EG&G Idaho, Inc.

FORM EG&G-398
(Rev. 11-79)

INTERIM REPORT

Accession No. _____

Report No. EGG-EA-5252

Contract Program or Project Title:

Electrical, Instrumentation and Control System Support

Subject of this Document:

Adequacy of Station Electric Distribution System Voltages, Trojan Nuclear Power Station, Docket No. 50-344, TAC No. 12957

Type of Document:

Informal Report

Author(s):

A. C. Udy

Date of Document:

September 1980

Responsible NRC Individual and NRC Office or Division:

Paul C. Shemanski, Division of Licensing

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EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

Prepared for the
U.S. Nuclear Regulatory Commission
Washington, D.C.
Under DOE Contract No. DE-AC07-76ID01570
NRC FIN No. A6256

INTERIM REPORT

1719F

TECHNICAL EVALUATION REPORT
ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

TROJAN NUCLEAR POWER STATION

Docket No. 50-344

September 1980

A. C. Udy
Reliability and Statistics Branch
Engineering Analysis Division
EG&G Idaho, Inc.

TAC No. 12957

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 Trojan Nuclear Power Station.

The offsite power sources, in conjunction with the onsite distribution system, has 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 Electrical, Instrumentation, and Control Systems (EICS) issues program being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Operating Reactors, by EG&C Idaho, Inc., Reliability and Statistics Branch.

The U.S. Nuclear Regulatory Commission funded this work under the authorization entitled "Electrical, Instrumentation, and Control System Support," B&R 20 19 01 03, FIN No. A6256.

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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.

Portland General Electric Company (PGE) supplied an analysis for this review in a letter of October 5, 1979[2]. Information supplied on January 11, 1980[3], subsequent additional analysis submitted for this review on February 25, 1980[4] and on June 30, 1980[5], and telephone conversations in September 1980[6] complete the information reviewed for this report.

Based on the information supplied by PGE, this report addresses the capacity and capability of the onsite distribution system of the Trojan Nuclear Power Station, 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.

3.0 SYSTEM DESCRIPTION

Section 8.1.2 of the Trojan Final Safety Analysis Report (FSAR) and Part II of Reference 2 discuss the onsite distribution system. Figure 1 of this report is a simplified sketch of the unit single-line diagram taken from Figure 8.3-1 of the FSAR.

Normal Operation of the unit has the main generator supplying power to all plant loads (class 1E and non-class 1E) through the unit auxiliary transformer (UAT)[2]. The plant loads remain powered by the unit generator for the duration of the 30-second time delay after a reactor trip, before a unit trip occurs. Class 1E loads required by any design basis accident (DBA) would be sequenced onto the UAT during this 30-second period.

