LACBWR GENERATING UNIT

ADEQUACY OF STATION

ELECTRICAL DISTRIBUTION SYSTEMS VOLTAGES

Project No. 6101-33

April 1, 1980

TABLE OF CONTENTS

SARGENT & LUNDY
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ADEQUACY OF STATION ELECTRICAL DISTRIBUTION SYSTEMS VOLTAGES LACBWR GENERATING UNIT

I. INTRODUCTION

The Nuclear Regulatory Commission (NRC) has required the licensees of all power reactors, in a letter dated August 8, 1979, to show that each plant's station electrical distribution system will provide an adequate supply of power to essential loads during the contingency which presents the largest load demand on the auxiliary system. This request was a result of the incident at Arkansas Nuclear One Station described in detail in the NRC's IE Information Notice 79-04.

This report documents the results of the study conducted to determine the adequacy of the electrical distribution system at the LACBWR Generating Unit to provide a power source of sufficient capacity and capability to supply the engineered safety feature loads in the event of a contingency presenting the maximum load demand on the system. The study has been made according to the guidelines outlined in Enclosure 2 of the NRC letter dated August 8, 1979.

II. STATION ELECTRICAL DISTRIBUTION SYSTEM

The station electrical distribution system for LACBWR Generating Unit is shown on Attachment 1. The auxiliaries for the unit are supplied from two, 2400V and four, 480V switchgear buses. Of these six buses, two, 480V buses are designated as essential buses, namely, 480V ESS bus 1A and 480V ESS bus 1B.

During normal operation the auxiliaries are supplied from unit auxiliary transformer #1 (UAT). When the unit is not in operation as during start-up, shutdown, unit trip, or a loss of coolant accident (LOCA), the auxiliaries are transferred to reserve auxiliary transformer #1 (RAT). The transfer of load from UAT to RAT is automatic provided the main feed breaker from UAT at 2400V bus is tripped and its overcurrent relays have not operated.

The offsite power to the safety related buses is available via RAT #1. The LACBWR Generating Unit does not have a generator breaker or any other available connection to the offsite network. Hence, the study has been conducted for RAT operation only. This is in reference to item #1 of the NRC guidelines.

III. LOADING ANALYSIS

The case chosen for detailed voltage evaluation represents the loading of the auxiliary system which will result in the worst voltages at the auxiliary buses as required by the guideline (item #1).

The LACBWR station is a one unit boiling water reactor. Hence, the multi-unit analysis required by the guideline (item #2) is not applicable in this case.

The worst loading condition for RAT operation exists when the unit experiences a loss of coolant accident. The unit was assumed to be generating rated output at the time of the event. All loads operating for the unit's 100% generation were transferred from UAT to the RAT. In addition, the RAT was assumed to carry the LOCA load. The largest motor among the auxiliaries has been started to determine the voltage dip during the motor starting condition. No manual load shedding has been assumed in the analysis. The above approach satisfies items 3, 4, and 5 of the NRC guidelines.

Bus loadings reflecting the above operating condition are shown on Attachment 2.

IV. OFFSITE POWER SUPPLY

The offsite power at LACBWR Generating Unit is supplied from the 69 kV generator plant bus. This bus can be connected either to the 69 kV main bus or to the 69 kV transfer bus

at the Genoa Substation. The voltage at the 69 kV generator plant bus varies between 70.8 kV and 73.2 kV. This voltage range has been determined on the basis of minimum and maximum steady state voltages experienced at the connection to the offsite circuit of the station electrical distribution system. The minimum voltage was used as a basis for determining the voltages at equipment terminals. This complies with item #6 of the NRC guidelines for voltage drop calculation.

A minimum of 718 MVA three phase short circuit level has been determined to be available at the 69 kV generator bus.

V. CRITERIA FOR ACCEPTABLE VOLTAGE

The criteria for the acceptable voltage range at motors, contactors, and control circuits is based on equipment ratings as defined by the National Electric Manufacturers Association. These standards require that the maximum voltage should be limited to 110% and the minimum voltage be limited to 90% of motor rated voltage. Alternating current contactors should withstand 110% of the rated voltage continuously and should close successfully at 85% of their rated voltage.

