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Director, Office of Nuclear Reactor Regulation
Attention: J. A. Zwolinski, Chief
Operating Reactors Branch No. 5
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

Subject: Docket No. 50-206
Auxiliary Transformer Tap Settings Optimization
San Onofre Nuclear Generating Station
Unit 1

References: A. Letter, M. O. Medford, SCE, to J. A. Zwolinski, NRC, dated December 20, 1984

B. Letter, M. O. Medford, SCE, to J. A. Zwolinski, NRC dated March 6, 1985

Reference A confirmed SCE's commitment to perform a voltage monitoring program to evaluate the tap settings chosen as a result of the Auxiliary Tap Setting Optimization Study dated November 13, 1984. In accordance with Reference B, the results of the voltage monitoring program are provided as an enclosure to this letter.

Based upon the results of the voltage monitoring program, the current tap settings are acceptable for plant operation in Modes 1 through 4. However, as indicated in the enclosure, under certain loading arrangements on the 480V buses the minimum 480V bus voltage in Modes 1 through 3 could be lower than the minimum starting motor voltage of the saltwater cooling pumps when a safety injection signal is combined with low 230 kV bus voltage. Therefore, administrative controls will be implemented to avoid the undesirable 480V bus loadings described in the enclosure during operation in Modes 1 through 3.

During Modes 5 or 6, the minimum load condition for the 480V plant system, operation could result in an over-voltage condition on the 480V bus for certain 230 kV bus voltages. In order to avoid this condition, additional administrative controls will be implemented for Modes 5 and 6 operation to lower the 480V bus voltage. These administrative controls could include, but are not limited to changing transformer tap settings or alternate transformer loading.

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If as a result of maintenance operations in the future, the saltwater cooling pump motors are modified to eliminate the potential starting voltage problem, the tap settings could be revised and administrative controls deleted.

If you have any questions, please contact me.

Very truly yours,

M. D. Mosher

Enclosure

cc: F. R. Huey, USNRC Senior Resident Inspector

AUXILIARY TRANSFORMER TAP SETTINGS VERIFICATION OF OPTIMIZATION STUDY WITH MONITORING PROGRAM SAN ONOFRE UNIT 1

I. INTRODUCTION

In order to verify the adequacy of the present auxiliary transformer tap settings resulting from the Auxiliary Transformer Tap Settings Optimization Study for San Onofre Unit 1, dated November 13, 1984, a voltage monitoring program was conducted on the Unit 1 auxiliary system. This report presents the results of the voltage monitoring program.

II. DISCUSSION

A. Monitoring Program

The monitoring program was conducted on the Unit 1 auxiliary system from November 1, 1984 to February 28, 1985. As indicated by Figure 1 strip chart recorders were installed to monitor the voltages of the 230 kV bus, 4.16 kV buses 1C and 2C, and 480V buses 1, 2, and 3, and also the power flows on the feeders serving these buses (kw, kvar, and Amps). Ampere loads of MCCs 1, 1A, 2, 2A, and 3, and the status of all loads were also monitored.

The program monitored all operating modes except Mode 6 (Refueling), including two start-ups and two SIS (Safety Injection Signal) tests.

B. Analysis of Results

The results of the monitoring program were analyzed in detail as a revision of the Auxiliary Transformer Tap Settings Optimization Study, San Onofre Unit 1.

The results were analyzed using the voltage criteria indicated by Reference 1 and as shown by Table 1. To evaluate the adequacy of the tap settings the most severe cases were extrapolated with computer simulations to obtain the limiting conditions indicated in Reference 1, using a minimum of 217.8 kV and a maximum of 240 kV for the 230 kV bus voltage, and, if needed, changing the load distribution to obtain the most extreme voltages. The major results are discussed in the following paragraphs.

1. Recorded Auxiliary System Voltages

All auxiliary system voltages, recorded under all conditions during the monitoring program, were within the voltage criteria shown in Table 1.

2. Ranges of Recorded 230kV Bus Voltages

Contrary to the results of studies of the 230 kV transmission system, indicated in Reference 1, the 230 kV bus voltage seems to be independent of the number of generating units in operation as shown in Figure 2. In particular, during 54 days of operation with both Units 1 and 3, the mean 230 kV bus voltage was only 224 kV with a maximum of 228.5 kV compared to a voltage of 231 kV which was expected with 2 or 3 units in operation.

