Attachment

Adequacy of Stacion Electric
Distribution System Voltages

Commonwealth Edison Company

Dresden Unit 1

February 1, 1980

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Dresden Unit 1

The NRC has required the licensees of power reactors to show that each plant's station auxiliary power system will provide adequate power to essential loads. Specifically, the licensee is asked to confirm the acceptability of the voltage conditions on the station electric distribution systems with regard to:

1. Potential overloading due to transfers of either safety or non-safety loads.

2. Adequacy of the offsite and the onsite distribution system to automatically start as well as operate all required safety loads.

Dresden Station Unit 1 has two possible sources of offsite power (see Figure 1 Attachment A). One is Reserve Auxiliary Transformer #12 (RAT-12) and the second is 34 KV Transformer #13. RAT-12 has the capacity to carry all the normal auxiliary power needs of Unit 1. 34 KV Transformer 13 has the capacity to carry all essential auxiliary power loads on Unit 1 except for the new Unit 1 HPCI loads.

There are two separate and complete HPCI systems being installed for Unit 1. Each HPCI system is driven from its own diesel generator set so that these loads are separated from either RAT-12 or 34 KV Transformer 13. This plant modification is being reviewed as part of the Dresden Unit 1 backfit program.

Attachment A provides an analysis of the Dresden Station Unit 1 auxiliary power system voltages for RAT-12 assuming the transformer is loaded with the maximum expected loading on the auxiliary power system, and for 34 KV Transformer 13 assuming the transformer is loaded with the maximum expected essential loads connected to 480 volt substations 14, 16, 116 and 117.

Attachment B provides a review of the electric power system to the requirements of GDC-17.

As indicated in Attachment A, the performance of the auxiliary power system at the 4 KV and 480 volt levels is adequate provided that the taps on RAT-12 are changed to provide a 2½% boost (i.e.: present tap 138.00 KV is changed to new tap 134.55 KV). This tap change will be made before Dresden Unit 1 is returned to service in June 1981.

A test was performed at Zion Station to verify the results of the computer program used to analyze the auxiliary power voltages. The results of that test were reported in a letter to W. Gammill from R.F. Janecek dated December 14, 1979. The same computer program was used to compute the Dresden 1 voltages as was used to compute the Zion voltages; therefore, we conclude that no further testing is necessary to verify the results of the Dresden Unit 1 voltage analysis.

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ATTACHMENT A

SARGENT & LUNDY
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CHICAGO

Project No. 6030-31
January 29, 1980

ADEQUACY OF STATION ELECTRICAL DISTRIBUTION SYSTEMS VOLTAGES

DRESDEN UNIT 1

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 auxiliary 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 auxiliary system at the Dresden Nuclear Station Unit 1 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.

II. OFFSITE POWER SUPPLY

The first offsite power at Dresden Unit 1 is provided from CECO 138 kV system (red bus) through transformer #12. The voltage at this high voltage bus varies from 133 to 142 kV. The short circuit level ranges from 1945 to 15000 MVA.

The second offsite power at Dresden Unit 1 is provided from CECO 34.5 kV line L7281 through transformer #13. The voltage at this high voltage line varies from 34.8 to 36.3 kV. The three phase symmetrical fault current at this line is 4900A at 34.5 kV.

The switchyard arrangement at Dresden Nuclear Station is shown on Figure 1.

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The station auxiliaries for the unit are served from six, 4.16 kV buses, four of which are designated for safety-related loads. The electrical distribution system at Dresden Nuclear Station is shown on Figure 2.

During normal operation, half the unit load is supplied from the unit auxiliary transformer #11 (UAT) and the other half from the reserve auxiliary transformer #12 (RAT). When the generator is not operation, as during start-up, shutdown, or unit trip, the loads fed from the UAT are transferred to the RAT. In the event voltage on both 4160V buses 11 and 12 drops to 25% of the rated voltage for 30 cycles, the feed breakers from transformers #11 and #12 to buses 11 and 12 open and the feed breaker from transformer #13 closes to bus 11. This transformer constitutes a second independent offsite auxiliary power source which is available to all essential auxiliaries (except for HPCI pumps) during abnormal operations.

III. LOADING ANALYSIS

The auxiliary system of Dresden Unit 1 is connected directly through its RAT (transformer #12) to 138 kV bus 3 (red). The auxiliary system of Dresden Unit 2 is connected directly through its RAT (transformer #22) to 138 kV bus 1 (blue). The tie breaker (104) between these two buses is normally open. The RATs of the two units are, therefore, electrically independent. The loading on one unit's auxiliary system will have no effect on the performance of the other unit's auxiliary system. Hence, the multi-unit analysis required by the guideline is not applicable in this case.

