Attachment

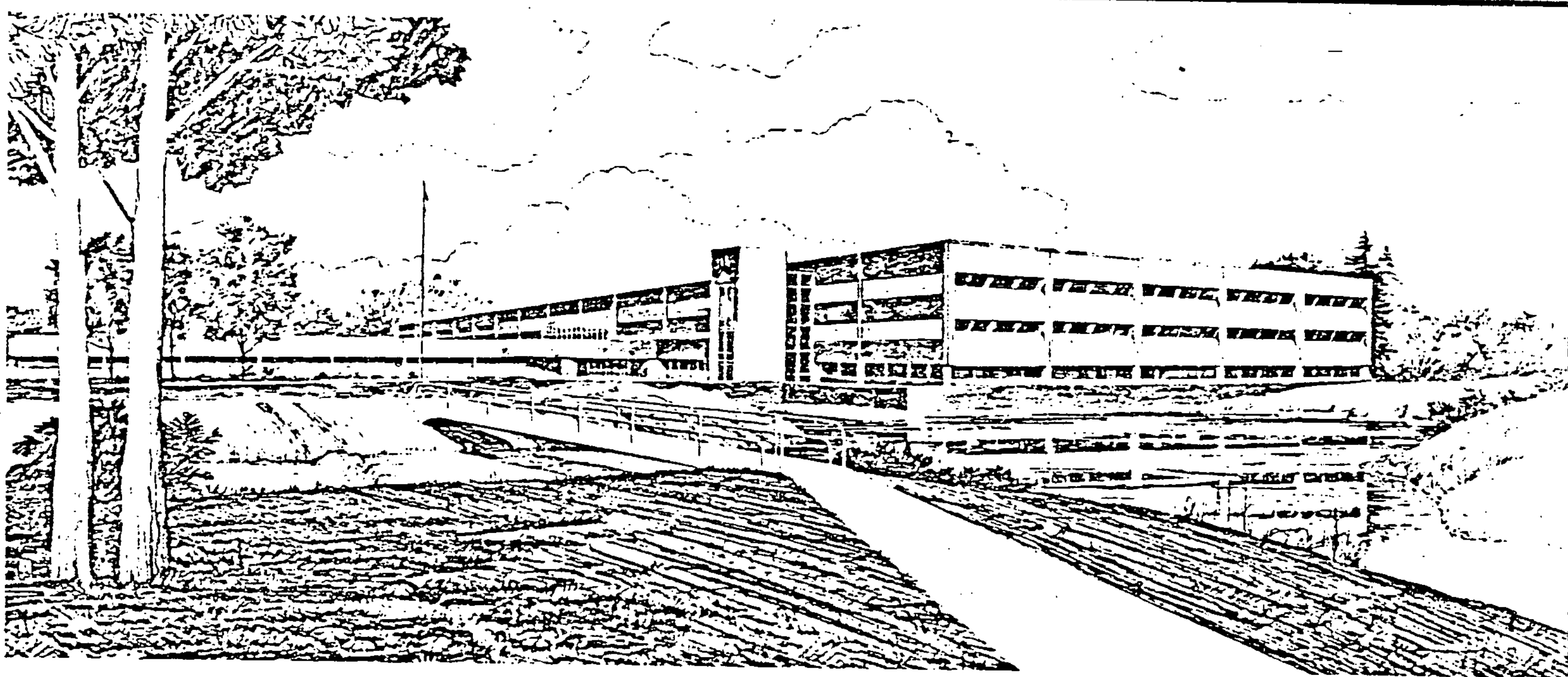
EGG-EA-6131

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

Prepared for the
U.S. NUCLEAR REGULATORY COMMISSION
Under DOE Contract No. DE-AC07-76ID01570
FIN No. A6429

EG&G Idaho

CONTENTS

FIGURE

TABLES

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,"[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, Duke Power Company submitted information and analysis on October 29, 1979,[2] January 31, 1980,[3] June 4, 1980,[4] February 5, 1982,[5] and November 8, 1982.[6] These submittals, the Oconee Final Safety Analysis Report and submittals of November 15, 1976,[7] July 21, 1977,[8] and October 19, 1978,[9] 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.[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. 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

