ABSTRACT

This report documents the technical evaluation of the adequacy of the station electric distribution system voltages for the Peach Bottom Atomic Power Station, Units 2 and 3. 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 indicates that the capacity is sufficient to meet the NRC requirements provided specific plant procedures are followed for shutting down the second unit after an accident in the first unit and with a loss of one offsite source.

FOREWORD

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TECHNICAL EVALUATION REPORT ON THE ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES FOR THE PEACH BOTTOM ATOMIC POWER STATION, UNITS 2 AND 3

(Docket Nos. 50-277, 50-278)

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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 December 31, 1979 [Ref. 2], November 13, 1980 [Ref. 3], June 16, 1981 [Ref. 4], February 4, 1982 [Ref. 5], and April 15, 1982 [Ref. 6], Philadelphia Electric Company submitted their analysis and conclusion regarding the adequacy of the electrical distribution system voltages at Peach Bottom Atomic Power Station, Units 2 and 3.

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 plant's station electric distribution 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 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]

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

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

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

3. SYSTEM DESCRIPTION

A one-line diagram of Peach Bottom Atomic Power Station's, Units 2 and 3 (Peach Bottom) electrical distribution system is shown in Figure 1. This figure was adapted from Figure 1 of a September 15, 1976 Philadelphia Electric Company letter to the NRC [Ref. 10]. There are eight 4160-volt Class 1E buses. Under normal operating conditions these buses are energized from the offsite power sources through emergency transformers No. 2 and No. 3. Emergency transformer No. 2 is energized by startup transformer No. 2 which is equipped with automatic tap changers that begin to index every 3-5 seconds after an initial 30-second time delay. Emergency transformer No. 3 is energized by a 50 MVA regulating auto-transformer. Upon shutdown of a main generator because of an accident or a transient trip, the unit auxiliary buses (normally supplied by the generator) are automatically transferred to the offsite power source .

