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TECHNICAL EVALUATION REPORT ON THE ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES FOR THE TURKEY POINT NUCLEAR GENERATING PLANT UNITS 3 AND 4

(Docket Nos. 50-250, 50-251)

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ABSTRACT

This report documents the technical evaluation of the adequacy of the station electric distribution system voltages for the Turkey Point Nuclear Generating Plant, Units 3 and 4. The evaluation is to determine if the onsite distribution system in conjunction with the offsite power sources has sufficient capacity to automatically start and operate all Class 1E loads within the equipment voltage ratings under certain conditions established by the Nuclear Regulatory Commission. The analysis submitted demonstrates that acceptable voltage will be supplied to the Class 1E equipment under the worst case conditions analyzed.

FOREWORD

This report is supplied as part of the Selected Electrical, Instrumentation, and Control Systems Issues Program being conducted for the U. S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Licensing, by Lawrence Livermore National Laboratory.

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(Docket Nos. 50-250, 50-251)

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1. INTRODUCTION

The Nuclear Regulatory Commission (NRC) by a letter dated August 8, 1979 [Ref. 1] expanded its generic review of the adequacy of the station electric distribution systems for all operating nuclear power facilities. 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. In addition, the NRC requested each licensee to follow suggested guidelines and to meet certain requirements in the analysis. These requirements are detailed in Section 5 of this report.

By letters dated November 9, 1979 [Ref. 2], December 18, 1980 [Ref. 3], June 10, 1981 [Ref. 4], February 24, 1982 [Ref. 5], and May 20, 1982 [Ref. 6], Florida Power and Light Company (FPL), the licensee, submitted their analysis and conclusion regarding the adequacy of the electrical distribution system's voltages at the Turkey Point Nuclear Generating Plant, Units 3 and 4.

The purpose of this report is to evaluate the licensee's submittal with respect to the NRC criteria and present the reviewer's conclusion on the adequacy of the station electric distribution systems to maintain the voltage within the design limits of the required Class 1E equipment for the worst case starting and load conditions.

2. DESIGN BASIS CRITERIA

The design basis criteria that were applied in determining the adequacy of station electric distribution system voltages to start and operate all, required safety loads within their required voltage ratings are as follows:

(1) General Design Criterion 17 (GDC 17), "Electric Power Systems," of Appendix A, "General Design Criteria for Nuclear Power Plants," in the Code of Federal Regulations, Title 10, Part 50 (10 CFR 50) [Ref. 7].

(2) General Design Criterion 13 (GDC 13), "Instrumentation and Control," of Appendix A, "General Design Criteria for Nuclear Power Plants," in the Code of Federal Regulations, Title 10, Part 50 (10 CFR 50) [Ref. 7].

(3) General Design Criterion 5 (GDC 5), "Sharing of Structures, Systems and Components," of Appendix A, "General Design Criteria for Nuclear Power Plants," in the Code of Federal Regulations, Title 10, Part 50 (10 CFR 50) [Ref. 7].

(4) ANSI C84.1-1977, "Voltage Ratings for Electric Power Systems and Equipment" [Ref. 8].

(5) IEEE Std 308-1974, "Class 1E Power Systems for Nuclear Power Generating Stations" [Ref. 9].

(6) "Guidelines for Voltage Drop Calculations," Enclosure 2, to NRC letter dated August 8, 1979 [Ref. 1].

3. SYSTEM DESCRIPTION

The electrical one-line diagram for Turkey Point, Units 3 and 4 is shown in Figure 1. Each of the two units has an auxiliary transformer which supplies power to the onsite distribution system during normal operation. The unit auxiliary transformer is connected to the main generator's isolated phase buses and has two secondary 4160-volt windings each supplying one load group of Class 1E equipment.

In addition to the unit auxiliary transformer, each unit has a startup transformer. The startup transformers, with two secondary 4160-volt windings, are connected to the 240 kV switchyard. The startup transformers supplies power to the onsite distribution system during startup, shutdown, and automatically after a unit trip. The adjacent startup transformer of one unit can supply one load group of the other unit by manually closing the 4160-volt tie breaker.

