August 11, 1982
Docket Nos. 50-254/265

Mr. L. DelGeorge
Director of Nuclear Licensing
Commonwealth Edison Company
P. O. Box 767
Chicago, Illinois 60690

Dear Mr. DelGeorge:

SUBJECT: RESOLUTION OF MULTIPLANT ACTION NO. B-48, ADEQUACY OF STATION ELECTRIC DISTRIBUTION VOLTAGE

Re: Quad Cities Nuclear Power Station, Units 1 and 2

We have completed our evaluation of your responses to our August 8, 1979 request for analyses related to the adequacy of station electric distribution system voltages at Quad Cities Units 1 and 2. This review was intended 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 rating.

We have determined that the voltage analysis and test results that you submitted for meeting the staff position is acceptable. This concludes our review of our Multiplant Action No. B-48 for Quad Cities Units 1 and 2.

Copies of our safety evaluation and our consultant's technical evaluation report are included.

Sincerely,

ORIGINAL SIGNED BY

Domenic B. Vassallo, Chief
Operating Reactors Branch #2
Division of Licensing

Enclosures:
As stated

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ENCLOSURE 1

SAFETY EVALUATION
QUAD CITIES STATION UNITS 1 AND 2
DOCKET NOS. 50-254 AND 50-265
ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

INTRODUCTION AND SUMMARY

Commonwealth Edison Company (CECo) was requested by NRC letter dated August 8, 1979 to review the electric power system at Quad Cities Station Units 1 and 2. was to consist of:

a) Determining analytically the capacity and capability of the offsite power system and onsite distribution system to automatically start as well as operate all required loads within their required voltage ratings in the event of 1) an anticipated transient, or 2) an accident (such as LOCA) without manual shedding of any electric loads.

b) Determining if there are any events or conditions which could result in the simultaneous or, consequential loss of both required circuits from the offsite network to the onsite electric distribution system and thus violating the requirements of GDC 17.

The August 8, 1979 letter included staff guidelines for performing the required voltage analysis and the licensee was further required to perform a test in order to verify the validity of the analytical results. CECo responded by letters dated November 1, 1979, December 14, 1979, June 11, 1980, June 30, 1980, August 18, 1980, April 24, 1981 and June 22, 1981. A detailed review and technical evaluation of the submittals was performed by EG&G under contract to the NRC, with general supervision by NRC staff. This work is reported by EG&G in Technical

Evaluation Report (TER), "Adequacy of Station Electric Distribution System Voltages, Quad Cities Station Units 1 and 2," dated February 1982 (attached). We have reviewed this report and concur in the conclusions that the offsite power system and the onsite distribution system are capable of providing acceptable voltages for worst case station electric load and grid voltages.

EVALUATION CRITERIA

The criteria used by EG&G in this technical evaluation of the analysis includes GDC 5 ("Sharing of Structures, Systems, and Components"), GDC 13 ("Instrumentation and Control"), GDC 17 ("Electric Power Systems") of Appendix A to 10 CFR 50; IEEE Standard 308-1974 ("Class 1E Power Systems for Nuclear Power Generating Stations"), ANSI C84.1-1977 ("Voltage Ratings for Electric Power Systems and Equipment - 60 Hz"), and the staff positions and guidelines in NRC letter to CECo dated August 8, 1979.

ANALYSIS AND TEST FEATURES

CECo analyzed each offsite power source to the onsite distribution system under maximum and minimum load conditions with the 345 kv grid at maximum and minimum anticipated voltages of 354 kv and 333 kv. The worst case Class 1E equipment voltages occur with the station auxiliary transformers supplying power under the following conditions:

1. Maximum voltage occurs when the offsite grid is at the highest anticipated voltage and there are no unit loads.

2. Minimum expected steady state voltage occurs when there is no sharing of the offsite power sources during a unit trip with grid voltage at minimum and all buses fully loaded with the exception of loads shed on a unit trip.

3. The minimum expected transient voltages occur under the conditions of item 2 above, concurrent with the start of a 1750 hp condensate booster pump on the 4160 volt bus or a 150 hp turbine building exhaust fan on 480 volt bus 29 when unit 1 station auxiliary transformer is supplying power from unit 2 bus 24-1.

