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July 1981

ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES, OYSTER CREEK NUCLEAR POWER STATION, DOCKET NO. 50-219

D. A. Weber

PRELIMINARY

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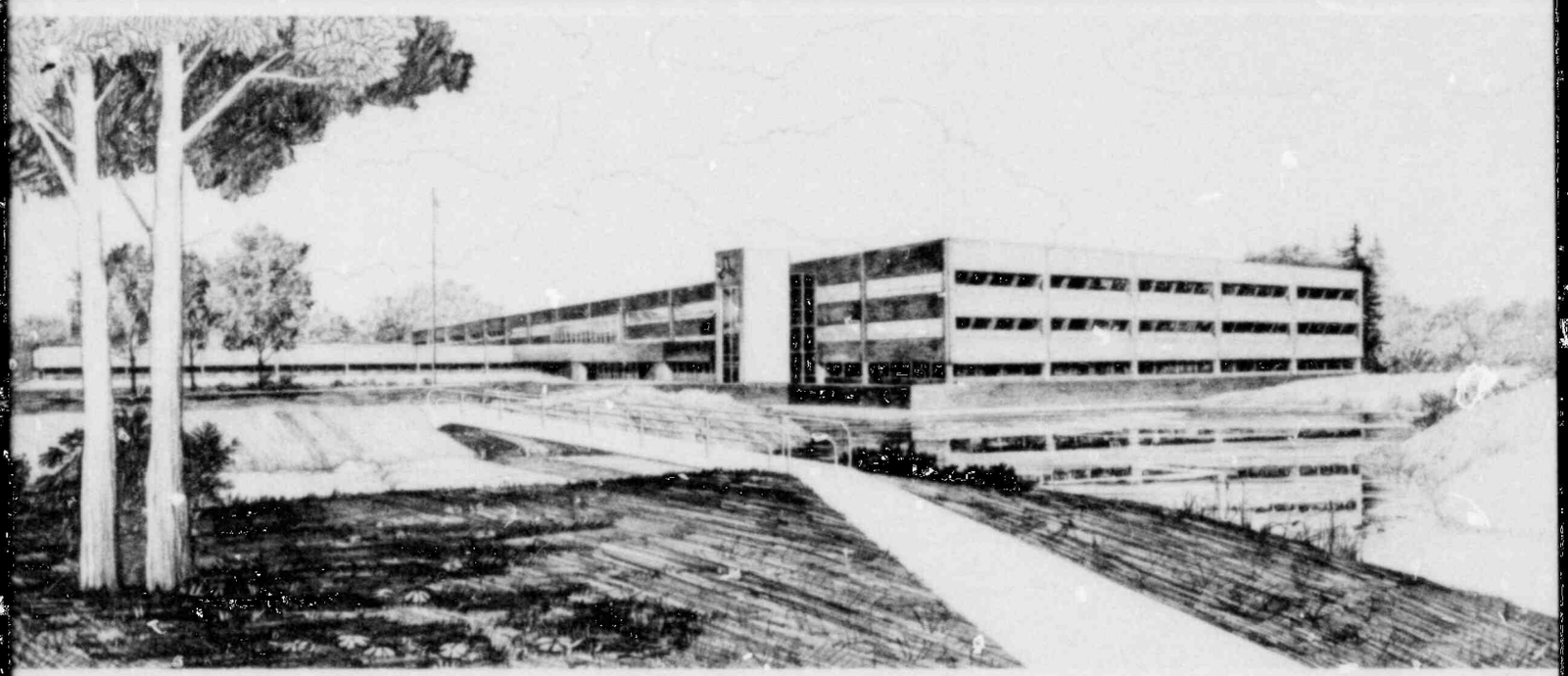

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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

OYSTER CREEK NUCLEAR POWER STATION

Docket No. 50-219

July 1981

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Reliability and Statistics Branch
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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 submittals for the Oyster Creek Nuclear Power Station.

The onsite distribution system in conjunction with the offsite power sources has, with voltage regulation, sufficient capacity and capability to 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. Certain 460 V motor starters and 480 V safety related motors could operate below their minimum allowable voltage and some 440 V motors could be operated in excess of their maximum allowable rating without voltage regulation.