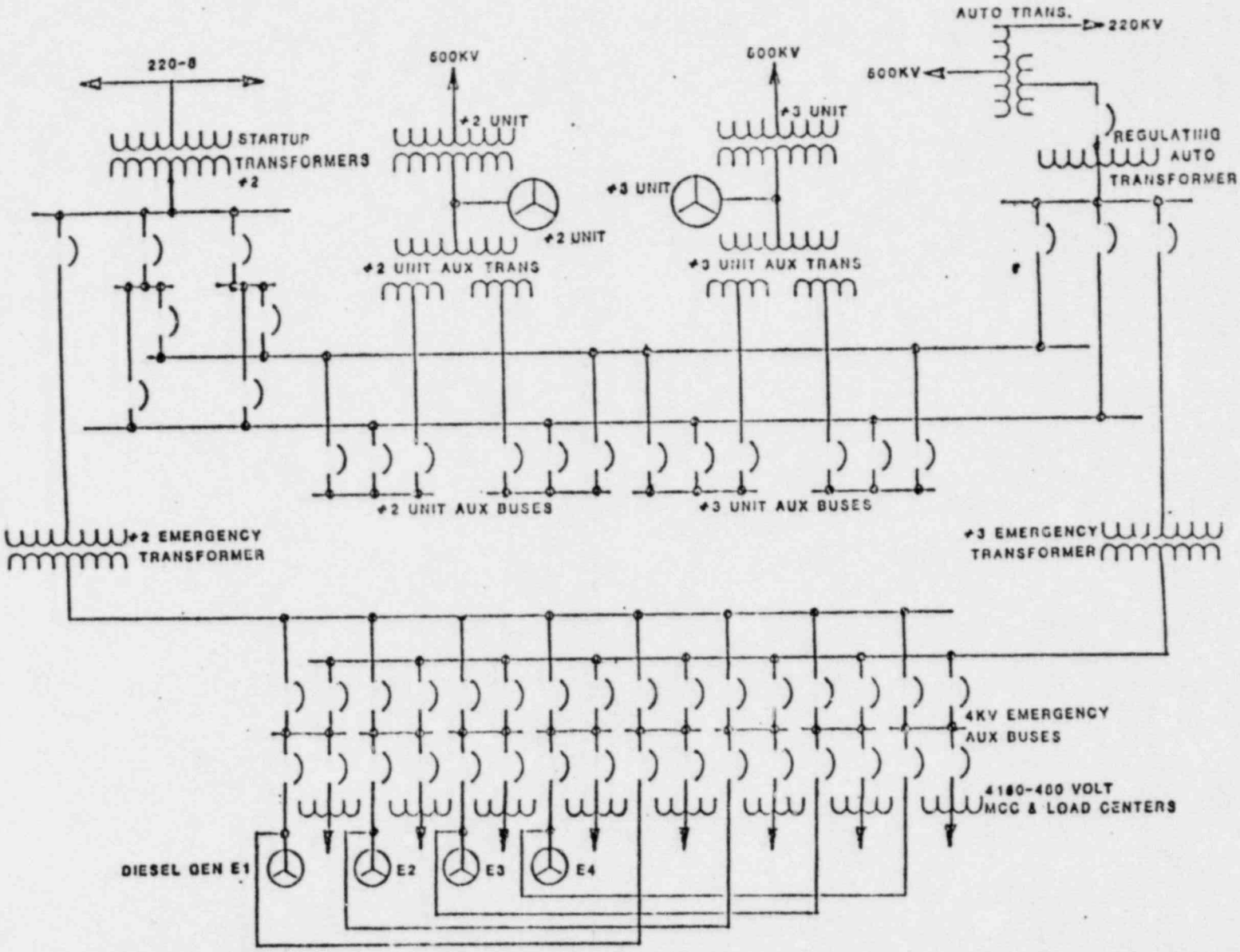

FIGURE 1 PEACH BOTTOM ATOMIC POWER STATION ELECTRICAL ONE-LINE DIAGRAM

The Class 1E equipment at Peach Bottom is protected from a loss of voltage by relays monitoring the Class 1E bus feeders. The setpoint of these relays is between 2275 volts and 2450 volts. These relays initiate tripping of the Class 1E bus from the offsite source. A second-level of undervoltage protection has also been proposed by the licensee. The proposed relay setpoints are 90% $\pm$ 2% of 4160 volts with a time delay of 60 seconds $\pm$ 5% if there is no accident signal present. When an accident signal is present the time delay is reduced to 6 seconds. Additional information on this proposed modification is available under separate cover. The report is titled "Technical Evaluation of the Proposed Modifications and Technical Specifications changes on Grid Voltage Degradation (Part A) for the Peach Bottom Atomic Power Station, Units 2 and 3" (Tac Nos. 10039 and 10040).

4. ANALYSIS

4.1 ANALYSIS CONDITIONS

Philadelphia Electric Company analyzed the Peach Bottom onsite distribution system using a load flow computer program. An analysis was completed for seven different possible plant loadings to establish the "worst case" conditions. The cases included one- and two-source operation, routine shutdown, an accident in one unit with the alternate unit shutdown, and a transient with the alternate unit shutdown. A minimum expected grid voltage of 95% of nominal value was used for the maximum-load/minimum-grid voltage calculations. A maximum expected grid voltage of 105% of nominal was used for the minimum-load/maximum-grid voltage calculations. The minimum load was considered to be the normal plant load with both units at power. Automatic actions concerning the transfer of the unit auxiliary buses to the startup transformer and the automatic tripping of recirculation motor generator (MG) sets and cooling towers were assumed to work as designed. Also, the load tap changers were assumed to operate.

The licensee also submitted an analysis showing the effect on the voltage distribution system of starting a large non-Class 1E load . The scenario used was an accident in one unit while the other unit was at full power. Only one offsite startup source was considered available. The large non-Class 1E motor that was considered to be started was the second of two condensate pumps that were considered to be lost in a transfer of power from the unit auxiliary transformer to the startup transformer.

4.2 ANALYSIS RESULTS

The analysis provided by the licensee shows that the worst case Class 1E distribution voltages occur under the following conditions:

4.2.1 Overvoltage

Normal plant load with both units at power and a maximum grid voltage of 105% of nominal.

4.2.2 Undervoltage - Steady State

Shutdown of the non-accident unit following an accident in the other unit with only one startup transformer available with the grid at 95% of nominal. This is the licensee's case No. 7 and requires that plant shutdown procedures be followed to maintain the onsite distribution voltages within equipment ratings.

Undervoltage - Transient

Startup of two residual heat removal (RHR) pumps following the transfer of the unit auxiliary buses to the offsite source. The voltage will momentarily dip to 71.8% of nominal on the 4160-volt buses.

