UCID- 19471

# TECHNICAL EVALUATION REPORT ON THE ADEQUACY OF ELECTRIC DISTRIBUTION SYSTEM VOLTAGES FOR THE POINT BEACH NUCLEAR PLANT UNITS 1 AND 2

(Docket Nos. 50-266, 50-301)

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February 9, 1983

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This work was supported by the United States Nuclear Regulatory Commission under a Memorandum of Understanding with the United States Department of Energy.

NRC FIN A-0250

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## ABSTRACT

This report documents the technical evaluation of the adequacy of the station electric distribution system voltages for the Point Beach Nuclear Plant, Units 1 and 2. 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.

For the worst case conditions study submitted by the licensee, it was shown that the station electric distribution system voltages would be adequate to start and operate 4160-volt and 480-volt Class 1E loads and their associated low voltage controls.

## FOREWORD

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

The U. S. Nuclear Regulatory Commission funded the work under the authorization entitled "Selected Operating Reactor Issues Program II," B&R 20-19-01-06, FIN A-0250.

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(Docket Nos. 50-266, 50-301)

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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 was to determine if the onsite distribution system in conjunction with the offsite power sources had 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 October 12, 1979 [Ref. 2], January 21, 1981 [Ref. 3], June 1, 1981 [Ref. 4], December 30, 1981 [Ref. 5], and June 1, 1982 [Ref. 6], Wisconsin Electric Power Company, the licensee, submitted their analysis and conclusion regarding the adequacy of the Point Beach Nuclear Plant, Units 1 and 2 station electrical distribution system's voltages.

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 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].

(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

A one-line diagram of Point Beach Nuclear Plant's (PBNP) electrical distribution system is shown in Figure 1. This figure was adapted from Attachment 1 of Wisconsin Electric Power Company's (WEPCO) letter of January 21, 1981 [Ref. 3]. A 345 kV switchyard energizes two 345/13.8 kV high voltage auxiliary transformers. The high voltage auxiliary transformers energize two low voltage 13.8/4.160 kV transformers which in turn energize the 4160-volt Class 1E buses.

There are two 4160-volt Class 1E buses and two 480-volt Class 1E buses for each unit. The 4160-volt Class 1E buses A05 and A06 are energized by switching-buses A03 and A04 for each unit. A03 and A04 also energize non-Class 1E buses A01 and A02 during shutdown and startup. The Class 1E buses are not energized by the unit auxiliary transformer, but are energized from the

