27
12/23/81
2424T1S

I-531

MASTER

UCID--19116

DE82 005458

TECHNICAL EVALUATION OF THE ADEQUACY OF
STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES
FOR THE R.E. GINNA NUCLEAR POWER STATION,
UNIT 1

James C. Selan

SELECTED ISSUES PROGRAM

(Docket No. 50-244)

November 5, 1981

Lawrence
Livermore
Laboratory

This is an informal report intended primarily for internal or limited external distribution. The opinions and conclusions stated are those of the author and may or may not be those of the Laboratory.

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

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

ABSTRACT

This report documents the technical evaluation of the adequacy of the station electric distribution system voltages for the R.E. Ginna Nuclear Power Station, Unit 1. 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 voltages will be supplied to the Class 1E equipment under worst case conditions.

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 Operating Reactors, by Lawrence Livermore National Laboratory.

The U. S. Nuclear Regulatory Commission funded the work under the authorization entitled "Electrical, Instrumentation and Control System Support," B&R 20 19 04 031, FIN A-0250.

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

TABLE OF CONTENTS

		<u>Page</u>
1.	INTRODUCTION	1
2.	DESIGN BASIS CRITERIA	1
3.	SYSTEM DESCRIPTION	2
4.	ANALYSIS	4
	4.1 Analysis Conditions	4
	4.2 Analysis Results	4
	4.2.1 Overvoltage	4
	4.2.2 Undervoltage	4
	4.3 Analysis Verification	6
5.	EVALUATION	6
6.	CONCLUSIONS	8
	REFERENCES	8

ILLUSTRATIONS

		<u>Page</u>
FIGURE 1	R. E. Ginna Unit 1 Electrical One-Line Diagram	3
TABLE 1	R. E. Ginna Unit 1 Class 1E Equipment Voltage Ratings and Analyzed Worst Case Terminal Voltages	5

TECHNICAL EVALUATION OF THE
ADEQUACY OF STATION ELECTRIC
DISTRIBUTION SYSTEM VOLTAGES
FOR THE R.E. GINNA NUCLEAR POWER STATION
UNIT 1

(Docket No. 50-244)

James C. Selan

Lawrence Livermore National Laboratory, Nevada

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 6, 1979 [Ref. 2], September 3, 1980 [Ref. 3], December 4, 1980 [Ref. 4] and September 30, 1981 [Ref. 5], Rochester Gas and Electric Corporation (RG&E), the licensee, submitted their analysis and conclusion regarding the adequacy of the electrical distribution system's voltages at R.E. Ginna, Unit 1.

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 ratings of the required Class 1E equipment for the worst case starting and load condition.

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. 6].
- (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. 6].
- (3) ANSI C84.1-1977, "Voltage Ratings for Electric Power Systems and Equipment" [Ref. 7].
- (4) IEEE Std 308-1974, "Class 1E Power Systems for Nuclear Power Generating Stations" [Ref. 8].
- (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 the plant's electrical distribution system is shown in Figure 1. The plant's main generator serves as the primary source of auxiliary electrical power during on-line operation of the plant. Auxiliary power is supplied via the unit auxiliary transformer no. 11. The auxiliary power required during plant startup, shutdown, or reactor trip is supplied from the 34.5 kV switchyard via the station auxiliary transformer no. 12. Each auxiliary transformer has two 4160-volt isolated secondary windings. The 34.5 kV supply to the primary of the station auxiliary transformer is provided by two equal capacity feeders; one is stepped-down to 34.5 kV at the 115 kV switchyard (circuit 767) and the other from a 34.5 kV substation (circuit 751). There is a total of four 480-volt Class 1E buses (two per redundant load group).

