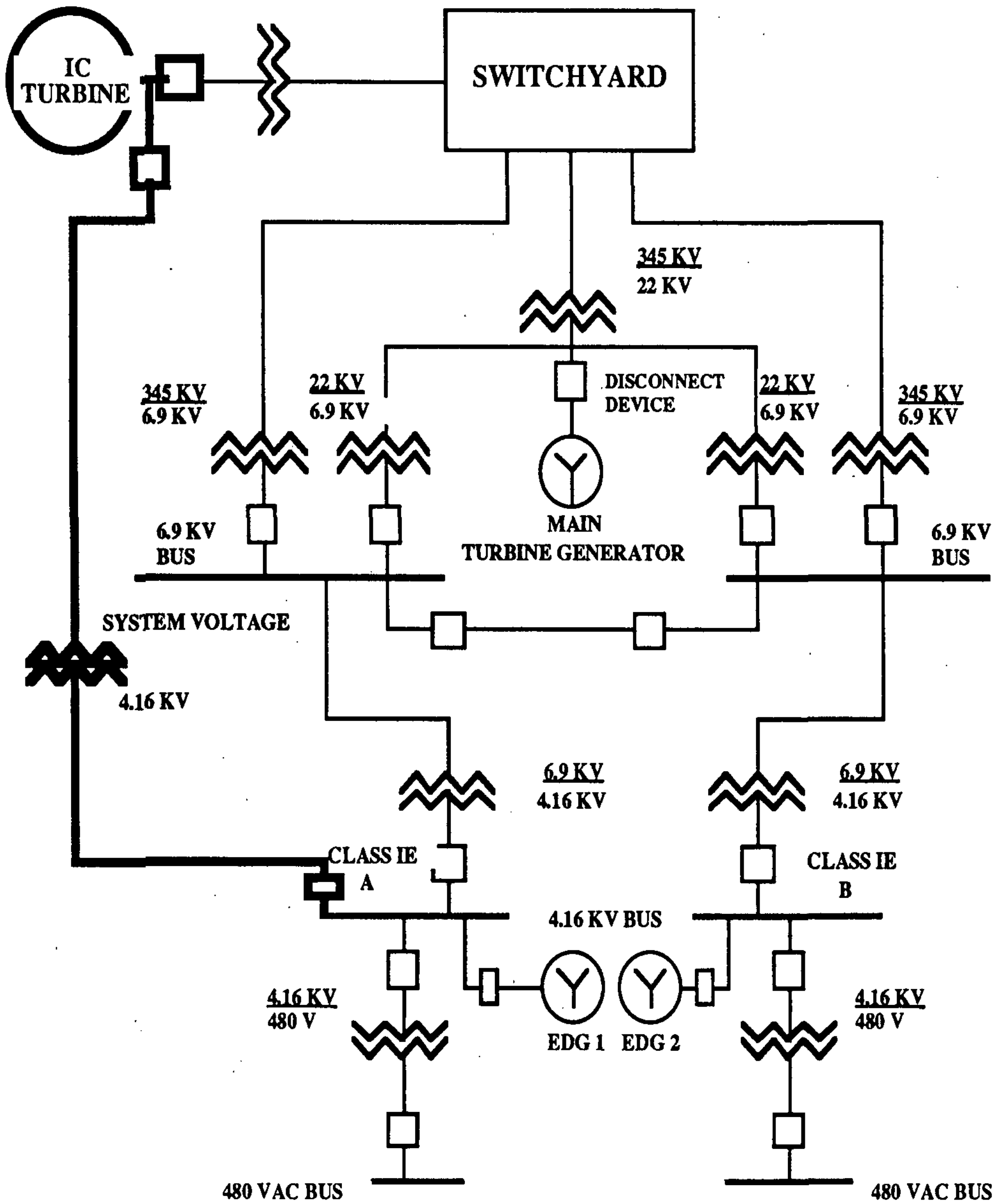
AAC Configuration 4A: Onsite IC Turbine Connected to a Non-Class 1E Bus

THE IC TURBINE AND CABLES FROM THE IC TURBINE TO THE 6.9 KV BUS ARE TO BE PROTECTED FROM EVENTS (E.G., SEVERE WEATHER) THAT COULD CAUSE LOSSES OF OFFSITE POWER TO THE NUCLEAR UNIT.



AAC Configuration 4B: Onsite IC Turbine Connected to a Class 1E Bus

THE IC TURBINE AND CABLES FROM THE IC TURBINE TO THE 4.16 KV BUS ARE TO BE PROTECTED FROM EVENTS (E.G., SEVERE WEATHER) THAT COULD CAUSE LOSSES OF OFFSITE POWER TO THE NUCLEAR UNIT



APPENDIX D. EDG RELIABILITY PROGRAM

D.1 BACKGROUND

The NRC proposed resolution to station blackout is based on a risk analysis presented in NUREG-1032. An important input parameter in the risk analysis is emergency diesel generator (EDG) reliability. While the NRC recognizes that the industry average EDG reliability is acceptably high, they are concerned that some plants have marginal machines and that current high reliability at some plants may degrade in the future. In order to ensure that EDG performance is maintained at a high level and improved for those machines that are currently marginal, the NRC is pursuing the resolution of Generic Issue B-56 *Emergency Diesel Generator Reliability*. The NRC Staff maintains that the resolution of USI A-44 *Station Blackout* should include (1) the identification of target EDG reliabilities and (2) the commitment to implement an EDG reliability program. An outline of a possible EDG reliability program to be developed under Generic Issue B-56 is described below.

D.2 EDG RELIABILITY PROGRAM

The reliable operation of on-site emergency AC power sources should be ensured by a reliability program. For emergency diesel generators, such a program might be comprised of the following elements (or equivalent):

(1) Establishment of individual EDG target reliability levels consistent with the plant category and coping duration determined in Section 3.2.5.

(2) Surveillance testing and reliability monitoring programs designed to track EDG performance and also support maintenance activities.

(3) A maintenance program which ensures that the target EDG reliability is being achieved and which also provides a capability for failure analysis and root cause investigations.

(4) An information and data collection system capability which services the elements of the reliability program, and which monitors achieved EDG reliability levels against target values.

(5) Identified responsibilities for the major program elements and a management oversight program for reviewing reliability levels being achieved and assuring that the program is functioning properly.

APPENDIX E: ANALYSIS OF THE EFFECTS OF LOSS OF VENTILATION UNDER STATION BLACKOUT CONDITIONS

E.1 Introduction

This appendix provides the technical basis for the methodology used in Section 7.2.4 to calculate 4-hour steady state temperatures for the dominant areas of concern.

E.2 Dominant Areas of Concern

Since normal ventilation is unavailable during a station blackout, equipment needed to achieve and maintain safe shutdown in a blackout may be subjected to elevated temperatures. Only a limited set of equipment, however, is needed to provide core cooling and decay heat removal during a station blackout. Loss of ventilation concerns are thus, limited to rooms and cabinets housing this equipment.

This approach focuses on rooms and plant areas labeled Dominant Areas of Concern. These rooms are limited to areas that will have significant heat load in a station blackout, and also contain safe shutdown equipment. AC-driven equipment will not be operable in a station blackout and process steam will not be in the plant. Similarly, only a few plant areas will contain safe shutdown equipment.

For PWRs, the pump room for the steam driven auxiliary feedwater system is the Dominant Area of Concern. The Dominant Areas of Concern in BWRs are the HPCI/HPCS and RCIC pump rooms and the main steam tunnel. In general, the size of RCIC turbines relative to AFW turbines, and relative room geometries make the RCIC results bounding.

E.3 Analysis of Compartment Heatup

Analytical models have been developed to estimate the temperature rise in compartments during a station blackout. In this analysis, a lumped parameter model is used to calculate the average air temperature as a function of time after loss of ventilation. The effect of mitigating actions, such as opening doors to promote air circulation, are also considered.

E.3.1 Model Description

A simple lumped parameter model of compartment heatup can be used to estimate the bulk air temperature as a function of time after loss of ventilation. The rate of change of the air temperature can be calculated by an energy balance if the appropriate heat sources and sinks can be described. An equation for the rate of change of the air temperature is given by:

$$\rho c_p V dT_{air}/dt = Q_{sources} - Q_{sinks} \qquad \text{(E-1)}$$

where:

ρ is the air density;

c_p is the constant pressure specific heat of air;

V is the volume of the compartment.

The sources of heat considered are hot steam pipes, and to a lesser extent in a station blackout, DC switchgear and equipment. The heat from either bare or insulated steam pipes is dissipated to the air and walls by natural convection and thermal radiation. Since the absorptivity of air is very small, the heat dissipated by thermal radiation will be absorbed primarily by the concrete walls.

There are two heat sinks available to remove heat from compartment air: concrete walls act as a large heat sink; and, compartment doors can be opened to remove heat by convection. Heat transfer to walls can be estimated by heat transfer coefficient correlations for natural convection along a vertical plate. Heat transfer to the walls via thermal radiation from steam pipes can be estimated if the temperature of the steam pipes and wall are known.

Equation (E-1) can then be expanded to:

$$\rho c_p V dT_{air}/dt = Q_{elec} + Q_{pipe} + Q_{pump} - Q_{wall} - Q_{door} \qquad \text{(E-2)}$$

where:

Q_{elec} is the heat load from major DC electrical equipment;

Q_{pipe} is the heat dissipated to the air from steam pipes by natural convection;

Q_{pump} is the heat dissipated to the air from steam driven pumps by natural convection;

Q_{wall} is the heat transferred to walls from the air by natural convection; and,

Q_{door} is the heat convected out of compartment openings.

Each term on the right hand side is discussed below.

The heat dissipated to the air from electrical equipment for a particular compartment can be found by adding up the power dissipated by major DC loads.

The heat transferred to the air from the steam pipes by natural convection can be estimated from the correlation for a long horizontal cylinder in a quiescent fluid. The heat transferred from steam driven pumps can be estimated from the correlation for a sphere in a quiescent fluid. The correlations for convective heat transfer rates of Churchill and Chu are used (Incropera [1981]):

For a cylinder:

$$Nu_D = (h_p D)/k = CRa^n{}_d \qquad \text{(E-3)}$$

where:

Nu_D is the Nusselt number

h_p is the heat transfer coefficient for free convection from a pipe;

D is the diameter of the pipe;

k is the thermal conductivity of air;

Ra_d is the Rayleigh number based on the pipe diameter; and,

C and n are empirical constants.

The Rayleigh number is defined as:

$$Ra_d = g\beta(T_{pipe} - T_{air})D^3/\alpha\nu \qquad \text{(E-4)}$$

where:

- g is gravitational acceleration;
- β is the volumetric thermal expansion coefficient;
- T_{air} is the bulk temperature of the air;
- T_{pipe} is the temperature of the pipe;
- α is the thermal diffusivity of air;
- v is the kinematic viscosity of air.

For an ideal gas, $\beta = 1/T_{air}$ (based on absolute temperatures).

Churchill and Chu have recommended a single correlation for a wide Rayleigh number range ($10^{-5} < Ra_d < 10^{12}$):

$$Nu_D = \left\{ 0.60 + \frac{0.387\,(Ra_d)^{1/6}}{[1 + (0.559/Pr)^{9/16}]^{8/27}} \right\}^2 \qquad \text{(E-5)}$$

where Pr is the Prandlt number.

The convective heat transfer coefficient for a cylinder can then be expressed as:

$$h_p = (k/D)\,[0.60 + 0.321(Ra_d)^{1/6}]^2 \qquad \text{(E-6)}$$

Similarly, for a sphere, the Nusselt number can be represented by:

$$Nu_D = 2 + \frac{0.589(Ra_d)^{1/4}}{[1+(0.469/Pr)^{9/16}]^{4/9}} \qquad \text{(E-7)}$$

For $Pr \geq 0.7$ and $Ra_d \leq 10^{11}$

The convective heat transfer coefficient for a sphere can then be expressed as:

$$h_s = (k/D)[2 + 0.454(Ra_d)^{1/4}] \qquad \text{(E-8)}$$

Natural convection to the walls is described by the Churchill and Chu correlation for free convection for a vertical plate (Incropera [1981]). This correlation is given by:

$$h_w = (k/L)\,[.825 + .324(R_{al})^{1/6}]^2 \qquad \text{(E-9)}$$

where l is the height of the wall. The Rayleigh number is based on L and the difference in temperature between the air and wall surface:

$$R_{al} = g\beta(T_{air} - T_{wall})L^3/\alpha\nu \qquad \text{(E-10)}$$

The temperature of the inside wall surface also varies as a function of time. An explicit finite difference model of one–dimensional transient heat conduction in a plane wall can be used to describe the wall temperature. This model considers a time dependent heat flux to the wall as a boundary condition to be satisfied at each time step. A fine mesh is used near the wall surface to accurately predict the temperature gradients resulting from the heat flux to the wall. Deep into the wall, where temperature gradients are relatively small, a coarse mesh is employed.

Application of this model to a typical room containing a heat flux of 80 KW, a total surface area of 514 m^2, and an 8 inch thick concrete wall resulted in a change in wall temperature of approximately 2.5 °C (4.5 °F) over a period of 4 hours.

The heat flux specifying the boundary condition for the wall conduction model is the sum of the convective flux, found by use of (E-9), and the radiative flux from hot steam pipes, which is found using the Stefan-Boltzmann law.

Correlations have been developed to estimate heat flow through openings by convection. These correlations are applicable to the compartment heatup scenario, where heat is convected from a room with a higher temperature to a room with a lower temperature through an opening. The following correlation is suitable for the dimensionless parameters associated with compartment heatup scenarios:

$$h_d = .2\ (k/H)\ Gr^{1/2}\ Pr \qquad \text{(E-11)}$$

where the Grashof number Gr is based on the door height H in the following manner:

$$Gr = gH^3\ (T_{air} - T_{\infty})/v^2 T_{ave} \qquad \text{(E-12)}$$

The temperature of the outside air is denoted by T_{∞} , and T_{ave} is the average of T_{air} and T_{∞}.

Equation (E-2) can now be expanded to:

$$\rho c_p V dT_{air}/dt = Q_{elec} + h_p(T_{air})A_p(T_{pipe} - T_{air}) + hs(T_{air})As(T_{pump} - T_{air})$$
$$- h_w(T_{air}, T_{wall})A_w\ (T_{air} - T_{wall})\ - h_d\ (T_{air})\ A_d(T_{air} - T_{\infty}) \qquad \text{(E-13)}$$

This equation can be solved numerically for a particular geometry if the initial conditions, namely the initial temperatures of the room air, walls, and outside air, are specified.

This steady state (i.e. $dT_{air}/dt = 0$) solution to this equation assuming no open doors can be derived by setting $Q_{door} = 0$. Equation (E-13) then becomes:

$$Q_{total} = h_w(T_{air}, T_{wall})\ A_w\ (T_{air} - T_{wall}) \qquad \text{(E-14)}$$

where, Q_{total}, represents the total amount of heat deposited in the building.

The natural convection coefficient can be calculated with the correlation shown in equation (E-9). For the range of air temperatures under consideration, (i.e., 22-50° C) the $.825$ term is much smaller than $.324R_{al}^{(1/6)}$, and therefore can be neglected. Equation (E-9) becomes:

$$h_w = (k/L)\ [.324(R_{al})^{1/6}]^2 \qquad \text{(E-15)}$$

Substituting in the Rayleigh number as defined in equation (E-10):

$$h_w = .1k[g\beta(T_{air} - T_{wall})/\alpha\nu]^{1/3} \quad \text{(E-16)}$$

Substituting this result into equation (E- 14) yields:

$$Q_{total} = .1k[g\beta/\alpha\nu]^{1/3} A_w(T_{air} - T_{wall})^{4/3} \quad \text{(E-17)}$$

Finally, for the temperature ranges being discussed:

$$.1k[g\beta/\alpha\nu]^{1/3} \sim 1$$

Hence, rearranging equation (E-17):

$$T_{air} = (Q_{total}/A_w)^{3/4} + T_{wall} \quad \text{(E-18)}$$

This is the result used in Step 4 of Section 7.2.4.

Scaled experiments performed by Brown [1962] suggest the following correlation for predicting heat transfer coefficients through vertical openings:

$$Q_{door} = V' \rho_{ave} C_p(T_{air} - T_\infty) \quad \text{(E-19)}$$

where

$$V' = .2\, W\, (g\, \Delta\rho/\rho_{ave})^{1/2} H^{3/2} \quad \text{(E-20)}$$

ρ_{ave} = the average of the densities of the air inside and outside of the room

$\Delta\rho$ = the change in density between the air inside and outside of the room

C_p = the specific heat of the room air at constant pressure

T_∞ = the temperature of the air outside of the room

T_{air} = the temperature of the air inside of the room

W = the width of the door

H = the height of the door

g = the acceleration due to gravity

It should be recognized that the Brown experiments are small-scale and should be used with an understanding of their underlying basis.

Since air can be modeled as a perfect gas:

$$\rho_{ave} = P/2R(1/T_{\infty} + 1/T_{air})$$

$$\Delta\rho = P/R(1/T_{\infty} - 1/T_{air})$$

where

P = atmospheric pressure

R = the universal gas constant

Equation (E-19) can then be written as:

$$Q_{door} = .2\, W H^{3/2} g^{1/2} [2(T_{air}-T_{\infty})/(T_{\infty} + T_{air})]^{1/2} \rho_{ave} C_p (T_{air}-T_{\infty}) \qquad \text{(E-21)}$$

For a typical RCIC room numerical analysis predicts a rapid temperature buildup within the first half hour. The temperature will increase by only a few degrees for the next three and one-half hours where it then approaches steady state. This rapid thermal buildup appears to characterize room geometries for dominant areas of concern.

Once a door is opened, analysis indicates the temperature of the room will decrease rapidly and approach steady state conditions in approximately 20 minutes for similar room geometries. From this analysis, it is apparent that the time at which a door is opened past thirty minutes will have little effect on either the peak temperature or the final steady state temperature that is achieved. For this reason the steady state solution of equation (E-2) will apply when calculating the final temperature for a four hour event.

The steady state solution to equation (E-2) is:

$$0 = Q_{elec} + Q_{pipe} + Q_{pump} - Q_{wall} - Q_{door}$$

$$Q_{elec} + Q_{pipe} + Q_{pump} = Q_{wall} + Q_{door}$$

$$Q_{total} = Q_{wall} + Q_{door}$$

From Equation (E-17)

$$Q_{wall} = A_w(T_{air} - T_{wall})^{4/3}$$

Therefore

$$Q_{total} = A_w(T_{air} - T_{wall})^{4/3} + .2\ W H^{3/2} g^{1/2}\ [2(T_{air}-T_\infty)/(T_\infty + T_{air})]^{1/2} \rho_{ave} C_p (T_{air}-T_\infty) \qquad \text{(E-22)}$$

By substituting

$$\Delta T = T_{air} - T_\infty$$

and

$$T_{wall} = T_\infty$$

$$Q_{total} = A_w \Delta T^{4/3} + .2\ W H^{3/2} g^{1/2} \rho_{ave} Cp\ (2)^{1/2} [(\Delta T)^{3/2}/(\Delta T + 2\ T_{wall})^{1/2}] \qquad \text{(E-23)}$$

After performing a Binomial expansion on the term $(\Delta T + 2\ T_{wall})^{1/2}$, Equation (E-23) becomes:

$$0 = -4\ T_{wall} Q_{total} - Q_{total} \Delta T + 4 T_{wall} A_w \Delta T^{4/3} + A_w \Delta T^{7/3} + 4\ (.2WH^{3/2} g^{1/2}) C_p \rho_{ave} T^{1/2}{}_{wall} \Delta T^{3/2} \qquad \text{(E-24)}$$

This transcendental equation cannot be solved explicitly for ΔT, although a numerical solution is possible. By using the results of this numerical solution for a wide range of input parameters, a correlation can be developed that approximates the actual solution as follows:

$$0 = -A - B\Delta T + C\Delta T^{4/3} + D\Delta T^{7/3} + E\Delta T^{3/2} \quad \text{(E-25)}$$

By solving this equation for $WH^{3/2}$, we find that:

$$WH^{3/2} = [\,(A + B\Delta T - C\Delta T^{4/3} - D\Delta T^{7/3}\,)/\,(4\rho_{ave}C_pT^{1/2}{}_{wall})(.2g^{1/2})\Delta T^{3/2}\,] \quad \text{(E-26)}$$

Where for the temperature ranges considered:

$\rho_{ave} \sim 1$

$C_p \sim 1$

Therefore equation (E- 26) becomes:

$$WH^{3/2} = [\,(A + B\Delta T - C\Delta T^{4/3} - D\Delta T^{7/3}\,)/\,(4T^{1/2}{}_{wall})(.2g^{1/2})\Delta T^{3/2}\,]$$

This equation can be solved for various values of Q_{total}, A_w, and ΔT. Several graphs of the results were plotted in order to obtain a factor for ΔT based on $WH^{3/2}$ using a power series curve fit of the data. The data used to develop these graphs is presented in Table E-1.

