ENCLOSURE 2

EGG-EA-6773

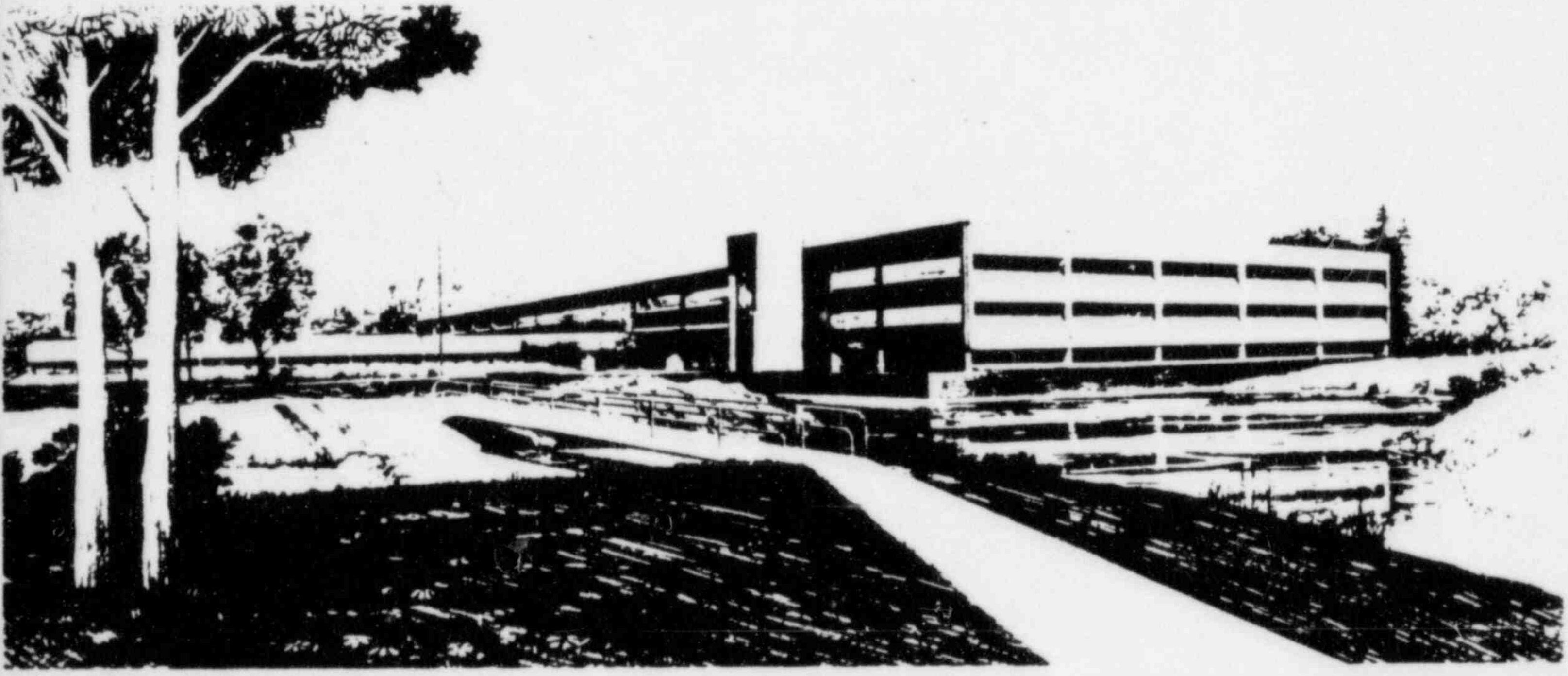
MAY 1985

ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES, BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2

A. C. Udy

Idaho National Engineering Laboratory **Informal Report**

Operated by the U.S. Department of Energy



Prepared for the
U.S. NUCLEAR REGULATORY COMMISSION
Under DOE Contract NO. DE-AC07-76ID01570
FIN No. A6429

EG&G Idaho

8506030352 XA

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Published May 1985

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Prepared for the
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
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ABSTRACT

The Nuclear Regulatory Commission has required all licensees to analyze the electric power system at each nuclear station. This review is to determine if the onsite distribution system, in conjunction with the offsite power sources, has sufficient capacity and capability to automatically start and operate all required safety loads within the equipment voltage ratings. This Technical Evaluation Report reviews the latest submittals for the Brunswick Steam Electric Plant.