3. Minimum Voltages

The minimum momentary voltages occurred during the SIS test (at time T=0 and T=11 sec of the SIS sequence), as predicted by the optimization study in Reference 1.

Extrapolation of the data collected during the monitoring program demonstrated that the minimum voltages meet the voltage criteria of Table 1 except for the following cases:

a. Minimum Momentary Bus Voltages (Starting Motors)

As shown by Figure 4, with the present tap settings (identified as "1") the minimum starting motor voltage of the saltwater cooling pump 480V motors (at time T=0 in SIS sequence), could be lower than the minimum starting voltage of 384V (80% of the 480V name plate rating) for the following cases:

i) The simultaneous start of both safety injection pumps from the 4.16 kV buses 1C and 2C, component cooling pump C from 480V bus 3, and component cooling pump A and saltwater cooling pump A from 480V bus 1 during an SIS would result in a starting voltage for saltwater cooling pump A which is less than the 80% criterion, if the 230 kV bus voltage is less than 236 kV (see Figure 4).

ii) The simultaneous start of both safety injection pumps from the 4.16 kV buses 1C and 2C, component cooling pump C from 480V bus 3, and saltwater cooling pump B and component cooling pump B from 480V bus 2 during an SIS would result in a starting voltage for saltwater cooling pump B which is less than the 80% criterion, if the 230 kV bus voltage is less than 225 kV (see Figure 4).

The undervoltage problem is more severe for saltwater cooling pump A due to the physical configuration of the plant (the distance from SWC Pump A to 480V bus 1 is almost twice the distance from SWC Pump B to bus 2.)

b. Minimum Continuous Bus Voltages

As shown by Figure 5, with the present tap settings (identified as "1") the minimum continuous 480V bus voltage could be low for both saltwater cooling pumps A&B 480V motors (less than the 90% criterion), if the 230 kV bus voltage is less than 221 kV. The lower limit of 93%, as shown on Figure 5, is representative of the 90% criterion and a 3% cable voltage drop. For all other motors powered by the 480V bus, the calculated voltages are higher than the minimum continuous bus voltages.

c. Maximum Voltages

After extrapolation, the maximum continuous voltages are in excess of the values expected in the optimization study of Reference 1. As indicated by Figure 3, under minimum load conditions in Modes 5 or 6, the 480V bus voltages could exceed the limit of 484V (110% of 440V) if the 230 kV bus voltage is more than 222 kV, and the 4160V bus voltage could exceed 4576V (110% of 4160V) if the 230 kV bus voltage is more than 236 kV.

III. CORRECTIVE ACTION

The results of the voltage monitoring program reveal that under certain combinations of plant grid voltage and operating conditions, both over and under voltage conditions can exist at motors fed from 480V buses. Therefore, to eliminate the possible over and under voltage problems, the following corrective actions will be taken.

1. Minimum Starting Voltage, Saltwater Cooling Pumps

To eliminate the possible undervoltage problems for the saltwater cooling pumps during an SIS, administrative controls will be implemented to avoid the undesirable bus loading described above. The administrative controls will avoid loading of both a saltwater cooling pump and component cooling pump to the same 480V bus during Modes 1 through 3 operation. During Modes 4 through 6, the automatic safety injection sequencer is blocked.

2. Minimum Continuous Bus Voltage, Saltwater Cooling Pumps

The minimum continuous voltage problem for the saltwater cooling pumps identified above is not considered to be a significant safety concern for the following reasons:

a) For the minimum 230 kV voltage of 217.8 kV the 480V bus voltage would be 437V (91% of 480V), 2% below the minimum continuous voltage criterion (see Figure 5).

b) 221 kV was the minimum 230 kV voltage recorded during the monitoring program, with none of the San Onofre Units on-line (see Figure 2).

c) 217.8 kV is the minimum 230 kV bus voltage resulting from a highly unlikely worst postulated failure of the 230 kV system.

Based on the above discussion, no action is required for the minimum continuous bus voltage conditions.