These worst case Class 1E distribution voltages are summarized in Table 1.

4.3 ANALYSIS VERIFICATION

The licensee validated the calculated values by taking actual measurements of bus voltages and comparing them to calculated values. These measurements were made for both steady-state and transient conditions. The steady state measurements were made with the 13.2/4 kV emergency auxiliary transformer at approximately 54% load. The transient tests were made by the starting of a 2000 hp RHR pump. The measured values were within 1.8% of the calculated values.

5. EVALUATION

The NRC generic letter [Ref. 1] stated several requirements that the plant must meet in the voltage analyses. 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 connection must be capable of starting and continuously operating all Class 1E equipment within the equipment's voltage ratings.

TABLE 1

PEACH BOTTOM ATOMIC POWER STATION, UNITS 2 AND 3
CLASS 1E EQUIPMENT VOLTAGE RATINGS AND WORST
CASE ANALYZED LOAD VOLTAGES
(in % of Equipment Nominal Voltage Rating)

		Maximum		Minimum		
		Rated	Analyzed	Rated	Analyzed	
Equipment	Nominal Voltage Rating (100 %)		Steady State		Steady State[a]	Transient
Motors	4160V					
Start				80[b]		71.8[c]
Operate		110	105	90	91	
Motors	460V					
Start				80		80
Operate		110	109	90	90	
MOV	460V					
Start				90		(d)
Operate		110	109	90	92	
Starters	115V					
Pickup					90	
Dropout						71.8[e]
Operate		110	109	90	90	

(a) These values are from the licensee's case No. 7, in which shutdown procedures are revised to prevent voltages from falling below equipment ratings.

(b) Plant tests have shown that the RHR pumps which would experience the lowest voltage are capable of starting at 60% nominal.

(c) This minimum transient voltage is defined in Section 4.2.2 of this report.

(d) A minimum value was not provided for the MOVs for starting transient, however the licensee has stated [Ref. 11, page 2 and Ref. 12] that all equipment will be capable of starting with a minimum grid condition.

(e) A test was conducted creating a transient voltage of 60% of nominal at the various voltage levels. All contactors and relays stayed in their picked up condition without interruption during the starting transient.

Philadelphia Electric Company performed several voltage analyses to determine the adequacy of their distribution system voltages. One "worst case" analysis consisted of an accident in one unit with a simultaneous shutdown of the second unit with only one offsite source and the grid at a minimum expected voltage. With this scenario the calculations showed that the voltage on the Class 1E buses could degrade below the setpoint of the second-level degraded voltage relays. The actuation of these relays would transfer the Class 1E buses to the onsite emergency diesel generators.

A second analysis was conducted within the scope of GDC 5. This analysis consisted of an accident in one unit with an orderly shutdown of the second unit with only one offsite source and the grid again at a minimum expected voltage. With this scenario plant procedures would be used to reduce non-essential loads and to conduct an orderly shutdown of the non-accident unit. The licensee has shown that these procedures would ensure the maintenance of plant voltages within equipment ratings. Also shown was that there would be no spurious trips from the off-site source due to the actuation of the degraded voltage under these conditions. This analysis is identified as Case 7 in the licensee's submittal dated December 31, 1979 [Ref. 2].

(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 analysis for overvoltage shows that the Class 1E equipment's rating is not exceeded for minimum-load/maximum-expected grid voltage. Under a maximum voltage of 105% on the offsite sources the voltage on all connected equipment would be within the +10% voltage ratings.

(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.

The voltage analysis showed that there could be a transient voltage dip to 71.8% of nominal on the 4160-volt bus. This transient would take place during the starting of 2 RHR pumps. The transient would be below the rated starting voltage of the equipment and the rated values of relays and contactors.

To ensure the proper operation of equipment and that relays and contactors would not drop out nor that there would be any spurious trips, Philadelphia Electric Company conducted voltage

tests at Peach Bottom. These tests involved producing a momentary voltage dip to 60% of nominal voltage on the 4160-volt bus and monitoring the operation of equipment, 460-volt contactors and 120-volt relays. The tests were conducted at voltages 11.8% lower than worst-case-expected.

The tests indicated that the transient dip would last for 3 seconds while the RHR pumps were starting. During this time there was no mis-operation of relays or contactors and all equipment functioned normally. Also, the RHR pumps started satisfactorily. The 3 second transient dip time is within the 6 second time delay of the degraded grid undervoltage relays. The procedures used to verify equipment operation are found to be acceptable.