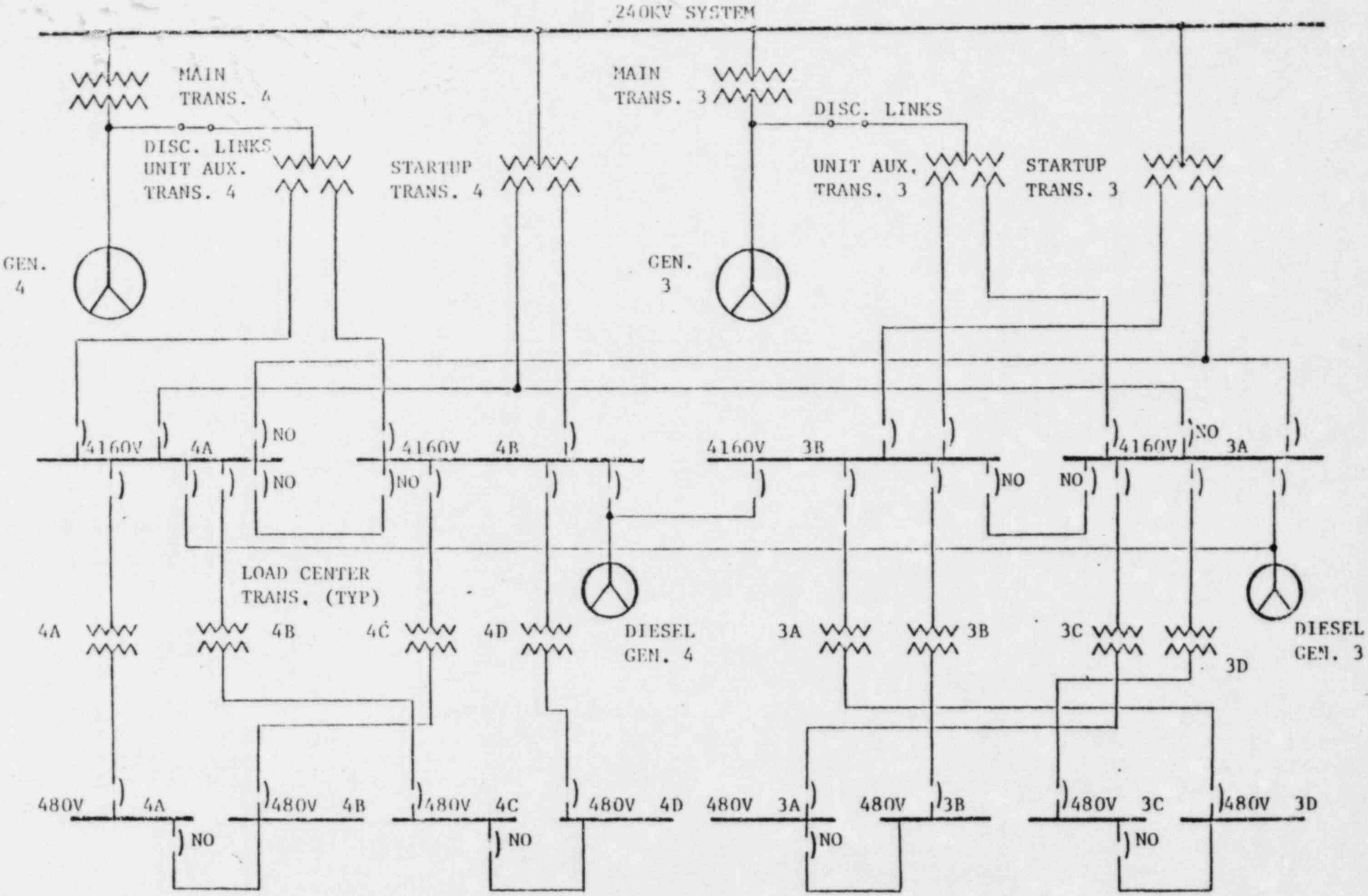

FIGURE 1 TURKEY POINT UNITS 3 AND 4 ELECTRICAL ONE-LINE DIAGRAM

The onsite distribution system can also be supplied by removing the generator links and backfeeding from the 240 kV switchyard via the main transformer and the unit auxiliary tranformer. The onsite distribution system of each unit consists of two 4160-volt and four 480-volt Class 1E buses.