Table E-1

Data Used for Power Series Curve Fit

Qtotal (KW)	Aw (sq.m)	DELTA T (°K)
65	400	10
65	400	20
65	400	30
65	400	40
65	500	10
65	500	20
65	500	30
65	500	40
65	750	10
65	750	20
65	750	30
65	750	40
65	1000	10
65	1000	20
65	1000	30
65	1000	40
80	400	10
80	400	20
80	400	30
80	400	40
80	500	10
80	500	20
80	500	30
80	500	40
80	750	10
80	750	20
80	750	30
80	750	40
80	1000	10
80	1000	20
80	1000	30
80	1000	40

The factor $(16.18(F_{door})^{0.8653})$ was incorporated into Equation (E-18) to obtain:

$$T_{air} = (Q_{total})^{3/4}/[(A_w)^{3/4} + 16.18(F_{door})^{0.8653}] + T_{wall} + 4 \qquad \text{(E-27)}$$

where

$$F_{door} = H^{3/2}W$$

This relationship has been shown to have a correlation coefficient (r^2) equal to 0.99. Since most heat transfer correlations contain r^2 factors between 0.9 and 1.0, this correlation is well within acceptable limits. To account for any uncertainties within this correlation a plot of temperatures obtained using equation (E-27) was compared to a plot of equation (E-23) with a specified temperature difference. It was found that, in general, equation (E-27) predicts temperatures from 3 -3.5 °C lower than predicted from this plot. To account for this uncertainty a correction factor of 4°C was added. This is the result used in Step 5 of Section 7.2.4. Note that this equation is a simplified form of the complete steady state solution. Heat transfer coefficients and thermal properties have been evaluated in MKS units. Therefore, this dimensionally inconsistent equation is valid only with the equation parameters in the following units:

Q_{total} = Watts

T_{wall} = °K or °C (units of T_{air} will result accordingly)

A_W = square meters

H = meters

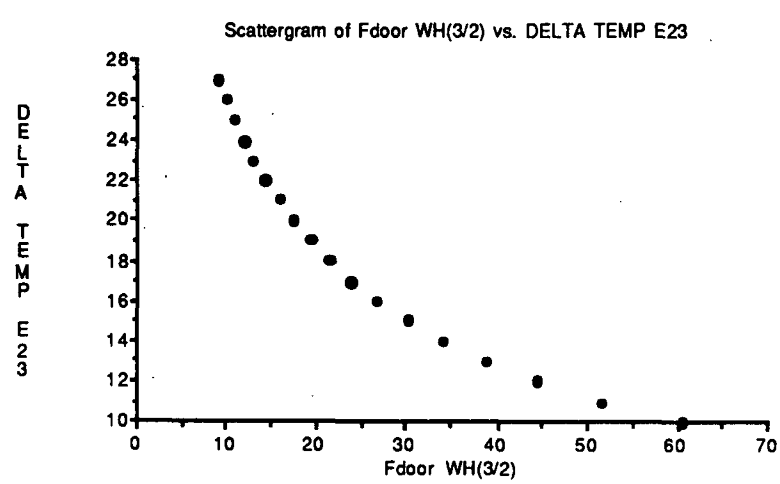
W = meters

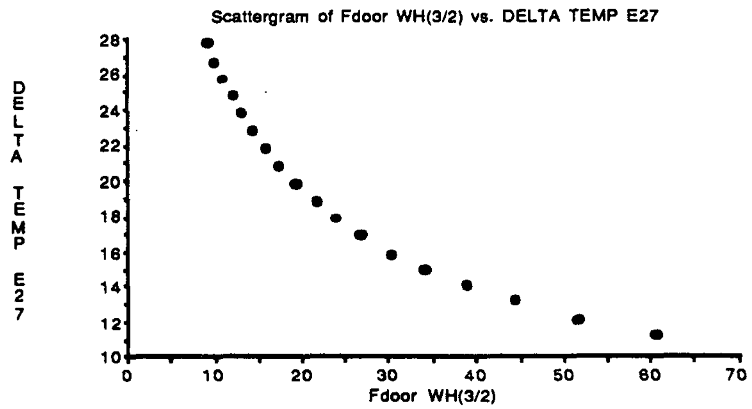
By testing the sensitivity of equation (E-26) it was found that this correlation is valid for the following parameter ranges:

$$24000W < Q < 100000W$$

$$0\ °C < \Delta T < 50\ °C$$

Plots for a sample case that illustrates the results of Equations (E-23) and the corrected form of Equation (E-27) are shown below:





E.3.2 RCIC Pump Room with No Openings

To provide an upper bound for the potential temperature rise which may be expected during a station blackout event, Equation (E-13) is solved with the assumption that A_d is zero -- effectively representing a closed compartment. The RCIC room chosen for analysis by Jacobus et. al. [1986] has been reevaluated for comparison. The geometry and initial conditions are specified in Table E-2, below.

Table E-2

RCIC Room Geometry and Initial Conditions

Wall Height	7.5 m
Surface Area	514 m^2
Volume	892 m^3
Steam Pipe dia.	.2 m
Steam Pipe length	15.4 m
Initial Air Temp.	40° C (104° F)
Initial Wall Temp.	40° C (104° F)
Pipe Temp. (uninsulated)	288° C (550° F)
Pipe Temp. (insulated)	93° C (200° F)
Pipe Emissivity	0.8
Electric energy dissipated	63 KW

If the steam pipes are insulated the temperature rise will be smaller, since less heat will be convected to the air and a relatively smaller heat flux will strike the wall surface. This case is considered more representative than the case with uninsulated steam pipes. Assuming insulated steam pipes, the calculated temperature rise is about 37° C (67° F) after 4 hours, and about 38° C (~~72°~~ 68° F) after 8 hours. This result compares to the 44° C (79°F) temperature rise obtained after 8 hours by Jacobus.

E.3.3 RCIC Pump Room with a Compartment Opening

NUMARC has determined that the effect of opening doors to promote natural circulation is determined to prevent compartments from reaching excessive temperatures during station blackout conditions. A heat transfer term accounting for convection of heat to outside air has been included into the energy balance.

Calculations have been made assuming that a 2m by 1m door is opened one-half hour into the station blackout event, and that heat transfer is described by (E-11). It is also assumed that the flow of exiting hot air is matched by the flow of incoming cool air from outside. Outside air is assumed to be constant at 40° C (104° F). For the case with insulated pipes, a temperature rise of 28° C (50° F), (using equation (E-27) 31.5 °C or 56.8 °F), was obtained after 4 hours, peak temperature of 165° F is predicted by simulation at the time the door is opened. If two 2m by 1m doors are opened one-half hour into the event, a temperature rise of 23°C (41°F), (using equation (E-27) 25.7°C or 46.3 °F), will be obtained after four hours. In comparison, a temperature rise of 37° C (67° F) was obtained for the same case with the door closed.

Sensitivity analyses were performed to measure the effect of changes in the heat transfer correlation used to describe convection through open doors. The heat transfer coefficient was reduced by 25% to account for the normal range of uncertainty associated with empirical heat transfer correlations. Little effect on temperature rises after four hours was observed -- reducing the heat transfer coefficient by 25% resulted in an increase in temperature rise of about one degree Centigrade for the two cases just discussed.

In conclusion, opening doors will reduce the temperature rise during station blackout to a level where equipment operability can be assured to a sufficiently high level of confidence. For the example case, the estimated temperature after four hours into a station blackout can be reduced from 171° F to 155° F if a door is opened one-half hour into the event. If two doors are opened, the estimated temperature can be reduced to 146° F. Furthermore, calculations reveal that rooms will cool rather quickly after doors are opened, and peak temperatures will exist for only a few minutes.

E.4 Nomenclature

ρ = density (Kg/m^3)

C_p = constant pressure specific heat (KJ/Kg °K)

V = volume (m^3)

T_{air} = temperature of the air inside of the room (°K)

T_∞ = temperature of the air outside of the room (°K)

T_{wall} = temperature of the room walls (°K)

g = acceleration due to gravity (m/s^2)

β = expansion coefficient (1/°K)

α = diffusivity (m^2/s)

ν= kinematic viscosity (m^2/s)

A_w = area of the wall (m^2)

L = length (m)

l = height of the wall (m)

W = width (m)

H = height of the opening (m)

D = diameter (m)

F_{door} = door factor ($m^{5/2}$)

Q = heat transfer rate (W)

k = thermal conductivity (W/m°K)

h_p, h_d, h_w = convective heat transfer coefficients (W/m^2°K)

R_{ad}, R_{al} = Rayleigh number (dimensionless)

P = pressure (bar)

R = universal gas constant (0.08314 (m^3 bar/Kmol °K))

r^2 = correlation coefficient

APPENDIX F. ASSESSMENTS OF EQUIPMENT OPERABILITY IN DOMINANT AREAS UNDER STATION BLACKOUT CONDITIONS (REVISION 1)

F.1 Introduction

This appendix outlines a methodology for providing reasonable assurance of the operability of equipment used to cope with a station blackout in the dominant areas of concern.

Station blackout is not a design basis accident and, therefore, is not subject to the requirements of 10 CFR §50.49 and the rigorous certification process for equipment operability. However, since station blackout coping equipment needs to operate in order to achieve safe shutdown, reasonable assurance should be provided that no thermally-induced failures will result due to loss of forced ventilation. Station blackout environments in the dominant areas of concern outside containment are expected to experience increases in air temperature. The resulting temperatures are expected to range from slight to moderate in most cases not exceeding 150° F.

Most equipment is expected to operate in these station blackout environments with no loss of function for the short duration (i.e., four hours). The basis for this general conclusion can be traced to previous studies and analyses performed, as well as plant operating experience. The approaches discussed in this appendix provide acceptable bases for reaching this conclusion on a plant-specific basis. In particular, the approaches justify removing classes of equipment (i.e., relays, switches) from further consideration and focusing attention on those components of concern. The approaches may be used individually or in combination in reaching a conclusion that an acceptable basis exists for equipment operability in a station blackout environment.

Six approaches may be used to establish equipment operability in a station blackout:

(1) Equipment previously evaluated (Section F.2);
(2) Equipment design capability (Section F.3);
(3) Materials (Section F.4);
(4) Equipment inside instrumentation and control cabinets (Section F.5);
(5) Generic studies and experience (Section F.6); or,
(6) Plant-specific experience and tests (Section F.7).

Each of these approaches is described in detail in this appendix; a general statement of a method, guidance, specific procedures, and examples are provided.

F.1.1 General Guidance

In the development of approaches, it became clear that station blackout response equipment fell into several generic categories. It also became clear that reasonable assurance of operability for these categories could be established within certain temperature ranges. A topical report has been prepared and is being made a part of Appendix F to address this situation. The Topical Report provides a technical evaluation of these categories establishing a temperature for which reasonable assurance of operability can be generically established in a station blackout environment.

Due to the variety of equipment types in each category, the temperatures established are necessarily conservative. It is recognized that equipment specific analysis may establish reasonable assurance of operability for higher temperatures. The Nuclear Utility Group on Station Blackout (NUGSBO) has compiled an equipment operability database (EODB) containing information which may be helpful for supporting such evaluations.

F.1.2 Procedure

Users may refer to and use the Topical Report and the EODB database as follows:

(1) Determine the station blackout temperature for the dominant areas of concern, T_{DAC}*, in accordance with Section 7.2.4.of NUMARC 87-00;

(2) Identify the station blackout response equipment located in these areas;

(3) (a) Determine the time period that the equipment must remain operable for the appropriate station blackout coping method; or,

(b) Assume the equipment must remain operable for the entire duration of the station blackout (i.e., up to one hour for plants using alternate AC, up to two hours for plants in the P1-A classification identified in Section 3.2 of NUMARC 87-00, otherwise up to four hours);

(4) Determine whether station blackout response equipment falls within any of the equipment categories whose operability is evaluated in the Appendix F Topical Report. If so, determine whether the assessed temperature and duration for the category envelopes the temperature of the dominant area of concern where equipment is located for the duration the equipment is necessary; if not,

(5) Establish reasonable assurance by following any of the approaches discussed in this appendix. The NUGSBO equipment operability database (EODB) may contain information to help support the evaluation.

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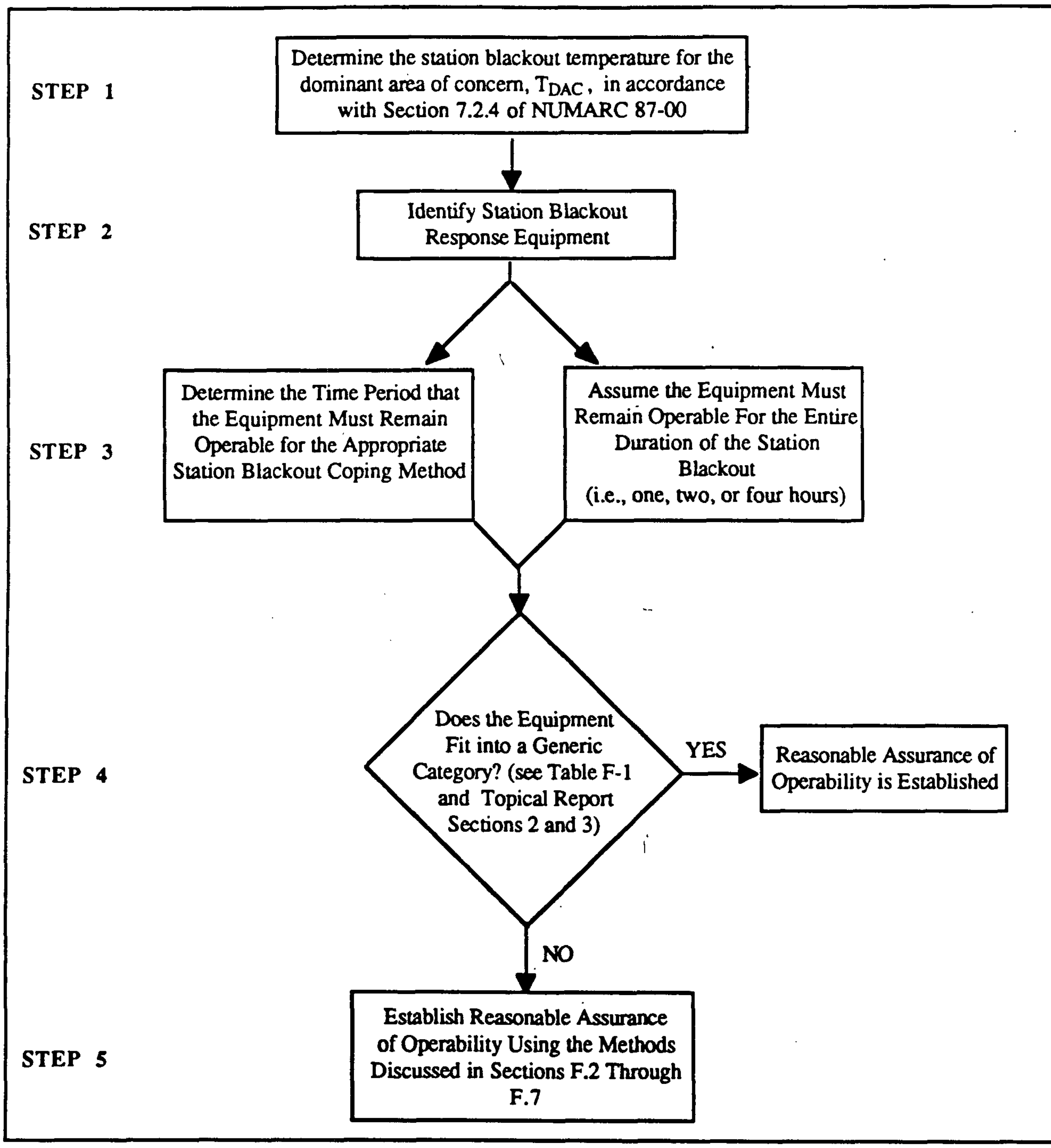
* See Section F.1.4 for definitions.



F.1.3 Example

A motor operated valve actuator manufactured by Limitorque is located in a dominant area of concern with a T_{DAC} of 150° F and is considered station blackout response equipment. This valve actuator needs to function for four hours in the station blackout environment. Section G.2.1.5 of the Topical Report evaluates all Limitorque valve actuators generically and concludes that reasonable assurance of operability is established for these components operating in rooms with ambient temperatures at or below 180° F for four hours. Reasonable assurance of operability is therefore established.

F.1.4 Assumptions and Definitions

The approaches described in this appendix are designed to establish reasonable assurance of operability of equipment and components in dominant areas of concern for station blackout environments. These methods are equally applicable to establishing the operability of individual components or of entire equipment categories. Table F-1 shows the results of evaluations supporting the operability of entire equipment categories provided in the Appendix F Topical Report.

Table F-1: Operability Conditions By Category

Equipment	Operability Temperature (°F)	Station Blackout Duration (hrs)	Appendix F Approaches Used
MECHANICAL EQUIPMENT			
Pumps	180	4	F.4, F.6
Turbines w/ Mechanical Governors	180	4	F.4, F.6
DC Motors, Fans, and Blowers	180	4	F.4, F.6
Valves	200	4	F.4, F.6
Motor Operated Valve Actuators			
Limitorque	200	4	F.2, F.3, F.6
Rotork	180	4	F.2, F.3, F.6
Other	180	4	F.4, F.6
ELECTRICAL AND ELECTRONIC EQUIPMENT			
Cables	185	4	F.2, F.3, F.6
Switches and Relays	185	4	F.2, F.4, F.6
Sensors and Electronic Transmitters	180	4	F.3, F.6
Electronic Turbine Governors	160	4	F.4, F.6

<u>Assumptions</u>

The following assumptions are consistent with establishing reasonable assurance of operability for equipment in station blackout environments:

(1) Documentation standards for equipment operability are not to be as rigorous as are typically required to meet the design basis requirements of 10 CFR §50.49. For example, there is no need to address the effects of aging or synergisms. In addition, engineering judgement may be exercised to permit the acceptance of installed configurations that diverge from test conditions. This is consistent with the scope and intent of 1

CFR §50.63. These assumptions are reasonable due to the low temperatures (and correspondingly slower reaction rates), and short durations (and correspondingly short reaction times) expected during a station blackout. Documentation records establishing operability need not address more than: (a) the equipment name and model number, (b) the dominant area of concern, (c) the station blackout temperature (T_{DAC}), (d) the station blackout operability temperature (T_{OPP}), and (e) the Appendix F method used or the Topical Report category.

(2) In accordance with Section 2.7.1 of NUMARC 87-00, only station blackout response equipment located in dominant areas of concern which have not been previously evaluated as a harsh environment need be assessed for operability.

(3) Determination of similarity does not need to consider the effects of aging or synergisms.

(4) Due to the short expected duration and relatively small temperature rises expected during a station blackout, aging effects on operability do not need to be considered. One of the most widely used models to simulate the aging effect of elevated temperatures is the Arrhenius reaction rate model[123]:

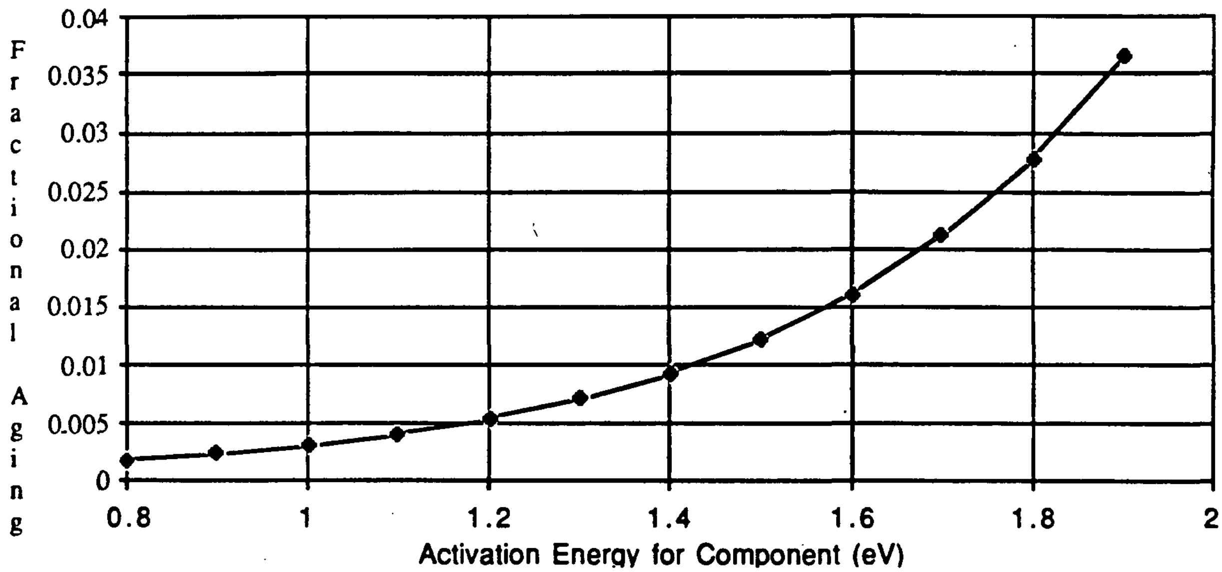
$$L_s = L \exp\left[\frac{-E}{k}\left(\frac{1}{T} - \frac{1}{T_s} \right) \right]$$

where L (hours) represents the time spent at a higher temperature T (K), L_s represents the equivalent time at the design temperature T_s (K), E represents the activation energy for the component (eV), and k is the Boltzman constant. The figure shown below illustrates the aging effects of a station blackout for a wide range of activation energies.