4. The minimum voltage occurs when sharing an offsite power source between units with one station auxiliary transformer supplying safe shutdown loads in its respective unit and accident loads in the other unit.

Given the minimum voltage condition, a brief period exists while starting a large load with the unit buses fully loaded that could momentarily prevent contactor pickup for 480 volt MCC loads until the voltage recovers. No contactor drop out or spurious shedding of loads will occur. This momentary inability to start a 480 volt load is not considered significant due to the very short time of concern and the fact that the voltage recovery required is less than 1%. The analysis indicates that an overvoltage condition of 2.6% above equipment design rating could occur under the maximum voltage no load condition on the 480 volt buses. This slight overvoltage condition is considered acceptable since the application of any appreciable loads will reduce the voltage to within the equipment design rating.

The voltage analysis was verified by measuring voltages at the switchyard and unit 2 Class 1E buses and selected Class 1E equipment terminal voltages while both units were shutdown. Since the bus loads were light, a digital voltmeter with an accuracy of ± 0.01% was used. The comparison showed that calculated voltages for the Class 1E buses are within + 0.7 and the measured voltages. This close correlation verifies the accuracy of the analysis submitted.

DESIGN CHANGES

As a result of the voltage analysis, CECo has proposed to replace the self-regulated motor-generator sets that supply power to the 120 VAC essential buses with inverters that contain voltage regulation.

CONCLUSIONS

We have reviewed the EG&G Technical Evaluation Report and concur in the findings that:

1. CECo has provided verified voltage analyses to demonstrate that after the proposed modifications are accomplished Class 1E equipment voltages will remain within acceptable operating limits for the worst case analyzed conditions.

2. The tests used to verify the analysis was valid and showed the analysis to be accurate.

3. CECo's reaffirmation of compliance with GDC 17 requirements is acceptable.

We, therefore, find the Quad Cities station Units 1 and 2 design acceptable with respect to adequacy of station electric distribution system voltage.