3. Maximum Voltages, Modes 5 and 6

To eliminate the potential over-voltage conditions which could occur during Modes 5 and 6 operation, administrative controls will be implemented to manage the 480V bus voltage. The administrative controls will require the 480V bus voltage to be maintained within the operating limits of the equipment so that excessive over-voltage conditions are avoided by tap setting changes or alternate transformer loading. Examples of the possible administrative controls are:

a) changing the tap settings on the service transformers
b) changing the tap setting on the auxiliary transformer C
c) transferring 4.16 kV buses 1C and 2C from auxiliary transformer C to transformers A and B

For planned outages of 7 days or greater, the administrative controls will be placed into effect at the beginning of the outage. During spurious unplanned outages, the administrative controls will be placed into effect within 7 days of entering and maintaining Mode 5 or 6. The administrative controls will provide for optimum 480V system voltage for both the maximum and minimum 230 kV system conditions.

4. Modes 5 and 6 System Operating Bulletin

The administrative controls for Modes 5 and 6 will reduce the maximum continuous 480V bus voltage. However, the maximum voltage may exceed the limiting voltage of 484V (110% of 440V) if the 230 kV bus voltage exceeds 230 kV in Modes 5 and 6 (see Figure 3). Therefore, Edison System Operations will implement a system operating bulletin to maintain the 230 kV bus voltage at 230 kV or less during Unit 1 Modes 5 and 6 operation when San Onofre Unit 2 or 3 is on line and as system demands allow.

It is recognized that the theoretically possible maximum 230 kV bus voltage is 240 kV, but this is an extreme limit and considered unlikely. However, if high 230 kV bus voltages do occur, it would be for short periods of time and would not significantly affect the electrical equipment fed from the 480V buses.

CONCLUSION

The present tap settings are acceptable for plant operation in Modes 1 through 4 and do not represent a significant safety concern. The potential undervoltage conditions for the saltwater cooling pumps will be eliminated through administrative control of the 480V bus loading. In Modes 5 and 6 the administrative controls and system operating bulletin will eliminate the potential over-voltage conditions on the 480V equipment.

REFERENCE

1. Letter to J. A. Zwolinski, NRC, from M. O. Medford, SCE, dated December 20, 1984.

DA:5293F

Table 1

VOLTAGE LIMITS CRITERIA
TRANSFORMER TAPS SETTINGS OPTIMIZATION
SAN ONOFRE UNIT 1 AUXILIARY SYSTEM

Voltage Limits	440V Motors %	440V Motors Volts	460V Motors %	460V Motors Volts	480V Motors %	480V Motors Volts	4160V Motors %	4160V Motors Volts
1. Bus Voltage Continuous:								
Maximum	110	484	110	506	110	528	110	4,576
Minimum	93	409	93	428	93	446	93	3,869
Momentary								
(Running Motors)	80	352 (for up to 60 sec)	80	368 (for up to 60 sec)	80	384 (for up to 60 sec)	75	3,120 (for up to 15 sec)
2. Motor Voltage Momentary								
(Starting Motor)	80	352	85	391	80	384	75	3,120

The minimum continuous bus voltage limit of 93% and momentary bus voltage limits of 80% and 75% are conservative. They were used to reduce the amount of calculations by avoiding the calculation of the voltage at every terminal. The actual limits are 90%, 75% and 70%, respectively at the motor terminals with a conservative design limit voltage drop between the bus and the motor terminals of 3% for the continuous voltage limit and 5% for the momentary voltage limits.

