ENCLOSURE 2

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TECHNICAL EVALUATION OF THE ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES FOR THE RANCHO SECO NUCLEAR GENERATING STATION, UNIT NO. 1

SELECTED ISSUES PROGRAM

Robert L. White

(Docket No. 50-312)

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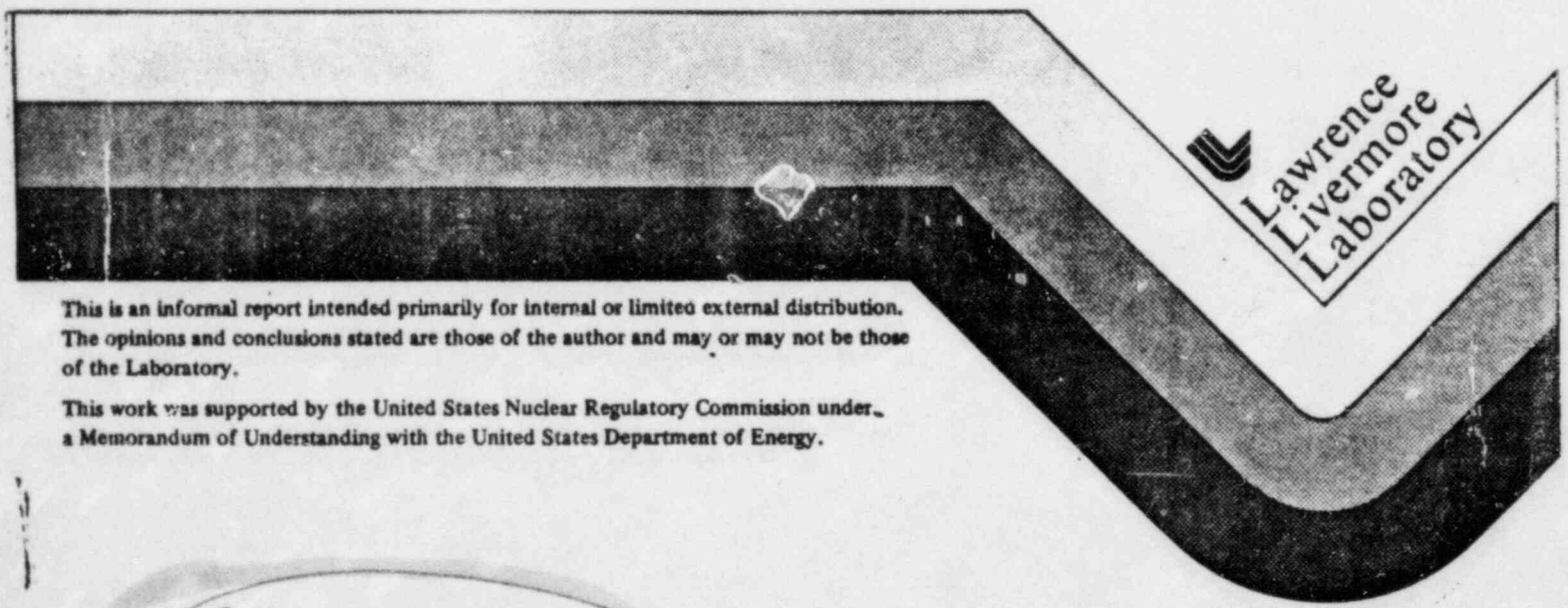

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ABSTRACT

This report documents the technical evaluation of the adequacy of the station electric distribution system voltages for the Rancho Seco Nuclear Generating Station, Unit No. 1. The evaluation is to determine if the onsite distribution system, in conjunction with the offsite power sources, has sufficient capacity to automatically start and operate all Class 1E loads within the equipment voltage ratings under certain conditions established by the Nuclear Regulatory Commission. The licensee demonstrates with the analysis that with certain modifications the guidelines and requirements of the NRC will be met.

FOREWORD

This report is supplied as part of the Selected Electrical, Instrumentation, and Control Systems Issues Program being conducted for the U. S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Operating Reactors, by Lawrence Livermore National Laboratory.

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TECHNICAL EVALUATION OF THE ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES FOR THE RANCHO SECO NUCLEAR GENERATING STATION

(Docket No. 50-312)

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1. INTRODUCTION

The Nuclear Regulatory Commission (NRC) by a letter dated August 8, 1979 [Ref. 1], expanded its generic review of the adequacy of the station electric distribution systems for all operating nuclear power facilities. 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. In addition, the NRC requested each licensee to follow suggested guidelines and to meet certain requirements in the analysis. These requirements are detailed in Section 5 of this report.