FOREWORD

This report is supplied as part of the "Selected Operating Reactor Issues Program (III)" being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Licensing, by EG&G Idaho, Inc., NRC Licensing Support Section.

The U.S. Nuclear Regulatory Commission funded the work under the authorization, B&R 20 19 01 06, FIN No. A6429.

Docket Nos. 50-325 and 50-324

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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2

1. INTRODUCTION

An event at the Arkansas Nuclear One station on September 16, 1978, is described in NRC IE Information Notice No. 79-04. As a result of this event, station conformance to General Design Criteria (GDC) 17 is being questioned at all nuclear power stations. The NRC, in the generic letter of August 8, 1979, "Adequacy of Station Electric Distribution Systems Voltages," (Reference 1) required each licensee to confirm, by analysis, the adequacy of the voltage at the Class 1E loads. This letter included 13 specific guidelines to be followed in determining if the load terminal voltage is adequate to start and continuously operate the Class 1E loads.

Carolina Power and Light Company, the licensee for the Brunswick Steam Electric Plant, has previously complied with the guidelines of the generic letter. However, in a letter dated February 6, 1984 (Reference 2), the licensee identified an error in the data used in their original analysis. They also committed to provide new analyses to replace the earlier submittals for the generic letter. The replacement information was submitted to the NRC on August 30, 1984 (Reference 3). Additional information was provided on January 18, 1985 (Reference 4).

Based on the information supplied by the licensee, this report addresses the capacity and capability of the onsite distribution system of the Brunswick Steam Electric Plant, in conjunction with the offsite power system, to maintain the voltage for the required Class 1E equipment within acceptable limits for the worst-case starting and load conditions.

2. DESIGN BASIS CRITERIA

The positions applied in determining the acceptability of the offsite voltage conditions in supplying power to the Class 1E equipment are derived from the following:

1. General Design Criterion 17 (GDC 17), Electrical Power Systems, of Appendix A, General Design Criteria for Nuclear Power Plants, of 10 CFR 50.

2. General Design Criterion 5 (GDC 5), Sharing of Structures, Systems, and Components, of Appendix A, General Design Criteria for Nuclear Power Plants, of 10 CFR 50.

3. General Design Criterion 13 (GDC 13), Instrumentation and Control, of Appendix A, General Design Criteria for Nuclear Power Plants, of 10 CFR 50.

4. IEEE Standard 308-1974, Class 1E Power Systems for Nuclear Power Generating Stations.

5. Staff positions as detailed in a letter sent to the licensee, dated August 8, 1979 (Reference 1).

6. ANSI C84.1-1977, Voltage Ratings for Electric Power Systems and Equipment (60 Hz).

Six review positions have been established from the NRC generic letter guidelines and the above-listed documents. These positions are stated in Section 5.0.

3. SYSTEM DESCRIPTION

A single-line diagram of the ac electric distribution system at Brunswick is shown in Figure 1. The following system description pertains to Unit 2; Unit 1 is similar.

During normal full-power plant operations, the Class 1E and non-Class 1E distribution systems are supplied from the unit auxiliary transformer 2. The Common B bus distribution system is supplied by the startup auxiliary transformer 2. Protection relays or a unit trip results in the automatic fast transfer of loads from the unit auxiliary transformer to the startup auxiliary transformer. The startup auxiliary transformer can be supplied from two independent 230 kV sources (not shown).