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.

The worst loading condition for transformer #12 operation exists when the unit experiences a reactor trip. 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, therefore, assumed to run from transformer #12.

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Upon completion of present modification work, the worst case loading on transformer #13 will occur when the transformer carries the loads connected to 480V substations 14, 16, 116, and 117. All other loads are tripped automatically upon a transfer to transformer #13. Administration procedures do not require any of the tripped loads to be reenergized.

Bus loadings reflecting the above operating conditions are shown on Table 1.

IV. 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% of equipment rated voltage and the minimum voltage to be limited to 90% of equipment 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 75% of motor rated voltage.

V. SYSTEM PERFORMANCE

Voltage analysis was made for transformer #12 and transformer #13 carrying their worst case loading.

The impedances of cable between the following buses were included in the evaluation:

1. 4160V Buses 11 and 112
2. 4160V Buses 12 and 110

The minimum calculated running voltages on the various buses for operation from transformers #12 and #13 are shown in Figures 3 and 4, respectively.

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Transformer #12 Operation

The results of voltage drop calculations shown in Figure 3 indicate that the voltages at the auxiliary buses are satisfactory when the present tap setting of 138.0 kV is reduced to 134.55 kV to provide a boost of 2½%. The 2½% voltage boost through the transformer #12 is acceptable as the no-load voltage at the motor terminals is limited to 110% of its rating with 142 kV voltage (maximum) at the 138 kV system (red). The no-load voltage on the auxiliary system buses are shown on Table 2. The no-load voltages at different levels are calculated by using the transformation ratio with the maximum voltage assumed at the switchyard source.

The minimum running voltage at the 4.16 kV buses is 3866V which is 92.9% of 4.16 kV or 96.6% of 4 kV. This allows enough margin to account for voltage drop in the motor feeder. A ½% drop in voltage is a typical value for a motor feeder cable at 4 kV level. In making the calculations, the minimum value of switchyard voltage and the maximum value of system impedance were assumed.

The starting bus voltage is also shown in Figure 3. The minimum starting voltage is 3577V (89.4% of 4000V) when a 1750 horsepower primary feed pump is started on bus 11 or 12. This value is well above the acceptable level.

Figure 3 also indicates that voltage at the 480V level is acceptable with unit substations set at the 4160V tap. The minimum running voltage at the 480V level is 426V (92.6% of 460V) at 480V motor control center 117 and allows for a 2.6% voltage drop in the feeder cable. A maximum voltage drop of 1% of 460V has been calculated in the cable between 480V motor control center and 460V motor terminal.

The running voltage at other 480V switchgear buses is 94.3% of 460V and has ample margin to account for the worst voltage drop in the feeder between a 480V switchgear and a 460V motor.

The running voltages at selected loads are shown in Table 3. These values do not include voltage drop in the cables from the bus to the load.

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Transformer #13 Operation

The results of voltage drop calculation shown in Figure 4 indicate that the voltages at the auxiliary buses are acceptable with the present high voltage tap setting of 34.4 kV. The maximum no-load voltage at the motor terminal is limited to 110% of its rating with this tap setting and with the maximum bus voltage of 36.3 kV. The no-load voltages on the auxiliary buses are shown on Table 2.

The minimum running voltage at 4.16 kV bus 11 is 4030V which is 96.9% of 4.16 kV or 100.75% of 4 kV. The minimum running voltage at the 480V level is 445V (96.7% of 460V or 92.7% of 480V). These minimum voltages are well above the minimum design criteria limits and have ample margin to account for the worst voltage drop in the motor feeder.

VI. UNDERVOLTAGE RELAYS

Undervoltage relays are provided for each ESF bus to transfer the ESF load to the onsite diesel generator in case offsite power is lost or degraded. The minimum voltage to transfer load to the ESF buses is 2929V or 73.0% of 4000V. Since the minimum expected voltage during normal motor starting operation (3577V) is well above the relay setting, transfer to the onsite power supply should not occur. The undervoltage relays incorporate sufficient time delay so that short circuits can be cleared without undervoltage relay operation.