In order to provide adequate torque for motor starting and to prevent contactors from dropping out at 480V motor control centers, the starting voltage should be limited to an acceptable level. This level is 80% of motor rated voltage.

VI. PERFORMANCE OF ELECTRICAL DISTRIBUTION SYSTEM

1. Existing RAT Tap Settings (72450-2400V)

The results of the study made for RAT #1 operation using the present tap settings of the RAT and the 480V auxiliary transformers are shown on Attachment 3. This attachment

indicates the voltage at the input and output of each transformer and at each bus between the connection to the offsite circuit and terminals of the safety related load and, therefore, complies with the requirement of item #7 of the NRC guidelines. The attachment also shows the maximum postulated loads on the buses and the existing tap settings and the nameplate impedances of the transformers. The attachment further shows the cable and bus duct impedances between different buses and between different transformers and switchgears used in the study.

Attachment 4 tabulates the maximum expected voltage, the minimum operating voltage, and the motor starting voltage at the terminals of various safety loads for the case analyzed. This attachment complies with the requirement of items #9 and #11 of the NRC guidelines.

Attachments 3 and 4 indicate that the maximum expected voltage at any motor terminal is within the criteria of acceptable voltages described in Section V of this report. However, the running voltage at 480V buses are below 85% of the bus rated voltage and the running voltage at some 440V motor terminals are below the minimum criteria of acceptable voltage.

2. Proposed RAT Tap Settings (70725-2400V)

In order to improve the voltages at the 480V system to an acceptable level, we evaluated the performance of the electrical distribution system by setting the HV tap of the RAT at 70725V. This was the only change made from the previous case evaluated in Section VI.1.

The results of this change case study are tabulated in Attachments 5 and 6. These results indicate that the maximum expected voltage, the minimum running voltage, and the motor starting voltage at the terminals of all safety or non-safety related loads are within the acceptable criteria.

3. Recommendation

In order to increase the distribution system voltages to acceptable levels during a contingency when the RAT is carrying the normal auxiliary load (corresponding to 100% unit generation) plus the emergency load, we recommend that the high side tap of the RAT be changed from its present setting of 72450V to 70725V (the next 2.5% lower tap). The taps of 480V auxiliary transformers will remain at their present settings (2520-480V).

VII. UNDERVOLTAGE RELAYS

Attachment 7 lists the existing voltage time settings of the undervoltage relays at different auxiliary buses. Two sets of undervoltage relays at 480V ESS buses 1A and 1B are required to transfer the load from the offsite power source to the onsite diesel generator if the offsite source is lost or degraded. The first set, devices 427 ESA and 427 ESB, will transfer the load in case the offsite source is lost and the new set of the undervoltage relays (planned by Dairyland Power Cooperative) will cause the transfer when the offsite source voltage is degraded.

We have determined that the bus voltage at 480V ESS bus 1B can go as low as 359V during the starting of the 1500 hp Rx feed water pump at 2400V bus and to 361V during an assumed simultaneous startup of all motors connected to the 480V bus.

The present and planned settings of the first set of undervoltage relays on these buses will, for the voltage dips evaluated, give a time delay in excess of 9 seconds before closing their contacts. The second set of undervoltage relays has a fixed time delay of 9 seconds. This delay in the operation of the undervoltage relays is sufficient to prevent relay operation during the transient voltage dips caused by motor starting. Further, these relays incorporate sufficient time delay (1.8 sec. or more) for a zero voltage condition on the bus; hence, the short circuits would be cleared without undervoltage relay operation.

VIII. VERIFICATION OF ANALYSIS BY "TEST"

Meter readings taken on February 2, 1980 at 21 hour during hot shutdown of LACBWR Generating Unit, while the auxiliary buses were fed from the RAT, were used to verify the validity of this analysis.

Attachment 8 shows the meter readings of the source voltage, bus voltage, the loads in amperes at the auxiliary buses, and the kilowatts flowing through the RAT. The attachment also indicates the calculated values of the bus voltage for the loading of the auxiliary system at that time.

A comparison between the meter readings and the calculated values of the bus voltages indicate that the differences are well within the metering accuracy errors.

It is, therefore, concluded that the results of the analysis are valid as demonstrated by the close agreement between the measured and calculated values.

