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A. C. Udy

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

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INTERIM REPORT

ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

MAINE YANKEE ATOMIC POWER STATION

Docket No. 50-309

January 1981

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

TAC No. 12774

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 Maine Yankee Atomic 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 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&G Idaho, Inc., Reliability and Statistics Branch.

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ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

MAINE YANKEE ATOMIC POWER STATION

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 voltage is adequate to start and continuously operate the class 1E loads. Maine Yankee Atomic Power Company (MYAPCo) responded to the NRC letter[1] and subsequent questions with letters of February 29, 1980[2] and June 30, 1980.[3]

Based on information supplied by MYAPCo, information found in the Final Safety Analysis Report (FSAR), and a telephone call of October 1, 1980[4], this report addresses the capacity and capability of the onsite distribution system of the Maine Yankee Atomic 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 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 Generating Stations."

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 are stated in Section 5.

3.0 SYSTEM DESCRIPTION

Section 8 of the Maine Yankee FSAR and the attachments of references 2 and 3 discuss the onsite distribution system. Figure 1 of this report, is a simplified unit one-line diagram of the Maine Yankee electric distribution system taken from Reference 2.

Figure 1 shows that the class 1E 4160V buses 5 and 6 are supplied power from auxiliary buses 3 and 4, respectively. When the unit generator is operating, these buses are powered by transformer x24. Upon loss of the unit generator, buses 3 and 4 (and hence class 1E buses 5 and 6) are automatically transferred[5] to receive power from the 115kV grid via startup transformer x14; non-class 1E, 6.9kV buses automatically transfer to startup transformer x16. The unit generator can be isolated from auxiliary transformer x24 and the main transformers enabling them to supply offsite power to the class 1E buses as a delayed second source from the 345kV grid. Bus 5 can also be powered by tertiary windings of startup transformer x16. Plant Procedure No. 1-22-3 prevents use of this source except when all other sources of AC power have failed.

Each 4160V class 1E bus supplies power for a 480V class 1E bus (Nos. 7 and 8) via separate 4160V/480V transformers. 120V vital buses are supplied power from uninterruptable power supplies (UPS),[3] which auctioneer power from station batteries or 480V buses 7 or 8.

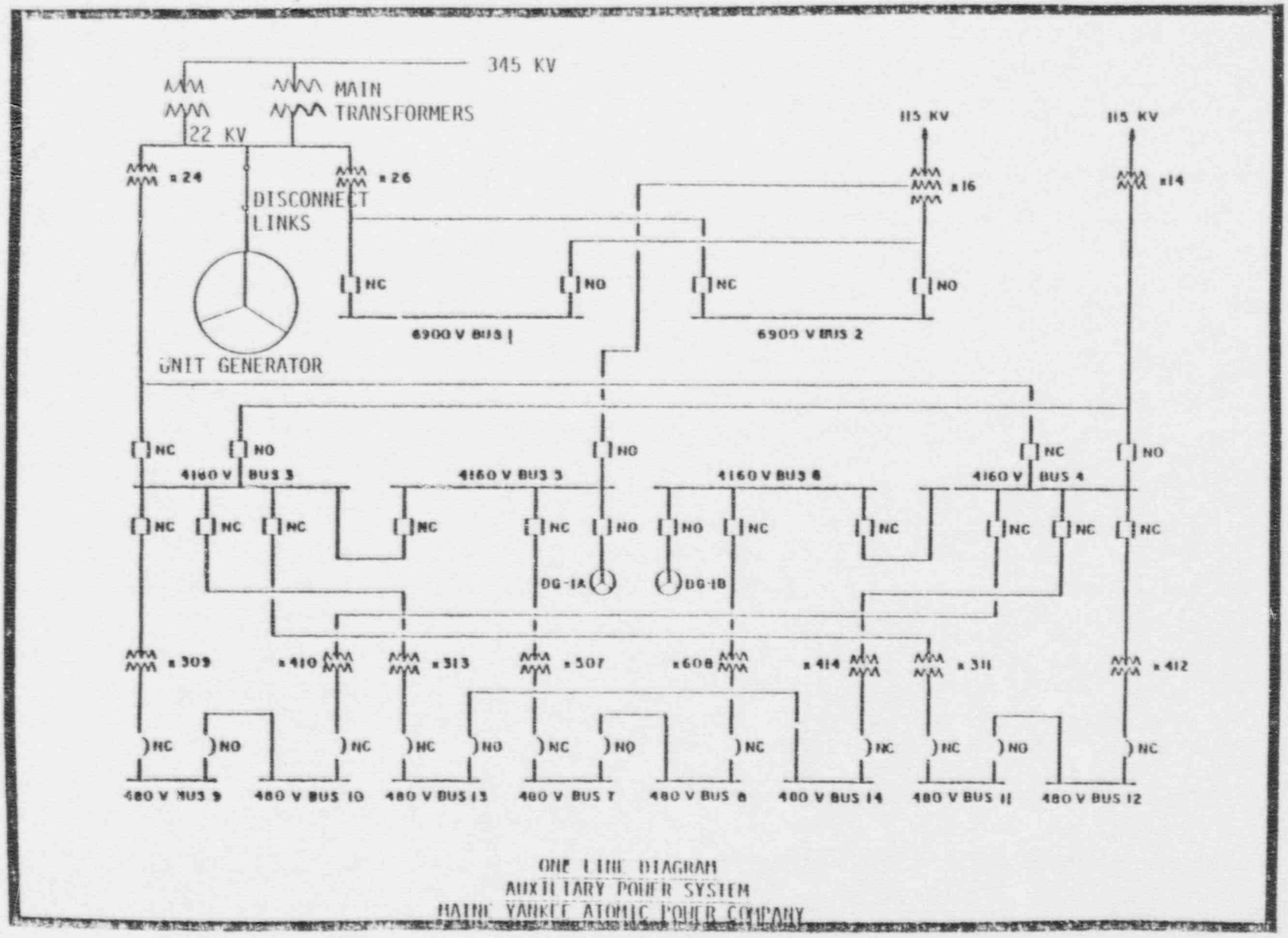
MYAPCo supplied the equipment operating ranges identified in Table 1 of this report.[5] The FSAR shows that station 125V DC buses supply power for the 4160V class 1E motor control circuits.