By letters dated October 17, 1979 [Ref. 2], December 6, 1979 [Ref. 3], August 1, 1980 [Ref. 4], and February 17, 1981 [Ref. 5], Sacramento Municipal Utility District (SMUD), the licensee, submitted their analysis and conclusion regarding the adequacy of the electrical distribution system voltages at Rancho Seco Nuclear Generating Station (Rancho Seco).

The purpose of this report is to evaluate the licensee's submittal with respect to the NRC criteria and present the reviewer's conclusion on the adequacy of the station electric distribution system at Rancho Seco to maintain the voltage for the required Class 1E equipment within the acceptable limits for the worst case starting and load conditions.

2. DESIGN BASIS CRITERIA

The design basis criteria that were applied in determining the adequacy of station electric distribution system voltages to start and operate all required safety loads within their required voltage ratings are as follows:

(1) General Design Criterion 17 (GDC 17), "Electric Power Systems," of Appendix A, "General Design Criteria for Nuclear Power Plants," in the Code of Federal Regulations, Title 10, Part 50 (10 CFR 50) [Ref. 6].

(2) General Design Criterion 13 (GDC 13), "Instrumentation and Control," of Appendix A, "General Design Criteria for Nuclear Power Plants," in the Code of Federal Regulations, Title 10, Part 50 (10 CFR 50) [Ref. 6].

(3) ANSI C84.1-1977, "Voltage Ratings for Electric Power Systems and Equipment" [Ref. 7].

(4) IEEE Std 308-1974, "Class 1E Power Systems for Nuclear Power Generating Stations" [Ref. 8].

(5) "Guidelines for Voltage Drop Calculations," Enclosure 2 to NRC letter dated August 8, 1979 [Ref. 9].

3. SYSTEM DESCRIPTION

A one-line diagram of Rancho Seco's electrical distribution system is shown in Figure 1. This figure was adapted from Enclosure 1 of SMUD's letter of September 17, 1976 [Ref. 9]. There are two 4160-volt and two 480-volt Class 1E buses. The 4160-volt Class 1E, buses 4A and 4B, are energized through startup transformers 1 and 2. The 480-volt Class 1E buses, 3A and 3B, are energized through station service transformers X43A and X43B. The unit auxiliary transformers are not an available source for the Class 1E buses.

The licensee recently proposed a modification in the degraded grid voltage protection circuitry. The proposal was to protect the Class 1E equipment at Rancho Seco from a degraded grid or loss of voltage by using three undervoltage relays to monitor each 4160-volt emergency bus. These relays are of the inverse time-voltage type, set to operate at approximately 3771 volts (90.6% of 4160 volts). Upon complete loss of voltage, the undervoltage relays will trip in less than 1 second. The details of this modification are covered in Lawrence Livermore National Laboratory report, UCID 18690, entitled "Technical Evaluation of the Proposed Design Modifications and Technical Specification Changes on Grid Voltage Degradation (Part A) for the Rancho Seco Nuclear Generating Plant" [Ref. 10].