123 Fuqua, N. B., *Reliability Engineering for Electronic Design*, Marcel Dekker Inc., New York, NY, (1987).

Figure F-1

Effective Aging During A Four Hour Station Blackout
As A Fraction of A Component's Expected Lifetime (20,000 Hours)



As can be seen, components with activation energies below 1.4 eV are expected to age by less than 1%, and activation energies as high as 1.9 eV still represent a lifetime reduction of less than 4%. While activation energies for components can vary widely, the vast majority of materials used in station blackout equipment have activation energies between 0.7 and 1.4 eV [124].

Definitions

The terms defined below were specifically developed for these guidelines and are consistent with the definitions used throughout NUMARC 87-00.

DOMINANT AREAS OF CONCERN (DAC) - The representative analysis provided in this section addresses a limited set of plant areas deemed to be potentially susceptible to heat-up upon loss of ventilation, such as would occur in a station blackout. These areas are defined by three factors: (1) their containing equipment normally required to function early in a station blackout to remove decay heat (i.e., equipment whose failure within the first hour of a station blackout would disable the auxiliary feed-water or boiler makeup systems), (2) the presence of significant heat generation terms (after AC power is lost) relative to their free volume (i.e. process steam or DC electrical power

124 Carfagno, S.P., Gibson, R.J., *A Review of Equipment Aging Theory and Technology*, Franklin Research Center, EPRI NP-1558, Electric Power Research Institute, Palo Alto, CA, (1980).

supplies in small rooms or enclosures), and (3) the absence of heat removal capability in a station blackout without operator action. These areas have been determined to be:

(1) Steam Driven AFW Pump Room (PWRs only);
(2) HPCI/HPCS Room (BWRs only);
(3) RCIC Room (BWRs only); and,
(4) Main Steam Tunnel (BWRs only).

It should be noted that any site specific plant area found meeting the three factors above should also be considered to be a dominant area of concern.

STATION BLACKOUT EQUIPMENT - equipment located in dominant areas of concern which are used to bring the plant to safe shutdown during station blackout conditions.

STATION BLACKOUT TEMPERATURE (T_{DAC}) - the average steady state bulk air temperature in a dominant area of concern during a four hour station blackout.

STATION BLACKOUT OPERABILITY TEMPERATURE (T_{OPP}) - the temperature for which reasonable assurance of operability has been established for a specific component or for an equipment category. This temperature is established for a variety of equipment categories in the Appendix F Topical Report, and may be established for individual equipment using the approaches described herein.

SIMILAR EQUIPMENT - equipment whose characteristics are such that:

(1) the limiting sub-components have comparable or less limiting thermal properties; and,
(2) the limiting materials have comparable or less limiting thermal properties.

In the context of station blackout, *limiting sub-components* or *limiting materials* are those sub-components or materials which are most susceptible to significant degradation at elevated temperatures. The application of this principle is illustrated in Example 3 of Section F.2.4.

F.2 Equipment Previously Evaluated

F.2.1 General Statement of Method

Equipment that is similar to equipment already qualified under 10 CFR §50.49 need not be further evaluated if the station blackout temperatures do not exceed qualification temperatures.

F.2.2 Guidance

Existing tests and analyses of specific equipment may be used to establish operability in a station blackout. Reasonable assurance of operability is met if the equipment or reasonably similar equipment has been previously qualified to a temperature and duration enveloping T_{DAC} and the required coping duration category.

F.2.3 Procedure

Apply the following steps for station blackout response equipment located in dominant areas of concern experiencing a total loss of forced ventilation.

(1) Determine T_{DAC} for the area containing the equipment in accordance with Section 7.2.4.

(2) (a) Determine the time period that the equipment must remain operable for the appropriate station blackout coping method; or,

(b) Assume the equipment must remain operable for the entire duration of the station blackout (i.e., one, two, or four hours).

(3) Locate a test or analysis that provides reasonable assurance of operability for the identified equipment (or similar equipment) for the temperature specified in Step 1 and the duration specified in Step 2. A partial list of equipment qualified under 10 CFR §50.49 for a number of participating utilities is available in the NUGSBO Equipment Operability Database.

(4) Reasonable assurance of operability is established if the specific equipment or similar equipment has been previously evaluated for conditions enveloping the temperature determined in Step 1 and the duration determined in Step 2.

F.2.4 Examples

The following examples illustrate the establishment of reasonable assurance of operability on the basis of previous qualification.

Example 1:

A limit switch is identified as being needed for station blackout response. The switch is located in a dominant area of concern with a T_{DAC} = 145° F and is required to function for one hour. This switch was evaluated under another utility's equipment qualification program and qualified for a temperature of 180° F for two hours. Reasonable assurance of operability is therefore established.

Example 2:

A limit switch required for station blackout is located in a dominant area of concern with a T_{DAC} = 150° F. The switch needs to function for one hour under station blackout conditions. The switch was evaluated for a temperature of 180° F for two hours under the plant's equipment qualification program. Reasonable assurance of operability is therefore established.

Example 3

A motor required for station blackout response is located in a dominant area of concern with a T_{DAC} = 150° F. The NUGSBO equipment operability database shows that a potentially similar motor has been evaluated under another utility's equipment qualification program for continuous operation below 200° F. A review of the Appendix F Topical Report reveals that (a) the most limiting sub-components for motors are their bearings and windings, and (b) the most limiting materials used in motors are the winding insulation and the bearing lubricant. After contacting the other utility, it is verified that:

(1) Both motors use journal bearings.

(2) Both lubricants used are rated for continuous operation above 200° F.

(3) Both motors use windings with the same insulation class.

These motors may therefore be considered *similar* for the purposes of determining operability in a station blackout. Reasonable assurance of operability is, therefore, established.

F.3 Equipment Design Capability

F.3.1 General Statement of Method

Equipment vendors generally provide a design temperature associated with the continuous operation of their equipment. A margin may exist above design temperature which varies according to equipment class (e.g., smaller margins for electronic equipment relative to electro-mechanical devices) and the expected operating conditions (e.g., temperature levels, time at these elevated temperatures, duty cycle, etc.). Reasonable assurance of equipment operability is provided if it is shown that the design temperature plus the expected margin for the equipment or component class does not exceed the bulk air temperature expected in a 4-hour station blackout.

F.3.2 Guidance

Vendors specify design temperatures associated with continuous operation of their equipment. In general, the equipment may still operate for the limited duration of a station blackout at even higher temperatures. This additional capability represents the equipment's thermal margin in a station blackout. This margin may be established on the basis of estimating thermally-induced failure rates, by locating vendor documentation, by performing tests and experiments, or as derived from experience. Using the thermal margin approach, reasonable assurance of equipment operability is established if the equipment's rated temperature for continuous operation plus its thermal margin envelopes station blackout conditions.

Vendor documentation certifying equipment operability at temperatures in excess of the rated temperature for continuous operation may be used to establish thermal margins. These documents include, but are not limited to:

(1) Published catalog data;
(2) Correspondence (including letters, memoranda, and technical advisories);
(3) Technical manuals; and,
(4) Engineering, design, or vendor test data.

In addition to vendor documentation, test data and documented operational occurrences may also be used to establish thermal margins. Operational occurrences, for example, may have created conditions that exceed the design of the equipment without adversely affecting operability.

Also, the mean time between failures for some station blackout components may be sufficiently long to enable reasonable assurance of operability to be established at elevated temperatures for short durations. Similarly, if operability is established for higher temperatures for shorter durations than needed for coping, the thermal effects on equipment reliability may demonstrate operability at lower temperatures for the longer duration needed for coping with a station blackout. Examples 4 and 5 illustrate the application of this methodology.

F.3.3 Procedure

Apply the following steps for station blackout response equipment located in dominant areas of concern experiencing a total loss of forced ventilation.

(1) Determine T_{DAC} for the area containing the equipment in accordance with Section 7.2.4.

(2) (a) Determine the time period that the equipment must remain operable for the appropriate station blackout coping method; or,

(b) Assume the equipment must remain operable for the entire duration of the station blackout (i.e., one, two, or four hours).

(3) (a) <u>Establishing Reasonable Assurance on the Basis of Available Thermal Margin</u>

(i) Determine the design temperature of the equipment.

(ii) Determine the available thermal margin based on vendor documentation, test reports, plant experience, or vendor correspondence for the specific equipment. The NUGSBO Equipment Operability Database contains a listing of equipment types sorted by vendor to allow utilities to locate other sites using equipment supplied by the same vendor.

(iii) Reasonable assurance of operability is established if the design temperature plus the available thermal margin exceeds T_{DAC} for the period determined in Step 2.

OR

(b) <u>Establishing Reasonable Assurance by Estimating Failure Rates</u>

(i) Determine the expected mean time between failures under normal operating conditions for the equipment.

(ii) Calculate the thermal effects on equipment failure rate for conditions determined in Step 1 and Step 2 (see Examples 4 and 5 in Section F.3.4).

(iii) Reasonable assurance of operability is established if the mean time between failures determined in Step (b)(ii) is greater than the duration specified in Step 2.

F.3.4 Examples

The following examples illustrate the establishment of reasonable assurance of operability on the basis of equipment design capability.

Example 1:

An electronic transmitter required for coping with a station blackout is located in a dominant area of concern with a T_{DAC} of 190° F. The manufacturer's catalog states that the maximum continuous operating temperature for the electronic transmitter is 190° F. Based on the catalog data the transmitter is considered operable for the assumed station blackout event.

Example 2:

A motor operated valve actuator has a maximum continuous operating temperature of 140° F. Correspondence from the manufacturer indicates that they routinely supply standard units for continuous operating temperatures up to 170° F with recommendations for increased grease surveillance and periodic maintenance. Based on this information, the utility concludes that the actuator is operable for a four hour duration at 170° F with additional special maintenance and surveillance actions.

Example 3:

A motor has published NEMA standard rating based on a 40° C (104° F) ambient temperature. The utility calculates a T_{DAC} of 150° F. Using the guidance provided in NEMA standard MG-1, the utility determines that the motor is rated for continuous operation at the higher temperature based on an operational load less than the rated full load[125]. Based on this analysis the motor is considered operable for an assumed four hour duration.

Example 4:

The thermal effects on the failure rate of some components can be estimated by utilizing engineering methods such the 10° C rule [126]. This rule states that a 10° C increase in the winding temperature of a motor decreases the mean time between failures of the motor by a factor of 2. This rule is represented by the following equation:

$$t_2 = (t_1)\, 2^{-\{(T_{DAC}-T_1)/10\}}$$

where:

- t_1 represents the mean time between failures for a motor operating continuously at a temperature T_1,
- t_2 represents the mean time between failures for a motor operating at a higher temperature T_{DAC},
- T_{DAC} represents the bulk air temperature in the dominant area of concern, and
- T_1 represents the temperature for which the motor is rated for continuous operation.

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125 It is assumed that the insulation temperature is based on ambient temperature plus a heat rise due to the motor load. It further assumes that the heat rise is proportional to (actual horsepower)^2 / (rated horsepower)^2 and determines the heat rise for an operational load less than the motor's rated full load.

126 Carfagno, S.P., Gibson, R.J., *A Review of Equipment Aging Theory and Technology*, Franklin Research Center, EPRI NP-1558, Electric Power Research Institute, Palo Alto, CA, (1980).

If, for example, the mean time between failures for a motor operating in a 40° C (104° F) room is 500 hours, the 10 degree rule can be used to estimate the mean time between failures for when the motor is operating in a 60° C (140° F) room.

$$t_2 = (500)\ 2^{-\{(60°\ C\ -\ 40°\ C)/10°\ C\}}$$

$$t_2 = 125\ \text{hours}$$

Since t_2 is still considerably longer than the four hours for which the motor is needed to perform its station blackout function, reasonable assurance of operability is established.

Example 5:

A pressure switch qualified for outside containment pipe break conditions of 100° C (212° F) for 30 minutes is required to operate in a dominant area of concern with a T_{DAC} of 71.11° C (160° F) for four hours. This switch may be demonstrated operable for the blackout event by determining the thermal degradation equivalency.

Thermal degradation equivalency is demonstrated using the following form of the Arrhenius equation:

$$E_a = \frac{k * \ln\left(\frac{t_1}{t_2}\right)}{\frac{1}{T_1} - \frac{1}{T_{DAC}}}$$

where:

- t_1 represents the mean time between failures for a motor operating at a temperature T_1,
- t_2 represents the mean time between failures for a motor operating at a temperature T_{DAC},
- T_{DAC} represents the bulk air temperature in the dominant area of concern in Kelvin (K),
- T_1 represents the temperature for which the motor is rated for continuous operation in Kelvins (K),
- E_a represents the activation energy for the component necessary to achieve equivalency and
- k Boltzman's constant = 8.63×10^{-5} eV / K

In this form, the activation energy (E_o) necessary to achieve equivalency is determined based on the two temperatures (T) and time (t) values. In this example the resulting value for E_o to achieve equivalency is 0.797 eV.

A review of EPRI NP-1558, *Review of Equipment Aging and Theory, and Technology*, Appendix B, reveals that activation energies for materials typically used in pressure switches exhibit activation energies above 0.85 eV. Since this value is higher than 0.79 eV, reasonable assurance of operability is established.

Thermal equivalency could also have been established using the 10° C rule, which is illustrated in Example 4.

Example 6:

The motor starters for selected coping equipment are located in a dominant area of concern. The stated maximum temperature for the starters is 104° F. Operability is required for a four hour duration at a T_{DAC} of 140° F. The utility reviews plant specific and industry generic data on failure rates for motor starters. The thermal effects on the failure rate can be conservatively approximated with the Arrhenius equation:

$$\lambda = \exp\left[\frac{E_a}{k}\left(\frac{1}{T} - \frac{1}{T_o}\right)\right]$$

where:

λ = Stress Acceleration Factor (decrease in reliability)

E_a = Activation energy (eV) (a unique constant for each specific chemical reaction or failure mechanism)

k = Boltzman's constant = 8.63×10^{-5} eV/K

T = Ambient temperature in degrees Kelvin (K)

T_o = Reference temperature (K) (used for normalization to the given temperature)

By selecting a conservative activation energy it is possible to establish an upper bound for the decrease in the reliability of the component. From the utility's review of failure rates for motor starters, it is determined that 0.9 eV corresponds to a conservatively high activation energy. That is, when this activation energy is used in the Arrhenius equation to predict increases in failure rates due to operation at higher temperatures, the equation consistently predicts higher failure rates than those determined in the utility's analysis. By entering this figure into the Arrhenius equation, a temperature increase from 40° C (104° F) to 60° C (140° F) will result in a decrease in reliability by a factor of 7.4. Thus, if the mean time between failures (MTBF) for a component is only one year (8760 hours) when operating at 104° F, then at 140° F the MTBF will be reduced to 1184 hours. Since this number is still considerably higher than four hours, it can be concluded that motor starters designed for continuous operation at 104° F can be expected to operate at 140° F for the full four hour duration of a station blackout.

Since operability of a typical safety related motor starter is verified by monthly surveillance testing, the total probability of a motor starter failure for the blackout duration should not exceed the failure probability for a 30 day period during normal operation. Consequently, the Stress Acceleration Factor must be less than or equal to 180 (i.e., 180 = 24 hrs / day x 30 days / 4 hours). The use of a bounding activation energy results in a calculated Stress Acceleration Factor less than 30 [127]. Consequently, operability is demonstrated for the four hour duration.

127 When performing such analysis, it should be noted that larger activation energy values result in larger Stress Acceleration Factors. If one conservatively assumes that relay components have values bounded by E_a = 2.0 eV, then the Stress Acceleration Factor for ambient temperature increases from 104° F to 130° F is approximately 26.

F.4 Materials

F.4.1 General Statement of Method

The primary consideration for equipment operability in a station blackout is the potential for thermally-induced failure. Most materials used in plant equipment and components are not subject to physical or chemical changes in the range of temperatures expected to result in a station blackout. Materials or combinations of materials that are susceptible to significant changes in these ranges will be identified and used to screen components that are potentially sensitive to station blackout conditions.

Reasonable assurance for equipment operability is provided if it is shown that the station blackout coping equipment does not contain materials that are susceptible to significant physical or chemical changes in a station blackout environment.

F.4.2 Guidance

Due to the relatively low temperatures expected to be encountered during a station blackout, the vast majority of materials used in nuclear grade equipment and components are not expected to impair operation. Non-metallic materials (i.e. insulators and lubricants) are generally recognized as being most susceptible to potential thermal degradation in the temperature ranges expected to be encountered in the dominant areas of concern. Reasonable assurance of operability is provided if the specific component does not contain materials known to be susceptible to significant thermal changes when exposed to T_{DAC} for the limited duration of a station blackout.

A reference table showing the maximum continuous service temperature for representative insulators and lubricants which may be found in station blackout equipment is provided in the Appendix F Topical Report.

F.4.3 Procedure

Apply the following steps for station blackout response equipment located in dominant areas of concern experiencing a total loss of forced ventilation.

(1) Determine the T_{DAC} for the area containing the equipment in accordance with Section 7.2.4.

(2) (a) Prepare a list of temperature sensitive materials for the station blackout equipment. (When the exact material types are not known but the material class is, the most thermally sensitive material type in the class should be used.)

(b) Determine whether the materials listed in step 2(a) are operating within their maximum continuous service temperature. A reference list of temperature sensitive materials commonly used in station blackout equipment is provided in the Appendix F Topical Report.

(c) Reasonable assurance of operability is established if the materials identified have a maximum continuous service temperature above T_{DAC}. Note: If the continuous service temperature for some of the most temperature sensitive materials falls below T_{DAC}, it may still be possible to establish operability for the limited duration of a station blackout. Section F.3 of this appendix introduces methods for establishing the operability of equipment for short durations above their rated temperature for continuous operation.

F.4.4 Examples

The following examples illustrate the establishment of reasonable assurance of operability on the basis of materials analysis.

Example 1:

An air operated diaphragm valve actuator is required for three hours in a dominant area of concern with a T_{DAC} of 140° F. A review of the components identified polystyrene as the only temperature sensitive material. A review of the Topical Report identifies a maximum continuous service temperature of 151° F which is greater than T_{DAC}. Based on this materials review the actuator is considered operable for the three hour duration.

Example 2:

A manufacturer's generic qualification report demonstrates qualification of a nuclear-grade solenoid operated valve (SOV) for in-containment conditions. A similar valve that has not been tested by the manufacturer is considered as station blackout response equipment and is located in a dominant area of concern. The manufacturer indicates that the only significant difference between the SOVs is the use of Buna-N instead of EPT as the valve elastomer. A review of the Topical Report reveals that the maximum continuous operability temperatures for Buna-N and EPT are 240° F and 300° F respectively. The utility determines that reasonable assurance of operability is established since the valve is only required to function for two hours in a dominant area of concern with a T_{DAC} of 145° F.

Example 3:

A pressure switch is rated for continuous operation at 125° F. The manufacturer believes the switch will function at higher temperatures but will not formally state this opinion. The utility reviews the switch design and determines that the thermally limiting sub-components are the internal snap-acting switch and the Viton pressure retaining diaphragm and seals. The snap-acting switch is rated by its manufacturer for a 90° C (194° F) maximum continuous service temperature. General material information indicates that the Viton pressure retaining diaphragm and seals are acceptable for temperatures in excess of a 350° F maximum continuous service temperature. Based on this data the utility can conclude that the pressure switch is operable for the four hour duration of a station blackout at a T_{DAC} of 160° F.

