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June 10, 1991

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Gentlemen:

Subject: **Docket No. 50-206**
Adequacy of Station Voltages
San Onofre Nuclear Generating Station, Unit 1

References:

1) Letter dated August 3, 1990, from SCE to NRC, Adequacy of Station Voltages

2) Letter dated August 8, 1979, from NRC to All Power Reactor Licensees, Adequacy of Station Electric Distribution Systems Voltages

3) Letter dated March 28, 1991, from SCE to NRC, Adequacy of Station Voltages

4) Letter dated April 19, 1982, from SCE to NRC, Degraded Grid Voltage

5) Letter dated January 2, 1990, from NRC to SCE, Order Confirming Licensee Commitments on Full-Term Operating License Open Items

6) Letter dated June 19, 1986, from SCE to NRC, Auxiliary Transformer Tap Settings Optimization

This letter presents a reanalysis of the station electric distribution system voltages for San Onofre Unit 1. This reanalysis takes into account significant modifications that were recently completed on the 480V electric system and it supersedes the analysis submitted to you during the 1980s. This new information will enable you to complete your review of Multiplant Action Item No. B-48, Adequacy of Station Electrical Distribution Voltages.

BACKGROUND

Reference 1 identified our previous submittals to you concerning the adequacy of station voltages. These submittals were the result of an NRC generic letter (Reference 2). Based on these submittals, the NRC issued a safety evaluation on July 29, 1983, concluding that the SONGS 1 electric distribution system is adequately designed with respect to the issues delineated in certain transformer tap settings in order to maintain proper operating voltages and to initiate a voltage monitoring program to verify the results of this optimization. In 1985 we completed these two commitments.

During the last (Cycle 11) refueling outage, we made significant modifications to our 480V electric system. These modifications included the addition of a fourth bus to this system and a redistribution of the electrical loads connected to the buses. While these modifications were under consideration, our NRC project manager at that time, Mr. C. M. Trammell, requested that our previous submittals be updated to reflect the new modifications. He also indicated that the NRC requires this information to complete its review of Multiplant Action Item No. B-48. By Reference 3, we committed to submit the results of our reanalysis by June 1, 1991.

RESULTS OF REANALYSIS

The results of our voltage reanalysis are presented in the enclosed report titled, "Adequacy of Electrical Auxiliary System Voltage." This report evaluates the adequacy of our modified electric distribution system in light of the same guidelines used for the previous analysis, which are contained in Reference 2. It concludes that our offsite power system and onsite power system are of sufficient capacity and capability to start and operate all the required safety loads within their required voltage ratings in the event of a transient or accident without manual load shedding. In addition, the results of our voltage reanalysis demonstrate that the onsite power system is adequate to start and operate all the required safety and non-safety loads under all modes of normal plant operations.

On May 20, 1991, we discussed our reanalysis report with the NRC staff. Following the staff's recommendation, we have clarified that the scope of the reanalysis is limited to the 4160V and 480V systems, including 120V AC control circuits for Motor Control Center loads. Also as a result of our discussion, we have reviewed the reanalysis against the applicable requirements (Section B, Paragraph 3) of Branch Technical Position (BTP) PSB-1. This position is stated in Appendix 8-A of the Standard Review Plan. We have determined that the reanalysis conforms to Section B, Paragraph 3 of PSB-1. We have also determined that the remainder of PSB-1 does not apply to the specific issue addressed in this reanalysis.

During our discussion, the NRC staff also pointed out that a separate analysis is required for each connection of the onsite distribution system to the offsite power system. At SONGS 1, there exists only one immediately available connection and it has been analyzed in the enclosed report. The need to enhance the existing undervoltage protection scheme was also discussed. By Reference 4, SCE has already agreed to do this and has submitted a conceptual design for this purpose. In accordance with Reference 5, the modifications required by this design change will be implemented during the Cycle 12 refueling outage.

CONTINUATION OF PREVIOUS ADMINISTRATIVE CONTROLS

As a result of our previous analysis of station voltages, we have been implementing administrative controls for Modes 5 and 6 operation to prevent potential overvoltage conditions at reduced electrical load (see Reference 6). We plan to continue this practice in the future for Modes 5 and 6 operation. This subject is further covered under Guideline No. 11 in the enclosed report.