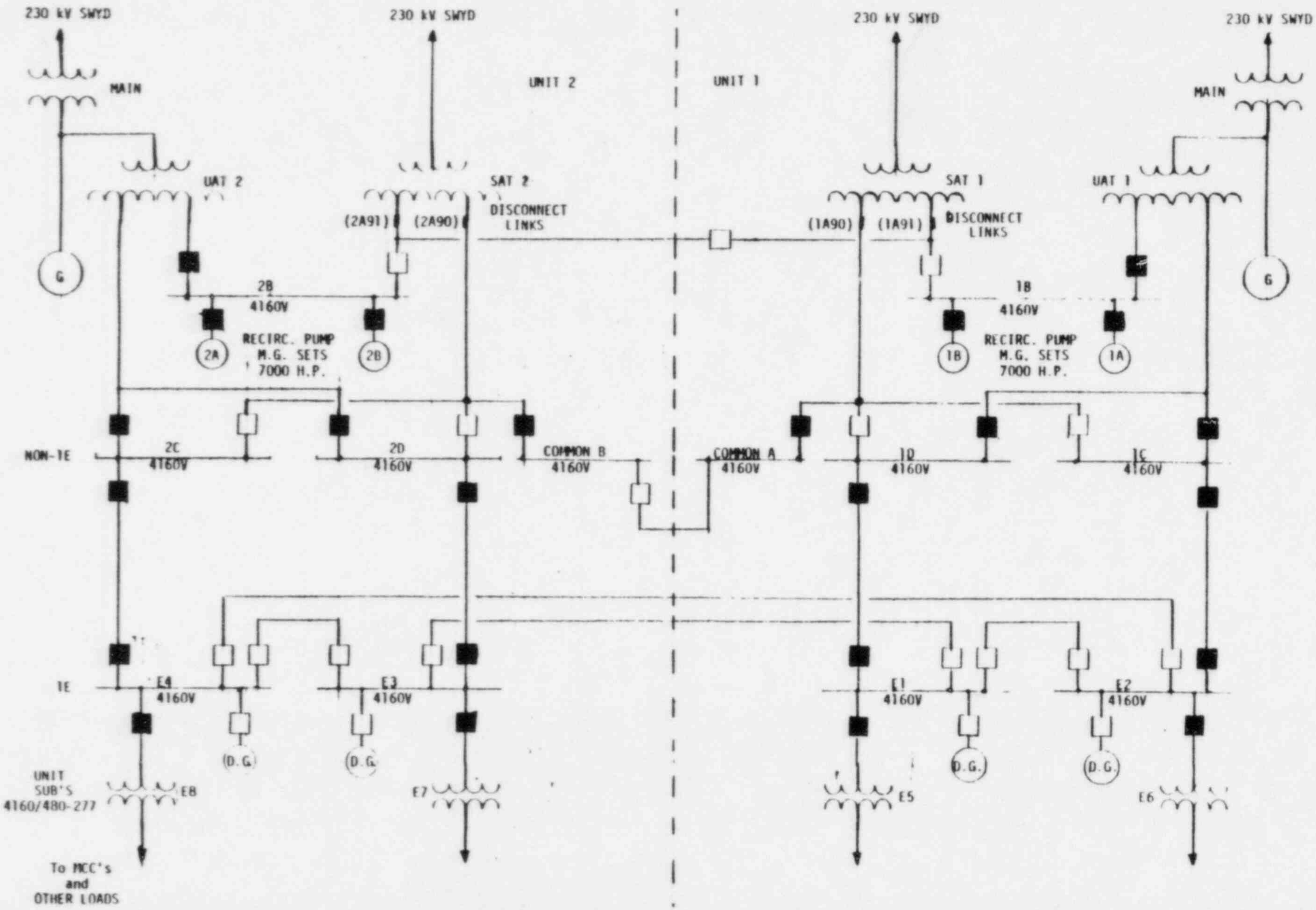
The Class 1E distribution system consists of two independent and redundant trains. Each train is connected to supply the required emergency loads. Each train has the capability of mitigating any design basis accident assuming a failure of the other train.

The Class 1E 4160 V buses supply the 4 kV motors, 4160-480/277 V unit substations E7 and E8, and 480 V motor control centers (MCCs) and their loads. Control circuits for the 4160 V circuit breakers are supplied from the 125/250 V dc system and from individual 480/120 V control power transformers for the MCC control circuits and circuit breakers.