IX. CONCLUSION

The study has demonstrated that, with its high voltage tap setting changed from present value of 72450V to 70725V, the RAT and the onsite distribution system are of sufficient capacity and capability to start as well as operate all required safety related loads within their required voltage ratings during a contingency which presents the largest load demand on the auxiliary system.

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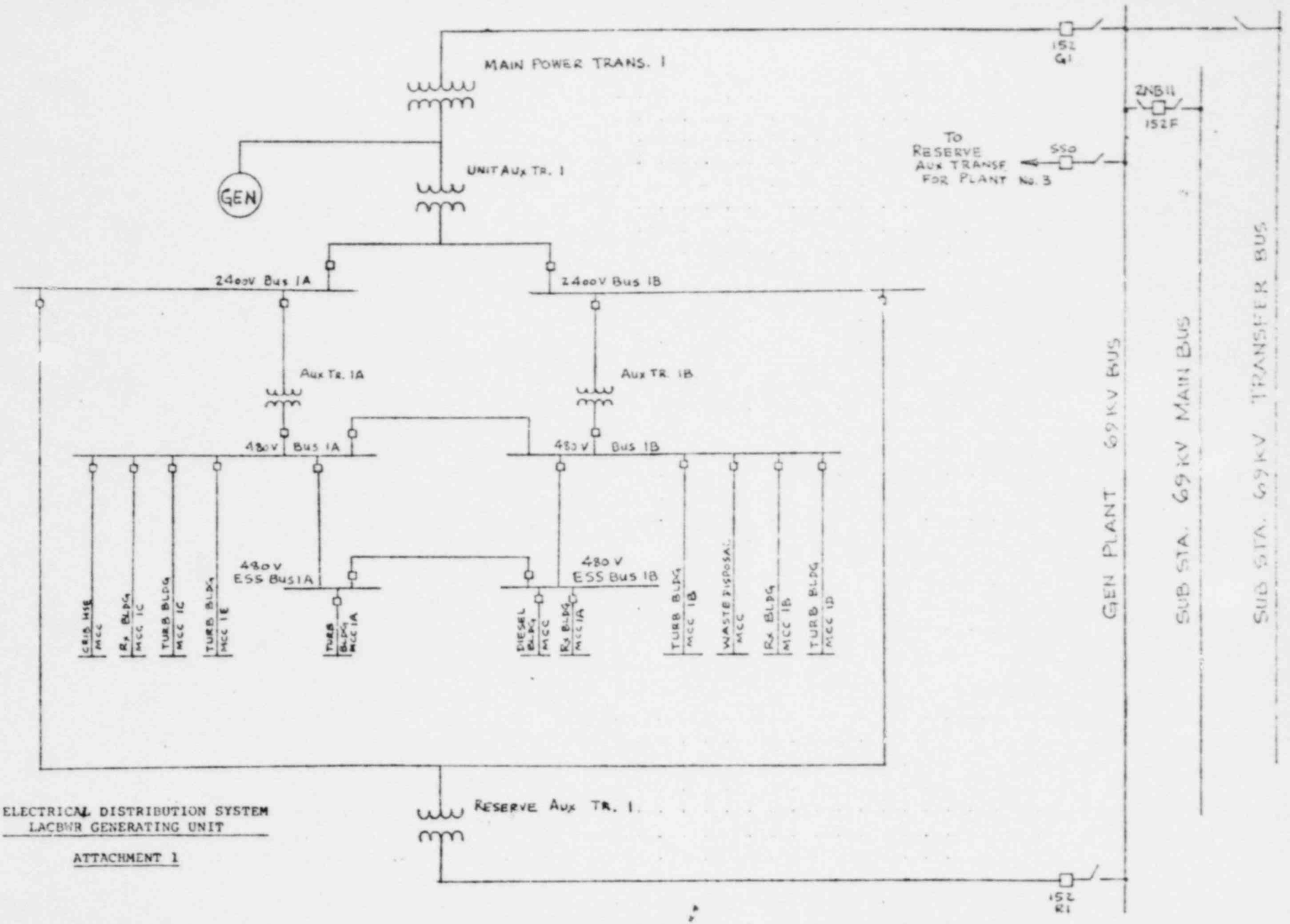