CONCLUSION

We have done a reanalysis of the 4160V and 480V electrical systems to assess the adequacy of the voltage levels during normal and accident conditions following recent modifications to the 480V system. The results demonstrate acceptable system voltages under all modes of plant operation.

If you have any questions, please call me.

Very truly yours,

Enclosure

cc: George Kalman, NRC Senior Project Manager, San Onofre Unit 1
J. O. Bradfute, NRC Project Manager, San Onofre Unit 1
J. B. Martin, Regional Administrator, NRC Region V
C. W. Caldwell, NRC Senior Resident Inspector, San Onofre Units 1, 2&3

ENCLOSURE

ADEQUACY OF ELECTRICAL AUXILIARY SYSTEM VOLTAGE SAN ONOFRE NUCLEAR GENERATING STATION UNIT 1

A. PURPOSE:

The purpose of this report is to provide the NRC with new information required by Multi-Plant Action Item B-48 as it applies to San Onofre, Unit 1. The adequacy of electric distribution system voltages to operate safety related loads within the equipment voltage ratings under adverse conditions is being evaluated generically under NRC Multi-Plant Action (MPA) Item No. B-48.

In a generic letter dated August 8, 1979 (Reference 1), the NRC required all nuclear reactor licensees to review the electric power system of their respective nuclear power plants to determine analytically if the offsite power system and the onsite power system is of sufficient capacity and capability to automatically start as well as operate all the required safety loads within their required voltage ratings in the event of a transient or accident without manual load shedding.

This report provides new information in regard to the adequacy of electric distribution system voltages in San Onofre Unit 1. The new information is based on the voltage analyses performed to reverify the adequacy of system voltages, which is required to support the modifications that were implemented in the 480-V system during Cycle XI refueling outage. These modifications reconfigured the Unit 1 distribution system from three 480-V bus configuration (Figure 1) to four 480-V bus configuration (Figure 2). The results of these voltage analyses were evaluated in accordance with the NRC staff's position and guidelines contained in the generic letter. These evaluations are addressed in Section C of this report.

The modified electric distribution system at San Onofre Unit 1 consists of two redundant power trains, A and B, supplied from the 220-kV offsite network via Auxiliary Transformer C. Train A includes the 4-kV Bus 1C which supplies power to the 480-V Buses 1 & 3, and Train B includes the 4-kV Bus 2C which supplies power to the 480-V Buses 2 and 4. The distribution system can also be supplied from the offsite network via Main Transformer and Auxiliary Transformers A and B. These transformers normally supply the 4-kV Buses 1A and 1B.

B. EVALUATION CRITERIA:

The new voltage analyses are based on the new four 480-V bus configuration. Two types of voltage analyses were developed: the STEADY STATE VOLTAGE ANALYSIS which analyzed the system voltages during normal plant operation and the DYNAMIC (MULTIPLE MOTOR START) VOLTAGE ANALYSIS which analyzed the system voltages under accident condition.

These analyses consider only the voltages in the 4-kV and 480-V systems, including the 120-V control circuits for MCC loads. Voltage analysis for the 120-V AC vital buses is not included for the following reasons:

1. The 120-V AC Vital Buses are normally aligned to their respective inverters which are supplied from the 125-V DC systems. In this alignment, these Vital Buses are not affected by degraded voltage in the switchyard or in the auxiliary power system.

2. The alternate power supplies for Vital Buses are the 480-V MCCs. Should a Vital Bus be aligned to its alternate power supply during Modes 1 through 6 plant operation, the bus is declared inoperable and appropriate Technical Specification Action Statement is invoked.

3. Critical instruments credited for accident mitigation are powered from regulated power supplies. Should a Vital Bus transfer to its alternate power supply during accident mitigation, the critical loads would not be adversely affected by the anticipated variations in Vital Bus voltage, resulting from the alternate alignment. Loss of voltage on a Vital Bus when it is aligned to its alternate power supply would be annunciated in the control room and would require operator action to restore power to that bus.