The Class 1E equipment is currently protected from voltage degradation by a loss-of-voltage protection scheme. This scheme utilizes two undervoltage relays on each 4160-volt Class 1E bus which will actuate at 40%-50% voltage with a time delay of 1 second. A second-level undervoltage protection scheme is presently being designed to add two inverse time delay relays on each 4160-volt Class 1E bus and two instantaneous relays at each 480-volt load center. The final voltage setpoints and time relays have not been selected.

4. ANALYSIS

4.1 ANALYSIS CONDITIONS

FPL analyzed the need for power to the onsite distribution system through the unit's startup transformer which was initiated by an accident condition (largest load demand). For this operating condition, various combinations of loading configuarations concurrent with a minimum grid voltage of 235 kV and a maximum grid voltage of 244 kV were analyzed. In addition to the various loading configurations, several other assumptions were made and are as follows:

(a) All safety loads start simultaneously with a safety injection signal (SIS).

(b) An SIS initiates an automatic fast transfer from the unit auxiliary transformer to the startup transformer.

(c) Running loads prior to SIS are based on highest recorded load values.

(d) Power factor for running loads of 0.85.

(e) Power factor for starting loads of; 0.20 for 4 kV motors; 0.42 for emergency containment coolers; 0.35 for emergency containment filters; and 0.60 for motor operated values (MOV's).

(f) Starting current of 6 times full load amperage (FLA) for motors and 2.1 times FLA for MOV's.

(g) Running loads assumed as constant kVA.

(h) The steam generator feedwater pumps (SGFP) trip automatically upon a SIS.

FPL chose to calculate the worst case minimum voltage required at each bus to start the Class 1E loads rather than repeatedly calculate Class 1E load terminal voltage for each case analyzed. If the voltage analysis results for each case are above the highest minimum bus voltage required, this would ensure that all Class 1E equipment would start within the voltage design rating.

4.2 ANALYSIS RESULTS

Using the assumptions defined previously and various running and load starting combinations, the worst case voltage analysis results occur under the following conditions and are shown in Tables 1 and 2:

4.2.1 Overvoltage

Maximum grid voltage of 244 kV, one-half normal loads on 480-volt buses and minimum motors running on the 4160-volt buses.

4.2.2 Undervoltage

Minimum grid voltage of 235 kV, accident condition, the SIS initiates automatic fast transfer from the unit auxiliary transformer to the startup transformer and with the Class 1E equipment starting simultaneously.

4.3 ANALYSIS VERIFICATION

FPL verified their voltage analyses by measuring voltage and current at all Class 1E buses. Using the measured loads, a voltage analysis was performed and the resulting voltages compared to the measured voltages. The test was conducted when both units were operating at full power. Bus loading was provided at each distribution level. The results indicated that the analysis is conservative in that the measured values were all higher than the calculated values. For unit 3's analysis, the worst case percent errors were -1.5%, -2.7%, and -3.0% at the 4160-volt bus, 480-volt load center bus, and the motor control center bus respectively. At unit 4, the worst case errors were -1.8%, -2.0%, and -1.8% at the 4160-volt bus, 480-volt load center, and the 480-volt motor control center bus respectively.