4.0 ANALYSIS DESCRIPTION

4.1 Analysis Conditions. MYAPCo has analyzed all but one offsite source connection to the onsite distribution system under extremes of load and offsite voltage conditions to determine the terminal voltages to 1E equipment. However, MYAPCo did not provide analyses for bus 5 receiving power from transformer x16 as the connection is not required by GDC 17, and it is not credited in the FSAR as being a source of offsite power. The MYAPCo voltage analyses show that:

1. The maximum load terminal voltage occurs during unit shutdown when transformer x24 carries the minimum auxiliary and class 1E loads with the 345kV distribution system at its maximum voltage of 362kV.

2. The minimum steady state load terminal voltage occurs when an accident occurs without loss of offsite power with transformer x14 carrying the maximum auxiliary and class 1E loads with the 115kV distribution system at its minimum continuous voltage of 116.5kV.



ONE LINE DIAGRAM
AUXILIARY POWER SYSTEM
MAINE YANKEE ATOMIC POWER COMPANY

FIGURE 1

TABLE 1

MAINE YANKEE ATOMIC POWER STATION
CLASS 1E EQUIPMENT VOLTAGE RATINGS AND
ANALYZED WORST CASE TERMINAL VOLTAGES
(% of nominal voltage)

		Maximum		Minimum		
		Rated	Analyzed	Rated	Analyzed	
Equipment	Nominal Voltage (100%)				Steady state	Transient
Motors	4kV					
Start		--	--	75	--	89.8[a]
Operate		110	108.2	90	95.8	--
	460V					
Start		--	--	80[b]	--	82.6[c]
Operate		110	108.3	90	90.4	--
Starters	480V					
Pickup		--	--	80	--	79.4
Dropout		--	--	70	--	79.4
Operate		d	103.8	80	88.5	--
Low voltage instrument and control circuits[e]						

a. Momentary minimum motor terminal voltage when starting a condensate pump. This assumes the condensate pumps, heater drain pumps, and circulating water pump have been previously shed.

b. Appendix A shows the torque-speed curve of the largest 480V class 1E load.

c. Momentary minimum motor terminal voltage when starting 460V Service Water Pump (250 hp).

d. Not supplied by licensee.

e. UPS is powered by station batteries or rectifiers only.

3. The minimum transient load terminal voltages occur with the conditions of 2 (above) with the start of a condensate pump[a] (for the 4000V class 1E equipment) and the start of a service water pump (for the 460V class 1E equipment).

The study accounted for cable and transformer impedences. Field inspections verified the transformer tap settings. The minimum load consists of component cooling water pumps, lighting, and some unspecified 480V loads. MYAPCo assumed a constant 120kV at the source connections due to automatic load tapchanging[2] autotransformers located there, while the Maine Yankee Atomic Power Station switchyard voltage was free to follow the load demand.