STEADY STATE VOLTAGE ANALYSIS CRITERIA:

The steady state voltage conditions during normal modes of plant operations are analyzed considering the worst case bus alignments and bus loadings that are permissible in each mode of plant operation. Voltage Regulation (Load Flow) calculations were performed for each case based on the voltage limit of the most limiting motor load considered running for the case being analyzed. For each running motor load, a voltage limit of $\pm 10\%$ of motor rated voltage was considered at the motor terminals, based on the ANSI Standard C50.41.

DYNAMIC VOLTAGE ANALYSIS CRITERIA:

The worst case voltage during accident condition occurs immediately following safety injection (SIS) actuation, when simultaneous starting of safety related and some non-safety related loads occurs. The analyses for this condition consider the following criteria:

1. The 220-kV system voltage at San Onofre switchyard was 217.8 kV.

2. All auxiliary loads were supplied from the Auxiliary Transformer C, with maximum loading postulated for the train under consideration.

3. Maximum starting loads and coincident running loads were considered.

4. Startup bus alignment, which results in the worst case post accident bus loading condition, was postulated.

C. TECHNICAL EVALUATIONS:

The results of steady state voltage analyses indicate that the steady state bus voltages are within the desired operating limits with the corresponding motor terminal voltages within ±10% rated motor voltage.

The results of dynamic voltage analyses indicate that all emergency motors will accelerate their loads successfully to their normal operating speed, considering the credible worst case running and starting load conditions with minimum expected voltage in the offsite circuit.

Based on these voltage analyses, technical evaluations in accordance with the NRC guidelines are presented. Each of the items identified in the "Guidelines for Voltage Drop Calculations", which were provided as an enclosure to the NRC generic letter (Reference 1), is addressed separately below:

<u>GUIDELINE NO. 1</u>

Separate analyses should be performed assuming the power supply to safety buses is (a) the unit auxiliary transformer; (b) the startup transformer; and (c) other available connections to the offsite network one by one assuming the need for electric power is initiated by (1) an anticipated transient (e.g., unit trip) or (2) an accident, whichever presents the largest load demand situation.

<u>RESPONSE:</u>

Separate analyses are not required on all available connections to the offsite network for the following reasons:

1. The electrical distribution system at San Onofre Unit 1 consists of two redundant power trains. Normally, power for these two redundant trains is supplied from the Auxiliary Transformer C. Power could also be supplied from the Main Transformer via Auxiliary Transformers A and B, by manual transfer during shutdown modes. In Modes 1 through 4, powering of either of the two redundant power trains from these transformers renders that train inoperable, i.e., it is not credited for accident mitigation. This condition requires entry into a Technical Specification Action Statement. Accordingly, only cases in which redundant power trains were supplied from the Auxiliary Transformer C were considered in the dynamic voltage analyses.

2. Since the largest load demand situation occurs during accident condition, dynamic voltage analyses for this condition were performed with multiple motor starting and with redundant power trains supplied from the Auxiliary Transformer C only. These analyses are considered to be the worst case combination of bus alignment and loading.

GUIDELINE NO. 2

For multi-unit stations, a separate analysis should be performed for each unit assuming (1) an accident in the unit being analyzed and simultaneous shutdown of all other units at that station; or (2) an anticipated transient in the unit being analyzed (e.g., unit trip) and simultaneous shutdown of all other units at that station, whichever presents the largest load demand situation.

RESPONSE:

Separate analyses were performed for SONGS Unit 1. The worst case postulated conditions are those provided in response to Guideline No. 1, concurrent with the minimum expected voltage at the 220-kV grid. Since Unit 1 onsite power system does not share a common power supply with the other units (except in the switchyard) and is fully independent of the other units with respect to loading conditions under any given mode, analyses for the two cases identified in this Guideline (No. 2) are not required.

GUIDELINE NO. 3

All actions the electric power system is designed to automatically initiate should be assumed to occur as designed (e.g., automatic bulk or sequential loading or automatic transfer of bulk loads from one transformer to another). Included should be consideration of starting of large non-safety loads (e.g., condensate pumps).