F.5 Equipment Inside Instrumentation and Control Cabinets

F.5.1 General Statement of Method

Components located inside instrumentation and control cabinets are normally exposed to the heat generated by electrical power supplies. Most cabinets are not equipped with forced ventilation, relying, instead, on natural convection through louvers in the cabinet. Guidelines direct operators to open doors for cabinets containing energized equipment relied upon to cope with a station blackout within 30 minutes in order to provide more extensive air mixing with the general area. This action is expected to reduce the potential for building up higher air temperatures in the immediate vicinity of electrical and electronic equipment and components.

Reasonable assurance for equipment operability is provided if it is shown that the station blackout coping equipment and components inside instrumentation and control cabinets with open doors will not be exposed to a thermal environment that exceeds normal operating conditions with the doors closed.

F.5.2 Guidance

Equipment located inside instrumentation and control cabinets normally operate at steady-state temperatures which are frequently higher than the expected room temperatures in dominant areas of concern during a station blackout. If cabinet doors are opened to improve ventilation within the first 30 minutes of a station blackout, these components are not expected to experience temperature environments which would be substantially different from their normal operating conditions. In fact, due to the size of the cabinet doors it is reasonable to assume that the cabinet internal temperatures do not exceed the ambient temperature of the room once the doors are opened. On this basis, reasonable assurance of equipment operability in a station blackout is established if it can be shown by analysis or measurement that such cabinets with open doors will not expose the components inside to a thermal environment that exceeds normal operating conditions with the doors closed.

Reliance on this method requires station blackout response procedures which direct operators to open cabinet doors in dominant areas of concern (please see Section 4.2.1(10)) within the first 30 minutes of a station blackout event.

F.5.3 Procedure

Apply the following steps for station blackout response equipment located in dominant areas of concern experiencing a total loss of forced ventilation.

(1) Determine T_{DAC} for the area containing the equipment in accordance with Section 7.2.4.

(2) Determine the maximum design temperature for the equipment or measure the normal bulk air operating temperature inside the cabinet (whichever is higher). One measurement at a location near the top of the cabinet is sufficient for the purpose of establishing operability during a station blackout.

(3) Reasonable assurance of operability is established if:

(a) The temperature determined in Step 2 is higher than the temperature determined in Step 1; and,

(b) Procedures requiring opening of cabinet panels and doors within 30 minutes of the loss of ventilation event are implemented.

F.5.4 Example

The following example illustrates the establishment of reasonable assurance of operability on the basis of equipment located inside instrumentation and control cabinets.

Example:

A cabinet containing heat generating station blackout instrumentation is located in a dominant area with a T_{DAC} of 140° F. The normal steady state bulk air temperature inside the cabinet, $T_{cabinet}$, is determined to be 150° F. Plant procedures are implemented to open the doors to this cabinet within one half hour of loss of ventilation. Reasonable assurance of operability is established since $T_{DAC} < T_{cabinet}$.

F.6 Generic Studies and Experience

F.6.1 General Statement of Method

The current state of knowledge concerning equipment operability in elevated thermal environments provides a substantial basis for concluding that plant equipment can properly function in thermal environments above design conditions. This state of knowledge, in the form of a variety of studies and reports, may be used to establish reasonable assurance of operability in station blackout environments.

F.6.2 Guidance

A variety of studies and reports contain information on the operability of equipment above design conditions. The information contained in these reports can be used to establish reasonable assurance of operability. Examples of these include:

(1) Licensee Event Reports;
(2) Nuclear Plant Reliability Data Systems (NPRDS);
(3) NUREGs;
(4) ANSI, ASME, ASTM, or ANS standards;
(5) Scientific literature; and,
(6) Vendor information.

F.6.3 Procedure

Apply the following steps for station blackout response equipment located in dominant areas of concern experiencing a total loss of forced ventilation.

(1) Determine T_{DAC} for the area containing the equipment in accordance with Section 7.2.4.

(2) (a) Determine the time period that the equipment must remain operable for the appropriate station blackout coping method; or,

(b) Assume the equipment must remain operable for the entire duration of the station blackout (i.e., one, two, or four hours).

(3) Determine whether any generic analyses, tests, or reports exist that address the operability of equipment exposed to the conditions which envelope Steps 1 and 2. A bibliography of reports which may be helpful to establish reasonable assurance of operability sorted by equipment category is provided in the NUGSBO Equipment Operability Database.

(4) Reasonable assurance of operability is provided if the temperature specified in Step 1 and the duration specified in Step 2 are enveloped by the conditions for the equipment as determined from generic studies and experiments.

F.6.4 Examples

The following examples illustrate the establishment of reasonable assurance of operability on the basis of generic studies and experience.

Example 1:

A solenoid valve is located in a dominant area of concern where T_{DAC} = 150° F. Vendor documentation is available supporting operability at 120° F. A generic report, however, is available documenting events in which similar solenoid valves operated without failure at 151° F for time periods longer than four hours. Reasonable assurance of operability is therefore established.

Example 2:

The expected T_{DAC} for an operating BWR is calculated for all dominant areas of concern. These values are compared to those calculated or measured for an actual loss of ventilation event at a similar BWR. If the T_{DAC} values at this second plant envelope those calculated for the first, then operability is established for similar equipment. Information describing the event and equipment performance should be obtained from the facility experiencing the event.

Example 3:

A utility determines that a piece of equipment is required in a T_{DAC} of 140° F for four hours. Similar equipment installed in another plant area functioned appropriately when subjected to local temperature excursions which exceeded the T_{DAC} value for four hours. Reasonable assurance of operability is based on this plant specific information.

F.7 Plant-Specific Experience and Tests

F.7.1 General Statement of Method

Some plants have actually experienced the effects of loss of ventilation or have studied the issue for specific applications. For such cases, reasonable assurance for equipment operability is provided if no failures of equipment needed to cope with a station blackout resulted from exposing the equipment to temperatures expected from a four hour station blackout during tests or operational events.

F.7.2 Guidance

This method allows the use of plant specific experience to establish operability. A loss of ventilation event, for example, may be used as a basis to establish operability. Reasonable assurance of operability for the duration of the event is established if the loss of ventilation does not impact the operability of station blackout components. Alternatively, utilities may demonstrate operability in a station blackout environment by testing.

F.7.3 Procedure

Apply the following steps for station blackout response equipment located in dominant areas of concern experiencing a total loss of forced ventilation.

(1) Determine T_{DAC} for the area containing the equipment in accordance with Section 7.2.4.

(2) (a) Determine the time period that the equipment must remain operable for the appropriate station blackout coping method; or,

(b) Assume the equipment must remain operable for the entire duration of the station blackout (i.e., one, two, or four hours).

(3) Reasonable assurance of operability is established if any plant specific analyses, tests, or experience subjected the equipment, without failure, to conditions enveloping those determined in Steps 1 and 2.

F.7.4 Examples

The following examples illustrate the establishment of reasonable assurance of operability on the basis of plant specific experience and tests.

Example 1:

During an extended loss of off-site power event a BWR achieved safe shutdown without restoring normal Reactor Building ventilation for ten hours. Ventilation through the Standby Gas Treatment System was available but provided insignificant cooling to the building areas. The RCIC system successfully operated throughout the event; the HPCI system was secured after the first hour of operation. After restoration of off-site power, all systems and equipment functioned normally and the unit was returned to power. No subsequent failures of the equipment due to exposure to elevated temperatures during the loss of ventilation were identified. No replacements with new designs had been made or were necessary for equipment required for coping with a station blackout in these dominant areas of concern. As a result of this operating experience, reasonable assurance is established that equipment in this BWR will perform during the four hour temperature environments anticipated during station blackout events.

Example 2:

Station blackout equipment located in the auxiliary feed-water (AFW) pump room is required to operate for one hour in order to cope with a station blackout event. The components in this room were shown to operate under station blackout conditions for two hours as part of post-TMI NRC requirements. Reasonable assurance of operability is, therefore, established for all equipment located in the AFW pump room of this PWR.

APPENDIX K. NRC CORRESPONDENCE

This section discusses the NRC's acceptance of the methodology outlined in this document. The NRC originally documented via Regulatory Guide 1.155 that NUMARC 87-00, Revision 0, provided guidance acceptable to the NRC staff for meeting the requirements of 10CFR50.63, station blackout. This acceptance was restated in the station blackout rule itself. Subsequently, the staff has documented acceptance of supplemental NUMARC 87-00 guidance via the following letters:

1. NRC to NUMARC letter dated October 7, 1988, providing approval of NUMARC documents on station blackout (Generic Response Formats, Station Blackout Seminar Q&A, Appendix F, Appendix F Topical Report, and Errata);

2. NRC to NUMARC letter dated June 16, 1989, providing acceptance of the clarification to station blackout seminar Q&A #53 on hurricane shutdown;

3. NRC to NUMARC letter dated January 3, 1990, providing approval of NUMARC 87-00 supplemental guidance documents (Supplemental Q&A and Major Assumptions); and,

4. Staff Requirements Memorandum (SRM) dated June 28, 1991 that provides Commission acceptance of the use of identified trigger values consistent with the methodology presented in Appendix D of this document.

Copies of this correspondence are provided in this section for reference.

Enclosure (1)

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

October 7, 1988

Mr. William H. Rasin
Nuclear Management and Resources Council
1776 Eye St. N.W.
Suite 300
Washington, D.C. 20006-2496

Dear Mr. Rasin:

SUBJECT: APPROVAL OF NUMARC DOCUMENTS ON STATION BLACKOUT (TAC 40577)

By letter to T.E. Murley (NRC) dated September 28, 1988, you submitted six final documents for staff approval. These documents have been discussed between NUMARC personnel and the staff in one or more of the working meetings that took place on July 28, September 15 and September 22, 1988 (summaries of these meetings are dated August 15, September 12 and October 3, 1988, respectively).

The technical staff has reviewed these six documents, and conclude that the final versions that you submitted on September 28, 1988, reflect agreements made in the three working meetings stated above. However, it is noted that on one particular issue, agreement was not required; NUMARC and the staff agreed to disagree. This issue involves the identification in the "Generic Response to Station Blackout Rule for Plants Using Alternate AC Power" of the unavailability of HVAC in specific areas of concern including the control room complex. It is our view that the explicit statement of this unavailability of HVAC in the licensee response is necessary to facilitate and assure the effectiveness of our review process, and of the subsequent audits of supporting documentation that may be required to establish full conformance to 10 CFR 50.63. Therefore, we request that this generic response document be revised as indicated below.

With the exceptions noted, these documents are approved as follows:

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

These two documents provide acceptable formats for a licensee to provide its plant-specific response in accordance with 10 CFR 50.63(C). However, pages 6, 7, 10 and 12 of the generic response for plants using alternate AC power should be revised as shown on the enclosed marked-up pages. With these revisions, these documents define the amount and depth of information needed by the staff; additional information may be requested of a licensee if needed to determine whether a licensee has achieved full conformance with 10 CFR 50.63.

Mr. Rasin - 2 -

3. "Responses to Questions Raised at the Station Blackout Seminars"

This document serves as appropriate clarification to the existing acceptable guidance for addressing the station blackout issue. This document should be revised as indicated on the enclosed marked-up pages.

4 & 5. "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors: Appendix F" and "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors: Appendix F Topical Report"

These documents provide an acceptable means of addressing equipment operability in a station blackout; they can be viewed as providing clarification of, and replacing, the existing Appendix F found in NUMARC 87-00. Therefore, the reference to Appendix F in Regulatory Guide 1.155 now refers to these documents. Appendix F should be revised as indicated on the enclosed marked-up pages.

6. "Errata to NUMARC 87-00"

This document is accepted as providing corrections, including those indicated on the enclosed marked-up pages, to NUMARC 87-00.

Copies of the above documents may be distributed to participating licensees.

Sincerely,

M. Wayne Hodges for

Ashok C. Thadani, Assistant Director
for Systems
Division of Engineering and Systems
Technology
Office of Nuclear Reactor Regulation

cc. NRC Public Document Room

Enclosure

ENCLOSURE TO LETTER, A. THADANI TO W. RASIN, DATED OCTOBER 7, 1938.

The following marked-up pages are included:

Document	Page
Generic Response, Alternate AC Power	6 7 10 12
Questions and Answers	13 16 21 37 52
Errata	8 (with NUMARC 87-00 pages 2-12 and 2-13 attached)
Appendix F	F-3 F-8

- 6 -

GENERIC RESPONSE TO STATION BLACKOUT
RULE FOR PLANTS USING ALTERNATE AC POWER

decay heat removal for [insert required coping duration category from NUMARC 87-00, Section 3.2.5] hours. LIST SOURCES AND NUMBER OF GALLONS PROVIDED BY EACH SOURCE.

SELECT ONE OF THE FOLLOWING TWO SENTENCES AND INSERT HERE:

a. No plant modifications or procedure changes are needed to utilize these water sources; or

b. The following plant modifications and/or procedure changes are necessary to utilize these water sources. LIST MODIFICATIONS(S) WITH A BRIEF DESCRIPTION.

2. Effects of Loss of Ventilation (Section 7.2.4)

SELECT ONE OF THE FOLLOWING TWO PARAGRAPHS.

The AAC power source provides power to HVAC systems serving dominant areas of concern. Therefore, the effects of loss of ventilation were not assessed; or

HVAC systems serving the following dominant areas of concern are not available: [list the dominant areas of concern]. Reasonable assurance of the operability of station blackout response equipment in the above area(s) has been assessed using Appendix F to NUMARC 87-00. NOTE: IF THE REQUIRED COPING DURATION CATEGORY IS LESS THAN EIGHT HOURS, NUMARC 87-00 TOPICAL REPORT MAY ALSO BE USED.

*additionally, if the control room complex is not identified as a dominant area of concern, also state whether HVAC is available for this area

SELECT ONE OF THE FOLLOWING TWO PARAGRAPHS.

No modifications and/or procedures are required to provide reasonable assurance for equipment operability; or

The following modifications and/or procedures are required to provide reasonable assurance of equipment operability. LIST AND BRIEFLY DESCRIBE.

3. Reactor Coolant Inventory (Section 2.5)

SELECT ONE OF THE FOLLOWING THREE PARAGRAPHS:

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

The ability to maintain adequate reactor coolant system inventory to ensure that the core is cooled has been assessed for [insert required coping duration category]. SELECT ONE OF THE FOLLOWING TWO SENTENCES. The generic analyses listed in Section 2.5.2 of NUMARC 87-00 were used for this assessment and are applicable to the specific design of [insert plant name]; or, A plant-specific analysis was used for this assessment. Note: THE GENERIC NSSS VENDOR ANALYSES REFERENCED IN SECTION 2.5 DO NOT APPLY FOR A SBO BEYOND FOUR HOURS. OTHER NSSS VENDOR ANALYSES OR PLANT-SPECIFIC ANALYSES MAY NEED TO BE REVIEWED IF THE REQUIRED COPING DURATION CATEGORY EXCEEDS FOUR HOURS. The expected rates of reactor coolant inventory loss under SBO conditions do not result in core uncovery (for a PWR) or more than a momentary core uncovery (for a BWR) in a SBO of [insert required coping duration category].Therefore, makeup systems in addition to those currently available under SBO conditions are not required to maintain core cooling under natural circulation (including reflux boiling); or

The ability to maintain adequate reactor coolant system inventory to ensure that core is cooled has been evaluated for the required SBO duration. It has been determined that the expected rates of reactor coolant inventory loss under SBO conditions result in core uncovery (for a PWR) or more than a momentary core uncovery (for a BWR) in the specified SBO duration. The following modifications and associated procedure changes are required to ensure that appropriate reactor coolant makeup water can be provided under SBO conditions. LIST AND BRIEFLY DESCRIBE.

COMPLETE THE FOLLOWING SECTIONS IF THE AAC POWER IS NOT AVAILABLE WITHIN TEN MINUTES OF THE ONSET OF STATION BLACKOUT:

1. <u>Condensate Inventory For Decay Heat Removal (Section 7.2.1)</u>

SELECT ONE OF THE FOLLOWING TWO PARAGRAPHS:

It has been determined from Section 7.2.1 of NUMARC 87-00 that [insert number] gallons of water are required for decay heat removal for [insert required coping duration category from NUMARC 87-00, Section 3.2.5].

GENERIC RESPONSE TO STATION BLACKOUT
RULE FOR PLANTS USING ALTERNATE AC POWER

AREA	TEMPERATURE
HPCI/HPCS Room	(insert value)
RCIC Room	(insert value)
Main Steam Tunnel	(insert value)

c. Control Room Complex for PWR's or BWR's

The assumption in NUMARC 87-00, Section 2.7.1 that the control room will not exceed 120°F during a station blackout has been assessed.

SELECT ONE OF THE FOLLOWING TWO PARAGRAPHS.

The control room at [insert plant name] does not exceed 120°F during a station blackout. Therefore, the control room is not a dominant area of concern; or

The control room at [insert plant name] has been calculated to reach a steady state ambient air temperature of [insert value] °F during a station blackout. Therefore, the control room is a dominant area of concern.

SELECT ONE OF THE FOLLOWING TWO PARAGRAPHS:

Reasonable assurance of the operability of station blackout response equipment in the above dominant area(s) of concern has been assessed using Appendix F to NUMARC 87-00 and/or the Topical Report. No modifications or associated procedures are required to provide reasonable assurance for equipment operability; or

Reasonable assurance of the operability of station blackout response equipment in the above dominant area(s) has been assessed using Appendix F to NUMARC 87-00 and/or the Topical Report. The following modifications and/or associated procedure changes are required to provide reasonable assurance for equipment operability: LIST AND BRIEFLY DESCRIBE.

5. Containment Isolation (Section 7.2.5)

SELECT ONE OF THE FOLLOWING TWO PARAGRAPHS:

d. HVAC systems serving the following dominant areas of concern are not available: [list the dominant areas of concern; additionally, if the control room complex is not identified as a dominant area of concern, also state whether HVAC is available for this area]

GENERIC RESPONSE TO STATION BLACKOUT RULE FOR PLANTS USING ALTERNATE AC POWER

systems in addition to those currently available under SBO conditions are not required to maintain core cooling under natural circulation (including reflux boiling); or

The ability to maintain adequate reactor coolant system inventory to ensure that core is cooled has been evaluated for the required SBO duration. It has been determined that the expected rates of reactor coolant inventory loss under SBO conditions result in core uncovery (for a PWR) or more than a momentary core uncovery (for a BWR) in the specified SBO duration. The following modifications and associated procedure changes are required to ensure that appropriate reactor coolant makeup water can be provided under SBO conditions. LIST AND BRIEFLY DESCRIBE.

The modifications and associated procedure changes identified in Parts B and C above will be completed [insert time] after the notification provided by the Director, Office of Nuclear Reactor Regulation in accordance with 10 C.F.R. 50.63(c)(3).

Very truly yours,

Company Official

cc: NUMARC

3.2.2 EAC Power Configuration

24. Q: Define emergency AC.

A: Emergency AC is your standby AC power supplies as defined in NUMARC 87-00 to meet GDC-17.

25. Q: If a site has two units, both 1 out of 2 EDG configuration, is there any argument for going to 2 out of 4 EDG CONFIGURATION at that site?

A: The 2 out of 4 EDG configuration is for diesels which are normally shared between the units. If the diesels are not normally shared, there is no basis for using the 2 out of 4 configuration.

26. Q: When determining the number of necessary EAC standby power supplies, what load requirements should be considered?

A: As described in NUMARC 87-00, Section 3.2.2 part 2.B, the safe shutdown loads associated with loss of offsite AC power are the minimum loads which should be considered when determining the number of necessary EAC sources. These loads do not necessarily include LOCA loads.

A: Current actual reliabilities are determined per Section 3.2.3 and these in turn are used to determine the EDG TARGET reliability in Section 3.2.4 and these target reliabilities are used in part to determine the required station blackout coping duration. Once the coping duration, with target reliabilities, is established then utilities will maintain these reliabilities through a program discussed in Appendix D of the NUMARC 87-00 document. This program is currently under further development by NUMARC as resolution to Generic Issue B-56. Detailed criteria for maintaining performance to sustainING the target reliabilities will be part of the EDG Reliability Program.

33. Q: What happens if a plant uses .975 reliability in order to get itself into the 4 hour category, then later falls below this level?

A: Target reliabilities should be maintained through a maintenance program which may be comprised of the elements found in NUMARC 87-00, Appendix D. The process of maintaining the target reliabilities will be detailed in the EDG Reliability Program developed as resolution to Generic Issue B-56.