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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OYSTER CREEK NUCLEAR POWER STATION

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 Jersey Central Power and Light Company (JCP&L) responded to this letter on November 1, 1979.[2] This submittal, submittals of November 5, 1976,[3] April 18, 1977,[4] September 25, 1979,[5] November 1, 1979,[6] August 11, 1980,[7] April 30, 1981,[8], and the Final Safety Analysis Report (FSAR) complete the information reviewed for the report.

Based on the information supplied by JCP&L, this report addresses the capacity and capability of the onsite distribution system of the Oyster Creek 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 5.0.

3.0 SYSTEM DESCRIPTION

Figure 1 is a sketch of the Oyster Creek single line diagram of the unit electrical distribution system.

During normal full power plant operations the Oyster Creek main generator supplies all onsite loads through the single 24/4.16kV Station Auxiliary Transformer (SAT) which supplies four 4160 V buses 1A, 1B, 1C, and 1D (1C and 1D are safety related). Should this source of power become unavailable the loads on these buses will automatically fast transfer to the Start-up Transformers (ST) A and B (buses 1A and 1C will transfer to ST-A and buses 1B and 1D to ST-B). Each 34.5/4.16kV ST can be supplied from the 34.5kV offsite distribution system or from the 230kV grid via a 230/34.5kV transformer. Voltage regulators installed on the 34.5kV system will maintain the 4160V bus voltage between 4100V and 4210V when the 230kV grid is between 214.82kV and 242kV.

The emergency 4160V buses 1C and 1D supply power to station loads important to plant safety and vital to safe shutdown under accident conditions. Each bus supplies three 480V unit substations which in turn