RESPONSE:

The dynamic voltage analyses considered all safety related loads the electric power system is designed to automatically start and operate, as well as certain other safety related and non-safety related loads which could start, or continue to run, depending on the system conditions. Safety related loads that are automatically started (during accident condition) were started at their predetermined or sequenced time (e.g., Safety Injection Pumps, Feedwater Pumps, etc.). Loads that are not automatically started but could start concurrently with the sequenced loads were considered started concurrently with those (sequenced) loads (e.g. Refueling Water Pumps, Auxiliary Feedwater Pumps, etc.,). Loads that could be running prior to accident condition and are not shed on accident signal were considered running (e.g., Pressurizer Heaters, Circulating Water Pumps, etc.,).

The starting of large non-safety load, i.e., Turbine Plant Cooling Water Pump, was considered in the analyses. Automatic bus transfer was not considered since this feature is not part of the SONGS 1 electrical distribution system design. Therefore, automatic transfer of bulk loads from one transformer (or bus) to another was not considered in the analyses. The analyses demonstrate acceptable auxiliary system performance under these conditions.

GUIDELINE NO. 4

Manual load shedding should not be assumed.

RESPONSE:

Manual load shedding was not assumed in the dynamic voltage analyses during load sequencing (safety injection phase). Some manual load shedding was credited for improving steady state voltages following load sequencing (post accident recirculation phase).

GUIDELINE NO. 5

For each event analyzed, the maximum load necessitated by the event and the mode of operation of the plant at the time of the event should be assumed in addition to all loads caused by expected automatic actions and manual actions permitted by administrative procedures.

RESPONSE:

For each event analyzed, the maximum load necessitated by the event and the mode of operation of the plant at the time of the event, in addition to all loads caused by expected automatic actions and manual actions permitted by administrative procedures, was assumed. The dynamic voltage analyses considered the maximum loads which could be running prior to the accident condition, sequenced loads that are required to start automatically at their sequenced time, and non-sequenced loads that could start during post accident condition. The analyses demonstrate acceptable auxiliary system performance under these conditions.

GUIDELINE NO. 6

The voltage at the terminals of each safety load should be calculated based on the above listed considerations and assumptions and based on the assumption that the grid voltage is at the "minimum expected value". The minimum expected value should be selected based on the least of the following:

a. The minimum steady state voltage experienced at the connection to the offsite circuit.

b. The minimum voltage expected at the connection to offsite circuit due to contingency plans which may result in reduced voltage from this grid.

c. The minimum predicted grid voltage from grid stability analysis (e.g., load flow studies).

In the report to NRC on this matter the licensee should state planned actions, including any proposed "Limiting Conditions for Operation" for Technical Specifications, in response to experiencing voltage at the connection to offsite circuit which is less than the "minimum expected value". A copy of the plant procedure in this regard should be provided.

RESPONSE:

The voltage at the terminals of each safety load was calculated based on the maximum loading condition and on the assumption that the grid voltage is at the minimum expected voltage at the connection to offsite circuit.

Based on the previous report to the NRC (Reference 2), load flow studies were performed for nine (9) possible contingencies, in order to determine the worst case condition that will result in the lowest offsite network voltage at the San Onofre 220 kV switchyard. The results of these studies indicate that the lowest possible system voltage is 217.8 kV. This could occur if San Onofre Unit 1 is off-line, and two SCE 220-kV lines and two SDG&E 220-kV lines are inoperable. Latest studies indicate that the minimum steady-state voltage expected in the 220-kV bus at San Onofre is 218 kV with all the Units off-line. For consistency with the previous analyses, the more limiting voltage of 217.8 kV was used for dynamic voltage analyses during accident condition.

The SCE Energy Control Center normally operates the 220-kV system at a maximum level to enhance stability and reduce system losses. It initiates remedial measures if the voltage is degraded below 220 kV. Since the maintained 220-kV system voltage is higher than the minimum voltage used in the dynamic voltage analyses, switchyard voltage below 217.8 kV is not considered credible.

GUIDELINE NO. 7

The voltage analysis should include documentation for each condition analyzed, of the voltage at the input and output of each transformer and at each intermediate bus between the connection to offsite circuit and the terminals of each safety load.