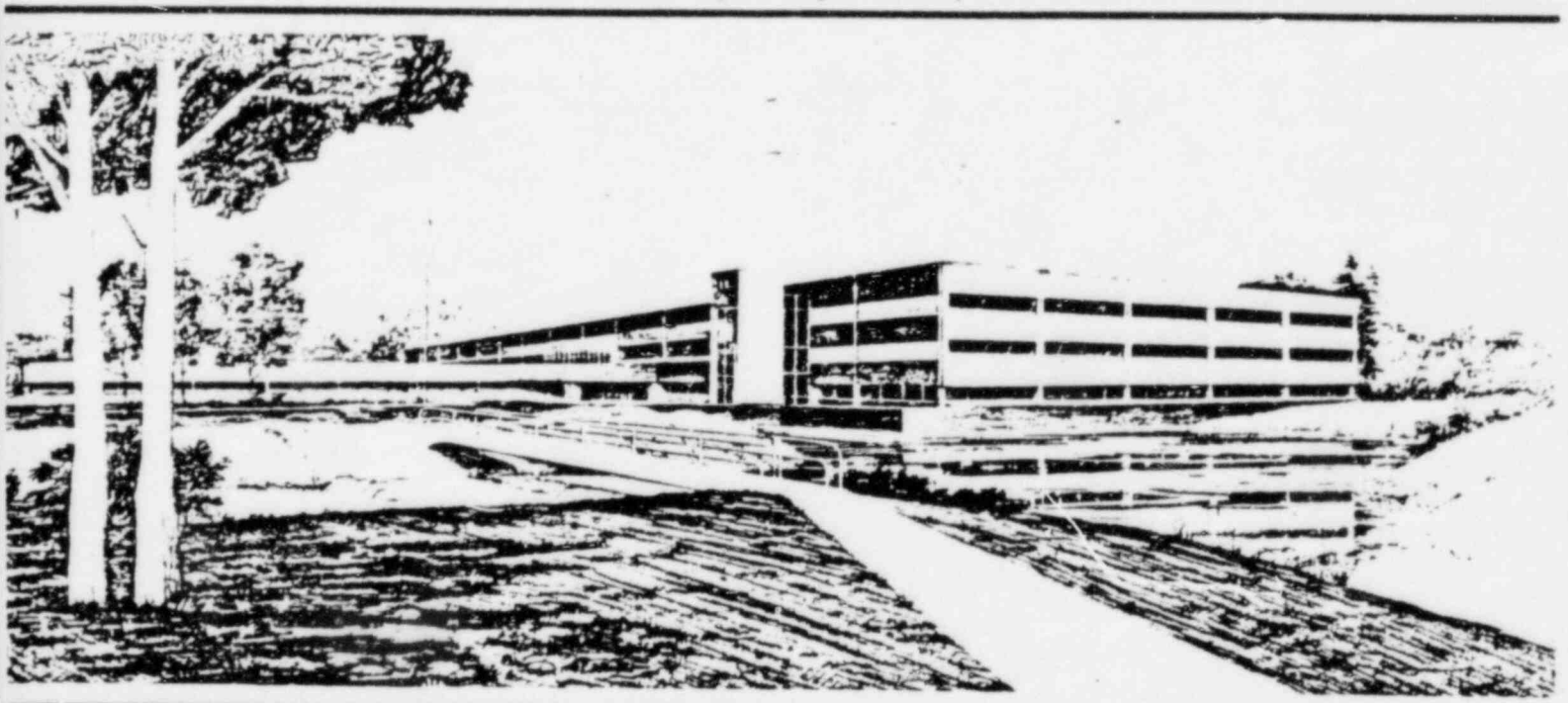
EGG-EA-5323, Rev. 1

FEBRUARY 1982

ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES, QUAD CITIES STATION, UNIT NOS. 1 AND 2

A. C. Udy

U.S. Department of Energy
Idaho Operations Office • Idaho National Engineering Laboratory



This is an informal report intended for use as a preliminary or working document

Prepared for the
U.S. Nuclear Regulatory Commission
Under DOE Contract No. DE-AC07-76ID01570
FIN No. A6429

AND NOT DESIGNATED

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PDR

EG&G Idaho

EG&G Idaho, Inc.

FORM EG&G 398
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INTERIM REPORT

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Washington, D.C.
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INTERIM REPORT

0196J

ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

QUAD CITIES STATION, UNIT NOS. 1 AND 2

Docket Nos. 50-254 and 50-265

February 1982

A. C. Udy
Reliability and Statistics Branch
Engineering Analysis Division
EG&G Idaho, Inc.

TAC Nos. 12808 and 12809

ABSTRACT

This EG&G Idaho, Inc. report reviews the capacity and the capability of the onsite distribution system at the Quad Cities Station, in with the offsite power sources, to automatically start and operate all required safety loads.

FOREWORD

This report is supplied as part of the Selected Operating Reactors Issues Program (III) being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Operating Reactors, 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 A6429.

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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

QUAD CITIES 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 supplied each Class 1E load. The letter included 13 specific guidelines to be followed in determining if the voltage is adequate to start and continuously operate the Class 1E loads.

Commonwealth Edison Company (CECo) responded to the NRC letter[1], for the Quad Cities Station, with letters of November 1, 1979[2] (which included a report on this subject, written by Sargent & Lundy) and December 14, 1979[3]. The Final Safety Analysis Report (FSAR), test results submitted on June 11, 1980[4], additional analyses submitted on June 30, 1980[5] to answer concerns on the original analysis, and a letter of September 14, 1976[7], complete the information reviewed for this report. Telephone conversations in September 1980[8] also provided information. Analysis on the use of the unit inter-tie was submitted on August 18, 1980.[9] This information was supplemented on April 24, 1981[10] and June 22, 1981.[11]

Based on the information supplied by CECo, this report addresses the capacity and capability of the onsite distribution system of the Quad Cities 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 steady-state load conditions.

2.0 DESIGN BASIS CRITERIA

The positions applied in determining the acceptability of the offsite voltage conditions in supplying power to 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.

