



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D. C. 20555

DMB 016

Dockets Nos. 50-269, 50-270  
and 50-287

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Dear Mr. Tucker:

DISTRIBUTION

Docket File

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We have completed our review of adequacy of Station Electric Distribution System Voltages for Oconee Nuclear Station, Units Nos. 1, 2 and 3. Our enclosed Safety Evaluation is based on EG&G Technical Evaluation Report, EGG-EA-6131.

Based on the results of your distribution system voltage verification tests, performed in accordance with our guidelines, for the Unit 3 distribution system, we find your voltage analysis acceptable. Due to the close similarity of the design and loading of the distribution systems for all 3 units, we agree to accept the results of the Unit 3 tests as being valid for Units 1 and 2 also. Therefore separate verification testing for Units 1 and 2 will not be necessary.

The voltage analysis you submitted, indicates that the distribution voltages at the safety buses were unacceptable when one unit startup transformer is shared between two units. Your staff has agreed to implement Technical Specifications (TSs) to prohibit the connection of more than one unit auxiliary and Class 1E loads to a single startup transformer. If our understanding of your commitment is incorrect, please inform us within 30 days after receipt of this letter.

We understand from your Mr. R. Gill, that the necessary TS changes are undergoing final review and will be submitted by March 31, 1983. We find this schedule responsive to our request.

Sincerely,

John F. Stolz, Chief  
Operating Reactors Branch #4  
Division of Licensing

Enclosure:  
Safety Evaluation

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SAFETY EVALUATION  
OCONEE NUCLEAR UNITS 1, 2, AND 3  
DOCKET NOS. 50-269/270/287  
ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

INTRODUCTION AND SUMMARY

Duke Power Company (DPC) was requested by NRC letter dated August 8, 1979 to review the electric power system at Oconee Units 1, 2 and 3. The review 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.

DPC responded by letters dated October 29, 1979, January 31, 1980, June 4, 1980, February 5, 1982, and November 8, 1982.

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, Oconee Nuclear Station, Units 1, 2 and 3, "dated January 1983 (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 DPC dated August 8, 1979.

#### ANALYSIS AND TEST FEATURES

DPC analyzed each offsite power source to the onsite distribution system under maximum and minimum load conditions with the offsite power sources at maximum and minimum anticipated voltage, 1.013 and .94 per unit on the 525 kv, and 1.004 and .943 per unit on the 230 kv systems. The analysis included the transient effects on the Class 1E equipment from starting a large Class 1E and non-Class 1E load. The maximum voltage expected at the 4kv bus is slightly higher than the equipment rating. However, this

voltage does not have detrimental effects on plant loads or motor feeder circuits. When voltage drops are accounted for, the maximum equipment terminal voltage is within the equipment rating. The minimum analyzed bus voltages shown in the DPC analysis are high enough to account for feeder voltage drops that exist between the bus and the loads. The minimum equipment terminal voltage is within the equipment rating. It has been established that the 4160 volt, 480 volt and 208 volt emergency loads will operate within allowable voltage limits when supplied from the offsite power system.

DPC performed a test in accordance with NRC guidelines for verification of voltages and currents for the Unit 3 distribution system while the unit auxiliary transformer of that unit supplied 100% of the normal full power operating loads. The measured voltage values were compared with calculated voltage values, and in all cases, the measured values were acceptably close to the analyzed voltage values (0.21-0.28% for the 4 kv buses; within 0.33% for 600 volt buses; and within 1.05 to 1.73 % for the 208 volt buses). This test verifies the accuracy of the analysis for the steady-state condition. The verification tests on Unit 3 are applicable to Units 1 and 2 also, since they employ identical equipment and distribution systems. Therefore, no separate tests are required on Units 1 and 2.

#### DESIGN/OPERATION CHANGES

DPC voltage analysis is based upon a limiting condition of operation that only two units will be permitted to operate when one of the three startup

transformers is failed. As a result of the voltage analysis DPC proposed the following operational changes:

- 1) Implement technical specifications change to prohibit the connection of more than one unit auxiliary and Class 1E loads to a single startup transformer (i.e. use of one startup transformer for one unit).

### CONCLUSIONS

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

1. The voltages are within the operating limits of Class 1E equipment for projected combinations of plant load and offsite power grid conditions provided one startup transformer is used for one unit.
2. Spurious separation from the offsite power system due to the operation of voltage protective relays will not occur (with the offsite grid voltage within its expected limits) as a result of starting safety loads.
3. DPC has determined (by analysis) that no potential for either a simultaneous or consequential loss of both offsite power sources exists.
4. The tests performed by DPC verifies the accuracy of their analysis.