A: No. A utility can determine the order in which water sources are used as long as they are defined procedurally.

44. Q: Do we need to perform a study to identify safe shutdown instrumentation?

A: A study is probably not needed since such a list was required for Appendix R. Also the EOPs should already identify the instrumentation being used to achieve and maintain safe shutdown.

45. Q: Can credit be taken for diesels that have dedicated water makeup capability?

A: Yes. Using the AC-independent approach, dedicated water makeup capability may be relied upon if the diesel does not normally provide power to the essential and non-essential power supplies (see the definition of station blackout). The support systems for such diesels must also be independent of these power supplies in order to credit their operation in a station blackout. In order for the diesel to be credited as an AAC machine it must also meet the criteria set forth in Appendix B of NUMARC 87-00.

supplies in small rooms or enclosures), and (3) the absence of heat removal capability in a station blackout without operator action. These areas are have been determined to be:

(1) Steam Driven AFW Pump Room (PWRs only);

(2) HPCI/HPCS Room (BWRs only);

(3) RCIC Room (BWRs only); and,

(4) Main Steam Tunnel (BWRs only).

It should be noted that any site specific plant area found meeting the three factors above should also be considered to be a dominant area of concern.

STATION BLACKOUT EQUIPMENT - equipment located in dominant areas of concern which are used to bring the plant to safe shutdown during station blackout conditions.

STATION BLACKOUT TEMPERATURE (T_{DAC}) - the average steady state bulk air temperature in a dominant area of concern during a four hour station blackout.

STATION BLACKOUT OPERABILITY TEMPERATURE (T_{OPP}) - the temperature for which reasonable assurance of operability has been established for a specific component or for an equipment category. This temperature is established for a variety of equipment categories in the Appendix F Topical Report, and may be established for individual equipment using the approaches described herein.

SIMILAR EQUIPMENT - equipment whose characteristics are such that:

(1) the limiting sub-components have comparable or less limiting thermal properties; and,

(2) the limiting materials have comparable or less limiting thermal properties.

In the context of station blackout, *limiting sub-components* or *limiting materials* are those sub-components or materials which are most susceptible to significant degradation at elevated temperatures. The application of this principle is illustrated in Example 3 of Section F.2.4.

affected by the temperatures reached in the steam tunnel?

A: Temperature sensors for detecting high energy line breaks are located in the main steam tunnel. In a station blackout, bulk air temperatures may rise to a level that could trip the RCIC turbine due to steam supply isolation.

85. Q: What assumptions apply to the area on the other side of a door that may be considered for providing supplementary ventilation?

A: To take credit for opening doors during a station blackout, the adjacent area must be sufficiently large to maintain a relatively constant temperature when considering the additional heat loads imparted to the room from the dominant area of concern. In addition, the adjacent room's bulk air temperature should not exceed the initial wall temperature in the dominant area of concern due to heat sources located in that adjacent area.

86. Q: What is the assumed location of doors?

130. Q: Are breakers that are necessary for the operation of AAC power required to be operated from a controller or can they be operated manually?

A: Manual operation of breakers is allowed as long as it can be demonstrated that the necessary actions can be carried out such that the AAC power source is available within one hour. Alternate AC that is considered available within 10 minutes must meet the requirements of NUMARC 87-00 Section 7.1.2.

131. Q: In the case of AAC configuration 2B, if the blacked-out diesel's batteries control the cross-tie breakers and we assume that the batteries fail, it would then be necessary to provide operator actions to supply power to the blacked out unit. Does this mean that the AAC source would not be able to be considered as a 10-minute AC source?

AAC

A: No. In order for an AAC source to meet the 10-minute criteria, circuit breakers necessary to bring power to safe shutdown buses must be capable of being actuated in the control room in that period.

132. Q: On AAC configuration 2B, are cross-ties required for both trains?

Errata to NUMARC 87-00
Page 8

35. P. C-4 - The "A" buses should be connected to each other and the "B" buses should also be connected to each other. For Unit 2 change the "A" to "B" and the "B" to "A".

36. P. E-14 - Appendix E, Section E.3.2 - in second to last sentence change "72°F" to "68°F" and in last sentence insert "(79°F)" after "44°C."

37. PP. F-1 through F-4 - delete in entirety and replace with Appendix F, Revision 1 dated September 26, 1988 and the Topical Report dated September 26, 1988.

38. PP. 2-12 - 2-13 - delete the last 4 lines on page 2-12 in entirety. delete line 1 in entirety on page 2-13. Page 2-13, section (3) "Control Room Habitability", second paragraph: delete the first sentence in entirety.

during a four hour station blackout. This assumption is based on operating experiences and studies concerning the operability of various classes of equipment exposed to elevated temperatures.

In a station blackout, forced cooling will be lost to most plant areas and the potential exists in Condition 1 areas for bulk air temperatures to rise up to 120° F. For most mechanical and electrical equipment and instrumentation found in Condition 1 dominant areas, temperature rises up to 120° F would likely not adversely affect operability.

Condition 2

Condition 2 rooms are likely to include a relatively substantial heat generation source and a small room geometry. These conditions are more typical of rooms containing steam-driven makeup pumps, such as RCICS and AFWS which are generally qualified or designed to operate in elevated temperatures.

The NRC has considered equipment operability during station blackout conditions (see Jacobus [1987]). One of the conclusions of this review is that certain classes of components (e.g., relays and switches) will likely remain operable in thermal environments of 150° F to 300° F for up to eight hours. While the Jacobus study was not extensive, the general assumption of equipment operability for Condition 2 thermal environments is considered valid because (1) only a four hour station blackout event is considered, and (2) in practice, less than the full four hours would be involved since there would be a period of thermal buildup during the front-end of the station blackout transient.

Condition 3

Condition 3 rooms represent classes of thermal environments where plant-specific consideration may be appropriate.

Appendix F provides a method for assessing the operability of equipment exposed to Condition 1, 2, and 3 environments.

~~*The operability of a representative set of control room complex (i.e., area(s) containing instrument indications and associated logic cabinets which the control room operator relies upon to cope with a station blackout) cabinet equipment was established with actual experience involving loss of control room ventilation for several hours (see Chiramal [1986]). During this extended loss of ventilation event at McGuire, there was negligible operability effe*~~

GUIDELINES AND TECHNICAL BASES FOR NUMARC INITIATIVES NUMARC-8700

~~(2) equipment or instrumentation.~~

(b) *Battery capacity is reduced if the electrolyte temperature drops significantly below design temperatures. Class 1E batteries are housed in seismic Category I structures, and are not typically subjected to the direct effects of the external environment. Therefore, the temperature decrease in the battery room is not significant over a four-hour period. Also, the mass of battery electrolyte is sufficient to resist significant temperature drops over a four-hour period due to lower battery room temperatures since battery cell materials are not efficient thermal conductors. Therefore, a decrease in battery capacity due to temperature decreases in electrolyte under station blackout conditions does not warrant further consideration.*

(3) *Control Room Habitability*

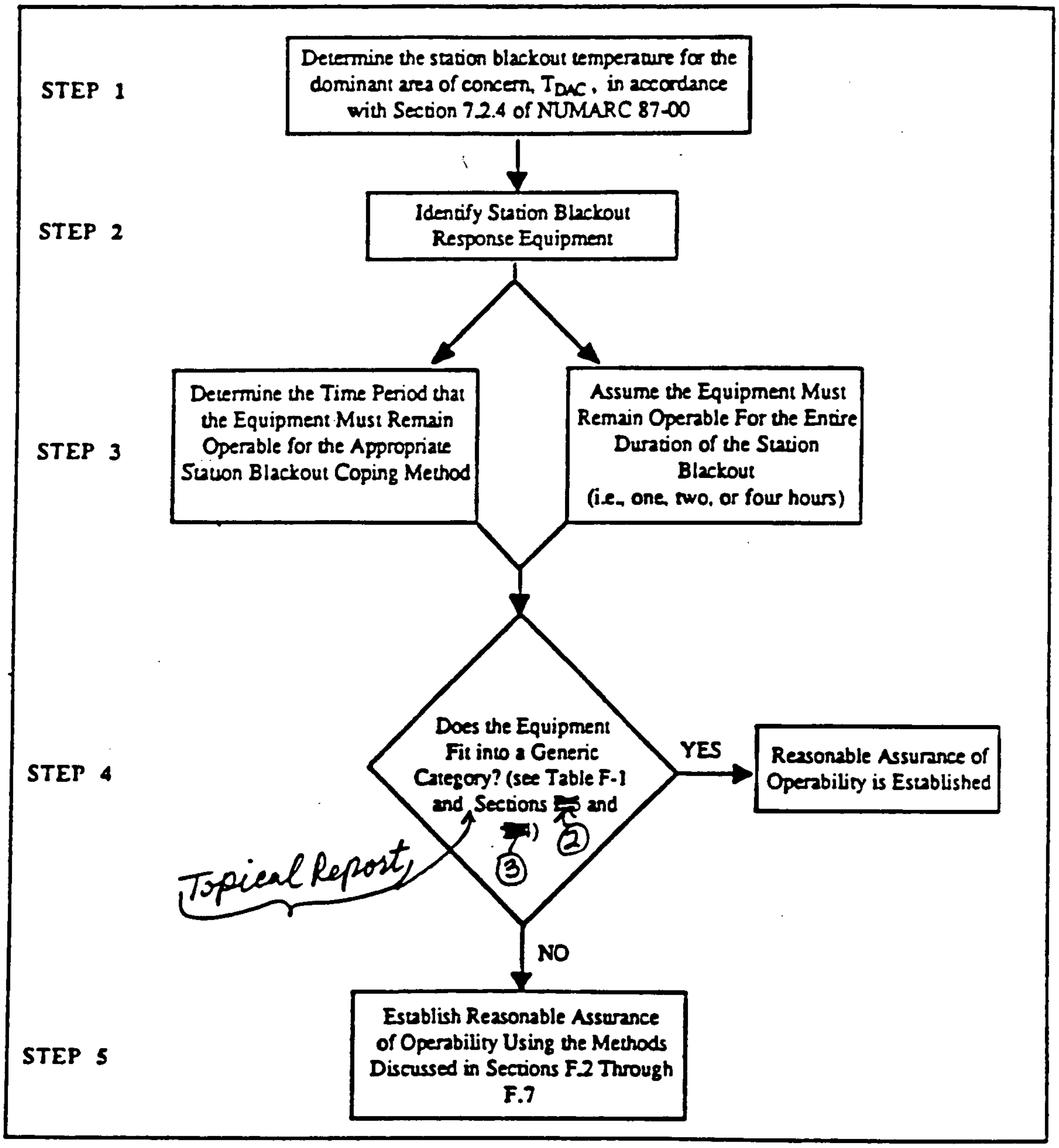
Control room habitability is not an important contributor to station blackout risk, particularly for events of 4-hour durations. NUREG-1032 points out that the dominant accident sequences involve either an early core cooling failure or a subsequent loss of core cooling (see Appendix C, NUREG-1032 for a more complete discussion of station blackout accident sequences). Both sequences are dominated by the failure of automatic equipment to properly function on demand. Even these events have failure probabilities of less than 1% per event, reflecting the exceptionally high reliability of these systems and components. With respect to human error, such as due to habitability concerns, NUREG-1032 states: "The potential effect of operator error causing loss of decay heat removal has not been found to be a large contributor to core damage frequency, if adequate training and procedures exist." (draft NUREG-1032, page C-15). Since NUMARC Initiative 2, as provided in Section 4 guidelines, assures adequate training and procedures will exist, the concern regarding operators' ability to perform cognitive tasks is insignificant.

~~(4) As the expected environment within the control room, it has been shown that temperatures are not likely to exceed 110°F should a station blackout event actually occur (Chiramal [1986]). In the McGuire event discussed by Chiramal,~~ *habitability was never an issue. Studies suggest that long term occupancy in higher temperature environments does not prevent performance of tasks of various difficulties (see Eichna [1945] and Humphries and Imalis [1946] for military applications). Such studies have been the basis of guidance in the heating and ventilating industry handbooks (e.g., ASHVE [1950] and ASHRAE [1985]). ASHRAE, in particular, correlates temperature, humidity, and pressure and concludes that light work at 110° F and relative humidities up to 50% would not be intolerable.*

Before the station blackout event, it is assumed that the control room is at 78° F and about 35% relative humidity. Although temperature increases may be expected due to loss of HVAC, the relative humidity actually decreases to approximately 30%. Guidance provided for military applications may establish a technical basis for defining

GUIDELINES AND TECHNICAL BASES FOR NUMARC INITIATIVES NUMARC 87-00

(5) Establish reasonable assurance by following any of the approaches discussed in this appendix. The NUGSBO equipment operability database (EODB) may contain information to help support the evaluation.



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

JUN 16 1989

Mr. William H. Rasin
Nuclear Management and Resources Council
1776 Eye Street, N.W.
Suite 300
Washington, D.C. 20006-2496

Dear Mr. Rasin:

SUBJECT: STATION BLACKOUT (TAC 40577)

This is in response to your letter of February 1, 1989, concerning clarification of the answer to question 53 of the questions raised at the NUMARC 87-00 seminars, October 1988.

Mr. Alex Marion of your staff recently called Ashok Thadani of my staff regarding this matter. However our technical staff had previously agreed to the clarification during a teleconference. The "clarification" submitted with your letter, as marked by the staff (Enclosure), is appropriate acceptable guidance for addressing question 53 as related to the station blackout issue. Copies of this answer may be distributed to participating licensees.

Sincerely,

Thomas E. Murley, Director
Office of Nuclear Reactor Regulation

Enclosure:
As stated

CLARIFICATION TO QUESTION 53 OF THE "RESPONSES TO QUESTIONS RAISED AT THE NUMARC 87-00 SEMINARS, OCTOBER 1988"

Question 53 reads:

> Q: Does NUMARC 87-00 require plants to have procedures to shutdown the plant two hours before a hurricane?

Current Answer:

> If you have evaluated a probable maximum hurricane during plant licensing, then you should specify a site-specific indicator which would ensure that the plant would be in safe shutdown two hours before the anticipated hurricane arrival at the site.

Revised Answer:

> Not all plants. However, plants which have evaluated a probable maximum hurricane during plant licensing, are in the eight-hour coping duration category and fall into one of the asterisked matrix cells in NUMARC 87-00, Tables 3-5b, 3-6b or 3-8 may achieve a four-hour coping duration by implementing the shutdown guideline in Action 4(a) of NUMARC 87-00. Eight-hour coping duration category plants which do not implement the guidelines in Action 4(a) cannot use Tables 3-5b or 3-6b. In such cases a reduction in the coping duration category may be achieved by making the necessary modifications to the plant. Installing or utilizing an AAC power source allows for appropriate coping.

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

JAN 3 1990

Mr. Alex Marion, Manager
Technical Division
Nuclear Management and Resources Council (NUMARC)
1776 Eye Street, N.W., Suite 300
Washington, D.C. 20006-2496

Dear Mr. Marion,

Your letter of December 28, 1989 (Enclosure), transmitted the following supplemental guidance documents for addressing the station blackout issue:

1. NUMARC 87-00 Supplemental Questions/Answers, dated December 27, 1989.

2. NUMARC 87-00 Major Assumptions, dated December 27, 1989.

We have reviewed these documents and conclude that they accurately reflect the resolution of all the remaining supplemental guidance issues as discussed in the publicly-noticed meeting of December 27, 1989. Therefore, these documents will provide acceptable clarification to the previously approved guidance for addressing the station blackout issue.

As discussed in all our meetings on supplemental guidance, in order to affect the resolution of the station blackout issue in accordance with the established program and with minimum impact on schedule, the NRC requires confirmation from licensees that: (1) analyses were conducted in accordance with established guidance, (2) the results are accurately reflected in the licensee response, (3) technically sufficient supporting documentation is available, and (4) a reliability program has been or will be implemented to attain and maintain the targeted level of emergency diesel generator reliability. We expect that licensees will expeditiously review and revise their response to the station blackout rule as necessary to provide this confirmation.

Sincerely,

Ashok C. Thadani, Director
Division of Systems Technology
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission

Enclosure:
As stated

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

OFFICE OF THE SECRETARY

CORRECTED COPY,
DATE CORRECTED

June 28, 1991

RELEASED TO THE PDR
7/26/91

MEMORANDUM FOR: James M. Taylor
Executive Director for Operations

FROM: Samuel J. Chilk, Secretary

SUBJECT: SECY-90-340 - "DIESEL GENERATOR RELIABILITY," RESOLUTION OF GENERIC SAFETY ISSUE B-56 (COMJC-91-001/001-A)

The Commission (with all Commissioners agreeing) has disapproved the use of a generic letter and the provisions of 10 CFR 50.54(f) as a vehicle for imposing requirements on, or securing enforceable commitments from, power reactor licensees to address Generic Safety Issue B-56. The need to establish a firm legal basis for the regulatory action, is such that this issue should be addressed through rulemaking.

With respect to the approach to be taken in addressing the issue of emergency diesel generator (EDG) reliability, the Commission has endorsed a results-oriented approach, consistent with the approach taken in the maintenance rule, that will focus on the overall objective of demonstrated EDG reliability, in lieu of the approach recommended by the staff in SECY-90-340. Accordingly, the staff should prepare for Commission approval a proposed rule and regulatory guidance as necessary in accordance with the approach outlined below.

(EDO) (SECY SUSPENSE: 12/91)

The approach endorsed by the Commission would consist of the following fundamental elements: (1) target reliability levels would be established for each licensee's EDGs (these reliability levels would comport with the reliability levels assumed in a licensee's coping analysis for station blackout (SBO)); (2) trigger values would be established with respect to EDG failures, to serve two purposes -- to provide an "early warning" of EDG degradation, and to provide a basis for taking regulatory action

SECY NOTE: THIS SRM, THE SUBJECT SECY PAPER AND THE VOTE SHEETS OF COMMISSIONERS ROGERS, REMICK AND CURTISS WILL BE MADE PUBLICLY AVAILABLE IN 10 WORKING DAYS FROM THE DATE OF THIS SRM.

(including the possibility of enforcement action) when it becomes clear that the target reliability level is not being met by a licensee (a more detailed discussion of the trigger values is set forth below); (3) a reporting regime would be established in accordance with the approach specified above.

The "early warning" trigger values should be used for the purpose of detecting potential diesel generator degradation at an early stage. These trigger values would consist of a requirement that licensees -- (i) report diesel failures to the NRC when such failures reach 3 failures out of 20 starts, measured on either a per unit or a per diesel basis; and (ii) undertake accelerated testing, as well as submit a report to NRC, in the event that diesel failures reach 4 out of 25 failures, measured on an individual diesel basis. Unlike the double trigger values established below -- which provide a clear indication that the true underlying reliability may have fallen below the target reliability -- activation of the "early warning" trigger values would not serve as a basis for taking regulatory action. These trigger values would serve strictly as an "early warning" mechanism to flag a potential decline in diesel generator reliability. If a "double trigger" value of 5 failures out of 50 starts <u>and</u> 8 failures out of 100 starts (at a .95 reliability target) or 4 failures out of 50 starts <u>and</u> 5 failures out of 100 starts for licensees (at a .975 reliability target) applied on a unit basis (<u>i.e.</u>, to the aggregate of all diesels at a given unit rather than to each individual diesel), is exceeded, it would provide a clear indication for concluding that the underlying reliability levels assumed in the SBO submittals have not been met. Failure to meet the specified double trigger values would serve as the basis for taking regulatory action, including the possibility of enforcement action.

At the time that the staff submits the proposed rule for Commission approval, staff should identify proposed regulatory actions to be taken, including possible enforcement action, when the "double trigger" criterion is met.

The Staff should address the industry's request for relief from the current accelerated testing requirements for a problem diesel generator, as discussed in NUMARC's May 21, 1991 letter to Commissioner Curtiss.

(EDO) **(SECY SUSPENSE: 10/15/91)**

cc: Chairman Carr
Commissioner Rogers
Commissioner Curtiss
Commissioner Remick
OGC
GPA
ACRS

APPENDIX I. RESPONSES TO QUESTIONS RAISED AT THE NUMARC 87-00 SEMINARS

I.1 General Questions

1. Q: Please explain the relationship between the NUMARC station blackout (SBO) Initiatives and the NRC's station blackout rule.