RESPONSE:

The dynamic voltage analyses and steady state voltage analyses include documentation for each condition analyzed, of the voltage at the input and output of each transformer and at each intermediate bus between the connection to offsite circuit and the terminals of each safety load.

GUIDELINE NO. 8

The analysis should document the voltage setpoint and any inherent or adjustable (with nominal setting) time delay for relays which (1) initiate or execute automatic transfer of loads from one source to another; (2) initiate or execute automatic load shedding; or (3) initiate or execute automatic load sequencing.

RESPONSE:

The setpoint of undervoltage relays at each bus is documented in the Safety Related Electrical Set Point List. There were 8 possible cases analyzed for dynamic voltage analyses during accident conditions (worst case scenarios). In all cases analyzed, the resulting voltage-time profiles at each bus were above the undervoltage relay voltage-time settings.

The minimum calculated bus voltages from these analyses and the corresponding undervoltage (UV) relay settings are as follows:

BUS	VOLTAGE DIP (Volts)	UV RELAY TRIP TIME (Seconds)	TIME TO RECOVER (Seconds)	STEADY STATE VOLTAGE (Volts)	RELAY TRIP SETTING CV-6 (Volts)	RELAY TRIP SETTING CV-7 (Volts)
4-KV BUS 1C	3466	>50	5.4	3924	3675±3.015%	2870±3.015%
4-KV BUS 2C	3379	>50	5.6	3924	3675±3.015%	2870±3.015%
480-V BUS 1	326	NOTE 1	3.6	430	NOTE 2	280±4.24%
480-V BUS 2	322	NOTE 1	4.2	432	NOTE 2	280±4.24%
480-V BUS 3	353	NOTE 1	3.8	437	NOTE 2	280±4.24%
480-V BUS 4	324	NOTE 1	4.1	432	NOTE 2	280±4.24%

NOTE: 1. The calculated voltages in the 480-V buses remain above the undervoltage relay settings.
2. There is no CV-6 relay in the 480-V buses.
3. "TIME TO RECOVER" is the time it takes for the bus voltage to recover from the initial voltage dip to steady state voltage value.

Although voltage dips in the 4-kV Buses 1C and 2C are lower than the relay trip settings of their undervoltage relay CV-6, these relays will not trip because it will take longer than 50 seconds for CV-6 relays to trip on these values of bus voltage, i.e., 3466 V in Bus 1C and 3379 V in Bus 2C, whereas it will only take less than 6 seconds for these bus voltages to recover to steady state values which are above the CV-6 relay trip voltage.

Based on the above, the calculated worst case degraded voltage condition cannot cause these undervoltage relays to affect automatic load sequencing and/or load shedding.

Based on the response to Guideline No. 3, automatic bus transfer is not credible and was not considered in the analyses.

GUIDELINE NO. 9

The calculated voltages at the terminals of each safety load should be compared with the required voltage range for normal operation and starting of that load. Any identified inadequacies of calculated voltage requires immediate remedial action and notification of NRC.

RESPONSE:

The calculated voltages at the terminals of each safety load have been compared with the required voltage range for normal operation and starting of that load.

For normal modes of plant operations (steady state condition), the minimum acceptable voltage was based on ANSI Standard C50.41, which indicates that the voltage range over which motor can operate continuously in the performance of its intended functions is ±10% of motor rated voltage.

For minimum voltage condition during normal modes of operations, 90% of motor rated voltage was made the basis for determining the acceptability of corresponding voltage at the offsite network (220-kV switchyard). The results of steady state voltage calculations indicate that the corresponding voltages are within the acceptable steady state voltage range expected at the 220-kV switchyard.

For motor starting (accident condition), the ANSI Standard C50.41-1982 and NEMA MG1-12.43 indicate that the motor voltage during starting must be such that the motor torque has sufficient margin over the load torque allowing acceleration to running speed. The dynamic voltage analysis demonstrate that the starting loads have sufficient voltage to accelerate to their operating speeds even under the worst degraded voltage conditions anticipated for the auxiliary system. The results of dynamic voltage analysis also indicate that some motors recover to a steady state voltage of less than 90%. This condition, however, is only temporary because existing station operating instructions require station operators to monitor the 4-kV and 480-V bus voltages and take action (e.g. redistributing the loads between buses) to restore the voltage within the desired voltage range established for these buses. In addition, the minimum expected grid voltage considered in the calculation would not persist for an indefinite period of time. The Edison Energy Control Center is required to maintain the voltage in the 220 kV grid within normal range.