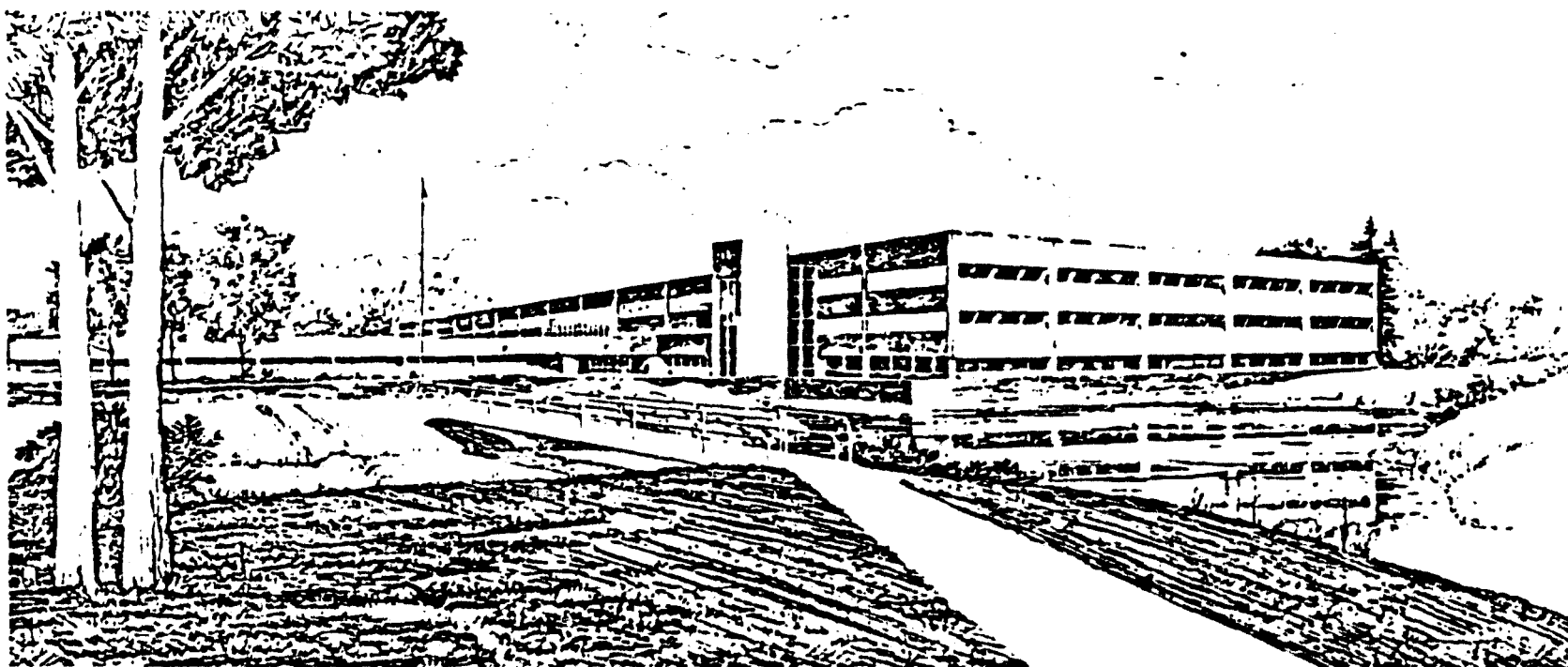
We, therefore, find Oconee Nuclear Units 1, 2 and 3 design to be acceptable with respect to adequacy of station electric distribution system voltages subject to the implementation of technical specifications change prohibiting the use of one startup transformer for more than one unit.

JANUARY 1983

ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM  
VOLTAGES, OCONEE NUCLEAR STATION, UNIT NOS. 1, 2  
AND 3

A. C. Udy

**Idaho National Engineering Laboratory**  
Operated by the U.S. Department of Energy



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

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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES  
OCONEE NUCLEAR STATION, UNIT NOS. 1, 2 AND 3

1. 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,"<sup>1</sup> 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, Duke Power Company submitted information and analysis on October 29, 1979,<sup>2</sup> January 31, 1980,<sup>3</sup> June 4, 1980,<sup>4</sup> February 5, 1982,<sup>5</sup> and November 8, 1982.<sup>6</sup> These submittals, the Oconee Final Safety Analysis Report and submittals of November 15, 1976,<sup>7</sup> July 21, 1977,<sup>8</sup> and October 19, 1978,<sup>9</sup> complete the information reviewed for this report.