Regarding unit and bus tie breakers, the licensee states that with the exception of non-Class 1E 4160 V buses common A and common B, electrical interlocks prevent the interconnection of Unit 1 and Unit 2 buses. Class 1E 4160 V tie breakers (between buses E4 and E3) have been disconnected and racked out (Reference 5). The tie breaker between non-Class 1E buses 2B and 1B can only be closed if one of the incoming feeder breakers from a startup auxiliary transformer is open and one of the disconnect links (2A91, Unit 2 or 1A91, Unit 1) is removed. The tie breaker between non-Class 1E 4160 V buses common A and Common B can only be closed if the incoming feeder breaker to one of the buses is open. The Class 1E tie breaker between Class 1E 4160 V buses E4 and E2 and between E3

and E1 are normally open and an accident signal will trip them to insure they are open in an accident situation. The tie breakers between Class 1E 480 V buses E7 and E8 (not shown) are normally open.

FIGURE 1 -- Brunswick Nuclear Power Station electrical single-line diagram



4. ANALYSIS DESCRIPTION

4.1 Analysis Conditions

The licensee has determined by load flow studies that the maximum expected 230 kV offsite grid voltage is 1.017 per unit (234 kV) and that the minimum expected 230 kV offsite grid voltage is 0.965 per unit (221.95 kV) when starting the LOCA loads and 0.991 per unit (227.93 kV) with the LOCA loads operating. The minimum grid voltage includes the contingency of the loss of a nearby steam electric unit during the summer peak load.

Using these grid voltages, they have calculated the worst case terminal voltages to the Class 1E equipment. A possible unit bus intertie between 4160 V common buses A and B was included in the calculations. Similarly, the licensee has also taken the limiting Class 1E equipment operating voltages and calculated the grid voltage necessary to maintain that voltage.

The licensee has determined that the worst case Class 1E equipment terminal voltages occur under the following conditions:

1. The maximum voltages occur when the offsite grid voltage is at its maximum value, with both units shutdown, with the minimum expected auxiliary loads and the startup transformers supplying offsite power to the Class 1E buses.

2. The minimum steady-state voltages occur when the offsite grid voltage is at its minimum value, with a LOCA in one unit while the other unit is in shutdown mode (rather than proceeding to shutdown mode), with the startup transformers supplying offsite power to the Class 1E buses.

3. The minimum [illegible]ient voltages occur under the conditions of 2 above, imme[illegible]tely after a unit trip concurrent with the block starting of all the unit residual heat removal and core spray pumps.

4.2 Identified Modifications

The licensee has identified the following as non-Class 1E modifications that either have been, or will be made as a result of their analysis, to maintain the equipment terminal voltage within the equipment capabilities.

1. Change the taps on the 4160/480 V unit substation common transformer C from -2.5 to -5.0 percent.

2. Change the taps on 480/208/120 V transformers GF4 and GF6 from -2.5 percent to nominal.

4.3 Analysis Results

Table 1 shows the projected worst case Class 1E equipment terminal voltages. It is derived from Tables 3 and 4 of the licensee's August 30, 1984, submittal. It shows that, in all steady-state cases, the Class 1E loads have voltages that are within the equipment rated limits.

The duration of the worst case transient voltage condition will be no greater than ten seconds due to the protective action of the degraded voltage relays. During this time, no contactors will drop out and no spurious tripping of loads will occur. The 460 V motors are not capable of starting at the voltages analyzed during this transient; however, they will start in less than ten seconds as the voltage recovers to above 85 percent.

The licensee demonstrated that those 120/208 V circuits where initial calculations showed a potential undervoltage condition due to simplified circuit assumptions, do, in fact, have voltages above the minimum required.