GUIDELINE NO. 10

For each case evaluated the calculated voltages on each safety bus should be compared with the voltage-time settings for the undervoltage relays on these safety buses. Any identified inadequacies of calculated voltage require immediate remedial action and notification of NRC.

RESPONSE:

For each case evaluated the calculated voltages on each safety bus were compared with the voltage-time settings for the undervoltage relays on these safety buses. Based on the results of dynamic voltage analysis (worst case condition), the degraded voltage conditions analyzed on each case were above the voltage-time settings of undervoltage relays in safety related buses (See response to Guideline No. 8).

There is no identified inadequacies of calculated voltage which will require immediate remedial action and notification of NRC.

GUIDELINE NO. 11

To provide assurance that actions taken to assure adequate voltage levels for safety loads do not result in excessive voltage, assuming the maximum expected value of voltage at the connection to the offsite circuit, a determination should be made of the maximum voltage expected at the terminals of each safety load and its starting circuit. If this voltage exceeds the maximum voltage rating of any item of safety equipment immediate remedial action is required and NRC shall be notified.

RESPONSE:

The maximum expected voltage at the connection to the offsite circuit (220-kV switchyard) is 238 kV with all three San Onofre units on-line. However, this overvoltage condition would not persist for longer period because the Edison Energy Control Center normally maintain the 220-kV offsite circuit between 220 kV and 228 kV.

Overvoltage condition in Unit 1 is most probable during shutdown modes (Modes 5 or 6) because of the reduced auxiliary loads. In these modes, Edison Energy Control Center is required to maintain the grid voltage at 230 kV or below to ensure acceptable level of voltages are maintained in the auxiliary system. In addition, administrative controls are also imposed on these modes to change the station service transformer tap settings to maintain the voltage at the buses within the desired operating limits. As a result of the voltage analyses for four bus configuration (Figure 2), new tap settings for the Station Service Transformers are recommended in Modes 5 and 6.

Applicable station procedures are being changed to reflect the new tap settings. These procedures will ensure that the auxiliary system loads are not subjected to voltages beyond their rated maximum voltage (110%) limits.

In normal operating mode (Mode 1), overvoltage condition in the auxiliary system is rectified by the operating instructions which require station operators to monitor the 4-kV and 480-V bus voltages and take action (e.g. redistributing the loads between buses or lowering the voltage in the 220-kV system in coordination with the SCE Energy Control Center) to restore the voltage within the desired voltage range established for these buses.

Based on the above provisions, adequate voltage levels for safety loads will not result in excessive voltage at these loads.

GUIDELINE NO. 12

Voltage-time settings for undervoltage relays shall be selected so as to avoid spurious separation of safety buses from offsite power during plant startup, normal operation and shutdown due to startup and/or operation of electric loads.

RESPONSE:

Based on the calculated voltages for each safety related bus, the existing undervoltage relay voltage-time settings are adequate to ensure that spurious actuation of these undervoltage relays in all modes of plant operation is avoided.

GUIDELINE NO. 13

Analysis documentation should include a statement of the assumptions for each case analyzed.

RESPONSE:

All assumptions made in the analyses are documented in detail in the Steady State Voltage and Dynamic Voltage Analyses.

D. CONCLUSION:

The results of dynamic and steady state voltage analyses, which were addressed in Section C "Technical Evaluations", indicate that the offsite power system and the onsite distribution system are of sufficient capacity and capability to automatically start as well as operate all the required safety loads within their required voltage ratings in the event of a transient or accident without manual load shedding. In addition, the results of these analyses demonstrate that the onsite power system is adequate to start and operate all the required safety and non-safety loads under all modes of normal plant operation.