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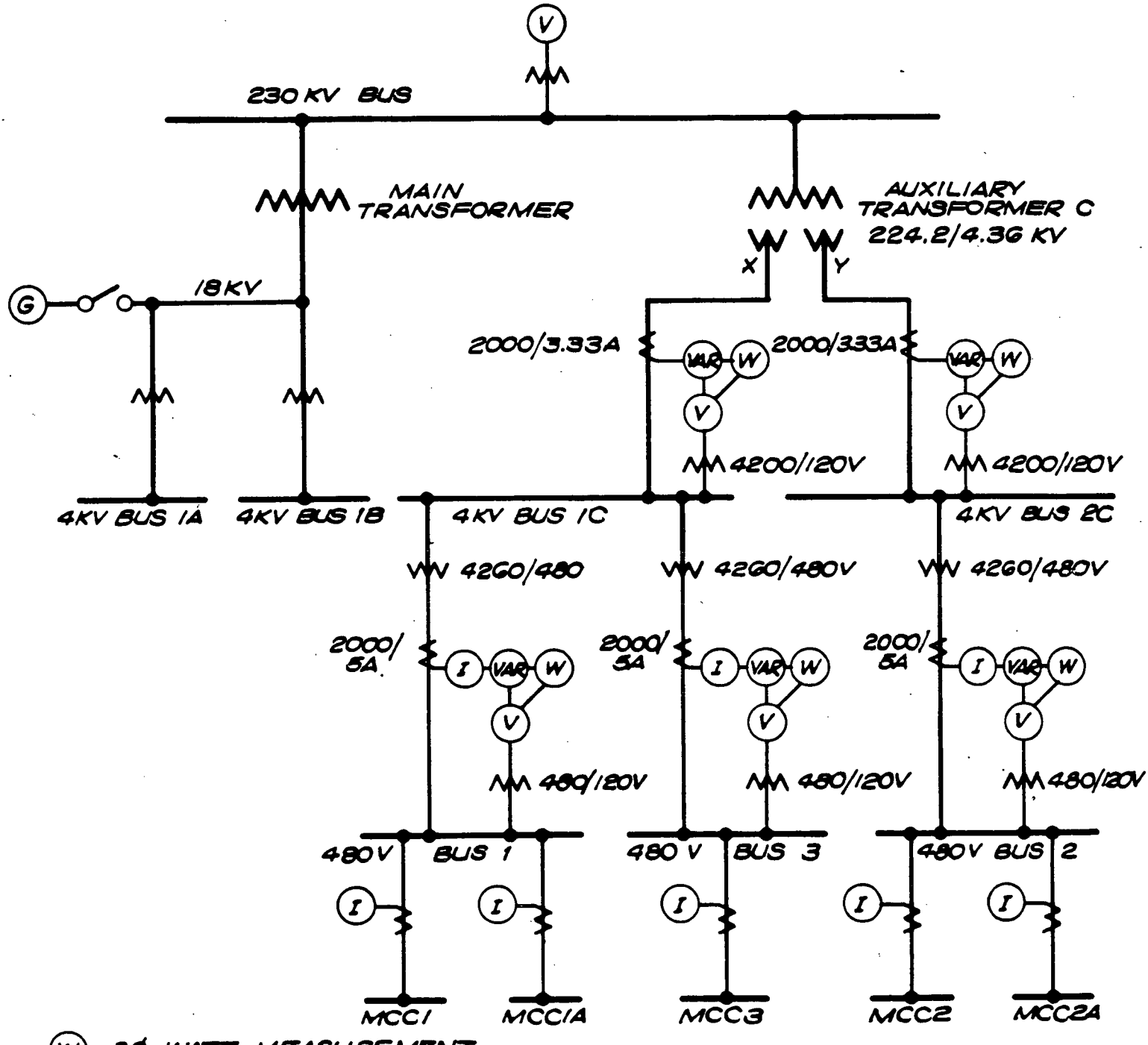
FIGURE 1

