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NRC Research and/or Technical Assistance Report

ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES, MONTICELLO NUCLEAR GENERATING PLANT, UNIT 1

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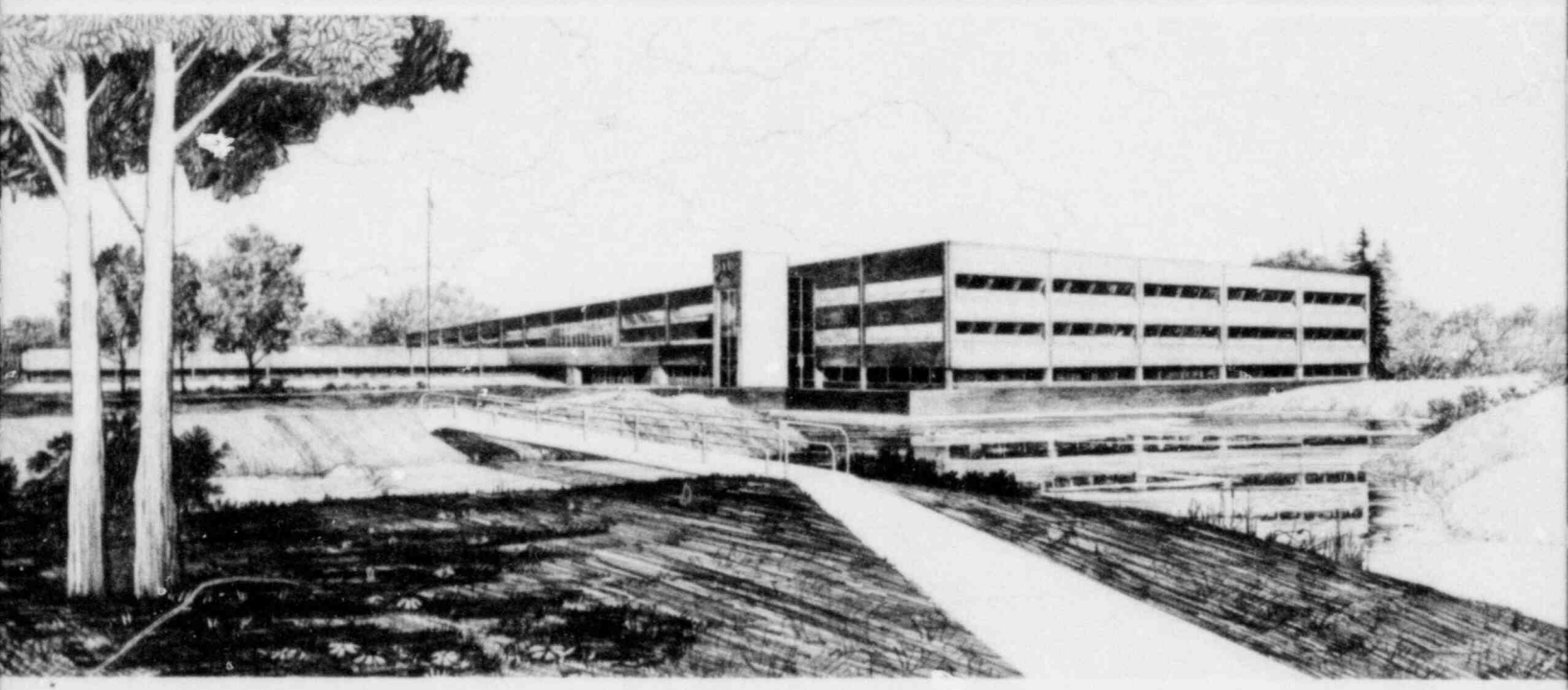

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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

MONTICELLO NUCLEAR GENERATING PLANT, UNIT 1

Docket No. 50-263

February 1982

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ABSTRACT

This report contains the EG&G Idaho, Inc. evaluation of the adequacy of the station 1E electrical distribution system voltages for the Monticello Nuclear Generating Plant, Unit 1.

