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INTERIM REPORT

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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

PALISADES PLANT

Docket No. 50-255

April 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 Palisades 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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PALISADES PLANT

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 analyses of January 9, 1980,[2] and March 7, 1980.[3] Information on required testing was supplied on July 18, 1980.[4] Subsequent concerns were addressed in letters dated August 22, 1980,[5] February 9, 1981,[6] and March 3, 1981.[7] Additional information was obtained in letters of October 2, 1978,[8] and February 27, 1980,[9] and in the Palisades Plant Final Safety Analysis Report (FSAR).

Based on the information supplied by CPCo, this report addresses the capacity and capability of the onsite distribution system of the Palisades 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."

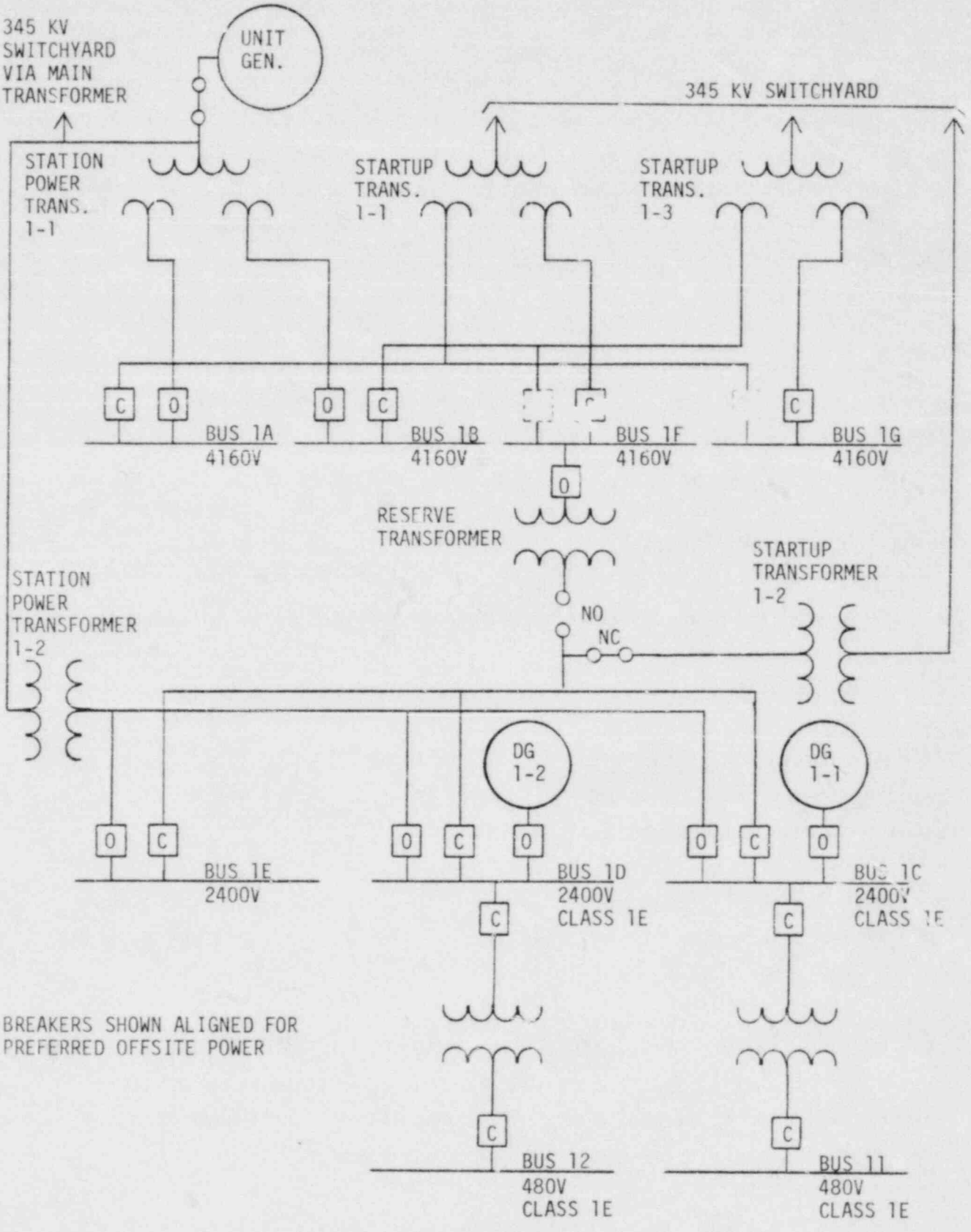
5. Staff positions as detailed in a letter sent to the licensee, dated August 8, 1979.[1]

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 is a simplified sketch of the unit electrical one-line diagram.[4,8] 2400V Class 1E Buses 1C and 1D can be supplied by either station power transformer (SPT) 1-2, startup transformer (SUT) 1-2, or the reserve transformer via 4160V Bus 1F. Technical specifications require that both SPT 1-2 and SUT 1-2 be operable before and during operation; however, no specific restriction on the use of or on the availability of the reserve transformer is found in the technical specifications.