SAN ONOFRE UNIT 1
AUXILIARY SYSTEM MONITORING PROGRAM
INSTRUMENT ONE LINE DIAGRAM



(W) 3Ø WATT MEASUREMENT

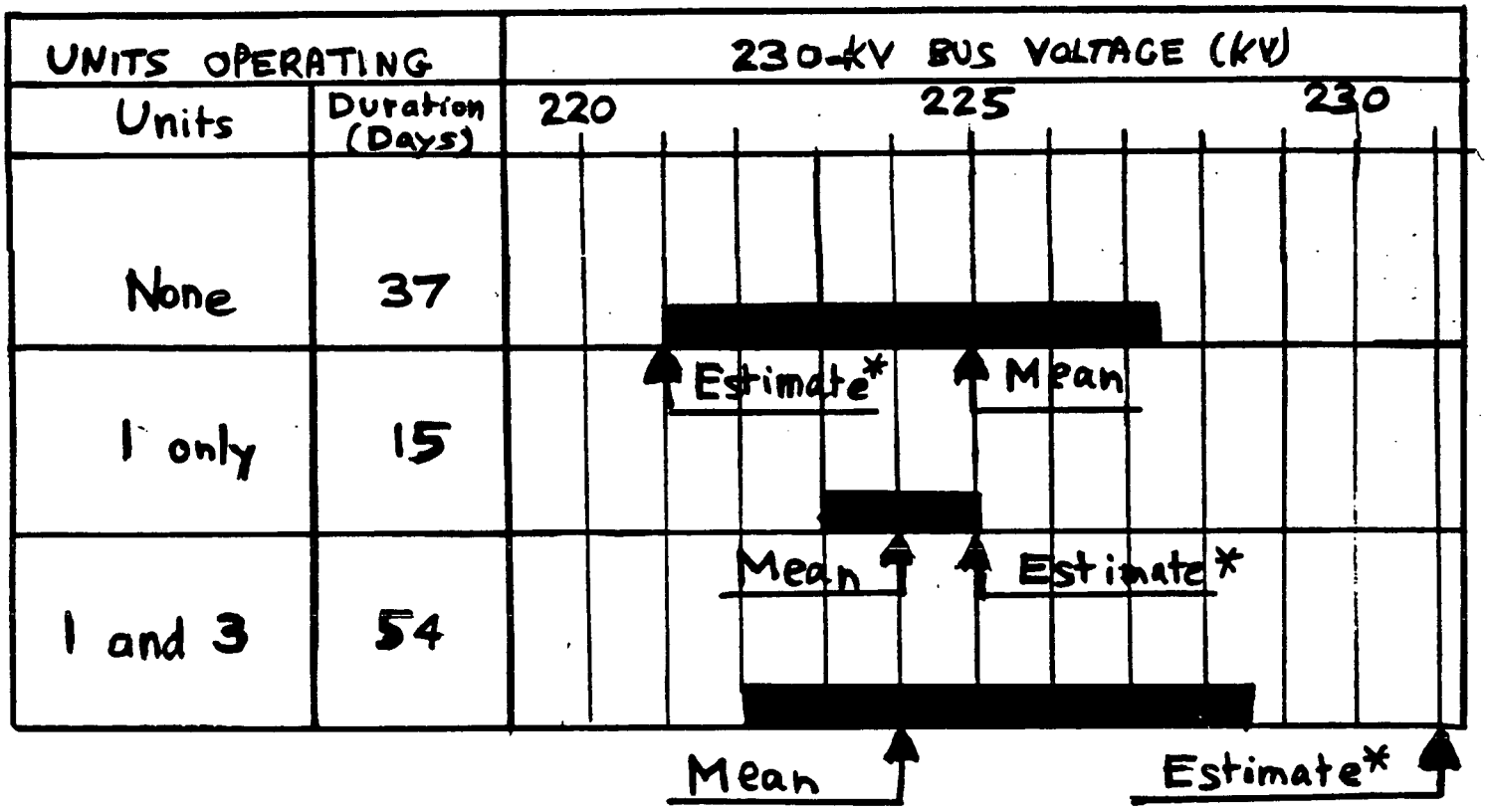
(VAR) 3Ø VAR MEASUREMENT

(V) AØ BØ VOLTAGE MEASUREMENT

(I) BØ CURRENT MEASUREMENT

FIGURE 2

RANGES OF VOLTAGES
RECORDED ON THE SAN ONOFRE 230-kV BUS
DURING VOLTAGE MONITORING PROGRAM
NOVEMBER 1, 1984 – FEBRUARY 28, 1985



* NOTE: Estimate Based on Transmission Studies of Reference 1.