ELECTRICAL DISTRIBUTION SYSTEM
LACBWR GENERATING UNIT

ATTACHMENT 1

ATTACHMENT 2

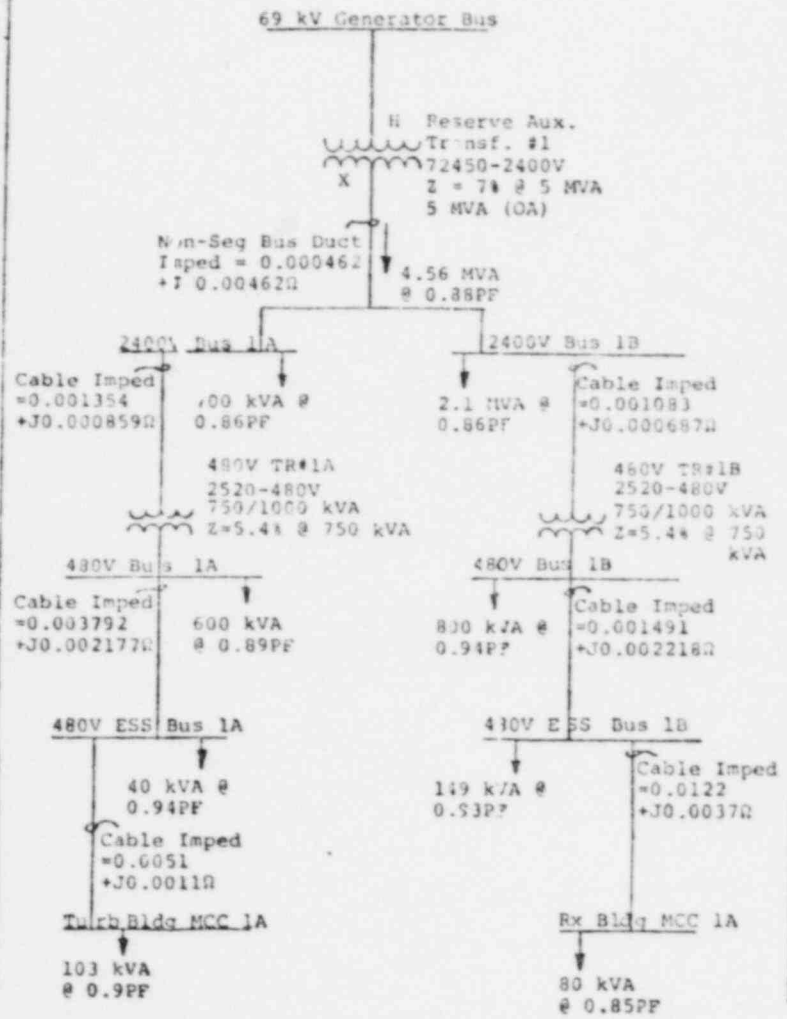
BUS LOADINGS ASSUMED FOR
OFFSITE POWER SUPPLY ANALYSIS

For Reserve Auxiliary Transformer #1 Operation

Bus	Load
2400V Bus 1A	700 kVA
480V Bus 1A	600 kVA
480V ESS Bus 1A	40 kVA
480V Turb Bldg MCC 1A	103 kVA
2400V Bus 1B	2100 kVA
480V Bus 1B	800 kVA
480V ESS Bus 1B	149 kVA
480V Rx Bldg MCC 1A	80 kVA
	4560 kVA

LACBWR GENERATING UNIT
RAT CARRYING NORMAL AUX. LOAD (FOR 100% GENERATION) + EMERGENCY LOAD
RAT WITH PRESENT TAP SETTINGS (72450-2400V)

	No Load Volt	Full Load Volt	Motor Start Volt	HP
Bus Volt kV	73.2	70.8	70.8	
% of 69 kV	106.1	102.6	102.6	
Bus Volt	2425	2232	2162	350
% of 2400V	101.0	93.0	90.1	
% of 2300V	105.4	97.0	94.0	
Bus Volt	462	407	393	60
% of 480V	96.2	84.9	81.9	
% of 440V	105.0	92.5	89.5	
Bus Volt	462	405	378	122 (combined ESS Motor HP)
% of 480V	96.2	84.6	78.7	
% of 440V	105.0	92.5	85.9	
Bus Volt	462	404		
% of 480V	96.2	84.2		
% of 440V	105.0	91.8		