PALISADES
UNIT ONE LINE DIAGRAM
FIGURE 1

480V Class 1E Buses 11 and 12 are supplied by independent transformers from Buses 1C and 1D, respectively. The four 120V preferred ac buses are normally powered by battery-supplied inverters; however, the FSAR, Section 8.3.5.2, indicates that a backup regulator, powered by the 120V instrument ac bus, is the backup source for all four of the 120V preferred ac buses. The 120V instrument bus is powered by a transformer connected to 480V Bus 11 or Bus 12.

There are undervoltage relays on both 2400V Buses 1C and 1D.[2] These relays separate the Class 1E buses from offsite power should there be a degradation of offsite power, and initiate sequencing onto diesel power.

There is a single transmission feeder from the 345kV switchyard to the three startup transformers.[6]

CPCo 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 licensee changing the taps on Transformers 11 and 12 to the 2400V setting. This has been accomplished in 1979.[7]

4.2 Analysis Conditions. CPCo has determined that the minimum expected offsite grid voltage is 327.75kV (95% of 345kV). CPCo has not supplied the maximum expected offsite grid voltage.

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 1E equipment. The worst case class 1E equipment terminal voltages occur under the following conditions:

1. The minimum expected continuous load terminal voltages occur when the grid is minimum and the startup transformers suply the maximum expected class 1E and non-class 1E loads. Startup transformer 1-2 will be supplying all class 1E loads.

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

		Maximum		Minimum		
					Analyzed	
Equipment	Condition	Rated	Analyzed	Rated	Steady State	Transient
2300V Motors	Start	--	--	a	--	73.4
	Operate	110	106.6	90	91.1	--
460V Motors	Start	--	--	a	--	51.4
	Operate	110	103.3	90	82.7	--
440V Motors	Start	--	--	a	--	53.8
	Operate	110	108.0	90	86.5	--
480V Starters	Pickup	--	--	85	80.9	53.4
	Dropout	--	--	50	--	53.4
	Operate	125	99.0	50	80.9	--
Other Equipment[b]						

a. Rated starting voltages for motors were not supplied. CPCo supplied speed-torque curves for typical motors in lieu of this data. The curves supplied showed a single curve for an unspecified voltage. It is impossible to determine this value from the CPCo-supplied information. However, CPCo indicates that the motors will start with the grid at 345kV. CPCo has not made such a statement with the grid at 327.75kV (95% of nominal).

b. Other equipment includes battery chargers, rated to full output voltage at an input voltage down to 432V. The output voltage decreases below this input voltage. Should the output voltage be reduced below the battery voltage, the battery will supply the dc loads; however, how long this condition will go uncorrected is not a part of the unit technical specifications. The four 120V ac preferred instrument buses can be powered by the 120V ac instrument bus. CPCo did not supply any information for these instruments or expected voltage levels.

2. The minimum expected transient load terminal voltages occur when the offsite grid is minimum and an accident trips the unit generator and initiates the simultaneous start of all the safety injection loads at an initial assumed power factor of 0.2.

3. CPCo identified the conditions that lead to a maximum continuous bus voltage as "normal grid and generator voltage extremes."[8]

CPCo has not provided an appropriate analysis for use of the reserve transformer, stating that it has "no normal operating conditions or automatic loading schemes."[7]

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

4.4 Analysis Verification. CPCo provided testing to verify the accuracy of their analysis.[4] All metering was within 2 1/2% accuracy.[7] The test consisted of measuring loads and voltages and calculating corresponding voltages for the same grid and load conditions. The deviation between the measured and the test calculation voltages was within ±1.07% for all buses.

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.

CPCo has not supplied evidence to show the capability of the class 1E motors to start under accident conditions concurrent with the offsite grid at 95% of nominal.

CPCo has shown (Table 1) that the 460V and 440V motors and the 480V battery chargers do not have sufficient voltage to operate continuously when the offsite grid is at 95% and the unit loads are maximum. Moreover, Table 1 shows that the 480V starters will not start additional loads, which may be required by the accident condition, at these expected steady-state

voltages. Additionally, CPCo has not shown that the instruments needed in an accident situation will have adequate voltage for correct readout when the voltages are at this level.