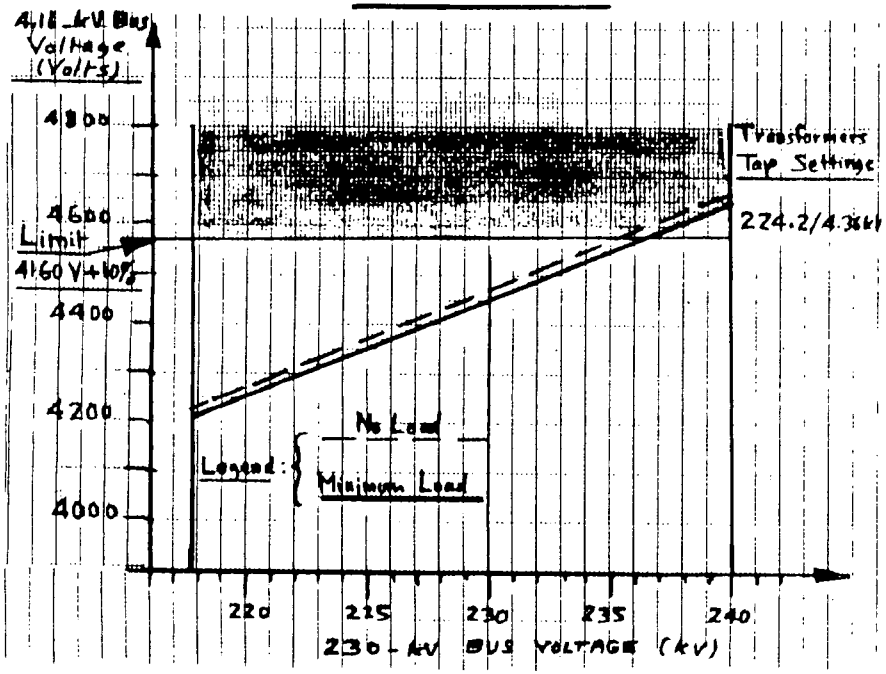
Figure 3

SAN ONOFRE UNIT 1 AUXILIARY SYSTEM
MAXIMUM CONTINUOUS BUS VOLTAGES

BASED ON EXTRAPOLATION OF FEBRUARY 18, 1985 MODE 5 CONDITIONS
VOLTAGE AND LOAD MONITORING PROGRAM

Sensitivity to 230-kV Bus Voltage
And to Transformer Tap Settings

4.16-kV BUSES



480-V BUSES

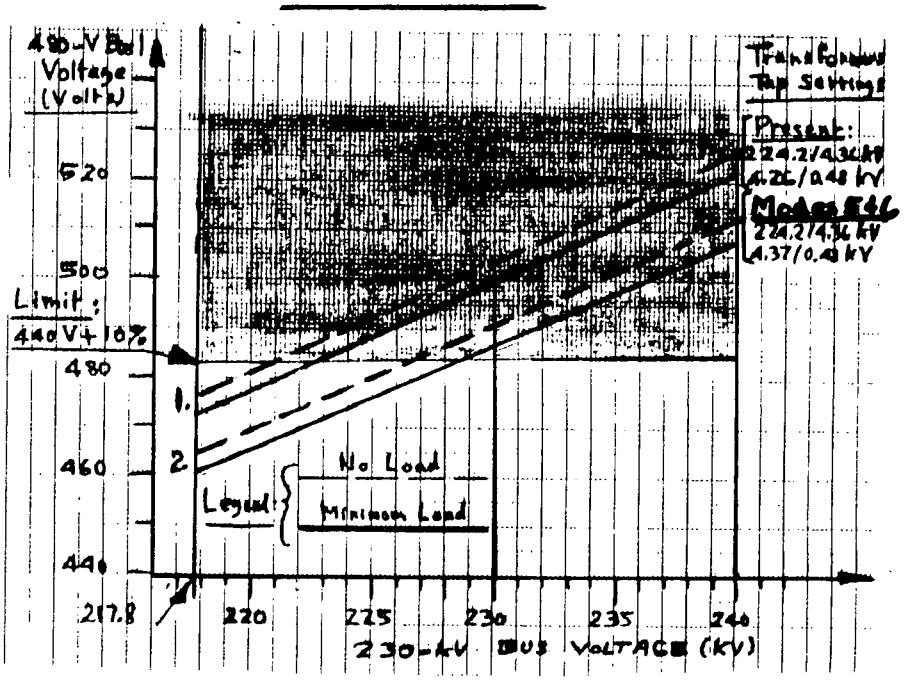


Figure 4

SAN ONOFRE UNIT 1 AUXILIARY SYSTEM

MINIMUM MOMENTARY STARTING MOTOR VOLTAGES

BASED ON EXTRAPOLATION OF NOV. 13, 1984 SIS TEST VOLTAGE AND LOAD MONITORING

Sensitivity to 230-kV Bus Voltage and to Transformer Tap Settings

Start of both 4.16 kV Safety Injection Pumps With Start of Component Cooling Water Pumps A or B, and C and Saltwater Cooling Pump A or B at T = 0 in the SIS Sequence, respectively from Bus 1 or 2

