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March 1981

ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES, D. C. COOK NUCLEAR PLANT, UNIT NOS. 1 AND 2

D. A. Weber

NRC Research and Technical Assistance Report

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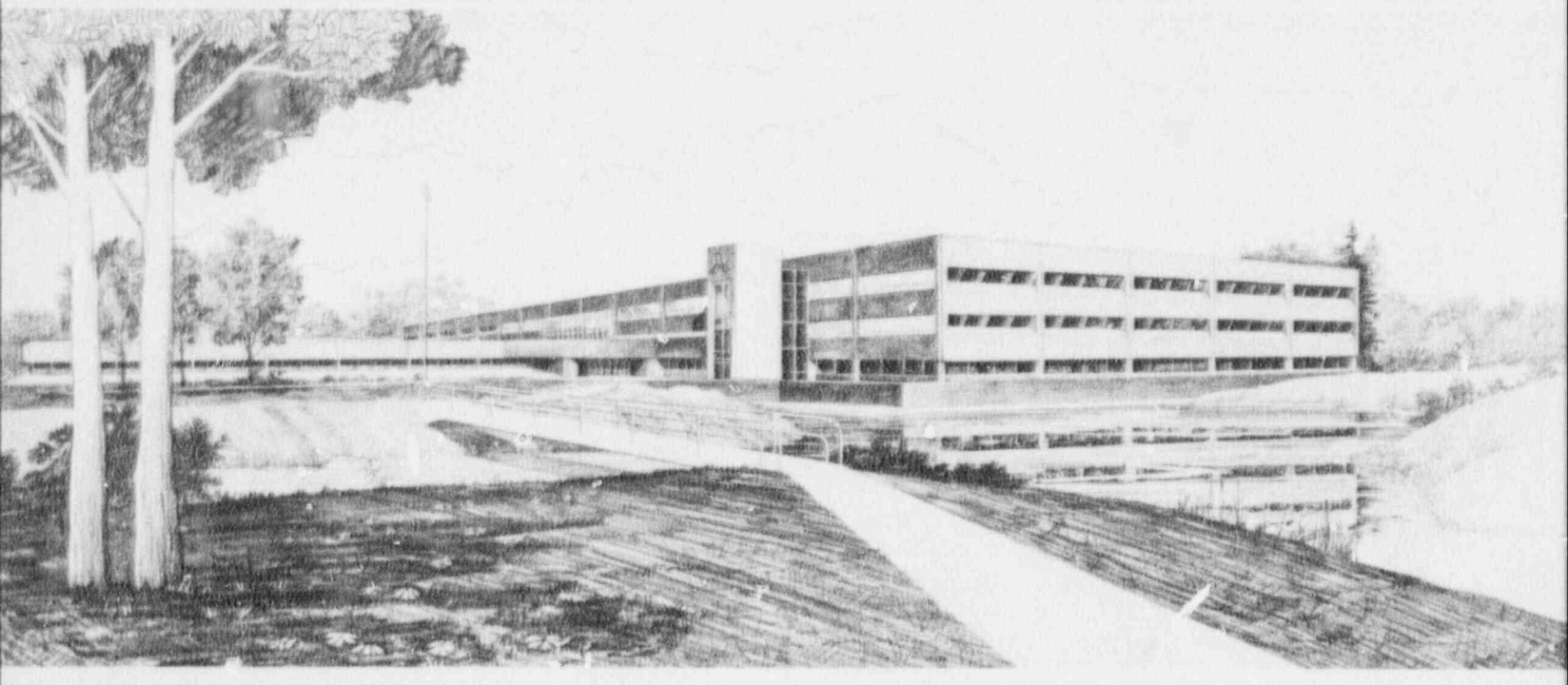

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INTERIM REPORT

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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

D. C. COOK NUCLEAR PLANT UNIT NOS. 1 AND 2

Docket Nos. 50-315 and 50-316

March 1981

D. A. Weber
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 D. C. Cook Nuclear Power Station.

The offsite power sources, in conjunction with the onsite distribution system, have been shown to have 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 upon completion of changes noted in Section 4.1.