5. EVALUATION

The NRC generic letter [Ref. 1] stated several requirements that the plant must meet in their voltage analysis. These requirements and an evaluation of the licensee's submittals are as follows:

(1) With the minimum expected grid voltage and maximum load condition, each offsite source and distribution system

TABLE 1

TURKEY POINT, UNIT 3
CLASS 1E EQUIPMENT VOLTAGE RATINGS AND ANALYZED
WORST CASE TERMINAL VOLTAGES
(in % of Equipment Nominal Voltage Rating)

		Maximum		Minimum		
		Rated	Analyzed	Rated	Analyzed	
Equipment	Nominal Voltage Rating (100%)		Steady State		Steady State	Transient
Motors	4000					
Start				80		93.9
Operate		110	107.8	90	98.2[(a)]	
	460					
Start				80		85.2
Operate		110	108.7	90	92.8[(a)]	
Starters	120					
Pickup				(b)	(c)	
Dropout		(b)				(c)
Operate		110	---	85	(c)	
Other[(d)] Equipment						

(a) Steady state value is with all Class 1E loads running in addition to the largest non-Class 1E load running (SGFP).

(b) The pickup and dropout voltage ratings (manufacturer's) of the various size starters are: size 1, 88.8 volts and 66.0 volts; size 2 and 3, 85.2 volts and 66.0 volts; size 4, 91.2 volts and 66.0 volts respectively.

(c) Tests were conducted to determine actual pickup voltages taking into consideration cable lengths and control transformer voltage drops. Calculations were then made to determine the minimum 480-volt MCC voltage required to assure starter pickup. These required voltages are listed in Ref. 6, Attachment A. These minimum required voltages are all less than the worst case transient voltages experienced which insure adequate starter operation.

(d) All low voltage AC (less than 480-volts) Class 1E buses supplying power to vital instrumentation and control circuits are powered by inverters supplied from the 125-volt DC station batteries.

TABLE 2

TURKEY POINT, UNIT 4
CLASS 1E EQUIPMENT VOLTAGE RATINGS AND ANALYZED
WORST CASE TERMINAL VOLTAGES
(in % of Equipment Nominal Voltage Rating)

		Maximum		Minimum		
		Rated	Analyzed	Rated	Analyzed	
Equipment	Nominal Voltage Rating (100%)		Steady State		Steady State	Transient
Motors	4000					
Start				80		94.1
Operate		110	107.9	90	98.4[a]	
	460					
Start				80		87.8
Operate		110	107.2	90	96.3[a]	
Starters	120					
Pickup				(:	( )	
Dropout		(b)				(c)
Operate		110	---	85	(c)	
Other[d] Equipment						

(a) Steady state value is with all Class 1E loads running in addition to the largest non-Class 1E load running (SGFP).

(b) The pickup and dropout voltage ratings (manufacturer's) of the various size starters are: size 1, 88.8 volts and 66.0 volts; size 2 and 3, 85.2 volts and 66.0 volts; size 4, 91.2 volts and 66.0 volts respectively.

(c) Tests were conducted to determine actual pickup voltages taking into consideration cable lengths and control transformer voltage drops. Calculations were then made to determine the minimum 480-volt MCC voltage required to assure starter pickup. These minimum required voltages are listed in Ref. 6, Attachment A. These minimum required voltage are all less than the worst case transient voltages experienced which insure adequate starter operation.

(d) All low voltage AC (less than 480-volts) Class 1E buses supplying power to vital instrumentation and control circuits are powered by inverters supplied from the 125-volt DC station batteries.

connection must be capable of starting and continuously operating all Class 1E equipment within the equipment's voltage ratings.

The voltage analysis submitted by FPL has shown that the offsite source connections to the onsite distribution system have the capacity and capability to start and continuously operate the Class 1E equipment within the voltage ratings under worst case conditions.

(2) With the maximum expected offsite grid voltage and minimum load condition, each offsite source and distribution system connection must be capable of continuously operating the required Class 1E equipment without exceeding the equipment's voltage ratings.

The voltage analysis submitted by FPL shows that the Class 1E equipment's upper design voltage ratings are not exceeded.

(3) The analysis must show that there will be no spurious separation from the offsite power source to the Class 1E buses by the voltage protection relays when the grid is within the normal expected limits and the loading conditions established by the NRC are being met.