3.0 SYSTEM DESCRIPTION

Figure 1 of this report is a simplified sketch of the unit one-line diagram taken from the Sargent & Lundy report[2]. Figure 1 shows that, for Unit 1, the Class 1E 4160V buses 13-1 and 14-1 are normally supplied power from auxiliary buses 13 and 14, respectively. With loss of the unit generator, these buses are supplied by the station auxiliary transformer (SAT)[a] from the 345kV switchyard. Class 1E 4160V bus 14-1 can be supplied power from the other unit via a manual connection[b] to Class 1E bus 24-1 of Unit 2. This inter-tie can also be used in the other direction to energize bus 24-1 of Unit 2 from the Unit 1 SAT. The Unit 2 distribution system is identified as similar in the FSAR, except for different bus and transformer numbers.

Each 4160V Class 1E bus supplies power for one 480V Class 1E bus via independent transformers (4055/480V tap). These 480V buses can be connected together without technical specification restrictions; however, each Class 1E 480V bus has an undervoltage alarm.[12]

CECo supplied the equipment operating ranges identified in Table 1. Station 125V DC buses supply power for all Class 1E switchgear, except for 480V MCC circuits which use individual control power transformers and contactors.

4.0 ANALYSIS DESCRIPTION

4.1 Analysis Conditions. CECo has determined by load-flow studies that the maximum expected offsite grid voltage is 354kV and the minimum is 333kV. The station auxiliary transformer was used for the analyses supplied.

CECo 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 with the SAT supplying power and under the following conditions:

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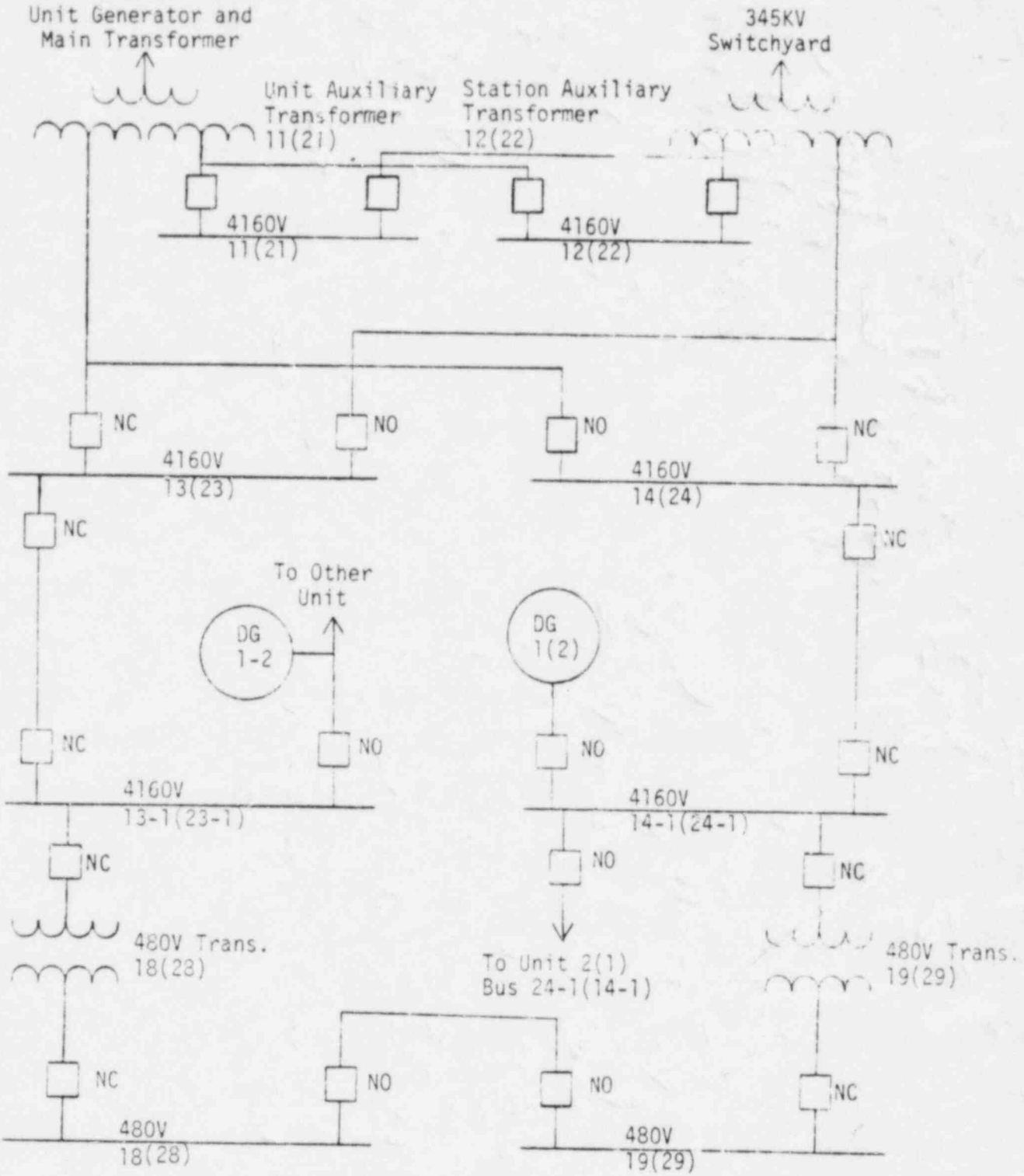
a. CECo also refers to this as a reserve auxiliary transformer (RAT).