Transformer Tap Settings:

1. Present: 224.2/4.36 kV
   4.26/0.48 kV
2. Mode 516: 224.2/4.36 kV
   4.37/0.48 kV

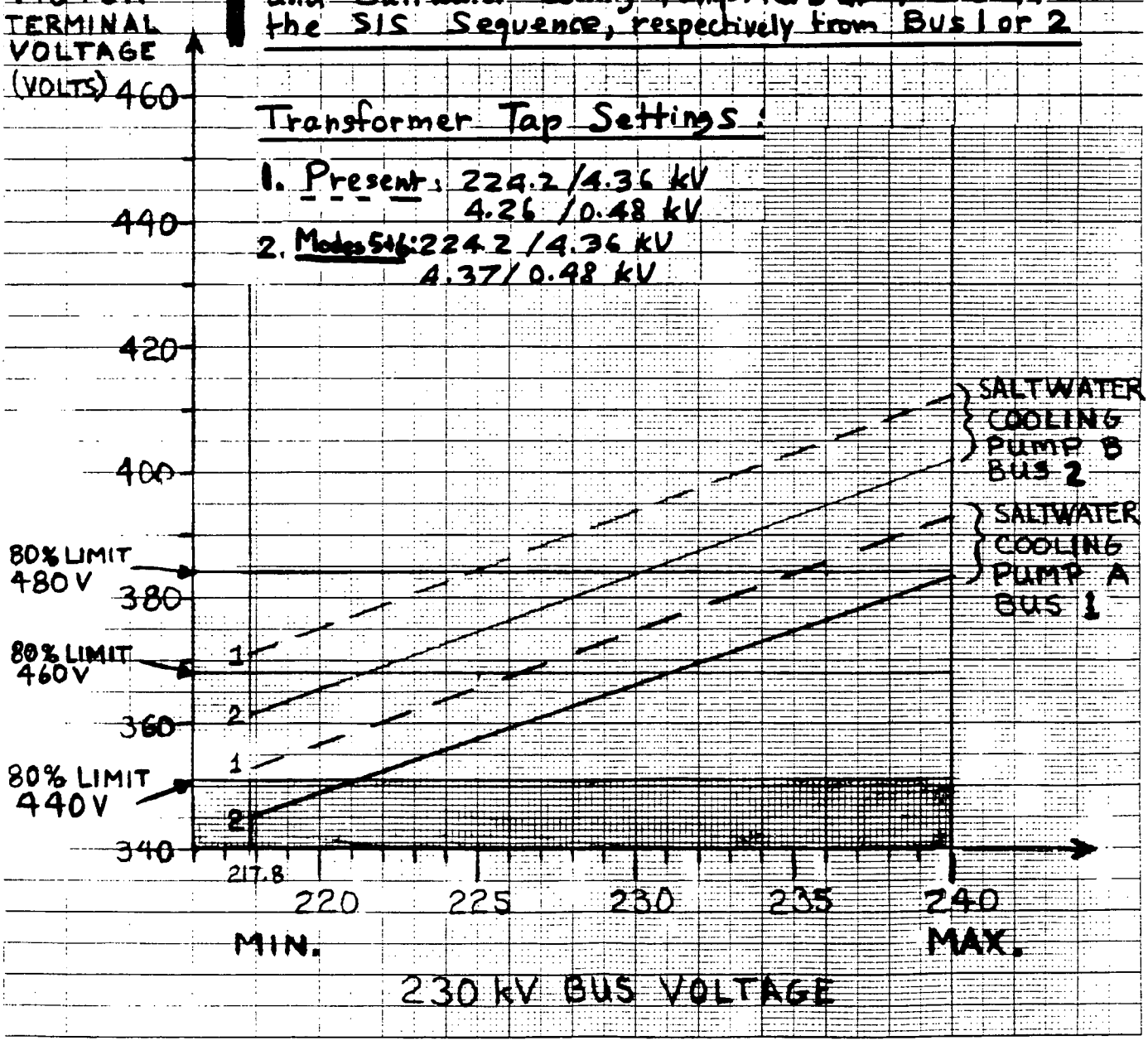


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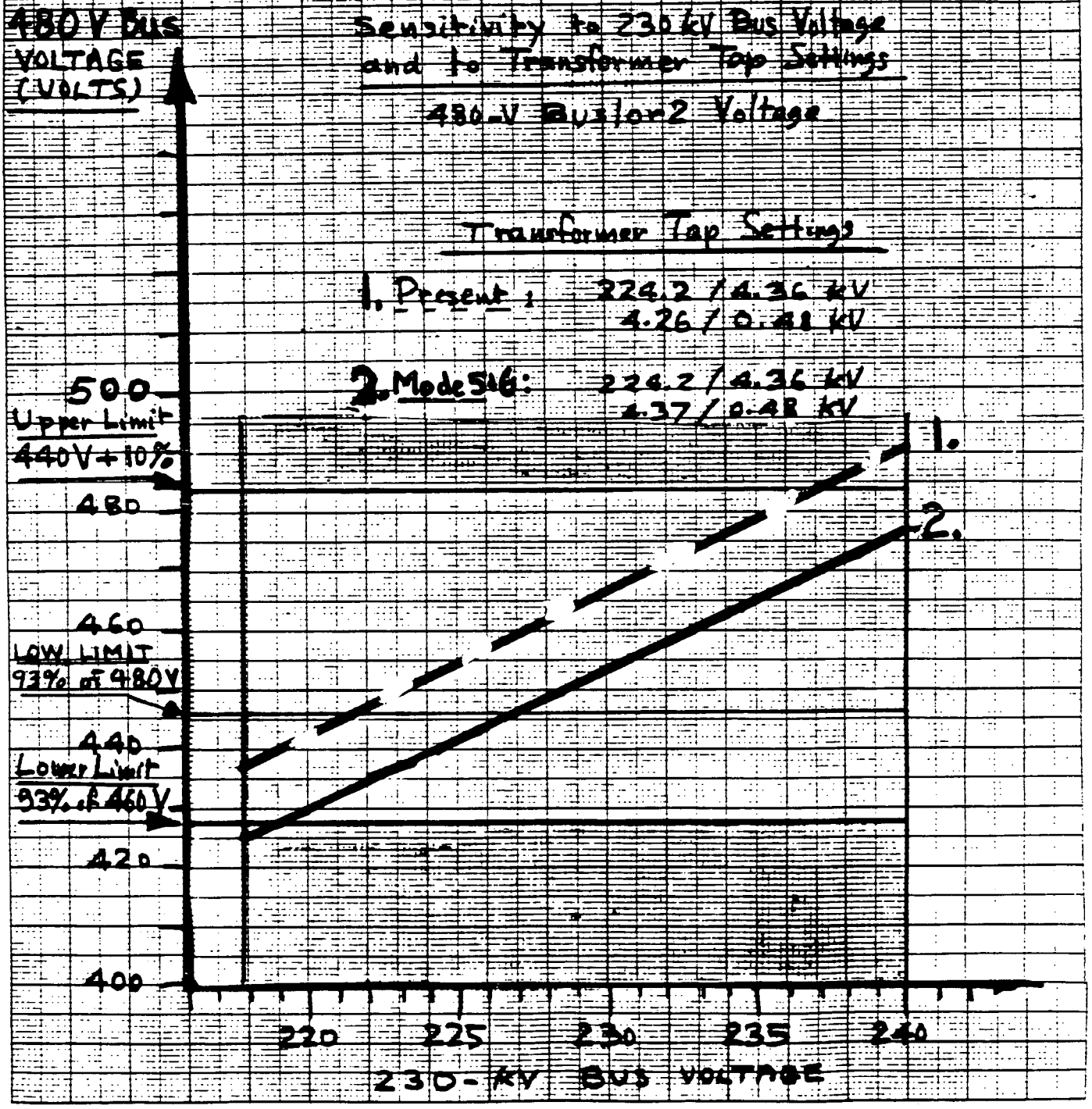
Figure 5

SAN ONOFRE UNIT 1 AUXILIARY SYSTEM MINIMUM CONTINUOUS BUS VOLTAGE

BASED ON EXTRAPOLATION OF JAN 7, 1985
MODE 1 - VOLTAGE AND LOAD MONITORING



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