The degraded grid undervoltage protection relays have a proposed setpoint of 90% of 4160 volts with a time delay of 60 seconds. If an accident signal is present the delay will be reduced to 6 seconds by a TR electronic timing relay connected to the output of the proposed second level under-voltage logic scheme. With these voltage setpoints and time delays all the Class 1E equipment will be able to start without causing a spurious trip.

An additional study to assure that there will not be spurious trips under minimum-grid/large-load conditions was conducted by the licensee. The analysis showed that with one unit operating and the second unit in an accident scenario, two condensate pumps could be restarted without causing a spurious trip.

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

The licensee has submitted a validation of the calculated bus voltages by comparing actual measurements with calculated values. These comparisons, made for both steady state and transient conditions, indicate that the measured values were within 1.8% of the calculated values. We find this difference 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 with GDC 17.)

The licensee states and we concur that with the proposed modifications the offsite sources have sufficient capacity and capability so as to not be in violation of GDC 17.

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

The licensee provided two case studies for this requirement. The first case (case 6 of Reference 2) showed that following an accident in one unit, the shutdown of the second unit with no regard for the load on the startup transformer could cause some voltages to fall below the voltage ratings of the Class 1E equipment. The second case (case 7 of Reference 2) showed that with procedure modifications the scenario of case 6 could be repeated without the Class 1E buses falling below the voltage ratings of the Class 1E equipment. This analysis was within the scope of GDC 5. In the analysis, the shutdown of the non-accident unit was not assumed to take place simultaneously with the accident unit but that after the accident unit is stabilized and non-essential loads are shed, the power level of the non-accident unit is reduced and then shut down. With these procedures the voltage remained above the minimum voltage rating of equipment.

The licensee has stated that a single offsite source would not be able to power the unit auxiliary buses for both units if they were both to transfer to the single source at the same time. If this were to happen, the undervoltage relays would actuate and transfer the Class 1E buses to the emergency diesel generators.

6. CONCLUSIONS

The voltage analyses submitted by Philadelphia Electric Company have shown that there are several cases where the voltage on the Class 1E equipment could drop below the rated voltage of the equipment. However, the licensee has demonstrated that all the Class 1E equipment is capable of starting and providing continuous operation during these momentary voltage transients without any damage to the equipment and without a spurious trip from the offsite source. Further, the licensee has stated that they have established plant procedures to conduct an orderly shutdown of the second unit in the event of an accident in the first unit with only a single offsite source available. These procedures will keep the steady state voltages within ratings of the Class 1E equipment and will prevent spurious trips.

In summary, Peach Bottom Units 2 and 3, will have adequate station electric distribution voltages with the implementation of the proposed plant procedures to meet the worst case conditions established in this evaluation. We recommend the NRC accept the analysis of the station electric distribution voltages submitted by Philadelphia Electric Company.

REFERENCES

1. NRC letter (W. Gammill) to all power reactor licensees, dated August 8, 1979.

2 Philadelphia Electric Company letter (S. L. Daltroff) to the NRC (T. A. Ippolito), dated December 31, 1979.

3. Philadelphia Electric Company letter (S. L. Daltroff) to the NRC (R. W. Reid), dated November 13, 1980.

4. Philadelphia Electric Company letter (S. L. Daltroff) to the NRC (J. F. Stolz), dated June 16, 1981.

5. Philadelphia Electric Company letter (J. W. Gallagher) to the NRC (J. F. Stolz), dated February 4, 1982.

6. Philadelphia Electric Company letter (S. L. Daltroff) to the NRC (J. F. Stolz), dated April 15, 1982.

7. Code of Federal Regulations, Title 10, Part 50 (10 CFR 50).

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

9. IEEE Standard 308-1974, "Class 1E Power Systems for Nuclear Power Generating Stations."

10. Philadelphia Electric Company letter (S. L. Daltroff) to the NRC (George Lear), dated September 15, 1976.

11. Philadelphia Electric Company letter (S. L. Daltroff) to the NRC (R. W. Reid), dated October 14, 1980.

12. Telcom, Philadelphia Electric Company (Bill Alden, Bruce Allshouse) with LLNL (Robert White), April 23, 1982.