4.4 Analysis Verification

The licensee has performed testing to validate their voltage analysis. The test measured current, voltage and power at the 4160V buses and at the 480V unit substations, both before and during the start of a

circulating water pump and a screen wash pump. At the time of the test, reactor power was greater than 70 percent, and the startup transformer of the unit tested supplied all unit loads, including three of the four intake circulating water pumps.

The data on the test was then input to the computer analysis program, which was then used to calculate the voltage at the measured points, using actual grid voltage and bus loads. The results between the actual test voltage and the analyzed voltage were then compared. In all cases, the 4160V voltages were within 2 percent of each other. For the 480V buses, the maximum steady state error was 2.27 percent, the maximum error for the transient motor starting condition was 3.68 percent.

TABLE 1. CLASS 1E EQUIPMENT VOLTAGE RATINGS AND ANALYZED WORST CASE TERMINAL VOLTAGES (Percent of Nominal Load Voltage)

Equipment	Condition	Maximum Rated	Maximum Analyzed	Minimum Rated	Minimum Analyzed Steady-State[a]	Minimum Analyzed Transient[a]
4 kV motors	Start	--	--	75	--	77.4
	Operate	110	106.6	90	92.4	--
480 V MCC	Pickup	--	--	85	--	72.6
	Dropout	--	--	70	--	72.6
	Operate	110	103.95	85	89.4	--
460 V motors	Start	--	--	85	--	72.6
	Operate	110	108.5	90	90.2	--

a. A 3 percent voltage drop between the motor control center and the motor was assumed.

b. Voltages shown do not include the possible ties between startup transformers or inter-unit bus ties.

5. EVALUATION

Six review positions have been established from the NRC analysis guidelines[1] and the documents listed in Section 2 of this report. Each review position is stated below, followed by the evaluation of the licensee submittals.

Position 1--With the minimum expected offsite grid voltage and maximum load condition, each offsite source and distribution system connection combination must be capable of starting and of continuously operating all Class 1E equipment within the rated equipment voltages.

The licensee has shown, by analysis, that the Brunswick Station has sufficient capability and capacity for starting and continuously operating all Class 1E equipment within the equipment voltage ratings.

Position 2--With the maximum expected offsite grid voltage and minimum load condition, each offsite source and distribution system connection combination must be capable of continuously operating all Class 1E equipment without exceeding the rated equipment voltage.

The licensee has shown, by analysis, that the voltage ratings of the Class 1E equipment are not exceeded.

Position 3--Loss of offsite power to either the redundant Class 1E distribution systems or the individual Class 1E loads, due to operation of voltage protection relays, must not occur when the offsite power source is within analyzed voltage limits.

As shown in Table 2, the undervoltage relays will not cause the loss of the Class 1E distribution system when the offsite grid is within expected voltage limits.

TABLE 2. COMPARISON OF ANALYZED VOLTAGES AND UNDERVOLTAGE RELAY SETPOINTS (in Percent of Bus Voltage)

	Minimum Analyzed[a]		Relay Setpoint	
Location of Relays	Voltage	Duration	Voltage	Operating Time
4160 V loss-of-voltage	91.8	Infinite	82.5[b]	Infinite
	77.5	--[c]	75[b]	5 seconds
			0[b]	1.5 seconds
4160 V degraded voltage	91.8	Infinite	89.5	10 seconds

a. The licensee has determined, by analysis, the minimum bus voltages with the offsite grid at the minimum expected voltage and the worst case station and Class 1E loads.

b. Inverse time delay relay.

c. Where the analyzed voltage is above the relay setpoint or the duration is less than the operating time, no spurious trips will occur. The licensee has shown that the safety related loads will accelerate to full speed in less than 10 seconds (assuming the minimum transient voltage is held constant). The voltage starts to recover as the speed increases. Therefore, we find that the voltage profile, with bulk starting the LOCA loads, will remain above the loss-of-voltage relay trip curve.

Position 4--Test results should verify the accuracy of the voltage analyses supplied.

The licensee has shown by test measurements and computer analysis of identical distribution system conditions, that the voltage analysis accurately reflects the actual distribution system voltage.