Based on the information supplied by the Duke Power Company, this report addresses the capacity and capability of the onsite distribution system of the Oconee Nuclear 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. 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), Electric 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, IEEE Standard Criteria for 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.<sup>1</sup>
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<sup>1</sup> and the above listed documents. These positions are stated in Section 5.0.

### 3. SYSTEM DESCRIPTION

Figure 1 of this report is a simplified sketch of the Oconee electrical single-line diagram. The following description pertains to Unit 1. Unit Nos. 2 and 3 are similar.

During normal plant full-power operation, auxiliary power is supplied by the unit auxiliary transformer No. 1T and during startup and shutdown, by the startup transformer No. CT1 via the 230kV switchyard. Provisions are made for automatic fast transfer of the auxiliary loads from the unit auxiliary transformer to the startup transformer on a unit trip. A second

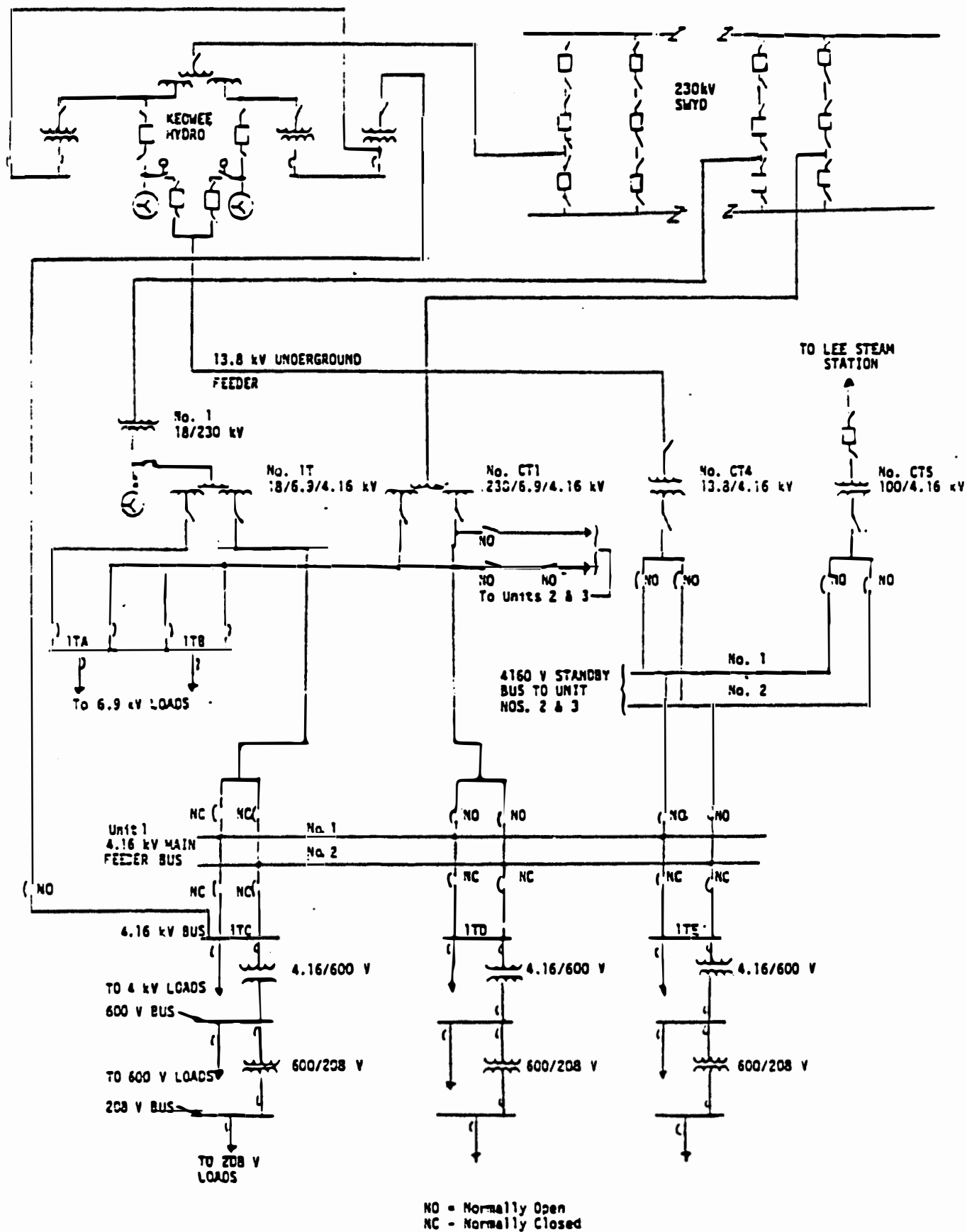


Figure 1. Oconee Electrical Single Line Diagram - Unit 1

independent circuit is available from the 230kV switchyard (525kV switchyard for Unit No. 3) to the onsite distribution system via the main transformer and the unit auxiliary transformer for that unit when the main generator bus disconnect links have been removed. Complete loss of all offsite power will result in the automatic transfer to either of the two onsite Keowee hydroelectric generators which are capable of supplying all the emergency and shutdown loads via CT4. Emergency and shutdown loads can also be supplied from a gas turbine generator at the Lee Steam Station via CT5. This generator is isolated from the grid and is considered an onsite source.<sup>5</sup>