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TABLE 1

BUS LOADINGS ASSUMED FOR OFFSITE POWER SUPPLY ANALYSIS

A. For Transformer #12 Operation

Bus	Load
4160V Bus 11 + 12	11.3 MVA
4160V ESF Bus 112 + 113	0.6 MVA
4160V ESF Bus 110 + 111	0.6 MVA
	12.5 MVA

B. For Transformer #13 Operation

Bus	Load
4160V Bus 11	1.5 MVA
4160V ESF Bus 112 + 113	0.6 MVA
	2.1 MVA

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TABLE 2

NO-LOAD VOLTAGES-TRANSFORMER #12 OPERATION

Bus	No-Load Volts	Percent of Equipment Rating
Switchyard	142,000	--
4.16 kV Buses	4,390	109.7
Unit Substations Fed From 4.16 kV	506.6	110.1

NO-LOAD VOLTAGES-TRANSFORMER #13 OPERATION

Bus	No-Load Volts	Percent of Equipment Rating
34.5 kV Line	36,300	--
4.16 kV Buses	4,390	109.7
Unit Substations Fed From 4.16 kV	506.6	110.1

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RUNNING VOLTAGES AT SELECTED LOADS

Load	HP	Rated Voltage (volts)	Running Volts	Percent of Motor Rated	Bus
For Transformer #12 Operation					
Reactor Recirc. Pump	650	4000	3869	96.7	11 + 12
Primary Feed Pump	1750	4000	3869	96.7	11 + 12
Emergency Primary Feed Pump	150	460	434	94.3	480V Swgr Bus 16
For Transformer #13 Operation					
Emergency Primary Feed Pump	150	460	447	97.2	480V Swgr Bus 16

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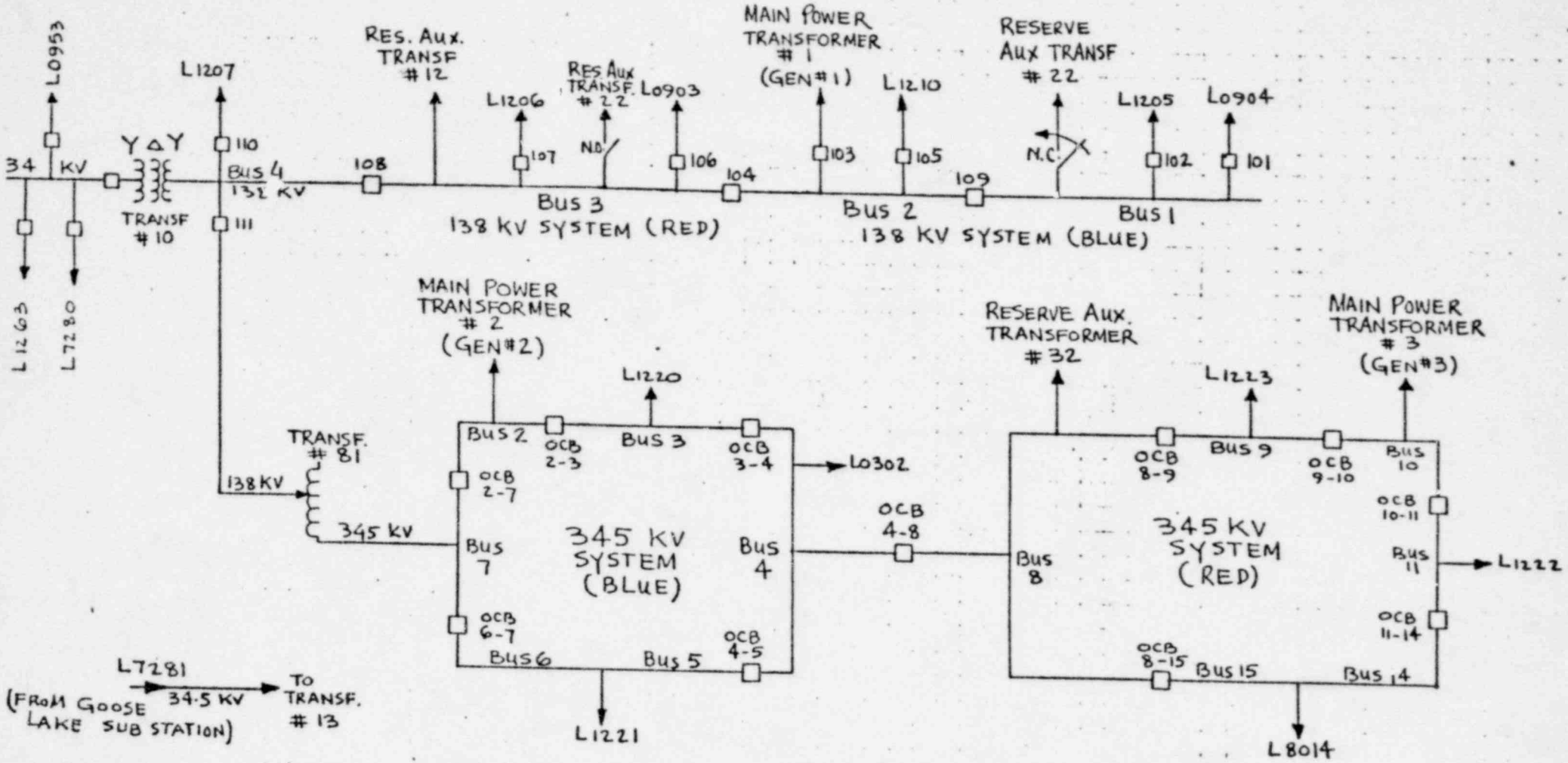