Position 5--No event or condition should result in simultaneous or consequential loss of both required circuits to the offsite power network (GDC 17).

The licensee has analyzed the connections of the Brunswick Station to the offsite power grid and has determined that no potential exists for either a simultaneous or a consequential loss of both circuits from the offsite grid.

Position 6--As required by GDC 5, each offsite source shared between units in a multi-unit station must be capable of supplying adequate starting and operating voltage for all required Class 1E loads with an accident in one unit and an orderly shutdown and cooldown in the remaining units.

The Brunswick Nuclear Power Station is the site of two nuclear units. Common bus A (Unit 1) can be connected to common bus B (Unit 2). The licensee's analysis has included this possible unit intertie. While other potential interties are either disabled or interlocked to prevent the interconnecting of the two units' buses during normal operation, the licensee has not analyzed these possible interties during abnormal conditions. The licensee states that their design precludes one startup transformer from supplying the electrical loads of both units.

6. CONCLUSIONS

The voltage analysis submitted by the licensee for the Brunswick Nuclear Power Station was evaluated in Section 5 of this report. We conclude that:

1. Voltages within the operating limits of the Class 1E equipment are supplied for all projected combinations of plant load and normal offsite power grid conditions.

2. The licensee has shown that the analysis is an accurate representation of the station electrical distribution system.

3. The licensee has determined that no potential exists for either a simultaneous or consequential loss of both offsite power sources.

4. Loss of offsite power to the Class 1E buses, due to spurious operation of voltage protection relays, will not occur with the offsite grid voltage within its expected limits.

7. REFERENCES

1. NRC letter, William Gammill, to All Power Reactor Licensees (Except Humboldt Bay), "Adequacy of Station Electric Distribution Systems Voltage," August 8, 1979.

2. Carolina Power and Light Company letter, S. R. Zimmerman to Director of Nuclear Reactor Regulation, NRC, "Electrical Distribution System Voltages," February 6, 1984.

3. Carolina Power and Light Company letter, A. B. Cutter to Director of Nuclear Reactor Regulation, NRC, "Electrical Distribution System Voltages," August 30, 1984.

4. Carolina Power and Light Company letter, S. R. Zimmerman to Director of Nuclear Reactor Regulation, NRC, "Response to Request for Additional Information: 1) Adequacy of Station Electric System Voltage, 2) Technical Specifications of Degraded Voltage Relays," January 18, 1985, Serial: NLS-84-515.

5. Carolina Power and Light Company letter, E. E. Utley to Office of Nuclear Reactor Regulation, NRC, "Adequacy of Station Electrical Distribution System Voltage," February 16, 1981, Serial No. NO-81-288.

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NRC FORM 335 (2-84) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE

1. REPORT NUMBER (Assigned by TIDC, add Vol. No., if any): EGG-EA-6773

2. TITLE AND SUBTITLE: Adequacy of Station Electric Distribution System Voltages, Brunswick Steam Electric Plant, Unit Nos. 1 and 2

3. LEAVE BLANK

4. DATE REPORT COMPLETED: MONTH May, YEAR 1985

5. AUTHOR(S): A. C. Udy

6. DATE REPORT ISSUED: MONTH May, YEAR 1985

7. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code): EG&G Idaho, Inc. Idaho Falls, ID 83415

8. PROJECT/TASK/WORK UNIT NUMBER

9. FIN OR GRANT NUMBER: A6429

10. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS (Include Zip Code): Division of Systems Integration, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, DC 20555

11a. TYPE OF REPORT: Technical Evaluation Report

b. PERIOD COVERED (Inclusive dates)

12. SUPPLEMENTARY NOTES

13. ABSTRACT (200 words or less)

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14. DOCUMENT ANALYSIS a. KEYWORDS/DESCRIPTORS

b. IDENTIFIERS/OPEN ENDED TERMS

15. AVAILABILITY STATEMENT: Unlimited Distribution

16. SECURITY CLASSIFICATION (This page): Unclassified (This report): Unclassified

17. NUMBER OF PAGES

18. PRICE