b. This connection between Units 1 and 2 is hereafter referred to as an inter-tie in this report.



NOTE: This diagram is for unit 1. The unit 2 class 1E distribution system is identical, with bus and equipment numbers shown in parenthesis.

Figure 1. Quad Cities Station, Unit One Line Diagram.

TABLE 1

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

Equipment	Nominal Voltage (100%)	Maximum		Minimum		
		Rated	Analyzed	Rated	Analyzed	
					Steady state	Transient
	4kV					
		--	--	75	--	89.9[a]
Operate		110	109.4	90	95.5[b]	--
	460V					
Start		--	--	75	--	83.6[c]
Operate		110	112.6	90	90.5[a,c]	--
Starters	480V					
Pickup		--	--	85	--	84.7
Dropout		--	--	70	--	84.7
Operate		110	107.9	85	89.8[a,c]	--
Other Equipment[d]						

a. Terminal voltage supplied by CECo.

b. This value includes the typical (0.5%) feeder cable voltage drop.

c. This is the lowest voltage that occurs in either unit in the CECo analysis. The inter-tie is used for these voltages. When in addition the intra-unit 480V bus-tie is used, the resultant steady-state voltage at the starters is 86.3%; at the 460V motors-87.0%.

d. Self-regulated motor-generator sets presently supply power for 120V AC essential buses. These are scheduled to be replaced with inverter sets that have their own voltage regulation.

1. The maximum expected load terminal voltages occur when the switchyard voltage is maximum and there are no unit loads.

2. The minimum expected steady state load terminal voltages, when there is no sharing of offsite power sources, occur when the switchyard voltage is minimum and all buses are fully loaded (except for loads shed due to a unit trip).

3. The minimum expected transient load terminal voltages occur under the conditions of 2, concurrent with the start of a 1750 hp condensate booster pump (4160V loads) or the start of the 150 hp Turbine Building Exhaust Fan on bus 29 when the Unit 1 SAT is supplying power from Unit 2 buses 24-1 and 29 (480V loads).

4. The minimum continuous and transient load terminal voltages, when sharing an offsite source between units, occur with a shutdown in the unit with offsite power supplied by its SAT and accident loads in the other unit.

4.2 Analysis Results. Table 1 shows the projected worst case Class 1E equipment terminal voltages for either Unit 1 or Unit 2.

4.3 Analysis Verification. The computer analysis was verified[4] by measuring the switchyard voltage and the Unit 2 Class 1E bus and selected Class 1E equipment terminal voltages while both units were shutdown. Since the bus loads were light, a digital voltmeter (±0.01% accuracy) was used to be sure that voltage drops could be measured. An analysis using the measured loads and switchyard voltage determined the expected bus and equipment voltages, and the results were compared with the measured bus and equipment voltages.

Even though the grid voltage varied between 353.4 and 352.2kV while the measurements were made, the comparison shows that the Class 1E calculated bus voltages are within +0.17/-1.58% of the measured bus voltages.

5.0 EVALUATION

Six review positions have been established from the NRC analysis guidelines[1] and the documents listed in Section 2. 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.