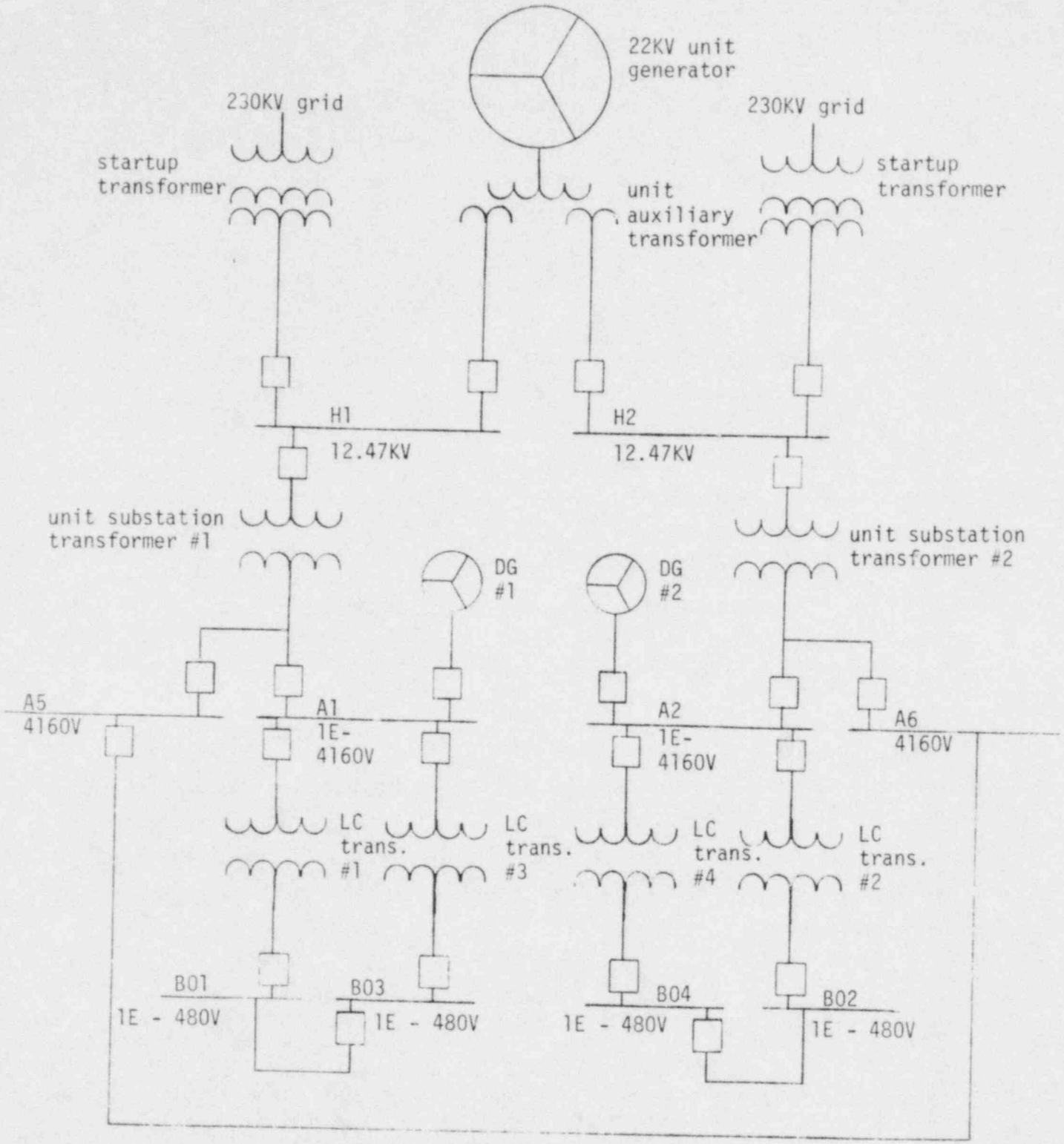

Figure 1
TROJAN NUCLEAR STATION
One-Line Diagram

Following a unit trip, the plant auxiliary load[a] has a fast transfer from the UAT to the two startup transformers (SUT)[2]. The power to the DBA equipment is dropped, and is again sequentially loaded. Upon failure of an SUT, use of the unit generator disconnect link allows the main unit transformer and the UAT to supply offsite power to the auxiliary and class 1E loads. This is not specifically prohibited by Technical Specifications.

Each SUT normally supplies, as the preferred source, power for one redundant safety train and one-half of the plant auxiliary loads. However, as can be seen in Figure 1, an intertie between 4160V buses A5 and A6 exists. However, Technical Specification limiting conditions of operation limit the use of this intertie. Trojan periodic operating test POT-21-2 verifies that interties are not used.

PGE supplied the equipment operating ranges identified in Table 1.[2]

4.0 ANALYSIS DESCRIPTION

4.1 Analysis Conditions. PGE has provided analyses for various conditions.[2,5] The analysis for each condition was for the buses aligned to the normal source of power without use of bus interties. Since the Technical Specification 3.8.2.1, prohibits use of the interties between redundant buses during operation, the use of the interties between the class 1E buses were not analyzed.

Among the conditions[2] PGE used for their analysis are the following:

1. The startup transformer tap will be the nominal tap for operating conditions, the +2.5% tap for shutdown conditions, however, PGE supplied analyses for the nominal tap for both the operating and the shutdown modes

2. The unit auxiliary transformer tap will be the nominal tap for operating conditions

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a. Auxiliary loads, as used in this report, refers to non-class 1E loads.

TABLE 1

TROJAN NUCLEAR POWER STATION
CLASS 1E EQUIPMENT VOLTAGE RATINGS AND
WORST CASE AVAILABLE LOAD TERMINAL VOLTAGES
(in % of equipment nominal voltage rating)

Equipment Nominal Voltage Rating	Maximum Steady State		Minimum Steady State		Minimum Transient	
	Rated	Analyzed[a]	Rated	Analyzed[a]	Rated	Analyzed[a]
4000V motor	110	109.5	90	96.2	70	85.4
460V motor	110	108.7	90	90.2	70	77.6
480V motor contactors						
pickup[b]	c	--	87.5	89.4	87.5	74.4
dropout[b]	c	--	55	89.4	55	74.4
less than 480V[d]						

a. The analyzed voltages are the extremes of the analyses provided by PGE, using both the start-up and the unit auxiliary transformers as sole sources.

b. These analyzed voltages for the motor contactors are at the 480V bus.

c. The maximum voltage the 480V contactors can withstand was not provided by PGE.

d. No analysis was provided for 120V AC instrumentation, as these are supplied power from inverters whose regulated output is independent of the other class 1E AC buses.