	No Load Volt	Full Load Volt	Motor Start Volt	HP
Bus Volt kV	73.2	70.8	70.8	
% of 69 kV	106.1	102.6	102.6	
Bus Volt	2425	2232	1966	1500
% of 2400V	101.0	93.0	81.9	
% of 2300V	105.4	97.0	85.5	
Bus Volt	462	403	380	100
% of 480V	96.2	84.0	79.2	
% of 440V	105.0	91.6	86.4	
Bus Volt	462	401	351	228 (Combined ESS Motor HP
% of 480V	96.2	83.7	73.1	
% of 440V	105.0	91.1	79.9	
Bus Volt	462	399		
% of 480V	96.2	83.1		
% of 440V	105.0	90.7		

ATTACHMENT 3

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April 1, 1980
6101-33

ATTACHMENT 4

VOLTAGE AT THE TERMINAL OF
SAFETY RELATED LOAD
LACBWR GENERATING UNIT

WITH EXISTING TAP SETTINGS

1. Maximum Voltage Expected at the Motor Terminal
(Acceptable Voltage is 110% of Motor Rated Voltage)

Motors Connected To	Max. No-Load Voltage*	Maximum Acceptable Voltage @ the Motor Terminal
2400V Buses	2425V*	2530V
480V Buses	462V*	484V

2. Motor Running Voltage for the Case Analyzed
(Acceptable Voltage is 90% of Motor Rated Voltage (440V) i.e., 396V)

Bus	Voltage @ the Bus	Worst Drop In the Motor Feeder	Motor	Voltage @ Motor Terminal
480V ESS Bus 1A	405V	5V	Emergency Core Cool Pump 1A	400V
Turb Bldg MCC 1A	404V	4V	Any motor fed from turb bldg MCC 1A	400V
480V ESS Bus 1B	401V	6V	Emergency Core Cool Pump 1B	395V
Rx Bldg MCC 1A	399V	5V	Any motor fed from Rx bldg MCC 1A	394V

*The maximum expected voltage at the motor terminal will be lower than the maximum no-load voltage due to voltage drop in the transformer and the cable supplying the connected equipment.

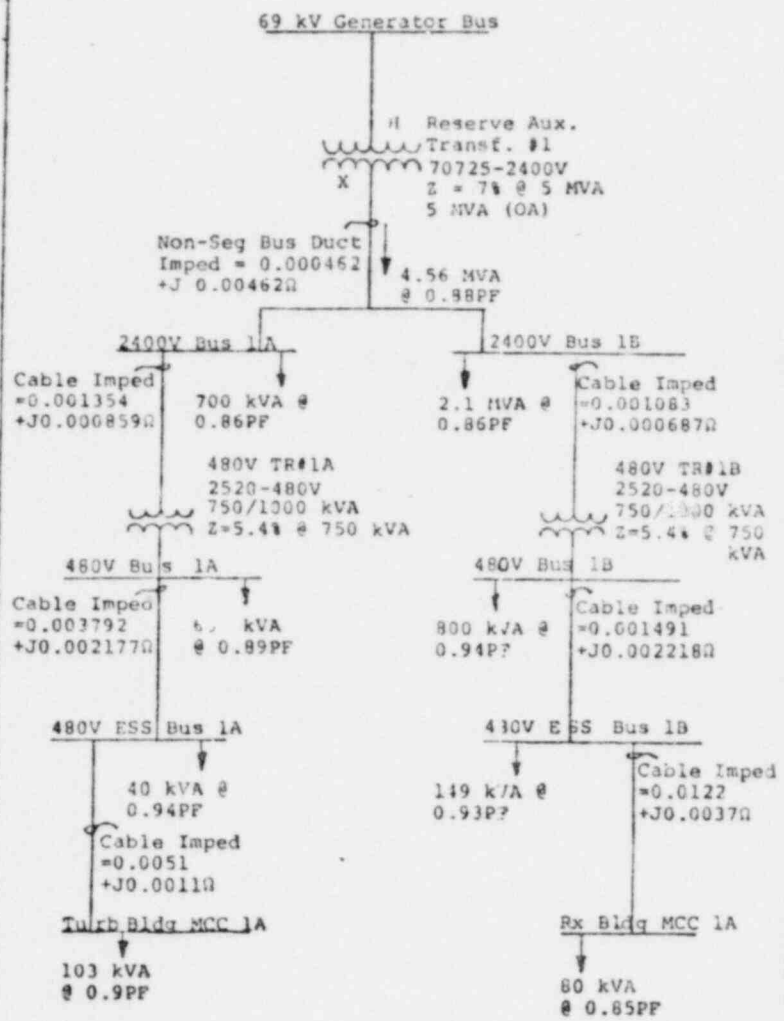
3. Motor Starting Voltage for the Case Analyzed
(Acceptable Voltage is 80V of Motor Rated Voltage (440V) i.e., 352V)