FOREWORD

This report is supplied as part of the "Selected Operating Reactors 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.

The U.S. Nuclear Regulatory Commission funded the work under the authorization, B&R 20 19 01 06, FIN No. A6429.

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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.

In response to the generic letter and questions from the staff, Northern States Power Company (NSP) submitted information and analysis on January 30, 1981,[2] June 25, 1981,[3] and November 2, 1981.[4] These submittals, submittals of March 4, 1977,[5], July 25, 1977,[6] October 14, 1977,[7] April 21, 1978,[8] October 31, 1979,[9] May 15, 1980,[10] August 4, 1980[11], December 16, 1981,[13] September 22, 1981,[14] February 5, 1982,[15] the EG&G Idaho, Inc., report on the Monticello degraded grid protection dated August 1980,[12] and the Monticello Final Safety Analysis Report completes the information reviewed for this report.

Based on the information supplied by NSP, this report addresses the capacity and capability of the onsite distribution system of the Monticello 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 5.0.

3.0 SYSTEM DESCRIPTION

Figure 1 of this report is a simplified sketch of the Monticello electrical single-line diagram.

During normal plant full-power operation, auxiliary power is supplied by the Unit Auxiliary Transformer (UAT) No. 11 and, during startup and shutdown, by the Startup Auxiliary Transformer (SAT) No. 1R. Provisions are made for automatic, fast transfer of the auxiliary loads from the UAT to the SAT upon unit trip. Inability of the SAT to supply power will cause an automatic transfer to the Reserve Auxiliary Transformer (RAT) No. 1AR.[2] Complete loss of all offsite power will result in the diesel generators supplying all the shutdown loads. The UAT and SAT each have the capacity to carry full plant loads. The RAT and the diesel generators have the capacity to supply all safety-related loads (all non-essential loads are automatically shed).

There are two essential 4.16kV buses; No. 15 and 16. One division of safety-related equipment is powered from each of these buses. Each bus supplies 4.16kV loads, the 480V load centers and motor control centers (MCCs), and the 250V dc, 125V dc, and 24V dc systems.

The FSAR and Reference 2 provide a detailed description of operation of the Class 1E AC and DC systems.

4.0 ANALYSIS DESCRIPTION

4.1 Design/Operation Changes. The voltages shown on Table 1 are based on the modifications, changes, and analysis described in the NSP letter of November 2, 1981.[4]

4.2 Analysis Conditions. NSP has determined through review of historical data that the maximum offsite grid voltage of 354kV (1.026 pu) will result in the highest offsite voltages when the RAT is supplying the 1E system. Load flow studies have determined that the minimum offsite grid voltage of 119kV (1.038 pu) will result in the lowest onsite voltages when the SAT is supplying the 1E system.

NSP has analyzed each offsite source to the onsite distribution system under extremes of load and offsite voltage conditions to determine the