SWITCH YARD ARRANGEMENT

DRESDEN GENERATING STATION

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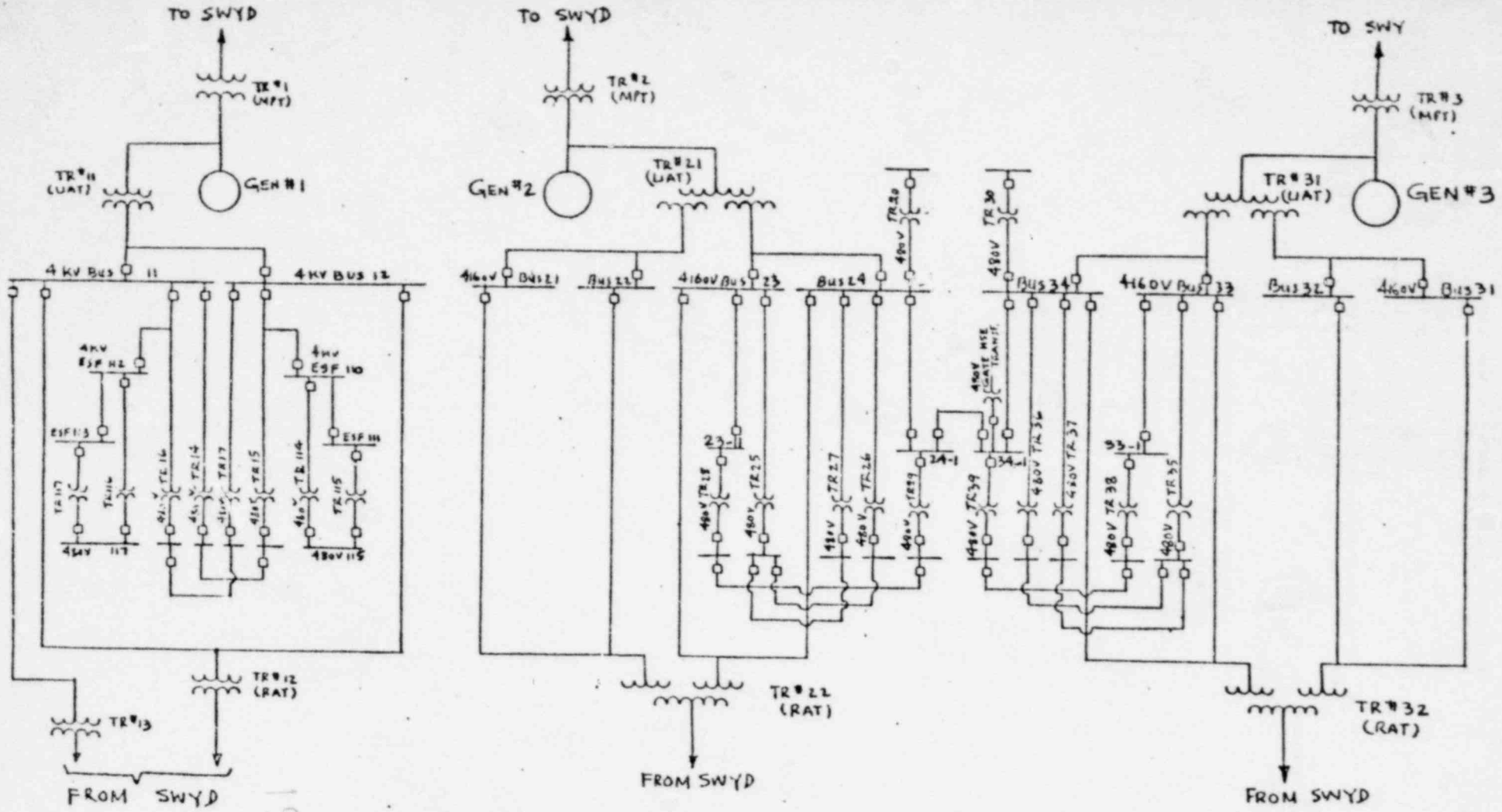
FIGURE 1