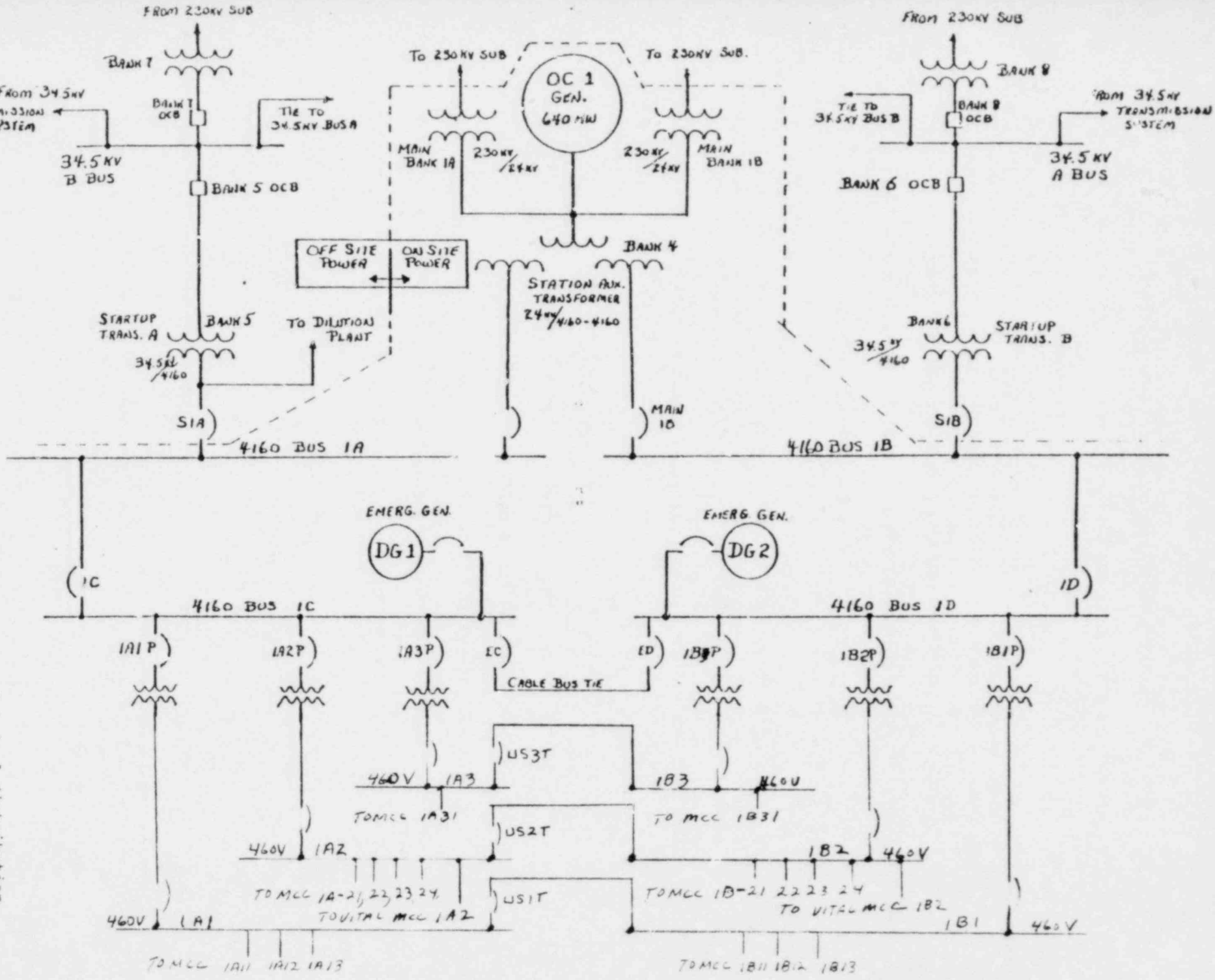

Figure 1. Oyster Creek Nuclear Power Station eletrical distribution system single-line diag am.

supply: medium sized electrical loads; 460V motor control centers (MCC's) including the vital MCCs and stepdown transformers (460/120-208) for lighting, instrumentation and plant service loads. During normal plant operation the tie breakers between the 4160V switchgear 1C and 1D are normally open and the breakers between the unit substations are racked out.

There are three 125V DC systems (DC-A, B, and C) which supply redundant DC control power to the switchgear and unit substations in addition to other DC loads. Each 125V DC system is supported from its own single 60 cell battery system, and solid state battery chargers or M-G sets.

4.0 ANALYSIS DESCRIPTION

4.1 Analysis Conditions. CP&L has determined by stability analysis that the maximum expected offsite grid voltage is 242kV and the minimum is 214.82.[8]

CP&L has analyzed each offsite source to the onsite distribution system under extremes of load and offsite voltage conditions, with and without the 34.5kV voltage regulators, to determine the terminal voltages to 1E equipment. This report considers the distribution system with and without the voltage regulators. The worst case class 1E equipment terminal voltages occur under the following conditions:

Maximum voltage occurs when the offsite grid is at the highest analyzed value and the plant is shutdown and operating only minimum loads.

The minimum steady state voltage occurs when the off site grid is at its minimum analyzed value and all normal and LOCA loads are running as well as the reactor feed pumps.

The minimum transient voltage occurs as in the minimum voltage conditions above accept for the start of a reactor feed pump. The longest time required for any large motor to accelerate to running speed, with rated voltage at its terminals, is seven seconds.[7]

4.2 Analysis Result. Table 1 shows the projected worst case class 1E equipment terminal voltages without voltage regulation. Table 2 shows a comparison of the undervoltage relay set points with the analyzed voltages.

4.3 Analysis Verification. In order to verify their computer analysis, CP&L conducted a test on July 23, 1980[8] at the Oyster Creek Plant. Using the existing grid voltage at the time of the test, a computer run was made to predict voltage levels at the 4160, 480, and 120V levels. These predicted values were then compared to actual readings taken at the Oyster Creek Station. Bus and transformer loading conditions during the test ranged from 39% to 100%.[8]

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

TABLE 1. CLASS 1E EQUIPMENT VOLTAGE RATINGS AND ANALYZED WORST CASE TERMINAL VOLTAGES WITHOUT VOLTAGE REGULATION
(% of nominal voltage)

		Maximum[a]		Minimum[b]		
					Analyzed	
Equipment	Condition	Rated	Analyzed	Rated	Steady State	Transient
4000V Motors	Start	--	--	80	--	89
	Operate	110	110	90	91.6	--
480V Motors	Start	--	--	85	--	78
	Operate	110	105	86.6[c]	85	--
460V Motors	Pickup	--	--	85	--	83
	Operate	110	110	86.6[c]	87.5	--
440V Motors	Start	--	--	85	--	77
	Operate	110	115	86.6[c]	90.5	--
460V Starters	Pickup	--	--	85	--	85.7
	Dropout	--	--	60	--	85.7
	Operate	110	110	90	87.5	--
Other Equipment	Rated 115V	110	<110	90	100.8	>90

a. Maximum values based on Table 1 and 2 of the November 1, 1979 submittal,[6] adjusted for a maximum grid value of 242kV and no allowance for voltage drop between load centers and motor control centers or the motor feeder cables.