4.2 Analysis Results. Table 1 shows the worst case class 1E equipment terminal voltages identified in the MYAPCo analysis. The worst-case motor starting voltage transient condition will last only while starting the 2500 hp condensate pump. At the minimum voltages identified in Table 1, no contactors will drop out to cause spurious tripping of loads.[3] Contactor pickup is prevented until the voltage recovers.

4.3 Analysis Verification. MYAPCo measured the grid, generator and bus voltages, and the actual load of the buses and selected equipment. This was done twice, with the transformer loading as follows:

	Loading (% of rated)		
Transformer	Test 1	Test 2	Buses Supplied
x24 (4160V)	63.4	65.6	3, 4, 5(1E), 6(1E)*
x26 (6900V)	95.2	96.0	1, 2
x507 (480V)	68.0	68.9	7(1E)
x608 (480V)	58.0	58.8	8(1E)

*Buses 3 and 5 are located adjacent to each other, and the study considered them at identical potential, with separate load groups. Buses 4 and 6 are the same.

Analyses were done using the measured generator source voltage and the measured loads, and the results compared with the measured bus voltages.

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a. This pump was studied as the largest load on the same transformer that supplies power to the class 1E buses. Although larger motors are in service at the Maine Yankee Atomic Power Station, they use 6.9kV from separate transformers.[3]

Two comparisons were made which show the analysis to be within +1.30/-2.42% of the actual measured bus voltages for the class 1E buses. For all buses, the deviation was within +1.30/-3.56%. A negative figure indicates that the actual measured voltage is higher than the predicted voltage.

5.0 EVALUATION

Six review positions have been established from the NRC analysis guidelines[1] and documents listed in Section 2.0. Each review position is stated below, followed by the 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 combination must be capable of starting and of continuously operating all class 1E equipment within the rated equipment voltages.

MYAPCo has shown by analysis that the Maine Yankee Atomic Power Station has sufficient capability and capacity for starting and continuously operating the class 1E loads within the equipment voltage ratings (see Table 1). However, MYAPCo has not analyzed for when the tertiary winding of the transformer x16 supplies power to class 1E bus 5.

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 all class 1E equipment without exceeding the rated equipment voltage.

MYAPCo has shown by analysis that the voltage ratings of the class 1E equipment will not be exceeded. MYAPCo states that even if a switchyard voltage of 124kV (4kV higher than the maximum expected voltage) was present, that no load would have its voltage limit exceeded.[3]

Position 3--Loss of offsite power to either the redundant class 1E distribution systems or the individual class 1E loads, 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 (FIN No. 10032).

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

MYAPCo has supplied the required information[2,4] which shows the calculations to be an accurate representation of the class 1E buses and loads. The test was performed using the unit auxiliary transformers; however, since the case studies using the unit auxiliary and the startup transformers are in close correlation, 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).

MYAPCo has analyzed the Maine Yankee connections to the offsite power grid and has determined that no potential exists for the simultaneous or consequential loss of both circuits from the offsite grid.[2]

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 stations. It does not apply to the single-unit Maine Yankee station.

6.0 SUMMARY

The analyses submitted by MYAPCo for this review were evaluated as stated in Section 5.0 of this report. It was found that:

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

   However, the NRC should require the MYAPCo to incorporate limiting conditions of operation in the unit Technical Specifications that restrict use of the bus 5 feeder from the tertiary windings of transformer x16 as prescribed in Plant Procedure No. 1-22-3.

2. The test used to verify the analysis shows the analysis to be an accurate representation of the worst case conditions analyzed.

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

EG&G Idaho, Inc., is performing a separate review of the undervoltage relay protection at the Maine Yankee station. This will evaluate the relay setpoints and time delays to determine that spurious tripping of the class 1E buses will not occur with normal offsite source voltages.