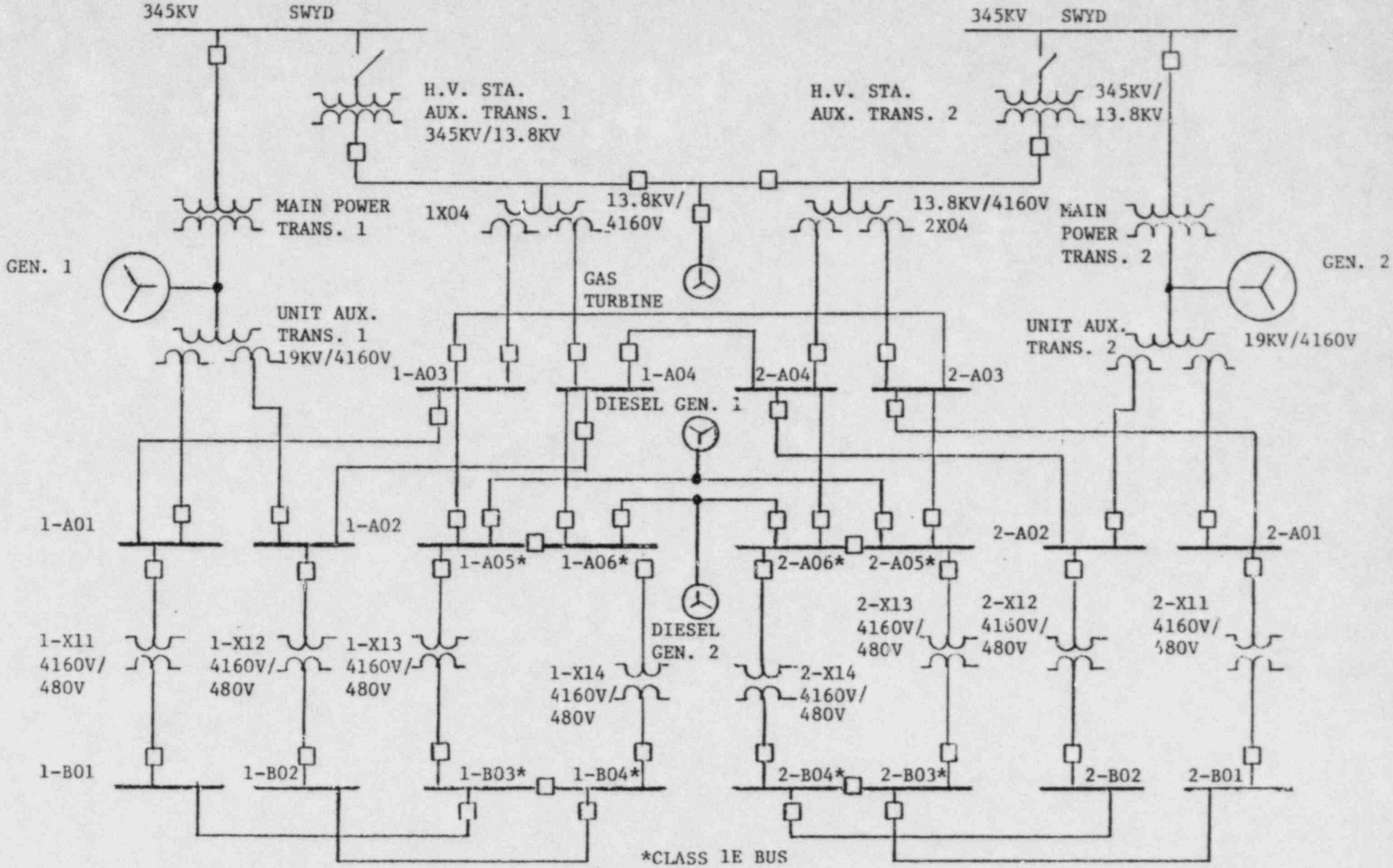


FIGURE 1 POINT BEACH NUCLEAR PLANTS UNITS 1 & 2 - ELECTRICAL ONE-LINE DIAGRAM

offsite source through the low voltage station auxiliary transformers. If the voltage on the 345 kV switchyard buses falls below 350 kV an alarm is initiated in the plant control room and at the system control center to alert the operators to attempt voltage adjustments. In the event of loss of offsite power or a degraded offsite voltage condition, the Class 1E buses are automatically transferred to the emergency diesel generators [Ref. 10]. In the event of a unit trip or plant shutdown, the non-Class 1E buses A01 and A02 are transferred to A03 and A04.

The Class 1E equipment at PBNP, Units 1 and 2, is protected by two levels of undervoltage relays. Loss-of-voltage and degraded-voltage relays monitor the voltage on the 4160-volt Class 1E buses. The loss-of-voltage relays are set to trip at 2450 volts ± 3% (59% of 4160 volts). The degraded-voltage relays are set to trip at 3762 volts ± 2% (90.4% of 4160 volts) with a time delay of a maximum of 30 seconds. This setpoint was selected after the plant experienced spurious trips when starting a reactor coolant pump (Ref. 11). The previous time delay of 13.5 seconds was considered too short to allow the pump to start. The loss-of-voltage relays and degraded-voltage relays initiate the disconnection of the effected Class 1E bus from the offsite source and the start of the emergency diesel generators.