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.

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

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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

D. C. COOK NUCLEAR POWER STATION UNIT NOS. 1 AND 2

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.

In response to the generic letter and questions from the staff, Indiana and Michigan Electric Company (IMECo) submitted information and analysis on December 17, 1979,[2] May 28, 1980,[3] and January 27, 1981.[4] These submittals, the EG&G Idaho, Inc., report on the D. C. Cook Unit 1 degraded grid protection,[5] and the D. C. Cook Unit 1 Final Safety Analysis Report complete the information reviewed for this report.

Based on the information supplied by IMECo, this report addresses the capacity and capability of the onsite distribution system of the D. C. Cook 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.

The discussion and evaluation which follows will apply to both units.

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."

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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 of this report is a simplified sketch of the D. C. Cook Unit 1 single-line diagram.

Both safety trains of each unit can be supplied from three sources: the "normal", "preferred", and "alternate" auxiliary sources.

With the unit producing power, the "normal" auxiliary power to each safety train is supplied from the unit generator via transformers 1-AB and 1-CD (2-AB and 2-CD for Unit 2). A unit trip results in automatic transfer to the "preferred" auxiliary source via TR-4 or TR-5 and TR-101-AB and TR-101-CD (TR-201-AB and TR-201-CD for Unit 2). After the unit generator disconnect links have been removed, the safety buses can be supplied from the "normal" auxiliary power source via TR-1 (TR-2 for Unit 2). TR-12-EP is an "alternate" auxiliary power source to both units.

Each 4160V bus supplies power to the 4kV motors, 600V load centers and motor control centers (MCCs), and the 575V motors and loads. The breaker control circuits for the 4160V switchgear and the 600V load centers are supplied by the station batteries and are independent of grid voltages. The MCC control circuits receive their control power from individual control power transformers.

IMECo supplied the equipment operating ranges identified in Table 1.

4.0 ANALYSIS DESCRIPTION

4.1 Design/Operation Changes. The voltages shown on Table 1 are based on the following licensee proposed changes:[2]

1. Change the tap setting on TR-12-EP (alternate power source) from the 67kV tap to the 68.8kV tap.

2. Install undervoltage protection on the 4kV buses A and D for Unit 1 and 2 with a voltage setting of 89.9% for two minutes.[4]

3. Modify the existing undervoltage relays at the 4kV buses for a voltage setting of 79.9% for two seconds.

4.2 Analysis Conditions. IMECo has determined by load flow studies and review of historical data that the maximum expected offsite grid voltage is 795.6kV, 370kV, and 72.45kV and the minimum is 744.35kV, 347kV, and 64.86kV on the 765kV, 370kV, and 69kV offsite sources, respectively.