7.0 REFERENCES

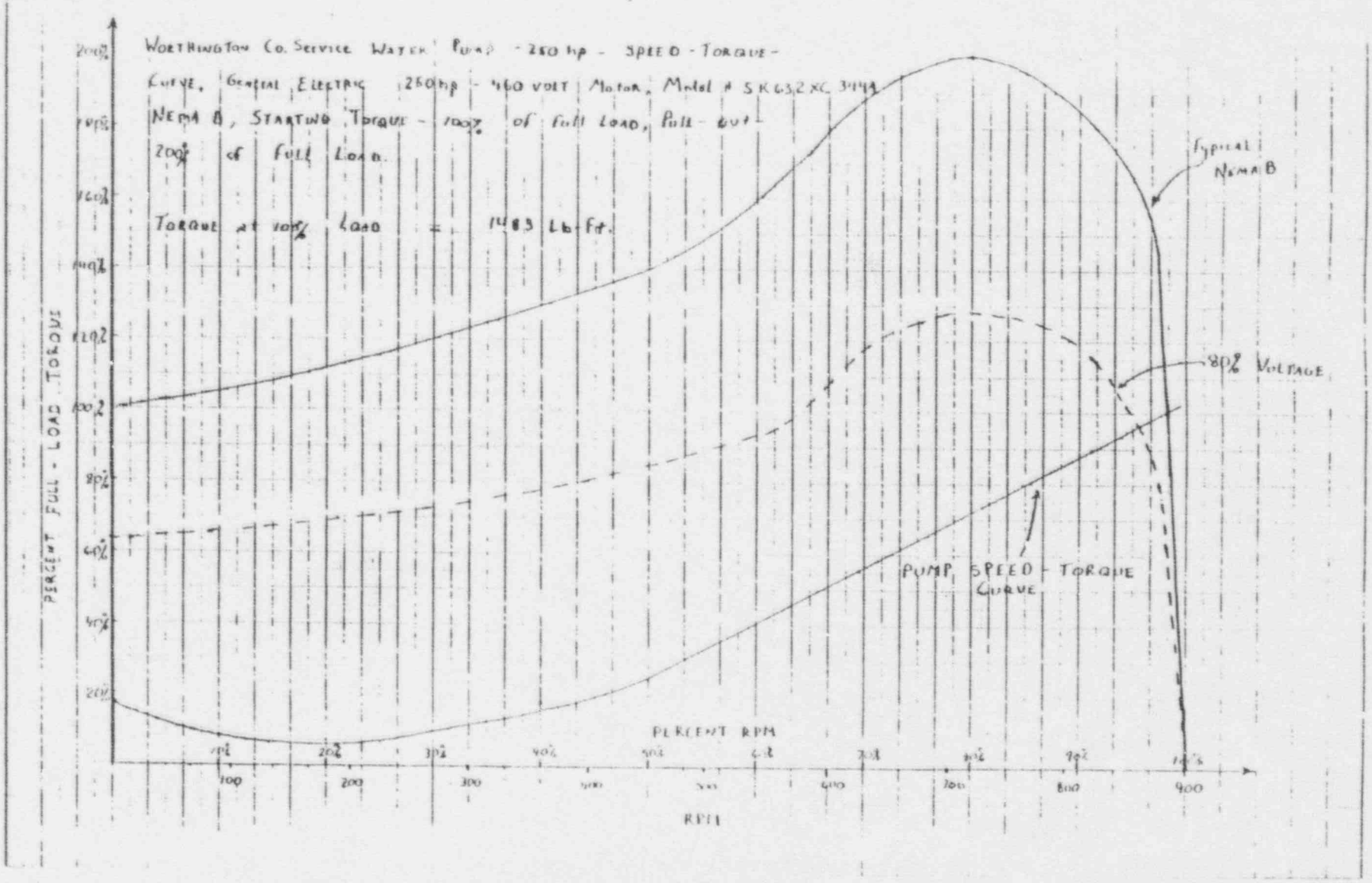
1. NRC letter, William Gammill, to All Power Reactor Licensees (Except Humboldt Bay), "Adequacy of Station Electric Distribution Systems Voltages," August 8, 1979.

2. MYAPCo letter, Robert H. Groce to Office of Nuclear Reactor Regulation, U. S. NRC, "Adequacy of Station Electric Distribution System Voltages," February 29, 1980.

3. MYAPCo letter, Robert H. Groce to U. S. NRC, "Request for Additional Information on Adequacy of Station Electric Distribution System Voltages," June 30, 1980.

4. Telecon, A. C. Udy, EG&G Idaho, Inc., P. Johnson, Yankee Atomic Electric Company, October 1, 1980.

5. Yankee Atomic Electric Company report No. 1204 "Auxiliary Power System Voltage Study for Maine Yankee Atomic Power Station," dated February 28, 1980, attachment to Reference 2.



APPENDIX A

TORQUE-SPEED CURVE FOR 480V SERVICE WATER PUMP
(Mailed to author on August 11, 1980 by P. Johnson, Yankee Atomic Electric Company)