In a more recent letter dated June 30, 1982 (Ref. 12) WEPCO proposed additional changes to the degraded-voltage relay setpoints. The proposed setpoints are 3875 volts ± 2% (93% of 4160 volts) with a time delay of less than 60 seconds. The proposal is being evaluated by the NRC staff as a separate issue.

Technical Specifications preclude the operation of both units with the station auxiliaries of each unit being supplied from a single low voltage station transformer.

## 4. ANALYSIS

### 4.1 ANALYSIS CONDITIONS

Wisconsin Electric Power Company analyzed the distribution system voltages using computer load flow programs. Several cases were analyzed to determine worst case transient voltage drops and steady state voltages. These cases evaluated voltages for maximum load/minimum offsite grid voltage, minimum load/maximum offsite grid voltage, and for the effects of starting a large non-Class 1E load. The minimum and maximum offsite grid voltages used were 348 kV and 362 kV, respectively, on the 345 kV system. In addition to these conditions several other assumptions were made for the minimum voltage steady state calculations and are as follows:

(1) The Unit 2 high voltage station auxiliary transformer is out of service causing both low voltage station auxiliary transformers to be supplied by Unit 1 high voltage station auxiliary transformer.

(2) Unit 2 trips while at 100% power due to an accident situation.

(3) Unit 1 is shut down from 100% power simultaneously with the Unit 2 accident.

(4) All automatically applied accident loads are placed on their respective Class 1E buses.

(5) There is no manual load shedding.

The worst case undervoltage-transient condition was determined to be the startup of a reactor coolant pump after the Class 1E loads have reached steady state values.

The worst case overvoltage condition was determined under no load conditions with the grid at a maximum expected value of 362 kV (105% of 345 kV).

## 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 Undervoltage - Steady State

A minimum steady state Class 1E equipment voltage is established with the conditions shown in Section 4.1. These voltages were calculated to be 3921 volts on the 4160-volt bus (98% of the rated voltage for the 4000-volt motors). On the 480-volt buses the voltage would be 427 volts (92.8% of the 460-volt motor rating).

The licensee was asked to analyze the condition where a 13.8/4.160 kV transformer could be out of service leaving only one 13.8/ 4.160 kV low voltage transformer for both units. The licensee pointed out that the existing Technical Specifications call for placing the unit with the out-of-service low voltage transformer into hot shutdown within three hours. As a result this condition could only exist for a short period of time. If both units were required to shut down simultaneously with the minimum grid conditions and a low voltage transformer out of service, the degraded voltage relays would operate and the Class 1E loads would be transferred to the diesel generators. Because the Technical Specifications require the unit with the out-of-service low voltage transformer to be in hot shutdown within three hours, it is acceptable that the licensee did not use this condition for the worst-case analysis.

### Undervoltage - Transient

The startup of the reactor coolant pump under minimum voltage/maximum load conditions establishes the worst case for transient undervoltage. The startup of this pump produces a larger voltage transient than the startup of any Class 1E load. The transient will produce a momentary minimum voltage on the 4160-volt Class 1E buses of 3412 volts (82% of 4160 volts) and 371 volts (77% of 480 volts) on the 480-volt Class 1E buses. The transient will last for approximately 28 seconds and would not cause any damage or equipment malfunction. The voltages and times of the transient are within the present setpoint values for the degraded-voltage relays.

4.2.2 Overvoltage

The maximum overvoltage condition was established to be at no load with the grid at the maximum expected voltage (362 kV). The results of the calculations for this condition were 4370 volts (109% of 4000 volts) on the 4160-volt Class 1E buses and 504 volts (110% of 460 volts) on the 480-volt Class 1E buses.

Table 1 provides a summation of the above "worst case" voltages on the Class 1E equipment. A complete evaluation of these voltages is in section 5 of this report.

