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INTERIM REPORT

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NRC Research and Technical Assistance Report

ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

IG ROCK POINT PLANT

Docket No. 50-155

May 1981

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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 Big Rock Point Plant.

The offsite power sources, in conjunction with the onsite distribution system, have not been shown to have sufficient capacity and capability to automatically start as well as 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.

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.

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NRC Research and Technical Assistance Report

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.

Consumers Power Company (CPCo) responded with letters dated February 19, 1980,[2] and August 29, 1980.[3] CPCo supplied further information requested for this review on March 23, 1981.[4] CPCo correspondence of June 14, 1978,[5] August 21, 1980,[6] and December 12, 1980,[7] were also reviewed for this report.

Based on the information supplied by CPCo, this report addresses the capacity and capability of the onsite distribution system of the Big Rock Point Plant, 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.

2.0 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."

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 unit single-line diagram of the Big Rock Point power distribution system. It is taken from Attachment 1[5] and Figure 1.[3]

The Big Rock Point station has a single class 1E Motor Control Center (MCC-2B) which is normally powered by MCC-2A from Load Center 2 via 2400V/480V transformer No. 22. Transformer No. 11, Load Center 1, and MCC-1A can also supply MCC-2B. Both transformer No 11 and transformer No. 22 are energized by the same 2400V switchgear which is supplied by

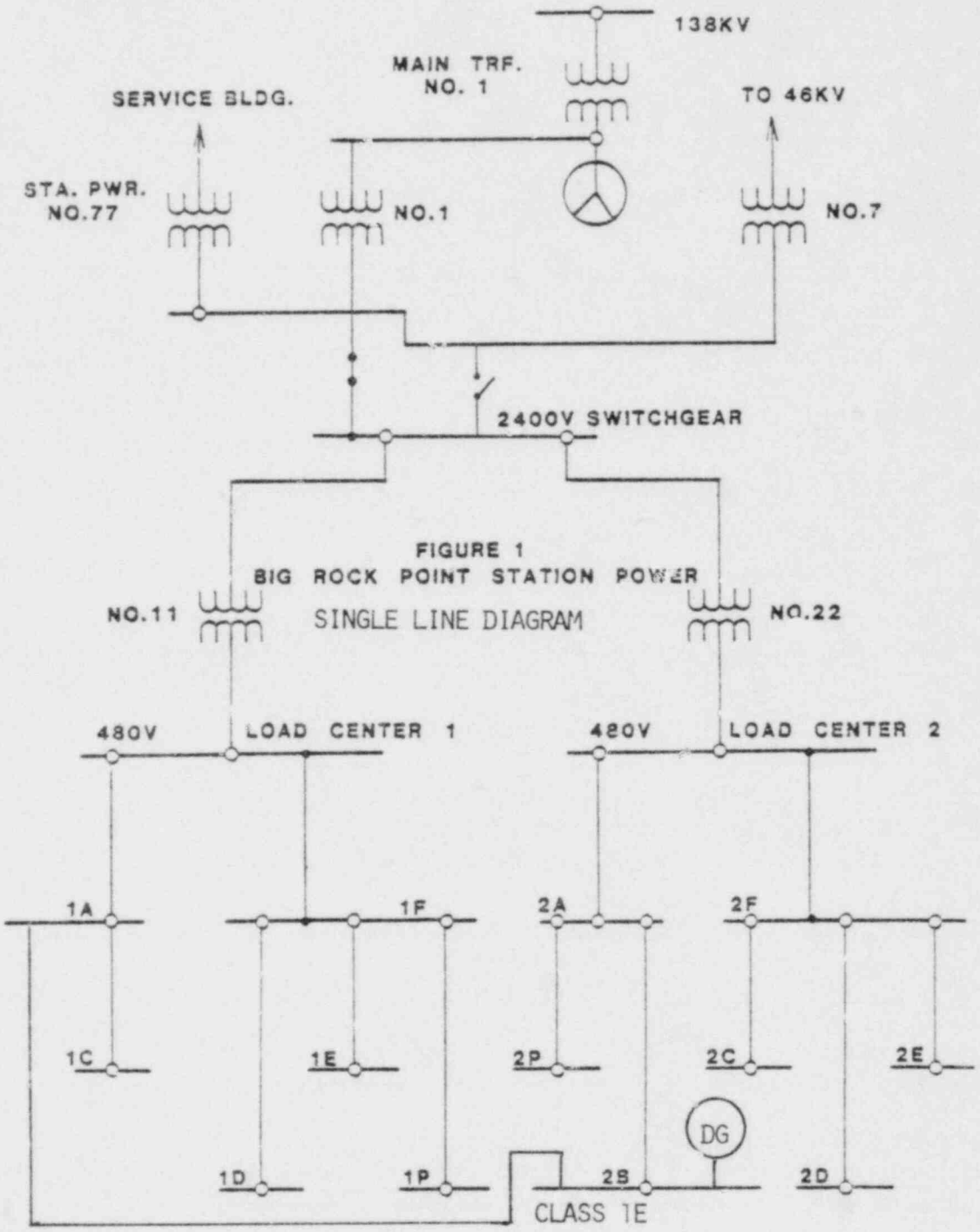

FIGURE 1
BIG ROCK POINT STATION POWER
SINGLE LINE DIAGRAM

transformer No. 1 (from the unit generator on the 138kV grid) or by the 46kV grid.

120V instrument and control panels are supplied from either MCC-1A or MCC-2B.

4.0 ANALYSIS DESCRIPTION

4.1 Analysis Conditions. CPCo has determined that the minimum expected offsite grid voltage is 95% of nominal. CPCo has not described what they expect the maximum grid voltage to be.