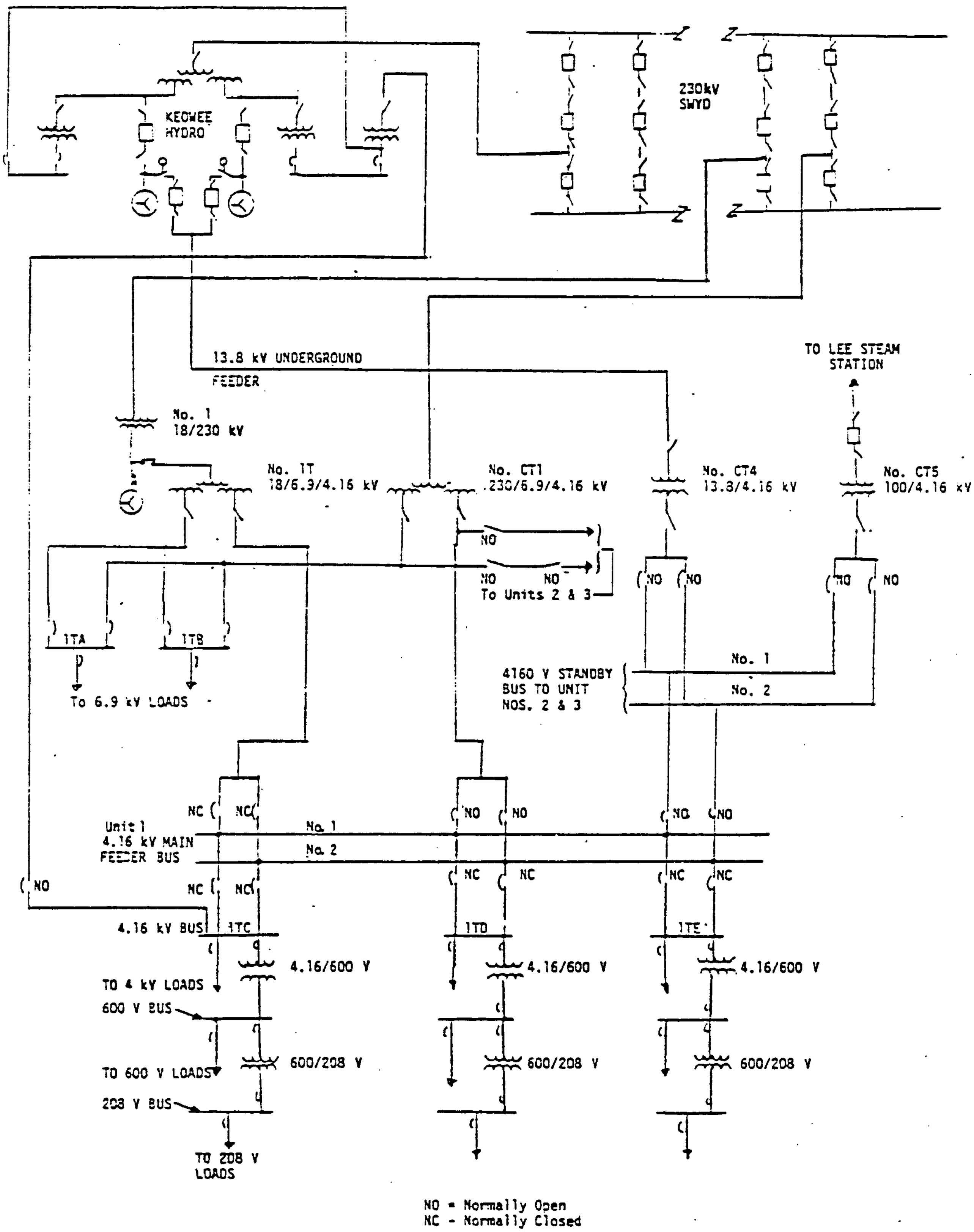


Figure 1. Oconee Electrical Single Line Diagram - Unit 1

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.[6]

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.[5,6]

4.2 Analysis Conditions

Duke Power Company has determined that the maximum 230kV offsite grid voltage is 231kV[6] (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)

		Maximum		Minimum		
					Analyzed	
Equipment	Condition	Rated	Analyzed	Rated	Steady State	Transient
4000V Motors	Start	--	--	80[a]	--	84
	Operate	110	110.9	90	94	--
575V Motors	Start	--	--	80[a]	--	75.5[b]
	Operate	110	109	90	92	--
200V Motors	Start	--	--	80[a]	--	73.7[b]
	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[c]						

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).[5]

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.[6]

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.[2]

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.[3]

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 tranformer 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[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 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[6] 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.[6]

Position 4--The NRC letter[1] 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,[4] verify the accuracy of the voltage analysis.

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

	Minimum Analyzed[a]		Relay Setpoint	
Location/Relays	Voltage	Recovery Time	Voltage	Time to Trip
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.[2,3,6]

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.[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.

The present Technical Specifications permit the alignment of one startup transformer to two units. However, their analyses of June 4, 1980,[4] and February 5, 1982,[5] 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 simultanous 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.