## 4.3 ANALYSIS VERIFICATION

To verify their calculations WEPCO submitted a comparison of calculated voltages versus measured voltages for the 4160-volt and 480-volt Class 1E buses. The plant conditions for the measured voltages were that the grid was at 354.5 kV (103% of 345 kV) and the load on the low voltage transformers was 60% of the transformer rating. The result of the verification test was that the largest difference between the measured voltage and the calculated voltage for this grid voltage was 1.9% on the 480-volt bus where the measured voltage was lower than the calculated voltage. This difference is acceptable as the voltage is within the interpolation error resulting in reading the voltage instruments. Also, if this voltage is subtracted from the steady state voltage values the result is still greater than the equipment minimum voltage rating.

# 5. EVALUATION

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

The worst case analysis was established with only one high voltage station auxiliary transformer available. The load path from this transformer was through the low voltage station auxiliary transformers to the 4160-volt Class 1E buses to the 480-volt Class 1E buses. The loads were those that would be expected if there was a trip by an accident in Unit 2 with a simultaneous shutdown in Unit 1. The offsite voltage used for the calculations was 348 kV.

TABLE 1

POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2
CLASS 1E EQUIPMENT VOLTAGE RATINGS AND
WORST CASE ANALYZED LOAD TERMINAL VOLTAGES
(In Percent of Equipment Nominal Voltage Rating)

| | | Maximum | | Minimum | | |
|---|---|---|---|---|---|---|
| | | Rated | Analyzed | Rated | Analyzed | |
| Equipment | Nominal Voltage Rating | | Steady State | | Steady State | Transient |
| Motors | 4000 | | | | | |
| Start | | | | 80 | | 85 |
| Operate | | 110 | 109 | 90 | 98 | |
| Motors | 460 | | | | | |
| Start | | | | 80 | | 80.6 |
| Operate | | 110 | 109.6 | 90 | 92.9 | |
| Starters | 480 | | | | | |
| Pickup | | | | 72.5 (a) | 92.95 | |
| Dropout | | 52.5 (a) | | | | 77.2 |
| Operate | | 110 | 105 | 90 | 92.95 | |

(a) Determined by tests made by the licensee for minimum voltage required for relay pickup and the maximum voltage at which a relay would drop out.

The analysis results shown in Table 1 show that for these conditions the voltage will remain above the rated minimum steady state operating voltages for the Class 1E equipment.

The licensee also provided an analysis of the transient voltages that would be experienced during the transfer of auxiliary loads, during the startup of the Class 1E loads, and during the startup of a large non-Class 1E load. The analysis showed that the worst case would be the starting of the reactor coolant pump. This worst case transient voltage dip will cause the voltage to drop to 80.6% of the nominal voltage rating of some 460-volt motors and 77% of some 480-volt contactors. This voltage is within the nominal operating range of all contactors and they will be able to pick up and will not spuriously drop out. The voltage transient lasts less than 28 seconds and will not cause the loss or degradation of any Class 1E equipment.

The "worst case" conditions established by the licensee indicate that with a grid voltage of 348 kV and with the maximum load conditions shown in Section 4.1 of this report, there will be adequate station electric distribution voltages for the starting and continuous operation of all 4160-volt and 480-volt Class 1E equipment.

(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 licensee has provided voltage values that show that under the maximum grid voltage with no load condition the ratings of the 4160-volt and 480-volt Class 1E equipment will not be exceeded. A 345 kV bus voltage of 362 kV was used for the minimum load/maximum grid voltage calculations. WEPCO has stated [Ref. 7] that an alarm is set for a high voltage of 362.3 kV on the 345 kV bus and that this corresponds to a high of 4250 volts (106% of 4000 volts) and 506 volts (110% of 460 volts) on the 4160-volt and 480-volt systems, respectively. As shown in Table 1 the maximum voltage ratings for the Class 1E equipment will not be 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.