b. Minimum values based on Table 2 and 3 of the August 11, 1980 submittal[7] adjusted for the minimum analyzed grid voltage of 214.82kV (3671V at the 4160V 1E buses).

c. Worst case safety related motors have a 1.15 service factor.[9]

TABLE 2. COMPARISON OF ANALYZED VOLTAGES AND UNDERVOLTAGE RELAY SETPOINTS (without voltage regulation)

Location/Relays	Minimum Analyzed[a] Voltage	Minimum Analyzed[a] Time	Relay Setpoint Voltage (Tolerance)	Relay Setpoint Time
4160V bus[a]				
Degraded grid	3671V	cont.	3671V ± 1%	10 sec ± 0.1%
Loss of grid	3594	7 sec	2864V	3 sec ± 0.5%

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 is stated below 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.

This position is not satisfied without voltage regulation as certain 460V motor starters and the 480V motors would be required to operate a voltage below the minimum ratings (Table 1).

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.

This position is not satisfied without voltage regulation as some of the 440V motors would have voltage in excess of maximum rating. Maximum voltages on equipment with 115V nominal rating not provided.

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.

This position is not satisfied as the second level undervoltage relays could operate if the grid is at or slightly above its minimum analayzed value (Table 2).

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

A review of JCP&L test procedure and results indicate that the analysis is satisfactory. The test result shows that the largest difference between the measured and computed values is $\pm$1%.

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).

JCP&L has analyzed the Oyster Creek Nuclear Power Station connections to the offsite power grid, and have 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.

This applies to multi-unit plants. It does not apply to the Oyster Creek single-unit station.

6.0 CONCLUSIONS

The voltage analyses submitted by JCP&L for the Oyster Creek Nuclear Power Station were evaluated in Section 5.0 of this report. It was found that:

1. With voltage regulation, voltages within the operating limits of the class 1E equipment are supplied for all projected combinations of plant load and offsite power grid conditions. Without regulation, voltages to certain class 1E loads are unsatisfactory.

2. The test used to verify the analysis shows the analyses to be an accurate representation of the worst case conditions analyzed.

3. JCP&L has determined that no potential for either a simultanous 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, should not occur with the offsite grid voltage within its expected limits and the 34.5 voltage regulators in operation. Without the regulators, spurious tripping could occur.

As a result of their original analysis JCP&L has installed voltage regulators on the 34.5kV grid, which maintain the 4160V bus between 4100V and 4210V for extremes of normal offsite grid voltages. These voltage regulators will maintain all safety related equipment within their operating limits and prevent spurious separation of class 1E buses from the offsite power sources. However, credit for these regulators is dependent upon inclusion of limiting condition of operation requirements in the plant technical specifications.

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. JCP&L letter, I. R. Finfrock, Jr. to Director of Nuclear Reactor Regulation November 1, 1979.

3. JCP&L letter, I. R. Finfrock to George Lear, Chief, Division of Operating Reactor, Branch No. 3, Nuclear Regulatory Commission, November 5, 1976.

4. JCP&L letter, I. R. Finfrock to George Lear, Chief Division of Operating Reactor, Branch No. 3, Nuclear Regulatory Commission, April 18, 1977.

5. JCP&L letter, I. R. Finfrock to Director of Nuclear Reactor Regulation, September 25, 1979.

6. JCP&L letter, I. R. Finfrock to Director of Nuclear Reactor Regulation, November 1, 1979.

7. JCP&L letter, I. R. Finfrock to Director of Nuclear Reactor Regulation, August 11, 1980.

8. JCP&L letter, I. R. Finfrock to Director of Nuclear Reactor Regulation, April 30, 1981.

9. Telcon, P. Wells, JCP&L, D. Weber, EG&G Idaho, Inc., May 29, 1981.