Two levels of undervoltage protection schemes are located on each Class 1E bus. The first-level scheme will protect the Class 1E equipment from loss-of-power. The undervoltage relay's setpoints are defined by an allowable operating range where the voltage may vary from 0% to 80% of 460 volts (0 to 368 volts) with a maximum time delay of 8.0 seconds. The second-level scheme will provide protection for degraded voltage conditions. The relay's operating range for this scheme is from 80% to 90% of 460 volts (368 volts to 414 volts) with an inverse time delay, where 1600 seconds is the limit at 414 volts.

FIGURE 1 R. E. GINNA NUCLEAR POWER STATION ELECTRICAL ONE-LINE DIAGRAM

4. ANALYSIS

4.1 ANALYSIS CONDITIONS

The licensee has provided data from an interactive computer load flow program. This program models the entire electrical distribution system. The voltage analyses submitted were based on all loads being supplied by station auxiliary transformer no. 12 which is supplied by the two independent circuit feeders. Voltage calculations were made under light, normal, and heavy load conditions for the various cases analyzed. The light and normal load values were taken from plant electrical logs, while the heavy load values were assumed to be when nearly all equipment is in operation (includes all Class 1E equipment). Under various loading and operating conditions, voltages were calculated using the normal expected operating voltage range of 34.5 kV to 36.2 kV for circuit 751 and 115 kV to 122 kV for circuit 767.

4.2 ANALYSIS RESULTS

Of all the cases analyzed, the following three cases resulted in developing the minimum and maximum (worst case) bus voltage conditions:

4.2.1 Overvoltage

Case 1: Plant off-line, light auxiliary loads, maximum expected grid voltage of 36.2 kV (circuit 751).

4.2.2 Undervoltage

Case 1: A unit trip to a hot shutdown, heavy auxiliary loads, normal Class 1E loads, grid voltage at minimum expected of 117 kV (circuit 767). Loading conditions decrease over a three hour period.

Case 2: Plant off-line, minimum expected grid voltage of 34.5 kV (circuit 751), heavy Class 1E loads, normal auxiliary loads, all loads being supplied by the station auxiliary transformer, a large non-Class 1E load is started (6000 hp reactor coolant pump).

Table 1 shows the voltage ratings of the Class 1E equipment and the calculated worst case bus voltages. Voltage drops to the terminals of the Class 1E equipment is considered negligible due to the short cable connections [Ref. 4].

TABLE 1

R.E. GINNA UNIT 1
CLASS 1E EQUIPMENT VOLTAGE RATINGS AND
ANALYZED WORST CASE TERMINAL VOLTAGES
(in % of Equipment Nominal Voltage Rating)

Equipment	Nominal Voltage Rating (100 %)	Maximum		Minimum	
		Rated	AnalYZed ^a	Rated	AnalYZed ^a
			Steady State		Steady State Transient
Motors	460 ^b				
Start Operate		110	106.5	80 90	81 88.0
Starters ^c	--				
Pickup					
Dropout					
Operate					
Other ^d Equipment	--				

- a. The analyzed voltages are the extremes of the analysis provided by RG&E using the station auxiliary transformer and both circuit feeders (751 and 767).
- b. All Class 1E motors and six motor-operated valves (MOV's) are rated 460 volts. All other Class 1E MOV's are rated 440 volts and 480 volts and are not required to operate for long periods of time under low bus voltage conditions. Therefore, the 460-volt motors are the voltage limiting motors.
- c. R.E. Ginna Unit utilizes D.C. type contactors.
- d. Class 1E equipment below 480 volts is supplied from either regulated 480/125-volt transformers or uninterruptable power supplies.

The licensee's analysis of the worst case undervoltage studies (Items 2 and 3) as well as those cases which fell within the minimum and maximum worst-case values, indicated the need for a change in operating procedures. To ensure adequate onsite distribution voltages, the licensee proposed that the grid voltage on circuit 751 be maintained at or above 35 kV and that the voltage for circuit 767 be maintained at or above 120 kV at the substation during plant startup conditions. The licensee states that maintaining circuit 767 at or above 117 kV will ensure adequate system voltages during normal operation and for shutdown cases. Grid voltage will be maintained using the load tap changers on the 115 kV transformers.