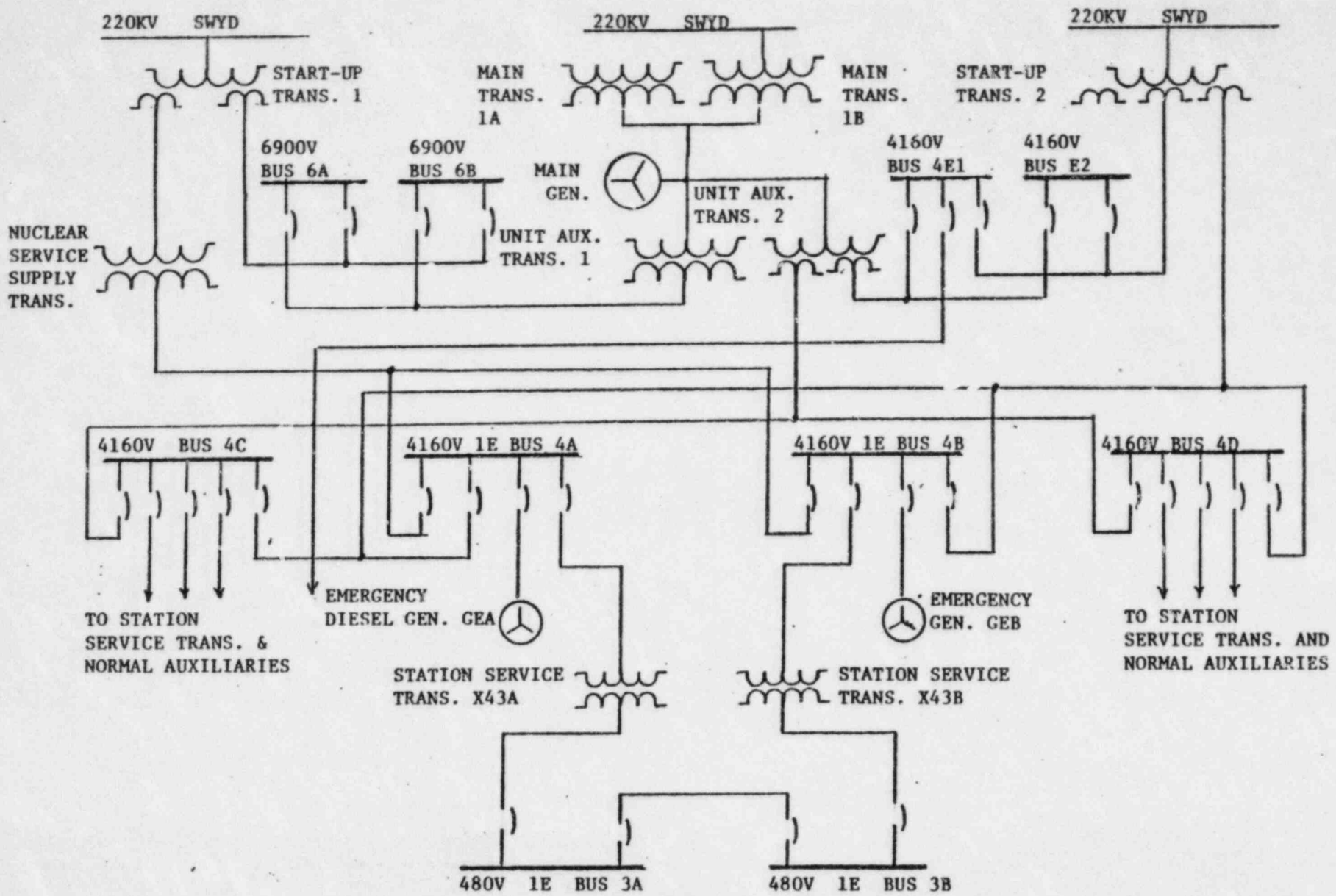

FIGURE 1 RANCHO SECO ELECTRICAL ONE-LINE DIAGRAM

4. ANALYSIS

4.1 ANALYSIS CONDITIONS

SMUD analyzed the onsite distribution system using a computer load flow program. Seven cases were established using different combinations of power sources and Class 1E loads. From these seven cases, the worst case for maximum-load/minimum-grid-voltage was established. Also, the worst case for minimum-load/maximum-grid-voltage was established. In performing the calculations several base criteria were used. These base criteria are:

(1) The load data for the Class 1E 4160-volt system and for Class 1E motors greater than 60 hp was based on actual field measurements.

(2) The impedance data for transformers was based on factory tests.

(3) The maximum load data was arrived at by assuming a LOCA with the reactor at 100% power. This was coincident with a turbine-generator trip and a safety features actuation signal to both redundant safety systems.

(4) All actions designed to automatically initiate were considered.

(5) Manual load shedding was not assumed.

(6) The minimum and maximum expected grid voltage used was 214 kV and 239 kV, respectively.

(7) Cable impedance was based on actual cable length and cable type.

In addition to the base criteria listed above, specific assumptions were made for each case studied. SMUD provided details for these specific assumptions in their analyses submitted to the NRC.

4.2 ANALYSIS RESULTS

The calculations made in the analyses developed the following worst case voltage conditions.

4.2.1 Overvoltage

A maximum Class 1E equipment terminal voltage would occur with a minimum plant load, a maximum expected grid voltage of 239 kV, and a no load condition on the Class 1E buses.

4.2.2 Undervoltage - Steady State

A minimum steady state Class 1E equipment terminal voltage occurs with a minimum expected grid voltage of 214 kV, buses 4A and 4b on startup transformer No. 2, and after the Class 1E equipment has been sequentially loaded on the Class 1E bus.

4.2.3 Undervoltage - Transient

a) A minimum transient Class 1E equipment terminal voltage occurs with a minimum expected grid voltage of 214 kV, buses 4A and 4B on startup transformer No. 2, and during the block loading of the Class 1E buses with the nuclear service air coolers and the nuclear service water pumps.

b) An additional minimum transient Class 1E terminal voltage occurs with a minimum expected grid voltage of 214 kV, buses 4A and 4B on startup transformer No. 2 with the Class 1E buses fully loaded in a steady state condition, and a condensate pump is being started. This transient will only last approximately 2 seconds.