CPCo has shown, by analysis, that the Palisades Plant does not 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.

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, the degraded grid voltage relay setpoints are higher than the minimum expected continuous operating voltage for the 2400V buses. Additionally, the time delay for the degraded grid undervoltage relays may not be sufficient to prevent the loss of the offsite source during the start of the safety injection loads. CPCo has not identified the duration of this transient condition when the offsite grid is 95% of nominal. Further, since no voltage or time tolerances have been provided by CPCo for either the degraded grid or the loss of grid relaying, all of the setpoints could be challenged. From the information supplied by CPCo, it appears that there is a potential of spurious separation of the class 1E buses from the offsite source with either set of relays when normally expected voltages are present.

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

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

	Minimum Analyzed[a]		Relay Setpoint[9]	
Location/Relays	Voltage	Time	Voltage (Tolerance)[b]	Time
2400V bus				
Degraded grid	87.3	continuous	91	6.5 s
Loss of grid	70.3	4.5 s[c]	70	0.5 s

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. Tolerance not identified by CPCo.

c. Based on a grid voltage of 100%. CPCo has not identified the duration of the voltage recovery for the worst case transient condition (grid at 95% and the simultaneous start of all the safety injection loads).

CPCo has supplied the required information which shows the analysis to be an accurate representation of the worst case voltage conditions for the class 1E buses and loads.

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).

CPCo does not meet the General Design Criteria (GDC) 17 requirements for two independent circuits from a minimum of two offsite power sources.

The switchyard that supplies the Palisades Plant is located 0.5 mile away from the unit. All three startup transformers (and, hence, the reserve transformer) are supplied power by a single overhead transmission from the switchyard. The feeder has a single disconnect device (#24R2) and no individual circuit breakers or isolation switches (per Palisades Drawing WD 1421).

CPCo justifies the departure from the GDC 17 requirements based on a low probability of losing both diesel generators and the offsite source simultaneously. CPCo identifies this probability as 2.9×10^{-6} (per year). This figure is arrived at by multiplying the probability (0.0029/year) of losing the single circuit to the switchyard by the probability (10^{-3}) of both diesels failing to start (units not identified, but WASH-1400 identifies this as per attempt). CPCo does not identify the number of attempted diesel starts per year. The probability of losing the single circuit to the switchyard (0.0029/year) is based on an outage of five minutes or more.[7] GDC 17 does not condition outage rates only for durations of five minutes or longer.

The CPCo analysis did not take into account the probability of the failure of the switchyard bus, of component failure leading to the failure of the bus, of startup transformer failure (there is no evident means to disconnect a faulty transformer from the feeder circuit), of the disconnect switch failure, or of component failure that contributes to failure of the switch.

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 the Palisades Plant, a single-unit station.

6.0 CONCLUSIONS

The voltage analyses submitted by CPCo for the Palisades plant were evaluated in Section 5.0 of this report. The change described in Section 4.1 has been completed, and 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.

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 potential for either a simultaneous or consequential loss of both offsite power sources. They have not provided adequate justification to be exempted from this GDC 17 requirement.

4. Loss of offsite power to class 1E buses, due to spurious operation of voltage protection relays, can occur with the offsite grid voltage within its expected limits.

I recommend that the NRC require CPCo to impose operative restrictions on the reserve transformer to prevent it from being overloaded to the point that inadequate voltages would be supplied to the class 1E loads.

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," January 9, 1980.

3. CPCo letter, Roger W. Huston, to Director of Nuclear Reactor Regulation, NRC, "Response to Adequacy of Station Electric Distribution Systems Voltages," March 7, 1980.

4. CPCo letter, Steven R. Frost, to Director, Nuclear Reactor Regulation, NRC, "Response to Verification of Analytical Models for Adequacy of Station Power," July 18, 1980.

5. CPCo letter, David P. Hoffman, to Director, Nuclear Reactor Regulation, NRC, "Response to Adequacy of Station Power," August 22, 1980.

6. CPCo letter, David P. Hoffman, to Director, Nuclear Reactor Regulation, NRC, "Response to Station Electric Distribution System Voltages," February 9, 1981.

7. CPCo letter, Steven R. Frost, to Director, Nuclear Reactor Regulation, NRC, "Response to Adequacy of Station Electric Distribution System Voltages," March 3, 1981.

8. CPCo letter, David P. Hoffman, to Director, Nuclear Reactor Regulation, NRC, "Response to Emergency Supply Generic Issues," October 2, 1978.

9. CPCo letter, Steven R. Frost, to Director, Nuclear Reactor Regulation, NRC, "Response to Additional Information for Degraded Grid Voltage," February 27, 1980.