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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES, BRUNSWICK NUCLEAR POWER STATION UNITS 1 AND 2, DOCKET NOS. 50-325 AND 50-324

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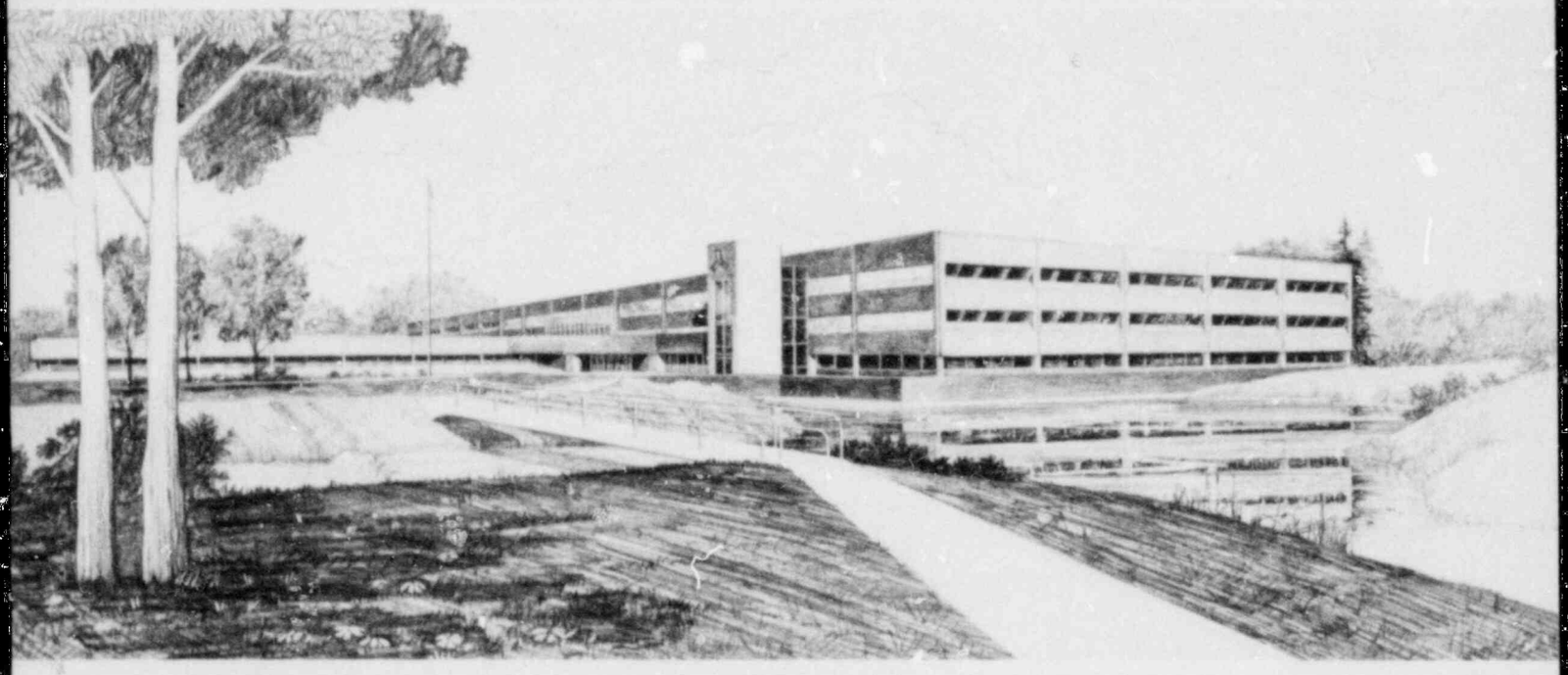

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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

BRUNSWICK NUCLEAR POWER STATION UNITS 1 AND 2

Docket Nos. 50-325 and 50-324

June 1981

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Engineering Analysis Division
EG&G Idaho, Inc.

TAC Nos. 12829 and 12830

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 submittals for the Brunswick Nuclear Power Station.

The offsite power sources, in conjunction with the onsite distribution system, have been shown to have sufficient capacity and capability to automatically start as well as continuously operate all required safety related loads within the equipment rated voltage limits in the event of either an anticipated transient or an accident condition.

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., Reliability and Statistics Branch.

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1.0 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," [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.