A summary of the worst case Class 1E equipment terminal voltages is shown in Table 1.

4.3 ANALYSIS VERIFICATION

The licensee states that the computer program used for the calculations has been checked by field tests at the Duane Arnold Energy Center in April 1980. In addition, the licensee states that in mid-1982 tests will be conducted to verify the assumptions and the computer program. Actual voltages and loads will be entered as data for a computer run and the calculated voltages will be compared with measured test results.

5. EVALUATION

The NRC generic letter [Ref. 1] stated several requirements that the plant must meet in the voltage analysis. These requirements and an evaluation of the licensee's submittals are as follows:

(1) With the minimum expected grid voltage and maximum load condition, each offsite source and distribution system connection must be capable of starting and continuously operating all Class 1E equipment within the equipment's voltage ratings.

SMUD used a minimum-experienced offsite grid voltage of 214 kV in the analysis of Rancho Seco's onsite distribution voltages. The values for this analysis are shown in Table 1. Several voltage inadequacies were identified and SMUD implemented modifications to correct the inadequacies. These modifications were:

TABLE 1

RANCHO SECO NUCLEAR GENERATING STATION, UNIT NO. 1
CLASS 1E EQUIPMENT VOLTAGE RATINGS AND WORST
CASE ANALYZED LOAD TERMINAL VOLTAGES
(in % of Equipment Nominal Voltage Rating)

		Maximum		Minimum		
		Rated	Analyzed	Rated	Analyzed	
Equipment	Nominal Voltage Rating (100 %)				Steady[a] State	Transient
Motors	4160V					
Start				75		82[c]
Operate		110	109[b]	90	90/92[a]	
Motors	460V					
Start				75		75[d]
Operate		110	111	90	85/87[a]	
Motor-Operated Valves	460V					
Start				-		>75[d]
Operate		110	111	80	85/87[a]	
Starters	120V					
Pickup				(e)	(e)	
Dropout						(e)
Operate		110	110	(e)	(e)	
Battery Chargers	460V	114	111	84	85/87[a]	>75[d]

(a) Percent of nominal voltage with grid at 214 kV/percent nominal voltage with grid at 218 kV. Proposed Technical Specification changes would require the Class 1E buses to be connected to the emergency diesel generators if the grid voltages were to drop below 218 kV for more than 24 hours.

(b) Overvoltage protection relays are set at 4626 volts (111% of 4160 volts).

(c) Transient voltage identified in 4.2.3b of this report.

(d) Transient voltage identified in 4.2.3a of this report.

(e) The licensee states [Ref. 5] that calculations were made and showed adequate margin for all MCC control circuits except for five size 3 starter coils. These five starters will be re-equipped with 480-volt coils. These 480-volt coils will remain within their rated operating range for maximum and minimum grid conditions.

a) The sequential block loading was changed. This change reduces the severity of the voltage transient dip to an acceptable level.

b) A Standing Order 15-79 was issued to describe operator actions when the grid voltage is less than 216 kV. The analysis has shown that for this voltage level, or higher, the terminal voltage at any Class 1E motor would never be less than its minimum required starting voltage.

c) The setpoint of the inverse-time delay undervoltage relays was changed to 90% of 4160 volts (3744 volts).

d) The coils for size 3 starters were changed from 120-volt coils to 480-volt coils.

In addition to the above implemented modifications, SMUD has proposed additional modifications. The proposed modifications include:

a) Additional changes of the setpoint of the inverse-time delay undervoltage relays to 91% of 4160 volts (~~3771~~ 3786 volts).

b) Technical specifications changes for grid voltages lower than 218 kV. These changes would require the Class 1E buses to be connected to the emergency diesel generators if the grid voltages were to drop below 218 kV for more than 24 hours. For grid voltages below 214 kV the Class 1E equipment would be automatically protected by the degraded grid voltage protection relays.

c) Blocking automatic condensate pump starting on a turbine trip and modifying the control circuit of the upper dome air circulators. These modifications would further prevent transient starting voltages below the ratings of the Class 1E equipment.

Even with the above implemented and proposed modifications, it would be possible for certain 460-volt Class 1E motors to be operating below the rated continuous operating voltage when the grid is below 218 kV but above the degraded grid voltage setpoint of 214 kV. The licensee has performed an analysis on these motors and determined that the 3% to 5% below minimum rated operating voltage would have a negligible effect on the total life of the motor. The main reason for their conclusion is that operation at a reduced voltage would only be for a limited time or 24 hours maximum.