Bus	Motor Started	HP	Starting Voltage @ the Motor Terminal
480V ESS Bus 1A	Simult. start of ESS motors	122	378V
480V ESS Bus 1B	Simult. start of ESS motors	228	351V

LACBWR GENERATING UNIT
RAT CARRYING NORMAL AUX. LOAD (FOR 100% GENERATION) + EMERGENCY LOAD

RAT TAPS AT 70725-2400V

	No Load Volt	Full Load Volt	Motor Start Volt	HP
Bus Volt kV	73.2	70.8	70.8	
% of 69 kV	106.1	102.6	102.6	
Bus Volt	2484	2293	2220	350
% of 2400V	103.5	95.6	92.5	
% of 2300V	108.0	99.7	96.5	
Bus Volt	473	419	405	60
% of 480V	98.6	87.4	84.4	
% of 440V	107.5	95.2	92.2	
Bus Volt	473	418	389	122 (combined ESS Motor HP)
% of 480V	98.6	87.1	81.0	
% of 440V	107.5	95.0	88.5	
Bus Volt	473	416		
% of 480V	98.6	86.7		
% of 440V	107.5	94.5		



	No Load Volt	Full Load Volt	Motor Start Volt	HP
Bus Volt kV	73.2	70.8	70.8	
% of 69 kV	106.1	102.6	102.6	
Bus Volt	2484	2293	2018	1300
% of 2400V	103.5	95.6	84.1	
% of 2300V	108.0	99.7	87.8	
Bus Volt	473	415	391	100
% of 480V	98.6	86.6	81.4	
% of 440V	107.5	94.3	89.1	
Bus Volt	473	414	361	228 (Combined ESS Motor HP
% of 480V	98.6	86.3	75.2	
% of 440V	107.5	94.1	82.2	
Bus Volt	473	411		
% of 480V	98.6	85.6		
% of 440V	107.5	93.4		

ATTACHMENT 5

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April 1, 1980
6101-33

ATTACHMENT 6

VOLTAGE AT THE TERMINAL OF
SAFETY RELATED LOAD
LACBWR GENERATING UNIT
2½% VOLTAGE BUCK THROUGH RAT

1. Maximum Voltage Expected at the Motor Terminal
(Acceptable Voltage is 110% of Motor Rated Voltage)

Motors Connected To	Max. No-Load Voltage*	Maximum Acceptable Voltage @ the Motor Terminal
2400V Buses	2484V*	2530V
480V Buses	473V*	484V

2. Motor Running Voltage for the Case Analyzed
(Acceptable Voltage is 90% of Motor Rated Voltage (440V) i.e., 396V)

Bus	Voltage @ the Bus	Worst Drop In the Motor Feeder	Motor	Voltage @ Motor Term
480V ESS Bus 1A	418V	5V	Emergency Core Cool Pump 1A	413V
Turb Bldg MCC 1A	416V	4V	Any motor fed from turb bldg MCC 1A	412V
480V ESS Bus 1B	414V	6V	Emergency Core Cool Pump 1B	408V
Rx Bldg MCC 1A	411V	5V	Any motor fed from Rx bldg MCC 1A	406V

*The maximum expected voltage at the motor terminal will be lower than the maximum no-load voltage due to voltage drop in the transformer and the cable supplying the connected equipment.