The Carolina Power and Light Company (CP&L) responded to the NRC letter on October 8, 1979.[2] This submittal, the submittals of July 24, 1980,[3] October 15, 1980,[4] December 2, 1980,[5] February 16, 1981[6], April 9, 1981,[7] the EG&G Idaho, Inc., report on the Brunswick Units 1 and 2 degraded grid protection,[8] and the Final Safety Analysis Report (FSAR) complete the information reviewed for this report.

Based on the information supplied by CP&L, this report addresses the capacity and capability of the onsite distribution system of the Brunswick Nuclear Power Station, 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.

2.0 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.[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 analysis guidelines[1] and the above-listed documents. These positions are stated in Section 4.0.

3.0 SYSTEM DESCRIPTION

A single-line diagram of the AC electrical distribution system at Brunswick Units 1 and 2 is shown in Figure 1. The breaker positions, open or closed, are shown for normal full-power plant operation.

The following system description pertains to Unit 2; Unit 1 is similar.

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

The 1E distribution system consists of two independent and redundant trains; each train capable of supplying the required emergency loads.

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

Regarding Unit and bus tie breakers, CP&L states that (a) the tie breaker between non-1E Bus 2B and Bus 1B can only be closed if one of the incoming bus breakers from the SATs in Unit 2 or Unit 1 is open and one of the disconnect links (2A91 in Unit 2 or 1A91 in Unit 1) is removed, (b) the tie breaker between non-1E 4160V Common B of Unit 2 and Common A of Unit 1 can only be closed if the incoming bus line breaker to one of the buses is open, (c) the 1E tie breakers between 1E 4160V E4 or E2 and between E3 and E1 are normally open, and an accident signal will cause them to trip should they be closed, and (d) the 1E tie breakers between E4 and E3 have been disconnected and racked out.[4] The 480V tie breakers between E8 and E7 (not shown) are normally open.

4.0 ANALYSIS DESCRIPTION

4.1 Analysis Conditions. CP&L has determined, by load flow studies and review of recordings, that the maximum expected offsite 230kV grid voltage is 234.6kV (1.02 pu) and the minimum 220.8kV (0.96 pu).

CP&L has analyzed each offsite source to the onsite distribution system under extremes of load and offsite voltage conditions to determine the