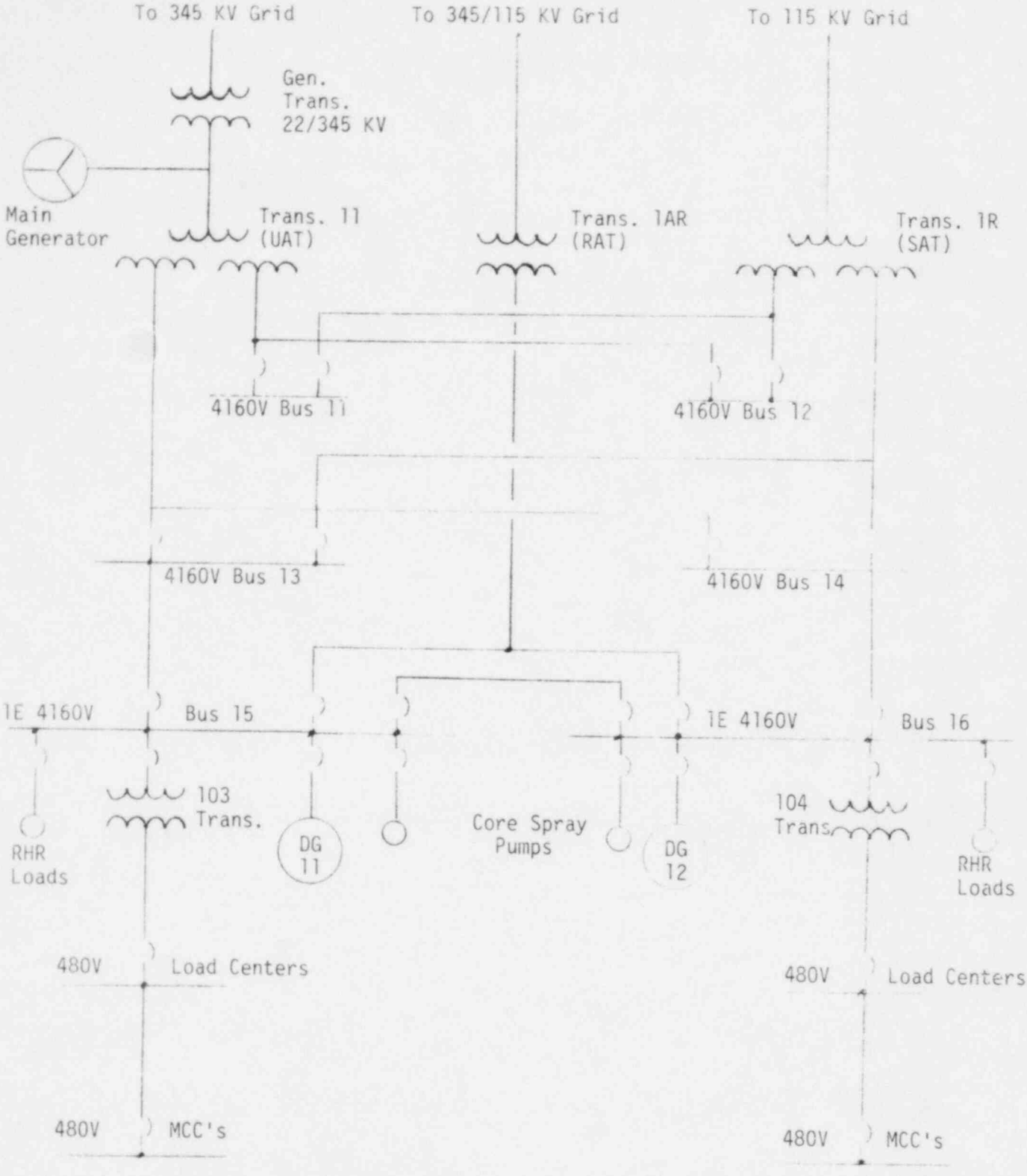

Figure 1. Monticello Electrical Single-Line Diagram

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[4]
4000V Motors	Start	--	--	80	--	85
	Operate	110	110	90	96.5	--
460V Motors	Start	--	--	80	--	80
	Operate	110	110	90	91	--
440V Motors[5]	Start	--	--	80	--	83.7
	Operate	110	110[15]	90	91	--
480V Starters[4]	Pickup	--	--	85	--	80[b]
	Dropout	--	--	60	--	80
	Operate	110	110	90	90	--
Other Equipment[a]						

a. The rating and effects of voltage variations on other equipment is described in the NSP submittal June 25, 1981.[3]

b. NSP indicates that there are no known problems with starting of 480 volt equipment during dips resulting from starting 4.16 kv equipment. This is verified annually during ECCS actuation tests.[13]

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

1. The maximum voltage occurs under station no-load conditions when the 345kV source is at its historical high of 354kV and the Class 1E system is supplied via the RAT.