There are three essential 4.16kV buses; No. 1TC, 1TD, and 1TE. One division of safety-related equipment is powered from each of these buses. Each bus supplies 4kV loads, the 600V load centers and motor control centers (MCCs), and, in turn the 208V MCC's and the 125/250VDC systems.

#### 4. ANALYSIS DESCRIPTION

##### 4.1 Operational Changes

The voltages shown on Table 1 are based on a proposed change to the Oconee Nuclear Station Technical Specifications that would limit the use of a startup transformer to one unit.<sup>5,6</sup>

##### 4.2 Analysis Conditions

Duke Power Company has determined that the maximum 230kV offsite grid voltage is 231kV<sup>6</sup> (532kV for the 525kV grid). They reviewed historical data to determine that the minimum 230kV offsite grid voltage is 217kV (494kV for the 525kV grid).

The licensee has analyzed the offsite source in conjunction with the onsite distribution system under extremes of load and offsite voltage conditions to determine the terminal voltages at typical Class 1E equipment. The worst case Class 1E equipment terminal voltages occur under the following conditions:

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

Equipment	Condition	Maximum		Minimum		
		Rated	Analyzed	Rated	Analyzed	
					Steady State	Transient
4000V Motors	Start	--	--	80 <sup>a</sup>	--	84
	Operate	110	110.9	90	94	--
575V Motors	Start	--	--	80 <sup>a</sup>	--	75.5 <sup>b</sup>
	Operate	110	109	90	92	--
200V Motors	Start	--	--	80 <sup>a</sup>	--	73.7 <sup>b</sup>
	Operate	110	108.8	90	91.4	--
600V Starters	Pickup	--	--	70.2	--	72.3
	Dropout	--	--	50.2	--	72.3
	Operate	110	104.7	80	87.8	--
208V Starters	Pickup	--	--	70.2	--	70.8
	Dropout	--	--	50.2	--	70.8
	Operate	110	104.7	80	87.8	--
Other Equipment <sup>c</sup>						

a. There is a ten second stall rating in addition to the starting voltage rating.

b. These voltages were from an analysis of the loads of two units on one startup transformer. With a technical specification prohibiting this lineup the minimum transient voltage will be higher. However, the voltage recovers and the motor is started within the 10 second stall rating of the motors even in the conservative case. Therefore, the motors will be able to start on the worst case voltage available when the technical specification restriction is imposed.

c. The rating and effects of voltage variations on other equipment is acceptable as described in the Duke Power Company submittal of February 5, 1982 (p 6).<sup>5</sup>

1. The maximum voltage occurs under station minimum load conditions when the 525kV source is at a high of 532kV and the Unit No. 3 Class 1E system is supplied via the startup transformer.<sup>6</sup>
2. The worst case transient voltage occurs when the 230kV source is at its minimum expected value supplying the maximum plant loads via the startup transformer with the bulk load starting of all required safety loads.<sup>2</sup>
3. The minimum steady-state voltage occurs when all Class 1E loads and the normally running unit auxiliary loads (including the condensate booster pump) are running.<sup>3</sup>

#### 4.3 Analysis Result

Table 1 shows the projected worst case Class 1E equipment voltages.

The maximum voltage expected at the 4kV equipment is higher than the equipment rating. This voltage is at the 4kV switchgear, and does not account for any plant loads or the voltage drop in the motor feeder cables. When these voltage drops are accounted for, the maximum equipment terminal voltage is within the equipment rating. The analyzed maximum switchgear voltage for Unit Nos. 1 and 2 is less than that for Unit No. 3, and is within the equipment rating.

The minimum analyzed bus voltages shown are high enough to account for feeder voltage drops that exist between the bus and the loads.

#### 4.4 Analysis Verification

DPC performed a test in accordance with NRC guidelines that measured voltages and currents for the Unit 3 distribution system while the unit auxiliary transformer of that unit supplied 100% of the normal full power operating loads. The test is deemed applicable to Unit Nos. 1 and 2 also, since they employ identical equipment and near identical distribution systems.