A: Through our NUMARC Executives, Industry has committed to complete five SBO Initiatives. Each plant should complete the station blackout Initiatives using NUMARC 87-00, which is Industry's guidance and methodology for completing the SBO Initiatives, and is identified in the Staff's SBO Regulatory Guide (1.155) as providing guidance which is acceptable to the Staff for meeting the requirements of the SBO rule (10 C.F.R. §50.63). However, two areas addressed in the Staff's Regulatory Guide are not covered by NUMARC 87-00 and should be addressed by each plant in accordance with the regulatory guidance:

1. Quality assurance requirements for SBO response equipment; and

2. Consideration of technical specifications for SBO response equipment.

Also, Section 3.3.6 of the Staff Regulatory Guide requires a system walk down and initial test for systems added to meet SBO recommendations. This walk down requirement is not specifically addressed in NUMARC 87-00, but should be completed by each plant as appropriate.

I.2 Section 1: Introduction

2. Q: NUMARC SBO Initiative 5 requires plants not using alternate AC response to station blackout to assess their ability to cope for four hours, however, NUMARC 87-00 Section 7 recognizes a 2-hour category. Must a 2-hour category plant assess coping for four hours?

A: When Industry developed Initiative 5, it was not clear whether the required coping duration categories would include a 2-hour category. Subsequently, the Staff revised the proposed rule and included 2 and 16-hour categories (which resulted in a revision to Initiative 1, called Initiative 1A). NUMARC 87-00, Section 7.1.2 states that a 2-hour category plant (P1, A) only needs to assess coping for a 2-hour duration. Thus, Initiative 5 is satisfied for a 2-hour category plant after assessing ability to cope for two hours.

3. Q: Do plants need to verify the assumptions used in NUMARC 87-00 to develop the various methods and conclusions in the document?

A: Yes. NUMARC 87-00, Section 1.3, "Supporting Information" states:

Utilities are expected to ensure that the baseline assumptions are applicable to their plants. Further, utilities are expected to ensure that analyses and related information are available for review.

Plants should consider whether their plant configurations, design and/or procedures conform with the NUMARC 87-00 assumptions. These considerations and judgments should b documented and available for NRC review. However, utilities are not expected to perform rigorous analyses or evaluations in verifying the assumptions of NUMARC 87-00.

I.3 Section 2: General Criteria and Baseline Assumptions

4. Q: To what extent will plants be required to verify the assumption regarding dominant areas of concern?

A: Utilities must consider an area to be a dominant area of concern if it satisfies all three of the following criteria:

(a) Contains equipment that is needed to function early in a station blackout (within 1 hour) to remove decay heat;

(b) Significant heat generation sources are present after AC power is lost and relative to the free air volume of the room; and

(c) Unless the operator takes action, the capability to remove heat is lost during a station blackout.

While the areas listed in Section 7 of NUMARC 87-00 are the areas that are most likely to be considered to be dominant areas of concern, all plant areas meeting the above criteria must be analyzed.

5. Q: When taking credit for operator actions to apply supplemental cooling to a room within 30 minutes, is it necessary to perform a room heat up calculation for the full four hours, or only for 30 minutes?

A: Section 7.2.4, which calculates the benefit of providing supplemental cooling by opening room doors, calculates an average steady state bulk air temperature for dominant areas of concern that is not time-dependent.

6. Q: If a plant has procedures that call for the operators to take actions during a station blackout and open cabinet doors in the control room within 30 minutes, can they assume that the equipment will survive a station blackout?

A: If (1) the control room does not exceed 120° F, and (2) the operators take action within 30 minutes to open doors, it is expected that the temperature inside the cabinets will not exceed 120° F. Control room components are assumed to operate properly in this environment.

7. Q: Is there a possibility that the RCP leakage rate may be revised in the future?

A: Yes. These is always a possibility. However, the assumptions and bases noted in NUMARC 87-00, Section 2.5 establish a bounding leakage rate of 25 gpm. The NRC Staff considers that RCP seal leakage rate of 25 gpm is conservative during a SBO without a gross RCP seal failure. If the final resolution of Generic Issue 23 postulates a possible gross seal failure, then this bounding rate assumption may need to be revised.

8. Q: In verifying the assumptions in NUMARC 87-00, and in completing the required assessments and analyses, must a plant assume a single failure of equipment or other assumptions normally considered for a design basis accident?

A. No. SBO is not a design basis accident. Single failures of equipment and other assumptions normally considered for design basis accidents and analysis, need not be considered, unless the equipment would fail due to loss of the AC power caused by the SBO.

1.4 Section 3: Required Coping Duration Category

9. Q: Is the occurrence of switchyard-related events considered in determining the P category?

A: The likelihood and duration of plant-centered events is reflected in the I1/2 and I3 switchyard criteria.

3.2.1 Off-site Power Design Characteristic Group

10. Q: In Part 1.A, how do you know if you "expect" to have a grid-related LOOP?

A: As discussed on Page 3-3 of NUMARC 87-00, only three sites have a grid-related LOOP frequency at the once-in-20-year rate. No other sites are expected to exceed the once per 20 year grid-related LOOP frequency.

11. Q: Is there a discrepancy between Table 4 in Reg. Guide 1.155 and Tables 3-5a and 3-5b in NUMARC 87-00 with respect to classification of P groups?

A: The Regulatory Guide would allow squares SW 3, ESW 1 and 2 to be P1, however, this would be based on an SWR 1 category which the Staff has stated is not achievable. As a result, it was appropriate to label these squares "P2".

12. Q: How do plants get credit for the asterisks in Tables 3-5b and 3-6b?

A: If you are a hurricane exposed plant (identified by having analyzed a probable maximum hurricane (PMH) in your FSAR) you will get credit for the hurricane procedures if you fall into the boxes with the asterisks.

13. Q: NUMARC 87-00 Tables 3-5b, 3-6b, and 3-8 include asterisks which denote site upgrade attributable to implementation of plant-specific pre-hurricane shutdown requirement and procedures. Why doesn't the Staff Regulatory Guide also include similar asterisks for their corresponding table?

A: The Staff's Regulatory Guide does not specifically recognize plant-specific pre-hurricane shutdown procedures, and their corresponding value to plant-specific SBO risk reduction. However, the Staff's Table 1 (Regulatory Guide 1. 155, Page 1.155-8) references NUMARC 87-00, Section 3 as being equivalent and acceptable guidance to Regulatory Guide, Section 3.1.

14. Q: Can a utility use its own snow data covering the last 30 years?

A: A utility always has the option of using site-specific data.

15. Q: Do plants in coastal areas have to use Tables 3-5b and 3-6b?

A: No. However, if your plant falls into a category with an asterisk in the proper box, you may want to consider the benefit of using the tables.

16. Q: By developing pre-hurricane shutdown procedures, does a plant reduce the risk of a hurricane-induced station blackout?

A: Yes.

17. Q: In determining a plant's Offsite Power Design Characteristic Group (P-Group), can a plant use weather data other than that provided in the NUMARC 87-00 tables?

A: Plants may use plant-specific weather data as available. The data provided in NUMARC 87-00 Tables 3-2 and 3-3 has been reviewed and accepted by the Staff and is provided to facilitate completion of the SBO Initiatives. However, use of plant-specific data which differs from that provided is acceptable, subject to Staff review.

18. Q: Can sites which may be considered susceptible to salt spray take credit for switchyard spray down systems?

A: Yes. A switchyard salt spray down system, which reduces or eliminates the effects of salt spray, may justify use of zero for the "C" factor in Section 3.2.1, subject to Staff review.

19. Q: To what degree will independence be required in order to be classified an I-1 category plant in Table 5 criteria 2B of Reg. Guide 1.155? Must IEEE-765 be met in order to comply with Reg. Guide 1.155?

A: IEEE-765 is a reference in both Regulatory Guide 1.155 and NUMARC 87-00. However, Table 5, category 2b identifies the specific criteria to be followed which is consistent with the definitions of preferred and alternate power sources found in Appendices A and B of the NUMARC 87-00 document.

20. Q: For Table 5 of Regulatory Guide 1.155 does item 2.b under Category I2 and I3 apply to both Category I2 <u>and</u> I3?

A: No. Item 2.b under Category I2 and I3 applies only to Category I2.

21. Q: If my FSAR has a 100-year return storm of 124 mph or less, does this mean that my ESW category is a 1?

A: No. All this means is you are definitely not an ESW 5 plant. If you want to show lower than an ESW 4 category, further statistical treatment of plant-specific data is necessary.

22. Q: How should a plant determine whether 12.5 or 72.3 is appropriate for use as the "b" factor in the equation for determining frequency of loss of offsite power due to severe weather?

A: While specific criteria were not discussed with the Staff, it was agreed that a plant would be justified in using 12.5 as the "b" factor if the transmission lines were separated by at least one-quarter of a mile commencing at a point one mile from the plant. Plants may rely on alternate criteria to justify use of the 12.5 "b" factor, but the criteria may be subject to Staff review.

23. Q: How should the frequency of loss of off-site power due to severe weather be determined for plants susceptible to salt spray?

A: The annual frequency of salt spray already considered the effect of storms. Thus, the annual expectation of storms should be entered either as h3 or as h4 depending on whether the site is susceptible to salt spray. The increased significance of salt spray is accounted for by its much larger multiplier (0.78 compared with 0.012) in the equation predicting loss of off-site power. Hence, if a site determines that it is susceptible to salt spray, they should enter the annual expectation of storms with wind velocities between 75 and 124 mph as h4 and zero as h3 in the equation shown in Part 1C section 3 of NUMARC 87-00.

3.2.2 EAC Power Configuration

24. Q: Define emergency AC.

A: Emergency AC is your standby AC power supplies as defined in NUMARC 87-00 to meet GDC-17.

25. Q: If a site has two units, both 1 out of 2 EDG configuration, is there any argument for going to 2 out of 4 EDG configuration at that site?

A: The 2 out of 4 EDG configuration is for diesels which are <u>normally</u> shared between the units. If the diesels are not normally shared, there is no basis for using the 2 out of 4 configuration.

26. Q: When determining the number of necessary EAC standby power supplies, what load requirements should be considered?

A: As described in NUMARC 87-00, Section 3.2.2 part 2.B, the safe shutdown loads associated with loss of offsite AC power are the minimum loads which should be considered when determining the number of necessary EAC sources. These loads do not necessarily include LOCA loads.

27. Q: Can a plant depart from existing procedures in order to satisfactorily respond to a station blackout?

A: 10 C.F.R. 50.54(x) allows a plant to bypass procedures, if necessary, to respond to an emergency situation. Compensatory measures should be taken to the degree foreseeable and practicable. For example, loss of ventilation concerns may require doors to be kept open in a vital area otherwise required by procedures to be secure.

28. Q: Can an Alternate AC (AAC) power source be considered in the determination of available EAC standby power supplies?

A: No. An AAC power source cannot be counted toward the available EAC determination and be considered as AAC at the same unit.

29. Q: On page 10 of Reg. Guide 1.155, should the last line of footnote C read "at each unit" rather than "at all units"?

A: No. The footnote is correct, and this is made clear in the NUMARC 87-00 document. See, NUMARC 87-00, pp. 3-14, 3-15 which makes a distinction between multiple and single-unit sites.

30. Q: If I am an EAC Group A, and I have a non-1E diesel which could be used as alternate AC, do I have to use AAC?

A: No. As long as you are in the 4-hour category or less, or take the necessary actions to get into that category, then you can either perform the NUMARC 87-00 Section 7 coping assessment or use an AAC source.

31. Q: In Appendix C, AAC configuration 2B, how many EAC sources are available?

A: There are two normally dedicated diesels per unit which would put you in EAC Group C for each unit. The cross-ties may provide for an AAC option but do not change the original EAC configuration.

3.2.3 EDG Reliability

32. Q: What is the distinction between target reliability and actual reliability? How is monitoring done?

A: Current actual reliabilities are determined per Section 3.2.3 and these in turn are used to determine the EDG target reliability in Section 3.2.4 and these target reliabilities are used in part to determine the required station blackout coping duration. Once the coping duration, with target reliabilities, is established then utilities will maintain these reliabilities through a program discussed in Appendix D of the NUMARC 87-00 document. This program is currently under further development by NUMARC as resolution to Generic Issue B-56. Detailed criteria for maintaining performance to sustaining the target reliabilities will be part of the EDG Reliability Program.

33. Q: What happens if a plant uses .975 reliability in order to get itself into the 4 hour category, then later falls below this level?

A: Target reliabilities should be maintained through a maintenance program which may be comprised of the elements found in NUMARC 87-00, Appendix D. The process of maintaining the target reliabilities will be detailed in the EDG Reliability Program developed as resolution to Generic Issue B-56.

34. Q: Is the INPO definition of how to monitor EDG failures and starts on demand consistent with the NSAC-108 definition?

A: Yes. It is our understanding that criteria for determining successful starts are consistent with NSAC-108 definitions.

35. Q: If I am using an AAC source can I pick an EDG target reliability of 0.95 instead of .975?

A: Yes. As long as you are not an EAC Group D plant and your AAC source can achieve and maintain safe shutdown for the longer duration that might result from using an EDG target of .95 instead of .975.

36. Q: Two diesels (one normal and one alternate) are available to each safe shutdown bus. How is unit average EDG reliability determined?

A: If both diesels are Class 1E and are required per your licensing basis, average the two diesels for each bus and then average the bus reliability to determine unit average EDG reliability. If only one diesel is required per your licensing basis, just use that Class 1E diesel in determining unit average EDG reliability. The other diesel may qualify as an AAC source.

37. Q: If I am using one of my existing Class 1E machines as an AAC source, how do I treat it in averaging EDG reliabilities?

A: It would still be averaged in with the other Class 1E diesels for that unit's SBO evaluation.

38. Q: If we have fewer than 50 demands on our diesels, then we can only use one of the three criteria, is that correct?

A: As noted in NUMARC 87-00, Section 3.2.4, any of the evaluation criteria are acceptable with EAC Grouping A, B or C to establish the 0.95 or 0.975 target reliability. The evaluation criteria is derived from the number of demands established as an indicator of past EDG performance. As such, it is possible that fewer than 50 demands may be the historical indicator, but if start-up testing is included in the demand sample then the number of demands could be increased.

3.2.5 Determine Coping Duration Category

39. Q: NUMARC 87-00 Table 3-8 indicates that a P1-EAC group D plant would be considered as a 4-hour plant if the diesel generator (DG) target reliability is .975. What happens if you cannot meet the criteria for selecting the .975 target reliability?

A: EAC group D plants are required to use the .975 DG target reliability. If the plant's DG's fail to qualify for this target, in accordance with NUMARC 87-00, Section 3.2.4, then the plant must increase the required coping duration to the next highest category (e.g., from 4-hour to 8-hour).

3.2.6 Required Action

40. Q: Is the implementation of hurricane guidelines another way to comply with NUMARC Initiative 1?

A: Yes, but only for those plants that fall into one of the asterisked boxes in Tables 3-5b and 3-6b.

41. Q: If we have .95 reliability based on past experience but can meet the criteria for selecting the .975 target can we do so and move to a lower coping category?

A: Yes. But be cautioned that under the resolution of Generic Issue B-56 you will likely have to demonstrate that you can achieve and maintain the higher target.

I.5 Section 4: Station Blackout Response Procedures

4.2.1 Station Blackout Response Guidelines

42. Q: Under NUMARC 87-00 Section 4.2.2(4), are plants required to have portable AC generators available as a backup power source?

A: No. Section 4.2.2(4) states that portable AC generators should be designated as backup sources <u>if available</u>. There is no need to purchase one. However, if such a source is going to be relied upon for coping purposes, procedures must be in place regarding its availability to be brought onto the site and used.

43. Q: Is it required for a BWR to exhaust the CST before switching to the suppression pool?

A: No. A utility can determine the order in which water sources are used as long as they are defined procedurally.

44. Q: Do we need to perform a study to identify safe shutdown instrumentation?

A: A study is probably not needed since such a list was required for Appendix R. Also the EOPs should already identify the instrumentation being used to achieve and maintain safe shutdown.

45. Q: Can credit be taken for diesels that have dedicated water makeup capability?

A: Yes. Using the AC-independent approach, dedicated water makeup capability may be relied upon if the diesel does not normally provide power to the essential and non-essential power supplies (see the definition of station blackout). The support systems for such diesels must also be independent of these power supplies in order to credit their operation in a station blackout. In order for the diesel to be credited as an AAC machine, it must also meet the criteria set forth in Appendix B of NUMARC 87-00.

46. Q: Do you have to open all control room cabinet doors?

A: No. Only those that contain equipment being relied upon in a station blackout.

47. Q: How should procedures treat a situation where necessary instrumentation readings are lost in a station blackout?

A: Those instrument indications that are necessary for the operator to cope with the blackout must be available during the blackout. Should normal instrumentation be lost, procedures should direct the operators to utilize alternative instrumentation that has reasonable assurance of operability during a blackout.

48. Q: Are you recommending that we create a station blackout procedure, or modify existing procedures?

A: That is up to each plant to decide. Some plants may find it easier to write a separate procedure while others may be able to augment existing procedures.

49. Q: When drafting or reviewing station blackout response procedures should a plant assume that AAC is available?

A: If a plant is utilizing an AAC source which meets all the requirements of NUMARC 87-00, Appendix B, then the plant's response procedures should utilize that source.

50. Q: When heat tracing is mentioned, does this include CST tracing?

A: Yes, if you are using the CST for a water source and it requires tracing to prevent freezing in the winter.

4.2.2 AC Power Restoration

51. Q: After power is restored does a utility have to justify the continued operability of the equipment located in the dominant areas of concern?

A: No. Since analysis of the effects of loss of ventilation (see revised Appendix F) indicate no significant thermally-induced erosion of component reliability during the coping period, no degradation upon power restoration need be considered.

4.2.3 Severe Weather Guidelines

52. Q: Do all plants have to meet the hurricane guidelines of Section 4.2.3, and do these guidelines qualify for the asterisks on Table 3-8?

A: Plants which have evaluated a probable maximum hurricane should use the guidelines in Section 4.2.3. Plants which meet these guidelines do satisfy the asterisks on Table 3-8.

53. Q: Does NUMARC 87-00 require plants to have procedures to shut down the plant two hours before a hurricane?

A: If you have evaluated a probable maximum hurricane during plant licensing, then you should specify a site-specific indicator which would ensure that the plant would be in safe shutdown two hours before the anticipated hurricane arrival at the site.

1.6 Section 7: Coping with a Station Blackout

54. Q: What systems are required to cope with a station blackout?

A: All systems necessary to achieve and maintain safe shutdown.

7.1.1 Coping Methods

55. Q: Does the implementation of Initiative 1A mean that the requirements for condensate inventory, fuel in the day tank, etc., need not be considered for greater than 4 hours?

A: Using the AC-independent approach, each plant will be in either a 2 or 4 hour coping duration category and accordingly, only 2 or 4 hours of resources are required, as appropriate. For plants using the Alternate AC approach, sufficient resources and capability must be provided to achieve and maintain safe shutdown for the duration of the current required coping time (i.e., 2, 4, 8 or 16 hours, as appropriate).

56. Q: If an 8 hour plant uses Alternate AC, how much condensate inventory is required?

A: Since the plant is in an 8-hour category, 8 hours of condensate would be required to remove decay heat.

57. Q: How much compressed air is required?

A: The amount necessary to operate valves for the required coping duration unless they can be manually operated. AAC plants would need a 1-hour supply if the air compressor is placed on the AAC source within 1 hour, unless the valves can be manually operated.

58. Q: Must AAC power the loads for all five items in Section 7.1?

A: The AAC machine must power all the shutdown loads necessary for coping with a station blackout. Therefore, at a minimum, the AAC source must power the loads related to the five topics in Section 7.1 that would normally be powered off of the EAC power source, except for HVAC as detailed in question 59. The utility should determine if any other systems are needed to achieve and maintain safe shutdown and appropriate containment integrity, and supply power to these associated loads from the AAC source.

59. Q: Is AAC required to power HVAC loads in the dominant areas of concern?

A: While the NRC has stated that they prefer AAC to power HVAC in all dominant areas of concern, there is a recognition that an AAC power source may not be able to power HVAC in all dominant areas. If HVAC is not powered by AAC for a dominant area of concern, then the AAC power source is acceptable as long as the lack of HVAC is considered in the loss of ventilation assessment pursuant to NUMARC 87-00, Section 7.2.4.

60. Q: Can an AC power source be used to assist a plant that chooses the AC-independent approach in providing coping capability?

A: Yes. Additional AC sources can be used by AC-independent plants to assist in meeting their coping requirements. These power sources and support systems must be independent of the essential and non-essential AC power buses.

61. Q: Should Mark III plants provide a power source for hydrogen igniters?

A: No, hydrogen igniters are not required coping equipment because it is the intent of the rule to ensure that there will be no core uncovery and, consequently, no generation of hydrogen as a result of zirconium-water reactions. There may be other NRC requirements related to hydrogen igniters outside of the station blackout rule.