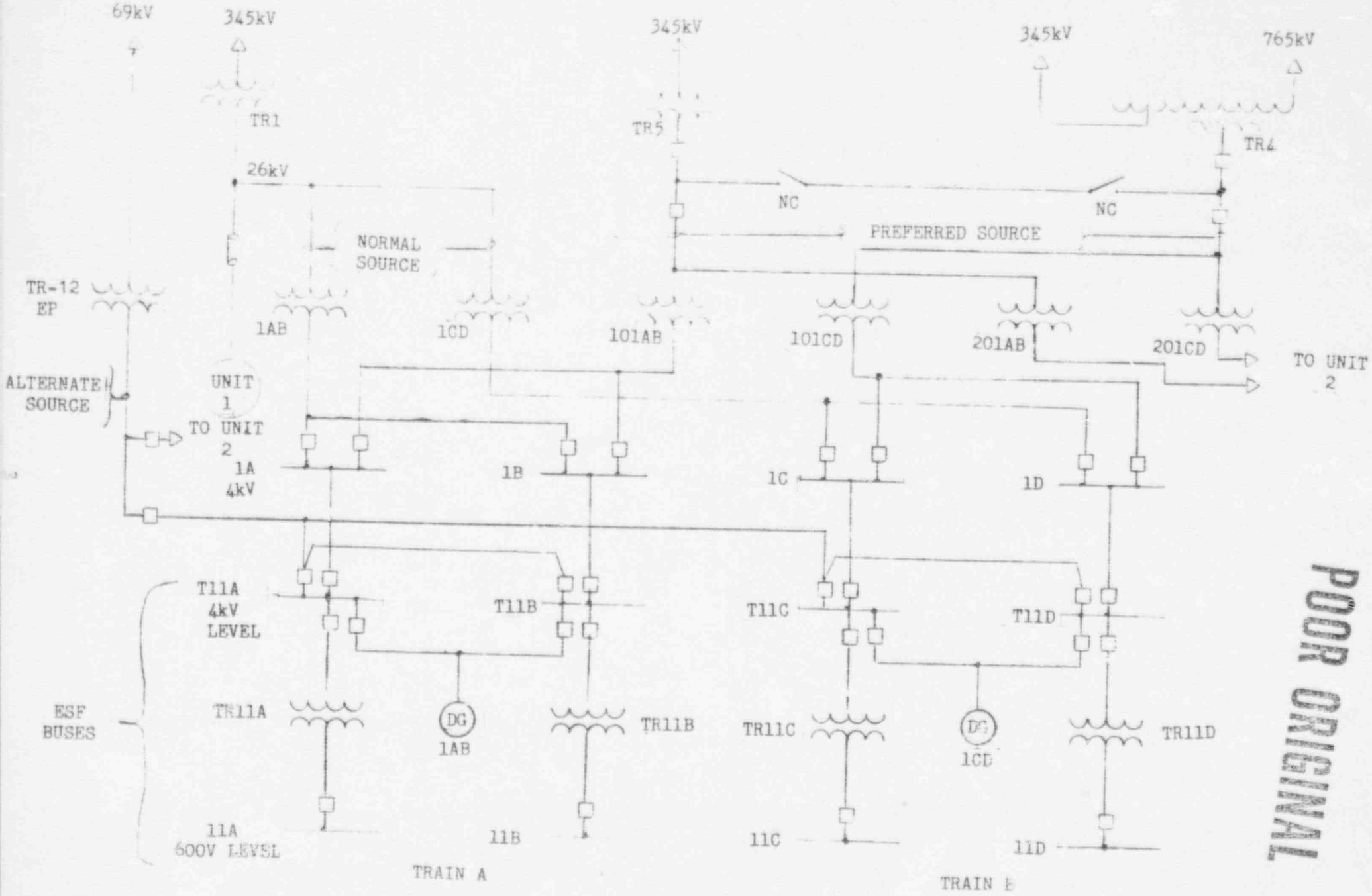

Figure 1. D. C. Cook electrical single-line diagram.

POOR ORIGINAL

TABLE 1

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

		Maximum[a]		Minimum[b]		
					Analyzed	
Equipment	Condition	Rated	Analyzed	Rated	Steady State	Transient
4000V Motors	Start	--	--	85	--	87.3
	Operate	110	111	90	93.3	--
575V Motors	Start	--	--	85	--	78.1
	Operate	110	107	90	90.4	--
600V Starters (575V base)	Pickup	--	--	85	--	78.1
	Dropout	--	--	70	--	78.1
	Operate	110	107	90	90.4	--
Other Equipment[c]						

a. 69kV "alternate" auxiliary source at 105%.

b. 345kV "preferred" auxiliary sources at minimum of 100.6%.

c. All other safety-related electrical, instrumentation, and control equipment required for safe shutdown will operate properly within a voltage range of 90% to 110% of nominal or of the 575V base as applicable.