4.3 ANALYSIS VERIFICATION

The licensee implemented test verification procedures which were conducted over a time period greater than a year. The test equipment used were nine four-channel strip chart recorders to simultaneously measure line voltages, amperes and watts on each of the four 480-volt Class 1E buses, the 4 kV and 34.5 kV offsite buses. The equipment continuously recorded the parameters for a number of specific operating modes in which to compare the test data to the analysis results submitted. The tests were conducted for both steady state and transient conditions. Since a substantial amount of data was collected, the percent error differences were averaged to give an overall percentage value at each voltage level. The results of the steady state tests were: 1.53% at the 480-volt level, 1.58% at the 4160-volt level, and 0.65% at the 34.5 kV level. These values were the results of the measured values being higher than the calculated which indicates the model used was conservative. Transient tests were conducted for the starting of the larger reactor coolant pumps. Due to the limited number of pump starts, the loading configurations used in the analysis could not be accurately represented in the tests, which led to higher percent differences (as high as 13%). Another contributing factor to these higher percent differences was the starting power factor value used in the model. Actual tests showed a more realistic value of 30% rather than the 20% value used. Again, based on these higher percentage differences, the model used reflects a higher degree of conservatism.

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.

RG&E has shown by analysis and test verification data that the offsite source has sufficient capacity and capability to automatically 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 analysis shows that the Class 1E equipment's voltage rating is not exceeded for minimum load and maximum expected offsite grid voltages.

- (3) The analysis must show that there will be no spurious separation of 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.

RG&E has shown, by analysis and test verification data, that there will be no spurious separation from the offsite source.

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

RG&E verified, by test, the voltage analysis results submitted. The test results produced percentage differences which indicated the calculated values to be lower than the actual measured values, thus indicating the model to be conservative. The percentage differences of the test results indicated that the proposed operating grid limits could be reduced to include the normal lower limit and that the 117 kV level is acceptable for plant startup voltages.

- (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).

A review of the plant's electrical distribution systems has determined that the present design of the offsite transmission network consists of a single circuit to the onsite distribution system, which does not meet the current requirements of GDC 17. This discrepancy was reviewed by the system evaluation program (SEP) to determine if any changes or modifications would be required. The SEP concluded that since the station has 8 hours of backup battery capability for supplying power to the auxiliary feedwater system and that 6 to 8 hours is required to enable backfeeding, no modifications were required.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

6. CONCLUSIONS

Based on the information submitted by Rochester Gas and Electric Corporation for the R. E. Ginna Nuclear Power Station, Unit 1, it is concluded that:

- (1) Under worst case conditions, 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. The test data indicates that the analytical results are lower than actual measured values; thus the model is conservative with acceptable percentage error differences.
- (4) Spurious trips will not occur for the voltages and plant operating conditions analyzed.

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.

REFERENCES

1. NRC letter (W. Gammill) to all Power Reactor Licensees, dated August 8, 1979.
2. RG&E letter (L. D. White, Jr.) to NRC (D. L. Zieman), dated December 6, 1979.
3. RG&E letter (L. D. White, Jr.) to NRC (D. M. Crutchfield), dated September 3, 1980.
4. RG&E letter (L. D. White, Jr.) to NRC (D. M. Crutchfield), dated December 4, 1980.
5. RG&E letter (L. D. White, Jr.) to NRC (D. M. Crutchfield), dated September 30, 1981.
6. Code of Federal Regulations, Title 10, Part 50 (10 CFR 50), General Design Criterion B and 17 of Appendix A for Nuclear Power Plants.
7. ANSI C84.1977, "Voltage Rating for Electric Power Systems and Equipment."
8. IEEE Std. 308-1974, "Criteria for Class 1E Power Systems for Nuclear Generating Stations."