In addition, the licensee states that an analysis of the MCC overload protection for these motors will be performed and any changes that are found to be required will be scheduled for the 1982 refueling [Ref. 11].

SMUD has determined by their analysis, and we concur, that all other Class 1E equipment will be capable of starting and operating within the equipment's rating with the implemented modifications and with the proposed modifications.

(2) With the maximum expected offsite grid voltage and minimum load condition, each offsite source and distribution system connection must be capable of continuously operating the required Class 1E equipment without exceeding the equipment's voltage ratings.

SMUD's analysis of overvoltage has shown that 460-volt motors and motor-operated valves could exceed the rated voltage. SMUD has analyzed these overvoltages and the effect on the equipment. The additional analysis shows that the equipment will be able to sustain the overvoltage without any derogatory effect on their operation. In addition, the overvoltage calculations were computed at a no-load condition so that as soon as any of the equipment is started the overvoltage condition will be lessened.

The licensee has also proposed that the overvoltage alarm relay be set at 110% of 4160 volts (4580 volts). An overvoltage alarm relay is also being added to the 480-volt Class 1E buses to alert the operator of voltages greater than 110% of 460 volts.

(3) The analysis must show that there will be no spurious separation from the offsite power source to the Class 1E buses by the voltage protection relays when the grid is within the normal expected limits and the loading conditions established by the NRC are being met.

The analysis shows that by implementing the proposed modifications there will be no spurious separation of the onsite distribution system from the offsite power source.

(4) Test results are required to verify the voltage analyses calculations submitted.

The licensee has proposed a test procedure to verify the voltage analyses. This procedure is covered in Section 4.3 of this report. The tests, when completed, will satisfy this requirement.

(5) Review the plant's electrical power systems to determine if any events or conditions could result in the simultaneous loss of both offsite circuits to the onsite distribution system. (Compliance with GDC 17.)

SMUD has reviewed the electric power distribution system at Rancho Seco and states that their review shows that there are no violations or potential violations of GDC-17. The review covered fires, seismic events, and random single failure.

6. CONCLUSIONS

The voltage analyses submitted by SMUD for Rancho Seco show that with the implementation of several modifications the Rancho Seco station electric distribution system voltages will be adequate to start and operate all Class 1E equipment under "worst case" conditions. The modifications include:

(1) Changing the sequential block loading.*

(2) Initiating standing orders and Technical Specifications on limiting conditions of operation.

(3) Setting the undervoltage relay at 91% of 4160 volts.

(4) Changing the operating coils in size 3 starters.*

(5) Blocking an automatic condensate pump start.

(6) Modifying certain 120-volt control circuits.

These modifications are detailed in Section 5 of this report.

Furthermore, the licensee has shown that Rancho Seco does not have any potential violations of GDC-17. They have also scheduled for the mid 1982 refueling any changes that may be required in overcurrent protection and the verification of the calculations used in the analyses.

*The licensee states that these modifications have already been completed.

Accordingly, it is recommended that the NRC accept the proposed modifications which will ensure the adequacy of station electric distribution system voltages at Rancho Seco Nuclear Generating Station, Unit No. 1.

REFERENCES

1. NRC letter (W. Gammill) to all Power Reactor Licensees, dated August 8, 1979.

2. SMUD letter (J. J. Mattimoe) to the NRC (W. Gammill), dated October 17, 1979.

3. SMUD letter (J. J. Mattimoe) to the NRC (W. Gammill), dated December 6, 1979.

4. SMUD letter (J. J. Mattimoe) to the NRC (R. W. Reid), dated August 1, 1980.

5. SMUD letter (W. C. Walbridge) to the NRC (R. W. Reid), dated February 17, 1981.

6. Code of Federal Regulations, Title 10, Part 50 (10 CFR 50)

7. ANSI C84.1-1977, "Voltage Ratings for Electrical Power Systems and Equipment."

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

9. SMUD letter (W. C. Walbridge) to the NRC (R. W. Reid), dated September 17, 1976.

10. Lawrence Livermore National Laboratory, "Technical Evaluation of the Proposed Design Modifications and Technical Specification Changes on Grid Voltage Degradation (Part A) for the Rancho Seco Nuclear Generating Plant," UCID-18690, dated October 1980.

11. SMUD letter (J. J. Mattimoe) to the NRC (J. F. Stolz), dated September 28, 1981.