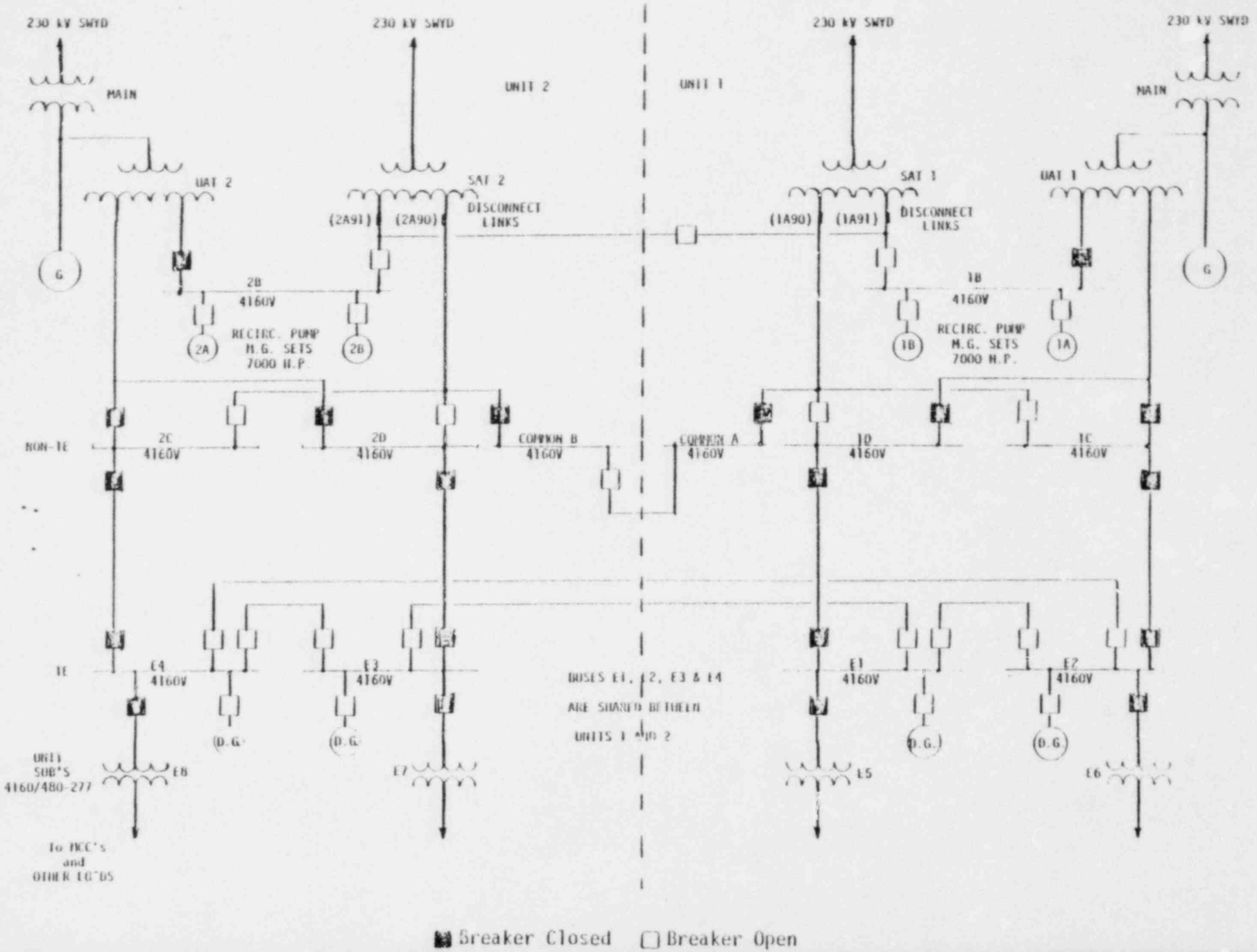

Figure 1. Brunswick Nuclear Power Station Unit single-line diagram.

terminal voltages to 1E equipment. The worst case class 1E equipment terminal voltages occur under the following conditions:

1. The maximum voltages occur when the 230kV grid is at its maximum value, Unit 1 is shut down, and SAT-2 is supplying the minimum plant auxiliary loads.

2. The minimum steady-state voltages occur when the 230kV grid is at its minimum value concurrent with a LOCA in Unit 2 and a simultaneous shutdown cooling of Unit 1, and SAT-2 is supplying all Unit 2 1E and non-1E loads and the non-1E loads from Unit 1 Common A bus (tie breaker between Common B and Common A bus closed and all other tie breakers open).

3. The minimum transient voltages occur under conditions of 2 above, except for the starting of all RHR and Core Spray System pumps due to the LOCA in Unit 2 and simultaneous shutdown of Unit 1.

4.2 Analysis Result. Table 1 shows the projected worst case class 1E equipment terminal voltages. Table 2 shows a comparison of the analyzed voltages with the undervoltage relay setpoints.[8] The analyzed values in these tables are calculated from information supplied by CP&L.

4.3 Analysis Verification. The CP&L letter of October 15, 1980,[4] describes the test to be used to verify the analysis. A telecon on December 19, 1980,[9] provided additional information. Steady state voltage measurements will be made at the 1E buses and 230kV grid. Then, one of the non-1E 4kV circulating water pumps will be started followed by the start of one of the 1E 460V screen wash pumps. The 230kV measured grid voltage will be used as a basis for calculating the voltages at the 1E buses. The calculated voltages will then be compared with the measured voltages. The test was performed near the end of January 1981 and the results submitted April 9, 1981.[7]

5.0 EVALUATION

Six review positions have been established from the NRC analysis guidelines[1] and the documents listed in Section 2.0 of this report. Each review position is stated followed by an 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 equipment voltage ratings.

CP&L has shown, by analysis, that the Brunswick Nuclear Power Station has sufficient capability and capacity for starting and continuously operating the class 1E loads within the equipment voltage ratings (Table 1).