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

1. The minimum expected continuous load terminal voltage for a class 1E load occurs when either the unit generator voltage is at its minimum with full-unit loads or the 46kV grid is at its minimum with normal unit loads.

2. The minimum expected transient load terminal voltage for a class 1E load occurs when the 138kV grid is at its minimum, normal unit loads are running and the 1500 hp reactor feed pump is started

3. The maximum expected continuous load terminal voltage for a class 1E load occurs when the unit generator voltage is at its maximum value and the unit loads are at a minimum.

4.2 Analysis Result. Table 1 shows the projected worst case class 1E equipment terminal voltages.

4.3 Analysis Verification. CPCo has verified the accuracy of the analysis for the Big Rock Point Plant by comparing voltages obtained by an

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

Equipment	Condition	Maximum		Minimum		
					Analyzed	
		Rated	Analyzed[a]	Rated	Steady State	Transient
440V Motors	Start	--	--	80	--	77.4[b]
	Operate	110	109.7	90	90.4[b]	--
120V Instru. and Controls	Start	--	--	--	--	--
	Operate	--	c	d	--	--
480V Starters	Pickup	--	--	85	--	76.6
	Dropout	--	--	50	--	76.6
	Operate	e	100.5	e	88.0	--

a. Bus voltage supplied by CPCo. Assuming no feeder voltage drop, the load terminal voltage would be the same.

b. CPCo supplied bus voltage minus the CPCo supplied worst feeder voltage drop (1.5% of steady state, 6.1% transient).[7]

c. CPCo did not supply this value. However, noting the no-load voltage and transformer ratios, it is felt that the 120V nominal rating would be only slightly exceeded, while typical instruments are rated to 110%. When minimal loads are added, feeder and transformer voltage drops would reduce this voltage to within 110%.

d. CPCo states that the worst case voltage to 120V instruments is 4.4% below the guaranteed rating. They state that these reduced voltages will not damage equipment prior to second level undervoltage relay operation and the connection of the diesel generator to the bus.[4] Some downscale error in the instrumentation is expected during this period.

e. CPCo has not supplied these ratings.

oscilligraph with analyzed voltates for the same condition (i.e., steady state and startup of the 100 hp fire pump on MCC-2B.) The test showed the analysis to be within the accuracy limits of the instrumentation used.

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.

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.

CPCo has not shown, by analysis, that the Big Rock Point Plant has sufficient capability and capacity for continuously operating the class 1E loads within the equipment voltage ratings (Table 1). The 120V instrumentation voltages are below the equipment minimum rated voltages; the CPCo analysis has not demonstrated that the distribution system has the capability to start any class 1E load when the offsite grid is at a minimum; and CPCo has not verified that the fire pump (required for short-term core cooling) will not stall when the reactor feed pump is started.

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.

CPCo has shown, by analysis, that the voltage ratings of the class 1E equipment will not be exceeded.

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 the loss of the class 1E distribution system when the offsite grid voltage is within expected voltage limits. Big Rock Point does not have a redundant class 1E distribution system.

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

Location/Relays	Minimum Analyzed[a]		Relay Setpoint	
	Voltage	Time	Voltage (Tolerance)	Time
2400V bus[a] Degraded grid	93.2	continuous	90.0 (±1.0)	10.5 s (±0.5 s)
480 V bus Loss of grid	76.6[b]	5 s or less	less than or equal to 50	instantaneous

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. For start of 1500 hp reactor feed pump, this produces the most degraded voltage for the undervoltage relays.

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

CPCo has verified, by test, the validity of the anaysis for the Big Rock Point Plant.

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).

The Big Rock Point unit does not comply with GDC 17 since it has only one transformer connecting the offsite grid to the class 1E distribution system; it has only one circuit supplying 2400 V to the 2400/480V

transformers; and it has only one class 1E bus. This does not comply with GDC 17.

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.

This applies to multi-unit plants. It does not apply to Big Rock Point, a single-unit station.

6.0 CONCLUSIONS

The voltage analyses submitted by CPCo for Big Rock Point 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 not supplied for all projected combinations of plant load and offsite power grid conditions. CPCo has not demonstrated the capability of all class 1E equipment to continue running during the start of large non-class 1E loads without the trip of thermal overloads or the blowing of control fuses. The CPCo analysis has shown that voltages below the equipment rating can be supplied to instrumentation needed for the safe shutdown of the unit. CPCo should correct these potential equipment problems.

2. The test used to verify the analysis shows the analyses to be an accurate representation of the worst case conditions analyzed.

3. CPCo has determined that no potential for either a simultanous or consequential loss of both offsite power sources exists. However, there are portions of the Big Rock Point distribution system where a single failure can negate both sources.

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. CPCo letter, David P. Hoffman, to Director, Nuclear Reactor Regulation, NRC, "Adequacy of Station Electric Distribution Systems Voltages," February 9, 1980.

3. CPCo letter, David P. Hoffman, to Director, Nuclear Reactor Regulation, NRC, "Adequacy of Station Electric Distribution Systems Voltages," August 29, 1980.

4. CPCo letter, David P. Hoffman, to Director, Nuclear Reactor Regulation, NRC, "Adequacy of Station Electric Distribution Systems Voltages," March 23, 1981.

5. CPCo letter, William S. Skibitsky, to Director, Nuclear Reactor Regulation, NRC, "On-site Emergency Power Sources," June 14, 1978.

6. CPCo letter, David P. Hoffman, to Director, Nuclear Reactor Regulation, NRC, "Degraded Grid Voltage," August 21, 1980.

7. CPCo letter, David P. Hoffman, to Director, Nuclear Reactor Regulation, NRC, "Response to Request for Additional Information Related to the Generic Issue on Onsite Power Systems," December 12, 1980.