3. A load survey determined shutdown load requirements

4. The reactor coolant pumps and heater drain pumps are considered as not tripped after the plant trip

5. The normal plant auxiliary considers the following equipment as not operating:

   a. Fire pump

   b. Control rod drive motors (not operating after a plant trip)

   c. Containment spray pump

   d. Charging pump

e. Safety injection pump

f. Residual heat removal pump

g. Room fans for the above pumps

6. Analyses for both the unit auxiliary transformers and the start-up transformers were provided by PGE

7. For the worst-case transient voltage degradation, PGE analyzed for the start of a circulating water pump when all the safety loads were operating.

4.2 Analysis Results. PGE has provided analyses as required by the NRC letter[1]. While a grid voltage of 235kV was identified as the historical low, 230kV was used for the analysis since the second level of undervoltage protection relays operate at this level.[5] The historical high grid voltage, 240kV, was used for the maximum voltage analysis.

Table 1 shows the worst case voltage levels identified from the PGE analyses. The analyses show that all class 1E loads are capable of starting and continuously operating over a grid voltage range that is wider than the historical grid voltage range at the Trojan station.

A brief condition while starting a circulating water pump when the unit buses already fully loaded will prevent contactor pickup for the 480V MCC loads until the voltage recovers. It will not cause contactor dropout or spurious shedding of any loads.

4.3 Analysis Verification. PGE verified the computer analysis.[2] This was done by measuring the unit generator voltage and by taking voltage, current, and power factor measurements on auxiliary buses H1 and A5, class 1E buses A1, B01, and B03, class 1E MCC buses B21, B23, and B25, and on service water pumps P-148A and P-148C, while the Trojan unit was operating at 100% capacity. All except one of the measured buses (B23, a 480V MCC) were loaded at greater than 29% of the maximum expected bus load.[6] Bus B23 was loaded at 19%.

The measured generator voltage and the measured loads were used in the analysis program to determine the bus and the equipment voltages. The

measured voltages were then compared to the calculated voltages. The analysis program accurately models the class 1E distribution system, as the calculated and the measured voltages were within ±0.58% of each other.

5.0 EVALUATION

Six review positions have been established from the NRC analysis guidelines[1] and the documents listed in Section 2 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 combiniation must be capable of starting and of continuously operating all class 1E equipment within the rated equipment voltages.

PGE has shown, by analysis, that the Trojan unit has sufficient capability and capacity for starting and continuously operating the safety related loads.

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 rated equipment voltage.

PGE has shown, by analysis, that the voltage ratings of the class 1E equipment are not 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 analyzed voltage limits.

EG&G Idaho, Inc., will verify, in a separate report, that the requirements of this position are satisfied (TAC No. 07328).

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

PGE has supplied the required information[2] which shows the calculations to be conservative for all of the class 1E buses and loads. The test was performed using the unit auxiliary transformer rather than the start-up transformer. However, the analysis cases using both transformers are in close correlation, so the test results are considered valid.

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).

PGE has analyzed the Trojan connections to the offsite power grid, and determined that no potential exists for violation of GDC 17. PGE states:

> "As designed, the offsite power source does not violate (the) GDC 17 requirement to provide two physically independent circuits designed and located to assure a reliable offsite power source for the Trojan plant."

Position 6--As required by GDC 5, each offsite source[a] 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 single-unit Trojan station.

6.0 CONCLUSIONS

The analyses submitted by PGE for this review were evaluated as stated in Section 5 of this report. These submittals show:

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a. Section 8.1.1 of IEEE Standard 308 permits the use of a single source of offsite power to be shared between units of a multi-unit station.

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

2. Voltages within the operating limits of the class 1E equipment are supplied for all projected combinations of plant load and offsite power grid conditions

3. PGE has determined that no potential for either a simultanous or consequential loss of both offsite power sources exists.

However, PGE has not verified that the voltage transient caused by starting large non-class 1E loads will not shed the class 1E buses during a safety injection. EG&G Idaho, Inc., is performing a separate review of the under-voltage relay protection at the Trojan station. This will evaluate the relay setpoints and time delays to determine that spurious tripping of the safety related loads will not occur with normal offsite source voltages.

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. PGE letter, C. Goodwin, Jr., to Director of Nuclear Reactor Regulation, dated October 5, 1979.

3. PGE letter, C. Goodwin, Jr., to Director of Nuclear Reactor Regulation. dated January 11, 1980.

4. PGE letter, C. Goodwin, Jr., to Director of Nuclear Reactor Regulation, dated February 25, 1980.

5. PGE letter, C. Goodwin, Jr., to Director of Nuclear Reactor Regulation, dated June 30, 1980.

6. Telecon, C. Trammell, U.S. NRC, A. Udy, EG&G Idaho, Inc., Ken Murakami, PGE, September 16 and 17, 1980.