TABLE 1

CLASS 1E EQUIPMENT VOLTAGE RATINGS AND
ANALYZED WORST CASE TERMINAL VOLTAGES
(% of nominal voltage)

		Maximum		Minimum		
					Analyzed[a]	
Equipment	Condition	Rated	Analyzed[b]	Rated	Steady State	Transient[c]
4000V Motors	Start	--	--	75	--	76
	Operate	110	111[d]	90	92.7	--
460V Motors	Start	--	--	85	--	72.39
	Operate	110	111[d]	90	89.6	--
480V Starters	Pickup	--	--	85	--	70
	Dropout	--	--	70	--	70
	Operate	110	107	85	86.5	--
Other Equipment[e]	Pickup	--	--	90	--	70.2
	Dropout	--	--	70	--	70.2
	Operate	110	116[d]	90	90	--

a. Analyzed voltages corrected for minimum grid voltage of 96%.

b. Analyzed voltages corrected for maximum grid voltage of 102%.

c. Transient due to start of 4kV motors: other IE equipment is operating. 460V motor transient = 84.4%

d. When the units are tripped, the switchyard voltage is expected to drop to 98%, which would result in voltages below the 110% maximum equipment safety.

e. All relay coils, solenoids, and instruments.[6]

TABLE 2

COMPARISON OF ANALYZED VOLTAGES AND
UNDERVOLTAGE RELAY SETPOINTS
(% of nominal voltage)

Location/Relays	Minimum Analyzed[a]		Relay Setpoint[c]	
	Voltage	Time	Voltage (Tolerance)	Time
4160V bus[a]				
Degraded grid	89.8	continuous	89.5 ± 0.2	10 sec ± 0.5
Loss of grid	74.87	less than 10 sec[9]	71.0 ± 4.0	10 sec

a. Licensee has determined by analysis the minimum bus voltages with the offsite grid at the minimum expected voltage and the worst case plant and class 1E loads.

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 the required class 1E equipment without exceeding the equipment voltage ratings.

CP&L has shown, by analysis, that the voltage ratings of the class 1E equipment will not be exceeded.

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

As shown in Table 2, voltage relays will not cause loss of class 1E distribution systems when the offsite grid voltage is within expected voltage limits. Also, see position 6.

Position 4--The NRC letter[1] requires that test results verify the accuracy of the voltage analyses supplied.

This position is satisfied as CP&L's test[7] verified the accuracy of the analysis. The equipment loading was sufficient to provide reasonable instrument readings and the maximum error between the measured and calculated values was within the instrumentation error.

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

CP&L has analyzed the 1E connections to the offsite power grid, and determined that no potential exists for simultaneous or 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.

CP&L has indicated that the tie breaker between Units 1 and 2 is open during normal full-power operations,[3] except that the tie breaker between Common A and Common B may be closed[6,9]. The status and use of these tie breakers is described in Section 3.0 of this report. Included in the CP&L analysis is the case where SAT-2 is supplying all Unit 2 loads with the tie breaker between Common A and Common B bus closed and a LOCA in Unit 2 and a false LOCA signal in Unit 1.[6] It should be noted that the CP&L analysis considers terminal voltages to non-1E equipment as well as 1E equipment. Although Tables 1 and 2 (based on a grid voltage of 0.96 pu) show satisfactory voltages for the 1E equipment, the CP&L report recognizes degraded conditions for non-1E equipment, which indicates that the switchyard voltage should not be degraded below 97.2%. Therefore, CP&L has proposed modifications should the grid degrade to 97.2% and the tie breaker between Common A bus and Common B bus is closed. These modifications would improve the minimum values noted in Tables 1 and 2.

6.0 CONCLUSIONS

The voltage analyses submitted by CP&L for the Brunswick Nuclear Power Station were evaluated in Section 5.0 of this report. It was found 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; including an accident in one unit and the safe shutdown of the other unit.

2. CP&L's test has verified the accuracy of their analysis.

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

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

7.0 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. CP&L letter, E. E. Utley, to Office of Nuclear Reactor Regulation, October 8, 1979.

3. CP&L letter, E. E. Utley, to Office of Nuclear Reactor Regulation, July 24, 1980.

4. CP&L letter, E. E. Utley, to Office of Nuclear Reactor Regulation, October 15, 1980.

5. CP&L letter, E. E. Utley, to Office of Nuclear Reactor Regulation, December 2, 1980.

6. CP&L letter, E. E. Utley, to Office of Nuclear Reactor Regulation, February 16, 1981.

7. CP&L letter, E. E. Utley, to Office of Nuclear Reactor Regulation, April 9, 1981.

8. EG&G, "Technical Evaluation Report of the Degraded Grid Protection for Class 1E Power Systems for the Brunswick Steam Electric Plant Units No. 1 and 2," February 1980.

9. Telecon, D. A. Weber, EG&G Idaho, Inc., D. C. Stadler, CP&L, December 12, 1980.