LLNL will verify in a separate report (TAC Nos. 10053 and 10054) that the conditions of this position are met as the proposed undervoltage setpoints and time delays associated with the design changes and modifications for a second-level of under-voltage protection has not been submitted.

(4) Test results are required to verify the voltage analyses calculations submitted.

FPL verified the voltage analysis by test. The percentage error differences between the actual measured and the calculated values confirm that the analytical results are acceptable.

(5) Review the plant's electrical power systems to determine if any events or conditions could result in the simultaneous loss of both offsite circuits to the onsite distribution system (compliance of GDC 17).

The licensee has not provided the required review of the plant's electrical system to determine if any event or condition could result in the simultaneous loss of both required offsite circuits to the onsite power distribution system. The licensee is required to submit this review.

(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 to all required Class 1E loads with an accident in one unit and a safe shutdown in the remaining unit(s).

The sharing of an offsite source is via the adjacent unit's startup transformer. This condition only occurs when one unit is shutdown. Manual actions are required to align this connection. This connection only allows for one train of each unit (the A buses) to be supplied by the adjacent unit's startup transformer. Should a safety injection occur during this connection, the Class 1E equipment would automatically be started. Due to the greatly reduced load (i.e. one unit is shutdown) for this condition, the voltages being supplied by the adjacent startup transformer would be more adequate than the worst case analyzed voltages presented in the tables. Therefore, the shared offsite source (startup transformer) has the capacity and capability of supplying adequate voltage to both unit's Class 1E equipment.

6. CONCLUSIONS

Based on the information submitted by Florida Power and Light Company for the Turkey Point Nuclear Generating Plant, Units 3 and 4, it is concluded that:

(1) Under the worst case conditions analyzed, the Class 1E equipment will automatically start and continue to operate within their voltage design ratings.

(2) The voltage at the Class 1E equipment will not exceed the upper design voltage rating under maximum offsite voltage and minimum plant loading conditions.

(3) The analysis submitted was verified by test and that the test data indicates the analytical results are acceptable.

(4) Spurious trips will be evaluated in a separate report by LLNL (TAC Nos. 10053 and 10054) entitled "Technical Evaluation Report on the Proposed Design Modifications and Technical Specification changes on Grid Voltage Degradation."

(5) The sharing of offsite sources has the capability and capacity to supply adequate voltage to both unit's Class 1E equipment should an accident occur.

The licensee is required to provide the requested review of the plant's electrical power system to determine if any event or condition exists which could cause the simultaneous loss of both offsite source circuits to the onsite distribution system.

Accordingly, I recommend that the NRC accept the voltage analysis submitted by the licensee which demonstrates that acceptable voltage will be supplied to the Class 1E equipment under the worst case conditions analyzed. The NRC should continue to pursue the licensee to submit the requested review of the plant's electrical power system for conformance with GDC 17.

REFERENCES

1. NRC letter (W. Gammill) to all Power Reactor Licensees, dated August 8, 1979.

2. FPL letter (R. E. Uhrig) to the NRC (S. A. Varga), dated November 9, 1979.

3. FPL letter (R. E. Uhrig) to the NRC (S. A. Varga), dated December 19, 1980.

4. FPL letter (R. E. Uhrig) to the NRC (S. A. Varga), dated June 10, 1981.

5. FPL letter (R. E. Uhrig) to the NRC (S. A. Varga), dated February 24, 1982.

6. FPL letter (R. E. Uhrig) to the NRC (S. A. Varga), dated May 20, 1982.

7. Code of Federal Regulations, Title 10, Part 50 (10 CFR 50), General Design Criterion 5, 13 and 17 of Appendix A for Nuclear Power Plants.

8. ANSI C84.1-1977, "Voltage Ratings for Electric Power Systems and Equipment."

9. IEEE STD. 308-1971, "Class 1E Power Systems for Nuclear Power Generating Stations."