Using the measured generator voltage and unit loads, the same computer model was used to calculate the distribution system voltages. These calculated voltages were then compared to the measured voltages. In all cases, the calculated voltage was higher than the measured voltage (by 0.21 to 0.28% for the 4kV buses; by 0.33% for the 600V buses; and by 1.05 to 1.73% for the 208V buses).

This tests verifies the accuracy of the analysis for the steady-state condition. There is no reason to believe that the analysis is less than adequate for the transient motor starting condition.

## 5. EVALUATION

Six review positions have been established from the NRC analysis guidelines<sup>1</sup> 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 implementation of the technical specification change 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.

The licensee has shown, by analysis, that the offsite power sources in conjunction with 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.

Duke Power Company has shown, by analysis, that the voltage ratings of the Class 1E equipment will not be exceeded (Table 1 and Section 4.3).



Position 3--Loss of offsite power to any 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 Figure 2<sup>6</sup> and in Table 2, below, the voltage relays will not cause the loss of the Class 1E distribution system when the offsite grid voltage is within expected voltage limits. The relays used have inverse time delay characteristics. Table 2 shows sample points from the relay characteristic and the motor starting characteristic that are derived from Figure 2.<sup>6</sup>

Position 4--The NRC letter<sup>1</sup> requires that test results verify the accuracy of the voltage analyses supplied.

The test results, provided by Duke Power Company in their submittal of June 4, 1980,<sup>4</sup> verify the accuracy of the voltage analysis.

TABLE 2. COMPARISON OF ANALYZED VOLTAGES AND UNDERVOLTAGE RELAY SETPOINTS (% of nominal voltage)

<u>Location/Relays</u>	<u>Minimum Analyzed</u> <sup>a</sup>		<u>Relay Setpoint</u>	
	<u>Voltage</u>	<u>Recovery Time</u>	<u>Voltage</u>	<u>Time to Trip</u>
4160V main feeder bus				
Steady-State	90.4	continuous	87.5 ± 3%	>5 sec
Transient Motor Starting	80.8	.2 sec	b	4 sec
	82.0	.5 sec	b	4.3 sec
	85	1.7 sec	b	>6 sec
	87.5	4 sec	b	>10 sec
	90	5.8 sec	b	no trip

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.<sup>2,3,6</sup>

b. For the transient voltages, the analyzed voltages are shown with the time the voltage will take to recover above this voltage. However, the relay setpoint is not shown, but the length of time needed for relay actuation if the voltage remains at the analyzed voltage is shown.

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).

Duke Power Company has analyzed the onsite connections to the offsite power grid and determined that no potential exists for the simultaneous or the consequential loss of both circuits from the offsite grid.<sup>2</sup>

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 present Technical Specifications permit the alignment of one startup transformer to two units. However, their analyses of June 4, 1980,<sup>4</sup> and February 5, 1982,<sup>5</sup> show that under degraded grid conditions, the Class 1E equipment would be required to operate below their minimum ratings. Therefore, DPC has proposed to change their technical specifications to limit the use of a startup transformer to one unit. This will insure adequate voltages for the Class 1E equipment.

## 6. CONCLUSIONS

The voltage analyses submitted by Duke Power Company for the Oconee Nuclear Station were evaluated in Section 5.0 of this report. It was found that:

1. Subject to the implementation of technical specifications prohibiting the connection of more than one unit auxiliary and Class 1E loads to a single startup transformer, voltages within the operating limits of the Class 1E equipment are supplied for all projected combinations of plant load and offsite power grid conditions.

2. The test performed by Duke Power Company verifies the accuracy of the analysis.
3. Duke Power Company has determined that no potential for either a simultaneous or a 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. 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. Duke Power Company (DPC) letter, W. O. Parker, Jr., to H. R. Denton, NRC, October 29, 1979.
3. DPC letter, W. O. Parker, Jr., to H. R. Denton, NRC, January 31, 1980.
4. DPC letter, W. O. Parker, Jr., to H. R. Denton, NRC, June 4, 1980.
5. DPC letter, W. O. Parker, Jr., to H. R. Denton, NRC, February 5, 1982.
6. DPC letter, H. B. Tucker to H. R. Denton, NRC, "Adequacy of Station Electric Distribution Systems Voltages," November 8, 1982.
7. DPC letter, W. O. Parker, Jr., to B. C. Rusche, NRC, dated November 15, 1976.
8. DPC letter, W. O. Parker, Jr., to E. G. Case, NRC, July 21, 1977.
9. DPC letter, W. O. Parker, Jr., to H. R. Denton, NRC, October 19, 1978.