IMECo has analyzed each offsite source to the onsite distribution system under extremes of load and offsite voltage conditions to determine the terminal voltages to 1E equipment. The worst case class 1E equipment terminal voltages occur under the following conditions:

1. The maximum voltage occurs when the 69kV "alternate" source is at its maximum expected value and supplying the accident loads of one unit and the shutdown loads of the other unit with TR-12-EP supplying one train in each unit.

2. The minimum steady state voltage occurs when the 345kV source is at its minimum expected value and TR-5 is supplying the accident loads of one unit and the shutdown loads of the other unit.

3. The worst case transient voltages occur when the 345kV source is at its minimum expected value and TR-5 is supplying the accident loads of one unit, the shutdown loads of the other unit, and the accident loads are bulk started.

4.3 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.

TABLE 2

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

Location/Relays	Minimum Analyzed[a] Voltage	Minimum Analyzed[a] Time	Relay Setpoint Voltage (Tolerance)	Relay Setpoint Time
4160V bus D[b] (4kV base)				
Degraded grid	93.3	continuous	89.9 ± 5	2 min ± 6 sec
Loss of grid	87.3	c	79.9 ± 5	2 sec ± 0.2 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.

b. Undervoltage relays are on bus A and D. The analyzed data is for bus D which represents the worst case.

c. Transient durations not provided, but the degraded grid undervoltage setpoint of two minutes is long enough to override any voltage dips caused by the starting of large motors or bulk loads.

4.4 Analysis Verification. During a startup of Unit 2, while Unit 1 was at power, measured voltage, current, and phase angle readings were made by IMECo at the "preferred" offsite power substation bus, the "alternate" offsite power sustation bus, and at the Unit 2 auxiliary buses. The measured values for current and voltages were employed as input data on the power distribution model previously used to compute the bus voltage levels at the auxiliary buses. Specifically, the 345kV (TR-5 feed) bus measured voltage and 1E bus currents were used to calculate the voltages at the 34.5kV, 4kV, and 600V buses. These calculated voltages were then compared with the actual measured voltages. The results showed a maximum 2% error at the 600V level.

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 below followed by an evaluation of the licensee submittals. The evaluations are based on completion of changes described in Section 4.1.

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.

IMECo has shown, by analysis, that the offsite sources and the onsite distribution system have sufficient capability and capacity for starting and continuously operating the class 1E loads within the equipment voltage 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.

IMECo has shown, by analysis, that the voltage ratings of the class 1E equipment will not be exceeded (Table 1).

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.

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

Review of the test data submitted by IMECo indicates that the original analysis is satisfactory. The largest difference between the measured and calculated voltage was 2% at two of the 600V 1E buses with the measured voltage less than the calculated voltage. The review considered plant loading conditions, instrumentation errors, and the 1.15 service factor for all class 1E motors. The results are applicable to Unit 1 based on similar loading conditions and identical onsite distribution systems.

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).

IMECo has analyzed the onsite 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 D. C. Cook Nuclear Station is the site of two nuclear units that can be supplied from these offsite sources where two of the sources are shared between units.

The IMECo analysis satisfies this position in that each shared offsite source was found to be capable of supplying adequate voltages to all class 1E loads with a shutdown in one unit and an accident in the other.

6.0 CONCLUSIONS

The voltage analyses submitted by IMECo for the D. C. Cook Nuclear Power Station were evaluated in Section 5.0 of this report. Upon the completion of changes described in Section 4.1, 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. The test used to verify the analysis shows the analyses to have accurately determined the worst case conditions analyzed.

3. IMECo 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, 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. IMECo letter, J. E. Dolan, to Director of Nuclear Regulation, dated October 17, 1979.

3. IMECo letter, J. E. Dolan, to Director of Nuclear Regulation, dated May 28, 1980.

4. IMECo letter, J. E. Dolan, to Director of Nuclear Regulation, dated January 27, 1981.

5. "EG&G Technical Evaluation Report on the Degraded Grid Protection for Class 1E Power Systems for the D. C. Cook Nuclear Plant Unit 1," Rev. 1, dated August 1980.