ELECTRICAL DISTRIBUTION SYSTEM

DRESDEN GENERATING STATION

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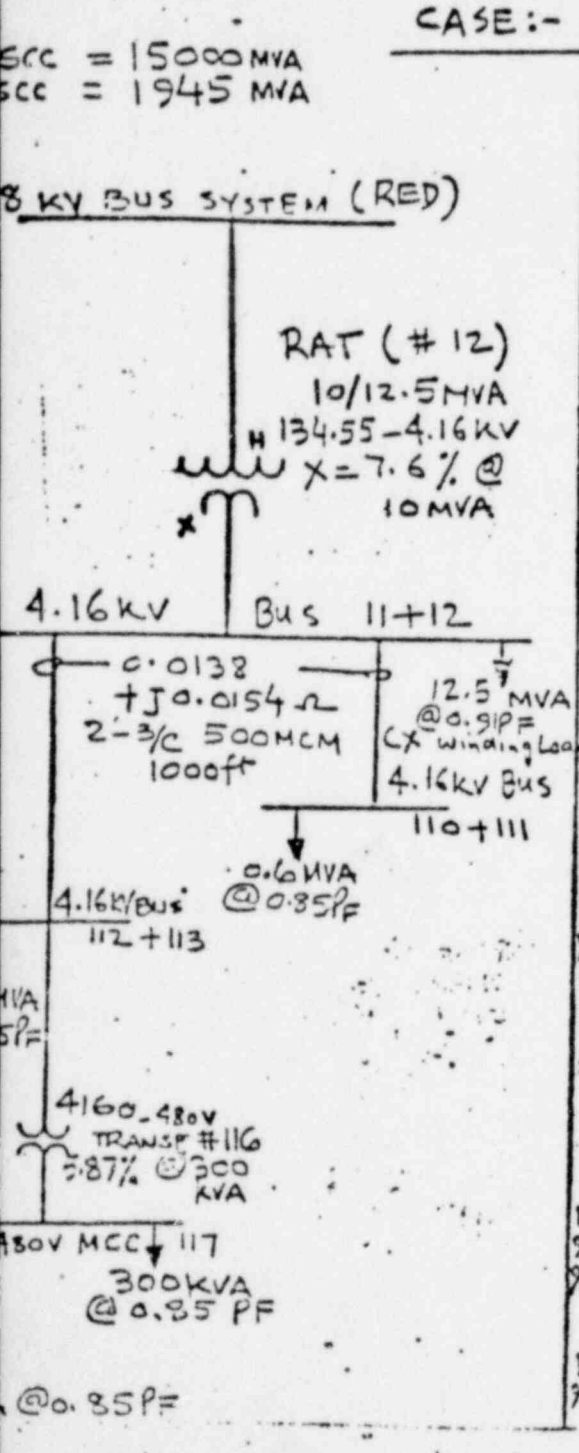
FIGURE 2

VOLTAGE REGULATION



CASE:- RAT #12 CARRYING Rx TRIP LOAD

	NO LOAD VOLT	FULL LOAD VOLT	MOTOR START VOLT	HP
Bus VOLT	142000	133000	133000	
% OF 138 KV	102.9	96.4	96.4	
Bus VOLT	4390	3869	3577	1750
% OF 4160 V	105.5	93.0	86.0	
% OF 4000 V	109.7	96.7	89.4	
Bus VOLT	4370	3866		
% OF 4160 V	105.5	92.9		
% OF 4000 V	109.7	96.6		
Bus VOLT	4390	3866		
% OF 4160 V	105.5	92.9		
% OF 4000 V	109.7	96.6		
Bus VOLT	506.6	426		
% OF 480 V	105.5	88.7		
% OF 460 V	110.1	92.6		
Bus VOLT	506.6	434		
% OF 430 V	105.5	90.4		
% OF 460 V	110.1	94.3		

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FIGURE 3