62. Q: If a plant can show that it can cope for four hours, must it use Alternate AC?

A: No. Plants in a four-hour category must either show that they can cope for four hours, or show that they have AAC available within one hour.

7.1.2 Coping Duration

63. Q: If your AAC source is available within two minutes, do you still have to have procedures to cope for one hour?

A: No. If AAC is available within 10 minutes as discussed in Section 7.1.2, no coping assessment is necessary other than to verify that sufficient water is available to remove decay heat for the required duration, that HVAC is addressed consistent with questions 58 and 59, and that the baseline assumptions in NUMARC 87-00 are applicable. General procedure revisions in accordance with NUMARC 87-00, Section 4, are required.

64. Q: If you use AAC, do you cope independent of AC power only for the time required to tie in the AAC source?

A: No. If your AAC source is available within 10 minutes, no coping assessment is necessary other than that discussed in question 63. If the AAC source is available between 10 minutes and one hour, an AC-independent coping assessment must be performed for the one-hour interval.

65. Q: Section 7.1.2 says the 10 minutes for AAC not requiring a coping assessment is from the onset of a station blackout. What is meant by that statement given that the EOPs are supposed to be followed and have numerous required actions before the decision to use AAC is even considered? Most, if not all, of the 10 minutes would be used up following EOPs.

A: The 10-minute requirement was meant to cover the period between when the operators realized a station blackout had occurred and the AAC source was started from the control room. Therefore, operators would perform the immediate steps in the EOPs to verify scram, primary system parameters, etc., and attempt to restore offsite power and start the EDGs from the control room per the EOPs. When actions from the control room are unsuccessful in restoring offsite and onsite emergency AC power, the onset of station blackout has been verified. If you can start and be ready to load the AAC source within the next 10 minutes, taking all actions from within the control room, the 10-minute criteria is met.

66. Q: Section 7.2.1 of NUMARC 87-00 states that "...after one hour, an AAC source may be used to provide power to pumps and valves if the equipment is powered from the AAC source." Does this mean that credit cannot be taken for use of the AAC source until one hour into the event?

A: Yes, unless the AAC source is available within 10 minutes from the control room, credit cannot be taken. However, you can use AAC whenever available.

7.2.1 Condensate Inventory

67. Q: If a plant has a condensate storage tank with a capacity which exceeds its technical specifications, will the NRC recognize this additional capacity?

A: It is expected that credit will be given for CST inventory in excess of technical specifications limits provided this excess is controlled by administrative procedures. However, as discussed in question 121, the NRC may require this to be a technical specification item.

68. Q: Has the Staff specifically said that it is acceptable to assume the technical specification numbers for normal RCS leakage rate?

A: Yes. See, NUMARC 87-00, Section 2.5.

69. Q: Do we have to consider primary system makeup capability?

A: Section 2.5 assumes a reactor coolant pump seal leakage rate of 25 gpm with no core uncovery during a 4-hour blackout. The utility should assess the applicability of vendor analyses to their plant.

Plants in a longer category using AAC may need to power a charging pump for seal injection or assess that core uncovery will not result from the longer duration.

70. Q: Given a procedural requirement during a station blackout to depressurize the RCS by initiating a maximum rate cooldown in order to reduce RCP seal leakage rate, can we take credit for this reduced leakage rate, or do we have to assume 25 gpm per pump?

A: The 25 gpm is the maximum allowed leakage rate assumption. Lower leakage rates may be used if justified by analysis or testing. Such justification may be based, in part, on system depressurization.

71. Q: Can steam generator inventory be used as a source of water for decay heat removal?

A: Yes, as long as you have the capability to recirculate this source and the steam generator tubes remain covered.

7.2.2 Class 1E Battery Capacity

72. Q: Are plants which use the AAC option required to power a battery charger?

A: Yes.

73. Q: If a 4-hour plant has a 3-hour battery, can the battery capability be extended by providing the capability to charge?

A: Yes, provided the source powering the battery charger is independent of preferred and onsite class 1E power.

74. Q: Can credit be taken for alternately using multiple battery channels or cross-connecting a non-safety station battery into its DC system to provide the additional capacity required to cope?

A: Yes. Provided appropriate electrical isolation features and procedures are utilized.

75. Q: Does load-stripping need to be performed from the control room?

A: No. Since load-stripping will not occur until 30 minutes into the blackout, local manual actions are permitted. Procedures should specify the necessary actions.

76. Q: Is battery aging to be taken into consideration?

A: Aging effects are already included in computing battery capacity in IEEE-STD-485.

77. Q: Is load-striping necessary?

A: No. If you can show the ability to cope for two or four hours without load-stripping, then it is not necessary. However, Section 4.2.1(6) requires plant procedures to identify individual loads that need to be stripped for the purpose of conserving DC power.

78. Q: Is hydrogen accumulation in batteries a concern, particularly when using an AAC source?

A: Hydrogen generation typically occurs during charging. For the AC-independent coping method, only discharging of batteries would occur and hydrogen accumulation is not expected. For the AAC approach, HVAC should be provided for the battery room(s).

79. Q: What are the minimum DC loads?

A: The DC loads required to achieve and maintain safe shutdown. The minimum normal safe shutdown loads are all that are required to be fed from the DC source.

7.2.3 Compressed Air

80. Q: What are the requirements for identifying the positions of valves in remote locations?

A: The operator must have a positive means of identifying the positions of valves either locally or from the control room. The only restriction is that the indication must be independent of the preferred and standby power sources. Otherwise, any means of indication is acceptable.

81. Q: What is the minimum required size of the backup compressed air accumulators?

A: If relied upon for coping, air accumulators must be sufficiently large to allow the valves to operate for the number of cycles that they are expected to go through in the course of the coping duration, unless the valves can be manually operated.

7.2.4 Effects of Loss of Ventilation

82. Q: Is the control room a dominant area of concern?

A: It is assumed that the control room temperature will not rise above 120° F during a 4-hour blackout; consequently it is not a dominant area of concern, provided that operators take action within 30 minutes to open instrument cabinet doors per NUMARC 87-00, Section 4.2.1(10). This assumption should be assessed, and if it is found that the assumption is not applicable, then the control room would be a dominant area of concern for that plant.

83. Q: Does a coping analysis have to consider RCP leakage coincident with loss of HVAC?

A: The coping analysis is limited to the items in Section 7 of NUMARC 87-00. Temperature effects inside containment are addressed in NUMARC 87-00, Section 2.7.1, and do not need further evaluation.

84. Q: Why is the main steam tunnel a dominant area of concern? What equipment in the steam tunnel is important to safe shutdown and will it actually be affected by the temperatures reached in the steam tunnel?

A: Temperature sensors for detecting high energy line breaks are located in the main steam tunnel. In a station blackout, bulk air temperatures may rise to a level that could trip the RCIC turbine due to steam supply isolation.

85. Q: What assumptions apply to the area on the other side of a door that may be considered for providing supplementary ventilation?

A: To take credit for opening doors during a station blackout, the adjacent area must be sufficiently large to maintain a relatively constant temperature when considering the additional heat loads imparted to the room from the dominant area of concern. In addition, the adjacent room's bulk air temperature should not exceed the initial wall temperature in the dominant area of concern due to heat sources located in that adjacent area.

86. Q: What is the assumed location of doors?

A: The area of doors, wherever located, are assumed in the equation used in Section 7.2.4, to be located in the walls at floor level.

87. Q: When doors are opened in a station blackout, is it appropriate to postulate the presence of a fire?

A: No. No other accidents need be postulated coincident with a station blackout. This is consistent with the SBO rule.

88. Q: Can credit be taken for HVAC penetrations to provide supplemental cooling?

A: Any sort of opening can be taken credit for as a source of supplemental ventilation. However, to use the correlations in Section 7, the opening must adhere to the same assumptions as those applied to doors, as well as verification that in-line dampers are open.

89. Q: Can supplemental HVAC be provided through the use of fans powered by portable generators?

A: The use of portable fans as a means of providing supplemental cooling is acceptable when considering the AC independent method of coping.

90. Q: What heat loads need to be considered when performing the loss of ventilations analysis in Section 7.2.4?

A: Heat generating equipment that is required to operate under station blackout conditions and all hot surfaces need to be considered.

91. Q: How do you handle the heat generation term for insulated pipes in performing the loss of ventilation analysis in NUMARC 87-00?

A: A reasonable surface temperature must be considered for T_S for insulated pipes. Generally, the amount of insulation that is applied is specified so as not to exceed a desired maximum surface temperature. This desired temperature would be a reasonable assumption for the initial surface temperature.

92. Q: Can the openings in the floor and ceilings and the additional surface area due to a floor be included when applying the correlations in Section 7.2.4 of NUMARC 87-00?

A: The correlations of Section 7.2.4 of NUMARC 87-00 do not include floor surface area or openings in horizontal surfaces. The purpose of these correlations are to allow the plant engineer the ability to easily perform a simple bounding analysis that will model the actual conditions.

93. Q: Is a utility required to analyze all areas in the plant to determine the additional dominant areas of concern?

A: Utilities are expected to consider whether additional dominant areas of concern exist, utilizing the criteria set forth in NUMARC 87-00, Section 7.2.4 (pp. 7-18 and 19).

94. Q: Why isn't the battery room a dominant area of concern?

A: In general, battery rooms do not possess significant heat loads. However, there may be a few battery rooms that are dominant areas of concern and they would have to be addressed on a plant-specific basis.

95. Q: Was there a discussion with the Staff on the average drywell temperature rise?

A: Average drywell temperature in an SBO is bounded by the GE high energy line break analysis for a 4-hour station blackout. Plants which relied upon the GE HELB analysis or a plant-specific analysis which bounds the GE analysis, need not address the drywell temperature effects.

96. Q: Is defeating secondary containment allowed for purposes of opening doors to provide supplemental cooling?

A: Yes.

97. Q: Must you assume that a station blackout could occur at 3:00 a.m. when staffing levels are at a minimum?

A: Yes. the blackout could occur anytime in a 24-hour period. Therefore, any manual actions called for must be capable of being performed by the minimum number of personnel that may be present.

98. Q: Is the utility required to use the initial wall temperature of 40° C in calculating the bulk air temperature?

A: The value of 40° C was used as a reasonable upper bound. A plant can justify a lower temperature based on plant experience or measurement.

7.2.5 Containment Isolation

99. Q: What is the difference between steps 2 and 3 on page 7-22 of NUMARC 87-00?

A: Step 2 covers valves which are being cycled to maintain safe shutdown whereas step 3 covers valves which are not being cycled, but may need to be closed to achieve containment integrity.

100. Q: Can we assume that if our procedures call for valves to be closed can they be considered locked closed per Section 7.2.5, step 1?

A: No. Locked closed means a mechanical device of some sort has been applied to the valve. Procedures calling for valve closure or administrative tagouts do not qualify as providing locked closed status.

101. Q: Do you have to show that you can close both the inboard and outboard containment isolation valves?

A: No. Since you do not have to assume a single failure in addition to the failures resulting in a station blackout, providing the capability to close one valve would establish containment integrity.

102. Q: Is it a requirement to establish containment isolation if a station blackout occurs?

A: No. You need only establish containment integrity if core damage is imminent.

103. Q: Do we need procedures to close the valves?

A: NUMARC 87-00 does not specifically address this. However, actions of this nature should be proceduralized.

I.7 Appendix A: Definitions

104. Q: How does the NUMARC 87-00 definition of station blackout compare with that found in Reg. Guide 1. 155?

A: They are identical.

105. Q: In a station blackout, are all the diesels at a unit assumed to fail?

A: Not necessarily. The definition of station blackout states, in part, that "[a]t single unit sites, any emergency AC power source(s) in excess of the number required to met the minimum redundancy requirements (i.e. single failure) for safe shutdown is assumed to be available and may be designated as an Alternate AC Power Source(s) provided it meets the Alternate AC power criteria in Appendix B."

106. Q: Under the definition of station blackout, can a single failure or DBA be assumed to occur at the unaffected unit?

A: At a multi-unit site, station blackout affects only one unit. The unaffected unit must be able to achieve safe shutdown with a single failure; a DBA need not be considered.

107. Q: Is maintenance factored into the single failure criterion?

A: Yes. Maintenance and other down-time events are factored in; the single failure criterion should not be applied to these events.

108. Q: Can AAC be used for peaking?

A: Yes.

109. Q: If a plant installs a dedicated diesel generator for RCP seal injection, will that diesel be available during a station blackout even though it is assumed that all AC power is lost?

A: The SBO rule does not require that all AC power be lost; the rule requires that off-site power and on-site emergency AC power required for minimum redundancy be lost.

110. Q: In the definition for "station blackout" does "preferred" mean "offsite"?

A: Yes, there should be a "normal preferred" and "alternate preferred" offsite power source.

111. Q: When an emergency diesel is lost, does the failure include the bus work and cables?

A: No, just the machine.

112. Q: Can credit be given for some portion of the switchyard being energized by an AAC source?

A: No. An AAC source must be independent of the onsite emergency system and the preferred power system, so it cannot pass through or be associated with the switchyards unless the AAC source can be isolated from the switchyard with an independent, isolated line for SBO use.

I.8 Appendix B: Alternate AC Power Criteria

113. Q: Under criterion B.3, what types of wind velocities should the AAC structure be able to withstand?

A: The structure must met the Uniform Building Code for your area which factors in wind velocities, snow loadings, etc.

114. Q: Does criteria B.3 preclude the use of aerial lines?

A: Aerial lines may be acceptable if they are protected from the likely severe weather events for the site area. See Note on p. C-5 of NUMARC 87-00.

115. Q: What is a likely weather-related event referred to in Criterion B.3?

A: These are the weather events considered in formulating the Uniform Building Code for your area. Therefore, if you meet the building code, you have designed for the likely weather-related events.

116. Q: Are criteria B.4 and B.6 essentially the same?

A: B.4 addresses physical separation, whereas B.6 addresses electrical separation.

117. Q: If you have four identical diesel generators, how do you address common mode failure concerns?

A: Satisfying the criteria in B.8 adequately minimizes the potential for common mode failure.

118. Q: In Appendix B, common cause failure criterion B.8(f) states that the AAC power system shall be capable of operating during and after a station blackout without any support systems powered from the preferred or blacked-out units' Class 1E power sources. What is meant by "support systems"?

A: Support systems would include cooling, lubrication, air supplies, exhaust and any other features required for the proper functioning of the AAC power source.

119. Q: Under B.9 does "shutdown" mean hot shutdown or cold shutdown?

A: The definition of safe shutdown in Appendix A is hot shutdown or hot standby as appropriate for your plant as defined in your technical specifications. You also have the option of cooling the plant down if your EOPs call for this.

120. Q: In criterion B.10, if you are using adjacent unit Class 1E EDGs as your Alternate AC power source, do you have to shutdown the adjacent unit in order to test the diesels?

A: No. It is not intended to take a plant off-line to test diesels. The adjacent unit diesels are covered by your existing technical specifications. Therefore, testing in accordance with your technical specifications satisfies B.10.

121. Q: Will there be technical specifications for allowed outage times for the AAC source?

A: As stated in Reg. Guide 1.155, technical specifications may be required pending resolution of the Commissioners' interim policy statement on technical specifications.

122. Q: If you are using a hydro unit as AAC and take it out of service for a three month outage, how do you meet the 95% availability requirement?

A: You would not meet the availability requirement. An on-line AAC source must have an availability of 0.95. Care should be taken in selecting an AAC source to ensure this requirement is met.

123. Q: Under B.13, is this an historical reliability, or one you must maintain?

A: One you must maintain.

124. Q: Do you have to have the data available to prove this reliability?

A: Yes.

125. Q: How do you handle the reliability issue if you have more than one AAC machine?

A: You would treat the multiple AAC sources as a system and show a system reliability of 0.95. For example, if you had eight IC turbines at a peaking station, and only need one for an AAC source, then you would meet the reliability requirements for AAC, as long as your aggregate reliability for the peaking station was 0.95.

126. Q: For a diesel in the non-blacked out unit to qualify as AAC, would it have to assume all the shutdown loads for both units for the determined coping duration period?

A: Yes. This diesel must be capable of supplying one train of shutdown loads for each unit.

I.9 Appendix C: Sample AAC Configurations

127. Q: Is the AAC source required to be tied directly into the emergency bus?

A: No.

128. Q: Is the AAC source that is intended to be connected to a non-safety bus required to be permanently tied into the bus, or does it must need to have the capability to be connected?

A: The AAC power source is not required to be permanently connected to the non-safety bus as long as it fulfills all of the Appendix B criteria which includes the capability to be ready to load within one hour. However, the NRC is likely to carefully review any non-permanently connected design.

129. Q: If a multi-unit site has a two out of three diesel configuration, and it can be shown by analysis that one diesel has the capability to shut down both units and the proper cross-tie capability exists, is it possible to consider one of the diesels as an AAC machine?

A: No. Appendix B criteria excludes the use of an adjacent unit's Class 1E power source from being considered as an AAC power source for one out of two shared, and two out of three emergency AC power configurations for multi-unit sites due to the requirement of considering a single failure at the non-blackout out unit.

130. Q: Are breakers that are necessary for the operation of AAC power required to be operated from a controller, or can they be operated manually?

A: Manual operation of breakers is allowed as long as it can be demonstrated that the necessary actions can be carried out such that the AAC power source is available within one hour. Alternate AC that is considered available within 10 minutes must meet the requirements of NUMARC 87-00 Section 7.1.2.

131. Q: In the case of AAC configuration 2B, if the blacked-out diesel's batteries control the cross-tie breakers, and we assume that the batteries fail, it would then be necessary to provide operator

actions to supply power to the blacked out unit. Does this mean that the AAC source would not be able to be considered as a 10 minute AAC source?

A: No. In order for an AAC source to meet the 10 minute criteria, circuit breakers necessary to bring power to safe shutdown buses must be capable of being actuated in the control room in that period.

132. Q: On AAC configuration 2B, are cross-ties required for both trains?

A: Yes. A single cross-tie would not satisfy the requirements because there is no way to predict which diesel at the unaffected unit would suffer the single failure.

133. Q: In a case where the reliability of a diesel is less than 0.95, would a utility assume that diesel to be the one that failed?

A: No. The reliability value does not predict which diesel fails. In addition, for station blackout the minimum reliability that can be committed to is 0.95. Should the reliability of a particular diesel fall below that figure, actions to be identified under resolution of Generic Issue B-56 should be taken to increase the reliability in order to meet the target.

134. Q: Can the AAC power source feed only one bus?

A: Yes. Since a single failure need not be assumed at the plant concurrent with the station blackout, all loads that are normally available to the bus are assumed to be available.

135. Q: Are there any criteria for the distance between transformers for AAC sources?

A: No. However, consideration should be given to the potential for a site-specific likely weather event to effect both the off-site and AAC transformers. Accordingly, protective measures should be provided, as appropriate.

136. Q: Should a peaking unit that is being used as an AAC source be looked at from an availability or reliability view point?

A: Since a peaking unit is not usually on-line, reliability would be the appropriate parameter.

1.10 Appendix F: Assessments of Equipment Operability in Dominant Areas Under Station Blackout Conditions

137. Q: Must all equipment used for station blackout response have a demonstration of reasonable assurance of operability?

A: No. Only station blackout response equipment which is located in dominant areas of concern needs to be evaluated for reasonable assurance of operability in accordance with NUMARC 87-00, Section 7.2.4 and Appendix F. However, Section 4.2.1(10) provides a guideline for considering loss of ventilation effects on specific energized equipment necessary for safe shutdown.

1.11 Rule Response Format and Schedule

138. Q: During the period required to perform modifications to install AAC, will the NRC require plants to demonstrate the ability to cope for 4 hours and write corresponding procedures?

A: No. No interim coping capability is necessary to cope while modifications are being made. Licensees must show that after the proposed modifications are made, they will be able to cope for the applicable duration. If you will be using AAC, you do not need to write procedures for AC independent coping pending the AAC installation.

139. Q: When do proposed modifications need to be completed?

A: The required modifications and a proposed schedule for completion must be identified in the 270 day response. However, the modifications need not be started until the Staff sends you an SER. The proposed schedule should therefore give the number of years or refueling outages <u>following</u> the receipt of the SER required to complete the modifications. Licensees have 30- days following receipt of the SER in which to confirm or modify their proposed schedule.

140. Q: The response format calls for the submittal of a one-line diagram of the AAC power source. How detailed should the AAC one-line diagram be?