The licensee provided an analysis of transient voltages caused by starting a large non-Class 1E load. During the start of a reactor coolant pump the 4160-volt bus voltage will drop to 3412 volts (85% of 4000-volt motors) and the lowest 480-volt terminal voltage will be 371 volts (80.6% of 460-volt motors). The length of the transient will be approximately 28 seconds. The licensee has shown that this voltage dip will not cause any equipment damage and that contactors will still pick up and likewise will not spuriously drop out. The licensee in a submittal dated June 30, 1982 [Ref. 12] requested that the time delay associated with second-level undervoltage protection be changed to 60 seconds from 30 seconds. This proposal is currently being evaluated by the NRC staff.

To prevent the occurrence of a spurious trip during the 28 second starting, the time setpoint on the degraded voltage relays has been set to a maximum value of 30 seconds with a voltage setpoint of 3762 volts (90.6% of 4160 volts) ± 2%. The licensee has shown that this setpoint will not cause the loss or degradation of any Class 1E equipment.

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

The licensee has submitted a verification of the calculations giving a comparison of measured values versus calculated values. The range of differences varied from +1.9% to -.2% with the minus value indicating a measured value greater than a calculated value. This range of differences is considered small and is acceptable; therefore, the tests do verify the calculations.

(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 did not provide a review of the existing electrical distribution system regarding Point Beach Nuclear Plant's compliance with GDC 17. They state, however, that the adequacy of the electrical distribution at PBNP is addressed in Section 8 of the FFDSAR [Ref. 4]. It is recommended that the licensee review the electrical distribution at PBNP to ensure that no event or condition could cause the simultaneous or consequential loss of both required offsite circuits to the onsite distribution system.

The licensee was requested to evaluate the proximity of the 1X04 and 2X04 transformers for the possibility of a fire or similar accident in one transformer having a detrimental effect on the other transformer. This issue is being investigated by the NRC Region 3 office.

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

The worst case analysis covered the scenario where only one offsite source is available, one unit is in an accident condition, and the other unit is in a safe shutdown mode. The analysis shows and we concur that each offsite source is capable of supplying adequate starting and operating voltages for all Class 1E loads under these conditions.

## 6. CONCLUSIONS

Based on the information submitted by WEPCO for Point Beach Nuclear Plant, Units 1 and 2 it is concluded that:

(1) Under the worst case conditions analyzed, the Class 1E equipment will be able to 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 the test data indicates the analytical results are acceptable.

(4) Spurious trips will be precluded under the worse case conditions with the voltage and time setpoints of 3762 volts $\pm$ 2% at a maximum time of 30 seconds.

(5) The sharing of offsite sources does not impair the ability of the onsite voltage distribution system to supply adequate voltage to both unit's Class 1E equipment if the plant is operating within its Technical Specifications.

The licensee should be required to provide the requested review of the plant's present 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.

Accordingly, it is recommended that the NRC accept the voltage analysis submitted by the licensee. The analysis demonstrates that acceptable voltage will be supplied to the Class 1E equipment under the analyzed "worst case" conditions.

# REFERENCES


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

2. Wisconsin Electric Power Company letter (C. W. Fay) to the NRC (W. Gammill), dated October 12, 1979.

3. Wisconsin Electric Power Company letter (C. W. Fay) to the NRC (R. A. Clark), dated January 21, 1981.

4. Wisconsin Electric Power Company letter (Sol Burstein) to the NRC (R. A. Clark), dated June 1, 1981.

5. Wisconsin Electric Power Company letter (Sol Burstein) to the NRC (H. R. Denton), dated December 30, 1981.

6. Wisconsin Electric Power Company letter (C. W. Fay) to the NRC (H. R. Denton), dated June 1, 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. Wisconsin Electric Power Company letter (Sol Burstein) to the NRC (George Lear), dated September 17, 1976.

11. NRC memorandum from Gus C. Lainas to Thomas M. Novak, dated December 31, 1981.

12. Wisconsin Electric Power Company letter (C. W. Fay) to the NRC (H. R. Denton), dated June 30, 1982.