As shown in Table 1, a brief condition exists when the buses are fully loaded, that would prevent Class 1E contactor pickup if a 480V MCC load were stopped and then restarted, until the voltage recovers. It will not cause contactor dropout or spurious shedding of any loads.

CECo has shown by analysis that the Quad Cities station has sufficient capability and capacity for starting and continuously operating the Class 1E loads within 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 all Class 1E equipment without exceeding the rated equipment voltage.

As can be seen from Table 1, all loads are operated within allowable voltage limits, except for the potential 112.6% on the 480V buses. CECo concluded that the safety loads at the Quad Cities Station would not be subjected to unacceptable overvoltages because the analysis was done for a no-load condition and, when a load is added, voltage drops in the supply transformers and feeder cables reduces the voltage to "very close to

as shown by analysis that the voltage ratings of the Class 1E equipment can be slightly exceeded with no loads connected to power. However, when loads are connected, feeder drops and transformer impedences lower the available terminal voltage so that overvoltages are not supplied to the Class 1E equipment.

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.

EG&G Idaho, Inc., will verify, in a separate report, that the requirements of this position are satisfied (TAC Nos. 10046 and 10047).

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

CECo has shown a close correlation between measured and calculated voltages that verifies the adequacy of the analysis submitted for Unit 2. Since both units' electric distribution systems are similar and unit dependent variables were field verified[5], this test for Unit 2 is considered as verification of the Unit 1 analysis.

on 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).

CECo has analyzed the connections of the Quad Cities Station to the offsite power grid, and has determined that no potential exists for the simultaneous or consequential loss of both circuits from the offsite grid.[2]

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.

CECo has shown that, by using the inter-tie between the two Quad Cities units, adequate starting and operating voltages are supplied to the Class 1E equipment for an accident in one unit and an orderly shutdown and cooldown in the remaining unit (Table 1).

6.0 CONCLUSIONS

The voltage analyses submitted by CECo for the Quad Cities 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. The test used to verify the analyses shows the analysis to be an accurate representation of the worst case conditions analyzed.

3. CECo has determined that no potential for either a simultanous or consequential loss of both offsite power sources exists.

EG&G Idaho, Inc., is performing a separate review of the undervoltage relay protection at the Quad Cities station. This will evaluate the relay setpoints and time delays to determine that spurious tripping of the Class 1E buses will not occur with normal offsite source voltages.

7.0 REFERENCES

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

2. CECo letter, Robert F. Janecek, to William Gammill, "Adequancy of Station Electric Distribution System Voltages", November 1, 1979.

3. CECo letter, Robert F. Janecek, to William Gammill, "Adequacy of Station Electric Distribution System Voltages", December 14, 1979.

4. CECo letter, Robert F. Janecek, to William Gammill, U.S. NRC, "Adequacy of Station Electric Distribution System Voltages," June 11, 1980.

5. CECo letter, Robert F. Janecek, to T. A. Ippolito, U. S. NRC, "Adequacy of Station Electric Distribution System Voltages," June 30, 1980.

6. CECo letter, Robert F. Janecek, to Darrell G. Eisenhut, U.S. NRC, "Second Level of Undervoltage Protection for 4kV Onsite Emergency Power Systems," June 26, 1980.

7. CECo letter, G. A. Abrell, to Karl R. Goller, U.S. NRC, "Information Concerning System Voltage Conditions," September 14, 1976.

8. Telecon, A. C. Udy, EG&G Idaho, Inc., to H. Stolt, CECo, September 11, 1980.

9. CECo letter, Robert F. Janecek, to U.S. NRC, Darrell G. Eisenhut, "Additional Response concerning Adequacy of Station Electric Distribution System Voltages," August 18, 1980.

10. CECo letter, Robert F. Janecek to T. A. Ippolito, NRC, "Adequacy of Station Electric Distribution System Voltages," April 24, 1981.

11. CECo letter, T. J. Rausch to T. A. Ippolito, NRC, "Response to Request for Additional Information Concerning Adequacy of Station Electric Distribution System Voltages," June 22, 1981.

12. Telecon, R. Bevan & R. Prevatte, NRC, T. J. Rausch, CECo, and A. Udy, EG&G Idaho, Inc., January 21, 1982.