2. The worst case transient voltage occurs when the 115kV source is at its minimum expected value supplying the maximum plant loads via the SAT with the sequenced starting of ECCS equipment concurrent with the starting of two core spray pumps.[4]

3. The minimum steady-state voltage occurs as in 2 above except all ECCS equipment is running.

4.3 Analysis Result. Table 1 shows the projected worst case Class 1E equipment terminal voltages. Table 2 shows a comparison of the analyzed voltages with the undervoltage relay setpoints.

4.4 Analysis Verification. NSP states that tests were performed in accordance with NRC guidelines and resulted in measured voltages approximately 2% higher than calculated voltages.[4,14]

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

Location/Relays	Minimum Analyzed[a] Voltage	Minimum Analyzed[a] Time	Relay Setpoint Voltage (Tolerance)	Relay Setpoint Time
4160V bus[a] 15 or 16				
Degraded grid	96.7	continuous	93.4 ± 0.5%	10 ± 1 sec
Loss of grid	76.3[b]	<8 sec	63 ± 6.7%	1 sec

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. Licensee states that the 4kV motors will accelerate to normal speed within 8 seconds and bus voltage will recover to 96.4% of nominal.

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.

NSP has shown, by analysis, that the offsite sources and the onsite distribution system connections 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.

NSP 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, voltage relays will not cause loss of Class 1E distribution systems when the offsite grid voltage is within expected voltage limits.

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

The test results provided by NSP in their submittal of November 2, 1981[4] verifies the accuracy of the voltage analysis.

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).

NSP has analyzed the onsite connections to the offsite power grid, and determined that no potential exists for simultaneous or consequential loss of both circuits from the offsite grid.

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 Monticello single-unit station.

6.0 CONCLUSIONS

The voltage analyses submitted by NSP for Monticello Nuclear Generating Plant were evaluated in Section 5.0 of this report. Upon the completion of changes described in Section 4.1, it was found that:

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

2. The tests performed by NSP verifies the accuracy of the analysis.

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

4. Loss of offsite power to Class 1E buses, due to spurious operation of voltage protection relays, will not occur with the offsite grid voltage within its expected limits.

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. NSP letter, L. O. Mayer, to Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, dated January 30, 1981.

3. NSP letter, L. O. Mayer, to Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, dated June 25, 1981.

4. NSP letter, L. O. Mayer, to Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, dated November 2, 1981.

5. NSP letter, L. O. Mayer, to D. L. Ziemann, Chief, Operating Reactors Branch #2, U.S. Nuclear Regulatory Commission, dated March 4, 1977.

6. NSP letter, L. O. Mayer, to D. K. Davis, Acting Chief, Operating Reactors Branch #2, U. S. Nuclear Regulatory Commission, dated July 25, 1977.

7. NSP letter, L. O. Mayer, to D. K. Davis, Acting Chief, Operating Reactors Branch #2, U. S. Nuclear Regulatory Commission, dated October 14, 1977.

8. NSP letter, L. O. Mayer, to Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, dated April 21, 1978.

9. NSP letter, L. O. Mayer, to Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, dated October 31, 1979.

10. NSP letter, L. O. Mayer, to Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, dated May 15, 1980.

11. NSP letter, L. O. Mayer, to Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, dated August 4, 1981.

12. "EG&G Technical Evauation Report on the Degraded Grid Protection for Class 1E Power Systems for the Monticello Nuclear Generating Plant," Rev. 2, dated August 1980.

13. NSP letter, D. Musolf, to Don Weber, EG&G Idaho, Inc., dated December 16, 1981.

14. Bechtel Power Corporation, C. B. Hogg to B. E. Tam, Supervising Electrical Engineer, Northern States Power, dated September 22, 1981.

15. NSP letter, D. Musolf, to Don Weber, EG&G Idaho Inc., dated February 5, 1982.