3. Motor Starting Voltage for the Case Analyzed
(Acceptable Voltage is 80V of Motor Rated Voltage (440V)i.e., 352V)

Bus	Motor Started	HP	Starting Voltage @ the Motor Terminal
480V ESS Bus 1A	Simult. start of ESS motors	122	389V
480V ESS Bus 1B	Simult. start of ESS motors	228	361V

ATTACHMENT 7

EXISTING UNDERVOLTAGE RELAY SETTINGS

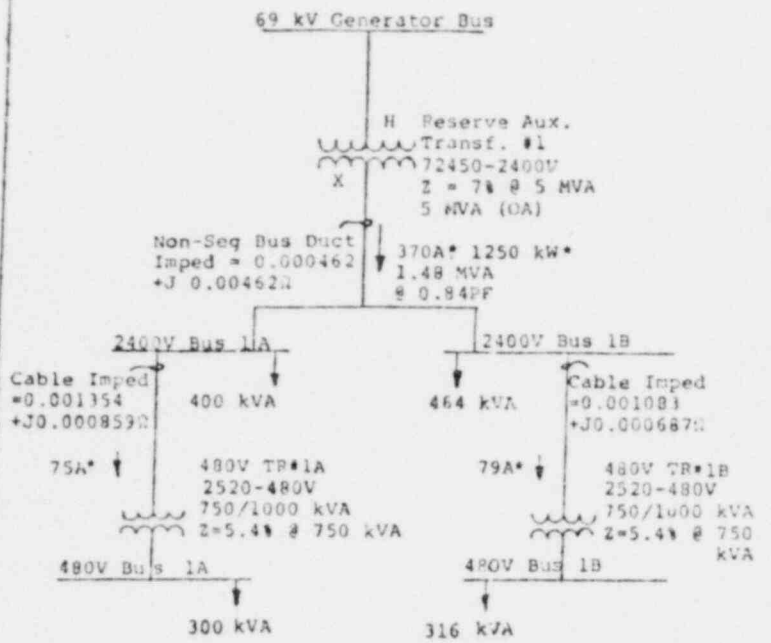
Undervoltage Relay At	Device No.	Voltage Setting	% Of Bus Voltage	Time Dial Setting	Function
2400V Bus 1A	227 1A	1860V	77.5	2 Sec	Trips all rod scram ckt #1, partial scram, CWP, Rx FCP, Alarm and seal in
2400V Bus 1B	227 1B	1860V	77.5	2 Sec	As above
480V Bus 1A	427 1A	220V	45.8	1 Sec	Trips main breaker at 480V swgr, Alarm and seal in
480V Bus 1B	427 1B	220V	45.8	1 Sec	As above
480V ESS Bus 1A	427 ESA	328/372*	68.3/77.5*	2.5/2*Sec	Starts diesel gen, trips DG test load bkr, trips feed from 480V bus
480V ESS Bus 1B	427 ESB	328/372*	68.3/77.5*	2.5/2*Sec	As above

Undervoltage Relay At	Device No.	Voltage Setting	% Of Bus Voltage	Time Dial Setting	Function
480V ESS Bus 1A	Second level* of UV protection for safety related loads	400V*	83.3*	9 Sec*	As above
480V ESS Bus 1B	Second level* of UV protection for safety related loads	400*	83.3*	9 Sec*	As above
480V Turb. Bldg. MCC 1A	427T	328V	68.3	1.5 Sec	Trips all rod scram ckt #1 and ckt #2 Alarm and seal in
480V Rx Bldg. MCC 1A	427R	220V	45.8	1.5 Sec	As above

*indicates planned action by Dairyland Power Cooperative.

LACBWR GENERATING UNIT
RAT CARRYING HOT SHUTDOWN LOAD

	Meter Reading	Calculated Value	Error	Justification
Bus Volt kV	* 72	72		
Bus Volt	*2310V	2348	1.6%	Metering Inaccuracy
Bus Volt	* 440V	440	0%	



	Meter Reading	Calculated Value	Error	Justification
Bus Volt kV	* 72	72		
Bus Volt	*2300	2348	2%	Metering Inaccuracy
Bus Volt	* 438	439	0.2%	

*indicates the meter reading.

ATTACHMENT 8