A: The NRC has indicated that a one-line diagram commensurate with that found in an FSAR or in NUMARC 87-00, Section C would be sufficient.

APPENDIX J. NUMARC 87-00 SUPPLEMENTAL QUESTIONS AND ANSWERS

J.1 General Questions

0.1 Q: Are utilities required to apply the NUMARC 87-00 assumptions and methodology to their station blackout calculations and supporting documentation?

A: NUMARC 87-00 consists of guidance acceptable to the NRC for demonstrating compliance with the station blackout rule. Alternative methodologies may be used by utilities, but will be reviewed independently by the Staff. It is recognized that utilities may have used alternative methodologies that conservatively bound those of NUMARC 87-00.

Virtually all utilities utilized the approved generic response format in providing to NRC information required under the station blackout rule. The generic response contains a statement that the utility used NUMARC 87-00 methodology and technical bases in preparing the submittal. Where this was not the case, it is important to identify and document the alternative methodology used. If this has not been done, utilities should consider providing additional information to the NRC.

0.2 Q: What level of planning must be complete to support modifications (if any) which a licensee proposed in the station blackout submittal?

A: Licensees should have identified the nature and objectives of any modifications required to meet the station blackout rule and a proposed schedule for implementation. The implementation status of proposed modifications should conform to 10CFR50.63 Sections C(1)(iii), C(3) and C(4).

J.2 Section 1: Introduction

1.1 Q: Is it necessary to perform further analyses to verify that baseline assumptions of NUMARC 87-00 are valid for each plant, or is an assumption a "given"?

A: Section 1.3 of NUMARC 87-00 suggests that utilities ensure baseline assumptions are applicable to their plants. Per Question/Answer 3 from Responses to Questions Raised at the NUMARC 87-00 Seminars (October 1988), "utilities are not expected to perform rigorous analyses or evaluations in verifying the assumptions of NUMARC 87-00." However, the validity of assumptions for each plant should be established and documented. A list of major assumptions among those to be verified has been provided to utilities by NUMARC. Each assumption on the list should be reviewed to assure applicability to individual plants.

J.3 Section 2: General Criteria and Baseline Assumptions

2.5 Reactor Coolant Inventory Loss

2.1 Q: Must the assumed 25 gpm reactor coolant pump seal leak rate be used by all plants (BWR and PWR)?

A: No. It is acceptable to NRC to use 18 gpm for BWR recirculation pumps. Leakage rates lower than 25 gpm for PWRs or 18 gpm for BWRs may be used, provided a justification exists and the NRC is informed that lower rates are being utilized.

2.7 Effects of Loss Ventilation

2.2 Q: Is it necessary to provide reasonable assurance of equipment operability in dominant areas of concern where temperatures are below 120° F?

A: The need to establish reasonable assurance of equipment operability applies only to dominant areas of concern. See Section 2.7.1 of NUMARC 87-00. A dominant area of concern (DAC) exists when, based on documented engineering judgment, areas containing station blackout response equipment have substantial heat generation terms and lack adequate heat removal systems due to the blackout. See NUMARC 87-00, p. 7-18.

If temperatures in the DAC are calculated to be equal to or less than 120° F, this establishes reasonable assurance of equipment operability without further analysis. If temperatures in the DAC are calculated to be in excess of 120° F, reasonable assurance of equipment operability must be provided. NUMARC 87-00, Appendix F, and its accompanying topical report provide acceptable methods for assuring equipment operability.

For the control room, even though it may not meet the DAC criteria, a heat-up analysis should be documented to demonstrate that temperatures do not exceed 120° F. If temperatures exceed 120° F, reasonable assurance of station blackout response equipment operability must then be provided. NUMARC 87-00, Appendix F, and its accompanying topical report provide methods for assuring equipment operability.

In the control room, cabinet doors should be opened within 30 minutes of the onset of SBO to provide adequate air mixing to maintain internal cabinet temperatures in equilibrium with the control room temperature. Refer to NUMARC 87-00, Section 2.7.1, p. 2-9 and 2-10.

For additional information, refer to Questions/Answer Nos. 4, 6, and 82 from the Responses to Questions Raised at the NUMARC 87-00 Seminars (October, 1988).

2.3 Q: May masonry, sheet metal or gypsum walls be assumed as heat sinks in the NUMARC 87-00 room heat-up calculations?

A: The NUMARC 87-00 methodology assumes poured concrete walls to be the heat sink. Other wall materials are not addressed by the methodology. If other wall materials are used, additional calculations must be performed and the use of such calculations should be identified to the NRC.

2.4 Q: May air volumes above drop ceilings, such as in the control room, be used for calculation of room temperatures using the NUMARC 87-00 methodology?

A: Generally, no. A continuous ceiling is assumed by the methodology to inhibit any heat transfer to the volume above unless ceiling tiles are removed, by procedure, at the start of the blackout. If air volumes above drop ceilings are used and ceiling tiles are not removed by procedure, additional heat transfer calculations would be necessary and the basis of such calculations should be identified to the NRC.

2.5 Q: What wall temperatures may be assumed when applying the NUMARC 87-00 methodology to poured concrete walls acting as heat sinks in air conditioned rooms?

A: If the room on the outside of the wall is warmer than the room on the inside, the average wall temperature should be used. The wall, in this case, will not be as effective a heat sink as a wall uniformly at the inside room temperature.

2.6 Q: Are any restrictions placed on taking credit for opening doors to an outside room?

A: Yes. To allow credit for opening doors for cooling, the outside room should be cooler than the room being analyzed, and should be sufficiently large that hot air from the inside room will not appreciably alter the temperature of the outside room. Opening the control room door to a closet or kitchen , for example, will not provide a sufficient heat sink and should not be credited. Furthermore, blackout response procedures should identify the doors to be opened.

2.7 Q: Are there circumstances where cabinet doors need not be opened as provided in Questions/Answer No. 82 of Responses to Questions Raised at NUMARC 87-00 Seminars (October, 1988) to ensure that the control room is not a DAC?

A: Yes. For example, cabinet doors need not be opened where fans are powered during SBO to provide forced ventilation of cabinets or if HVAC is provided during SBO.

J.4 Section 3: Required Coping Duration Category

3.2.1, Part 1D Evaluating Independence of Off-site Power System

3.1 Q: How quickly must manual transfers be made, when evaluating the independence of off-site power systems (I Group)?

A: Any manual method of transferring power sources for all safe shutdown buses is acceptable providing the transfer can be accomplished in a reasonable time, such as less than one hour. Thus, a manual transfer involving operation of a disconnect link requiring several hours to complete is not acceptable.

3.2 Q: How independent must switchyards be for the purpose of I Group determinations?

A: A "no" answer to Criterion A, p. 3-11 of NUMARC 87-00 requires that multiple switchyards must be physically and electrically independent. Electrical independence can be provided by normally open breakers, i.e., two open breakers in series, between switchyards or busses. Physical independence would be satisfied by two separate and distinct switchyards each bounded by a perimeter fence. Supplying power to plant unit safety busses via, (1) multiple voltage transformations occurring within a single switchyards area, or (2) via designated switchyard busses originating from a single switchyard, <u>does not</u> satisfy the intent for physical switchyards independence.

3.3 Q: Where normal AC power is provided by the unit main generator and only one of two safe shutdown buses is automatically or manually transferred to preferred or alternate off-site sources, does that qualify as a transfer of all safe shutdown buses?

A: No. All safe shutdown buses must be transferred per Criteria B(1) and B(2), p. 3-11, of NUMARC 87-00.

3.2.2, Part 2.B Determine the Number of Necessary EAC Standby Power Systems

3.4 Q: When determining the number of EAC standby power sources necessary to operate safe shutdown equipment, what safe shutdown loads should be considered.

A: From NUMARC 87-00, p. 3-14:

The number of necessary EAC standby power sources should be determined by accounting for the individual safe shutdown loads or inferred from the site's design basis for operating Class 1E equipment without off-site power.

This determination does not need to take into consideration a simultaneous design basis event (other than loss of offsite power). Furthermore, any variations (from the design basis) in the assumptions for loss of off-site power loads should be identified in SBO responses to NRC and fully justified with documentation available.

Additionally, the shutdown loads powered must be capable of maintaining the plant in a safe condition for an extended period (i.e., longer than the required coping duration).

3.5 Q: Does safe shutdown mean cold shutdown?

A: No. The plant should be brought to the design basis safe shutdown condition, which may be hot standby, hot shutdown, or cold shutdown.

3.6 Q: At a multi-unit site, if an EAC source is used as an AAC source, should that EAC/AAC source be excluded from the number of EAC standby power supplies used to determine the blacked-out unit's EAC Group?

A: Yes. An AAC source which is also an EAC source must be subtracted from the number of EAC sources available as EAC standby power supplies. To do otherwise would be double-counting as discussed in NUMARC 87-00, p. 3-14.

J.5 Section 4: Station Blackout Response Procedures

4.2.1 Station Blackout Response Guidelines

4.1 Q: Is it acceptable to dispatch an operator from the control room to the remote shutdown panel for the purpose of providing power from the Appendix R diesel or the safe shutdown facility?

A: Yes. However, the control room should not be abandoned. It is anticipated that recovery from a station blackout may require operator action or monitoring from the control room.

J.6 Section 7: Coping with a Station Blackout Event

7.1 Q: When ensuring containment integrity, can normally closed valves be excluded from consideration similar to valves normally locked during operation per NUMARC 87-00, Section 7.2.5, Step 1 (1).

A: No. A normally closed valve may not be considered to be a normally locked closed valve unless some action is taken to prevent valve operation. Such actions would include removing control power fuses or racking out breakers supplying power to motor operators.

7.2 Q: Can the main control room be disabled and evacuated to reduce the battery loads when assessing battery capacity to support decay heat removal during SBO?

A: No. The normal battery-backed plant monitoring and electrical system controls are an integral part of the control room and are considered essential for successfully coping with and recovering from the SBO. Therefore, it is unacceptable for a utility to disable and evacuate the control room for the purpose of reducing battery loads.

J.7 **Appendix B: Alternate AC Power Criteria**

B.1 Q: What single failure considerations are applicable at a multi-unit site where EAC sources are utilized for AAC?

A: When a Class 1E emergency AC (EAC) source is used as an AAC source, a single failure is applied to one of the AC power sources in the non-blacked-out (NB0) unit. If the remaining EAC source meets the criteria of NUMARC 87-00 Appendix B, AC power is assumed to be available to the blacked-out unit. Refer to NUMARC 87-00, p. 2-2 through 2-4.

B.2 Q: What single failure considerations are applicable to SBO AAC power systems?

A: Per Criterion B.8.e of NUMARC 87-00, the AAC power source must not be susceptible to a single point vulnerability whereby a likely weather-related event or single active failure could disable any portion of the on-site emergency AC power sources, or the preferred (off-site) power sources, and simultaneously fail the AAC power source. Random failures other than the type addressed by Criterion B.8.e are not contemplated and need not be considered. See also Question/Answer C.1, below.

B.3 Q: What loads must be carried by an AAC source which is also an EAC source?

A: The AAC source must carry: (1) the loss of off-site power safe shutdown loads on the non-blacked-out (NBO) unit as described in Questions/Answer 3.4, above, and (2) the station blackout loads on the blacked-out unit for the required coping duration. The capacity of the EAC source of the NBO unit to be credited as an AAC source for the blacked-out unit can only be the excess capacity above the loss of off-site power loads of the NBO unit. Shedding of any loads should not lead to degradation of the NBO unit's loss of off-site power safe shutdown capability. Beyond the duration of SBO, the NBO unit should retain the capability to support its loss of off-site power safe shutdown loads.

Criterion B.9 of NUMARC 87-00 states, "The AAC power system shall be sized to carry the required shutdown loads for the required coping duration determined in Section 3.2.5, and be capable of maintaining voltage and frequency within limits consistent with established industry standards that will not degrade the performance of any shutdown systems or component. At a multi-unit site, except for 1/2 Shared or 2/3 emergency AC power configurations, an adjacent unit's Class 1E power source may be used as an AAC power source for the blacked-out unit if it is capable of powering the required loads at both units"

It is expected that AAC sizing determinations consider both steady state and dynamic loading effects.

J.8 Appendix C: Sample AAC Configurations

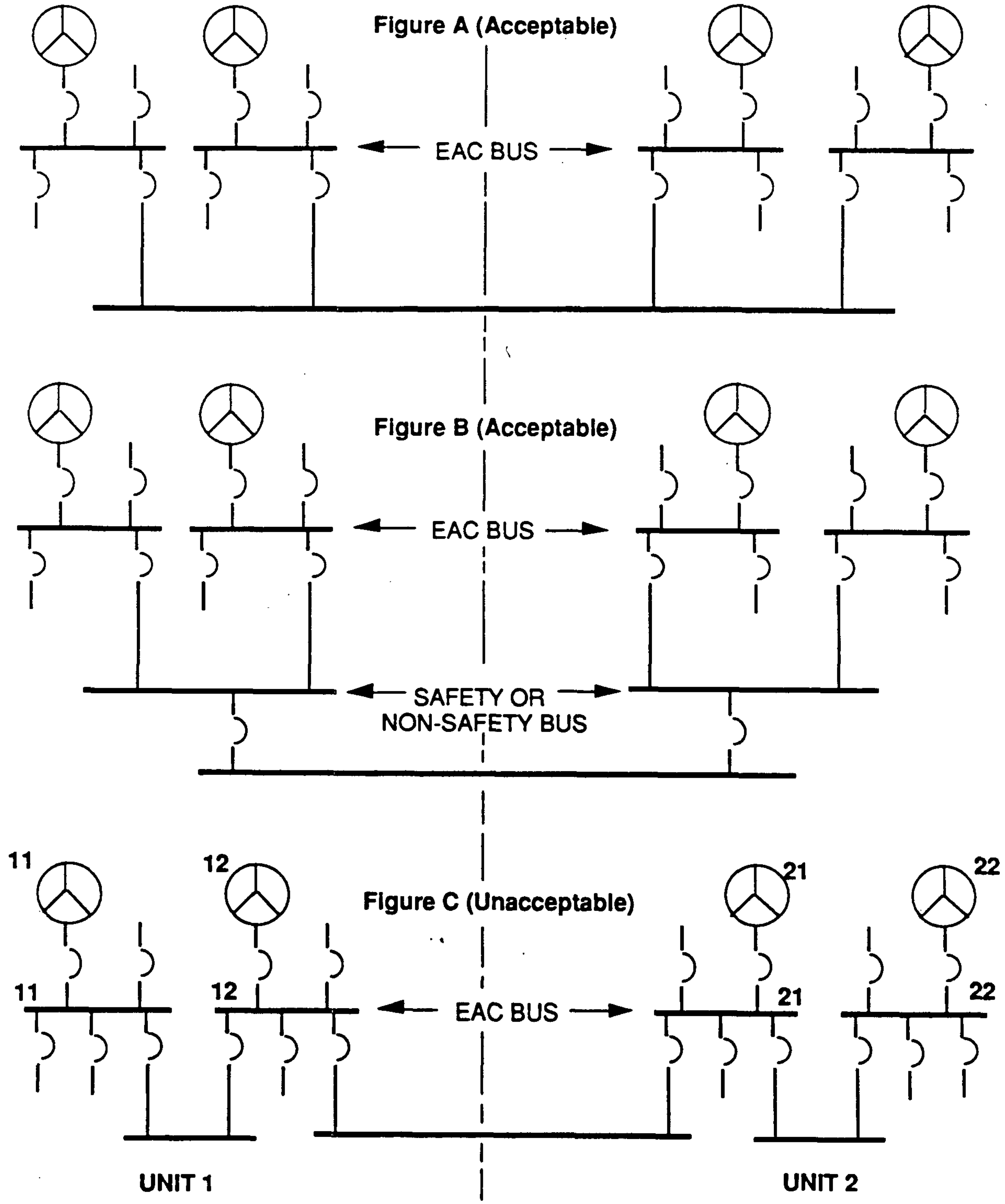
C.1 Q: Is it acceptable to connect the AAC source to the blacked-out unit by a single cross-tie?

A: Yes. However, when the AAC source is one of the available Class 1E EAC sources, the cross-tie must be able to supply power to the blacked-out unit from any EAC/AAC source.

Example 1. A single cross-tie connected to either of two EAC source is acceptable. Figures A and B, Attachment 1, show two such cross-tie configurations, although acceptable configurations are not limited to these examples. In this case, s single failure of one EAC source does not prevent use of the second EAC source for AAC power.

Example 2. Figure C, attached, illustrates a potentially unacceptable single cross-tie connecting one EAC source to a second EAC source, and then connecting the second EAC source to the black-out unit.

In Figure C, assume Unit 1 is the blacked-out unit. Thus, diesels 11 and 12 are not available, and either diesel 21 or 22 is assumed to fail per the single failure. The remaining diesel (21 or 22) may be designated as an AAC source provided Appendix B criteria are satisfied. However, a single active failure of Bus 21 would violate Criterion B.8.e regardless of which EAC source (21 or 22) is the AAC source.



Attachment 1

J.9 NUMARC 87-00 Major Assumptions

As stated in NUMARC 87-00 Section 1.3, it is important that utilities verify that baseline assumptions are applicable to their plants. Chapter 2 of NUMARC 87-00 discusses baseline assumptions; however, other chapters include additional assumptions, as well. Many assumptions are verified in the course of performing the various coping calculations, but some assumptions require specific verification.

The rigor to be applied by licensees in verifying assumptions is stated in Question/Answer 3 of Responses to Questions Raised at the NUMARC 87-00 Seminars (October 1988): "utilities are not expected to perform rigorous analyses or evaluations in verifying the assumptions of NUMARC 87-00." However, utilities are expected to evaluate the applicability of the assumptions to individual plants, and this evaluation should be documented and available for NRC review.

Listed below are major assumptions which in some cases have not been satisfactorily verified. Preceding each assumption is the number of the applicable NUMARC 87-00 section.

2.4.1(1) The event ends when AC power is restored to shutdown busses from any source. To support AC power restoration it will be necessary to close breakers. This can be done either manually or electrically via DC power. For those utilities utilizing DC power, the ability to close breakers at the end of the blackout should be included in the battery calculation. The first available power source can be an EDG; therefore flashing of the EDG field should also be included in the calculation.

2.5.2 Reactor coolant pump seal leakage is assumed not to exceed 25 gpm per pump. It is recognized that BWRs do not have reactor coolant pumps; however recirculation pump leakage should be evaluated. The NRC staff has indicated that 18 gpm is an acceptable assumed leakage rate for BWR recirculation pumps. BWRs/PWRs taking credit for lower leakage rates should have documentation to support use of the lower rates.

2.7 Loss of ventilation effects

2.7.1 Temperatures resulting from loss of ventilation are enveloped by LOCA and HELB profiles. LOCA/HELB transients dump large amounts of energy into a containment in a short time, thus, this assumption may seem intuitive. However, LOCA/HELB analyses assume fans and coolers are operating. During

SBO, containment fans and coolers may not be available. This assumption, therefore, should be verified.

2.7.1(2)(a) Control room temperature does not exceed 120° F. Utilities usually verify this assumption, but sometimes misapply the methodology of NUMARC 87-00, Section 7.2.4. See below.

Typical problems encountered with utility use of the methodology of Section 7.2.4 to calculate SBO temperatures in the control room and dominant areas of concern are as follows.

1) Initial wall temperatures assumptions are not verified by actual measurement.

2) Wall temperatures for walls acting as heat sinks in air conditioned rooms are assumed to be at the initial room temperature. This is valid if the rooms on both sides of the wall are air conditioned to the same temperature. If the outside wall temperature is hotter, i.e., not air conditioned, the average wall temperature, not the air conditioned room temperature, should be used;

3) Where a continuous drop ceiling prevents free passage of air out of the dominant area of concern, air volumes above can not be included in the analyzed room's free volume when using the NUMARC 87-00 methodology. Other analyses can properly take credit for heat transfer across the ceiling tiles, and these additional analyses should be identified to NRC;

4) Only poured concrete walls may be used as heat sinks, not cinder block or wallboard (Section H.3.1). Other analyses can properly take credit for other types of wall materials, and these additional analyses should be identified to NRC;

5) In order to take credit for opening doors to an adjacent room, the adjacent room must be large and at a lower temperature relative to the room in questions. (See Section H.3.3) Opening a closet door, for example, will not provide a significant heat sink and can not be credited.

2.7.1(2)(b) Loss of heating in the battery room is assumed not to affect battery capacity. Provided battery capacity calculations used the lowest electrolyte temperature anticipated under normal operating conditions, further consideration of loss of battery capacity is not required, per NUMARC 87-00, p.7-7.

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