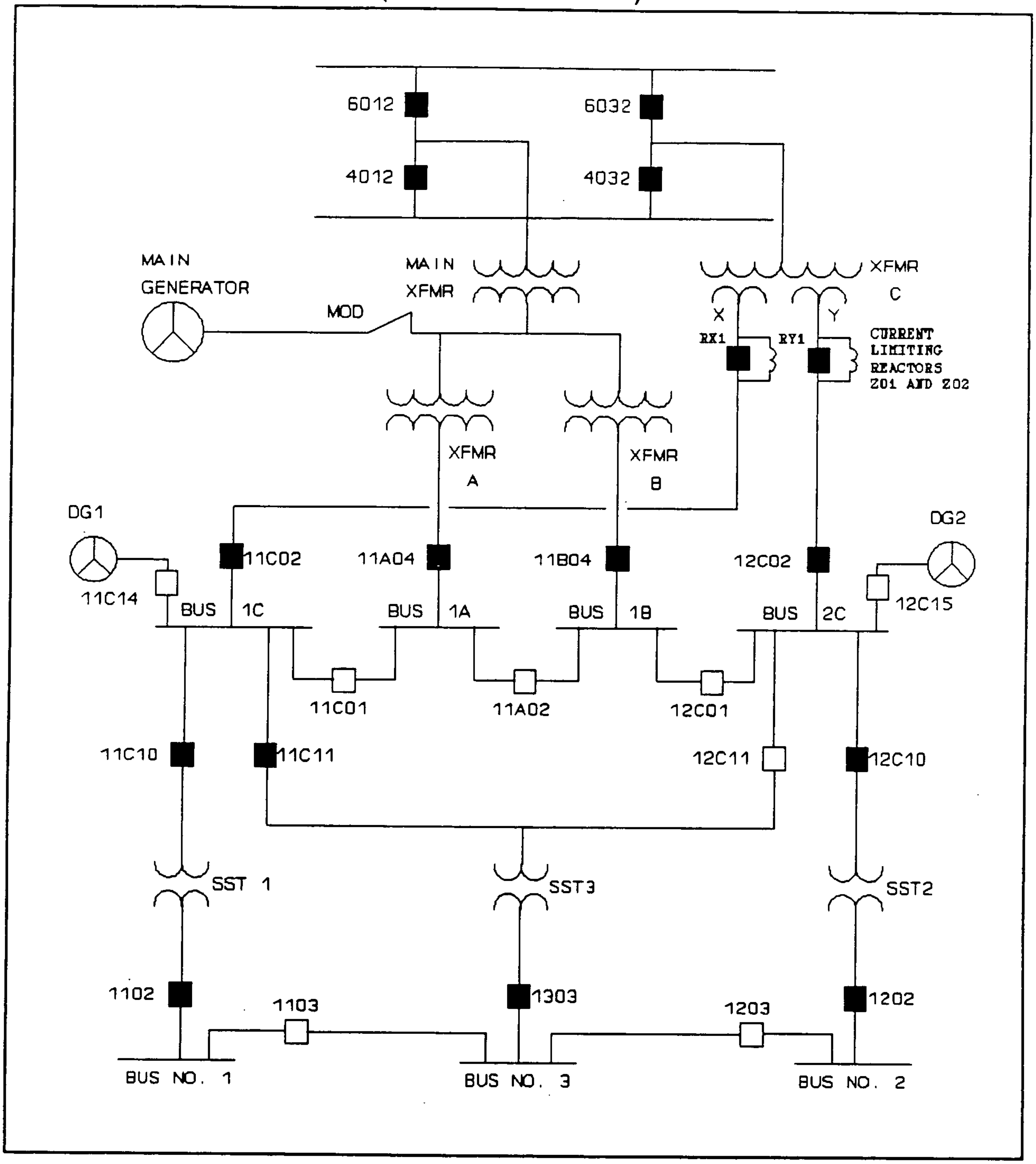
E. REFERENCES:

1. NRC (W. Gammill) letter dated August 8, 1979, Subject: Adequacy of Station Electric Distribution Systems Voltages.

2. Letter dated May 1, 1980, from K. P Baskin (SCE) to D. L. Ziemann (NRC), Subject: Adequacy of Electrical Distribution Systems.

ENCLOSURE

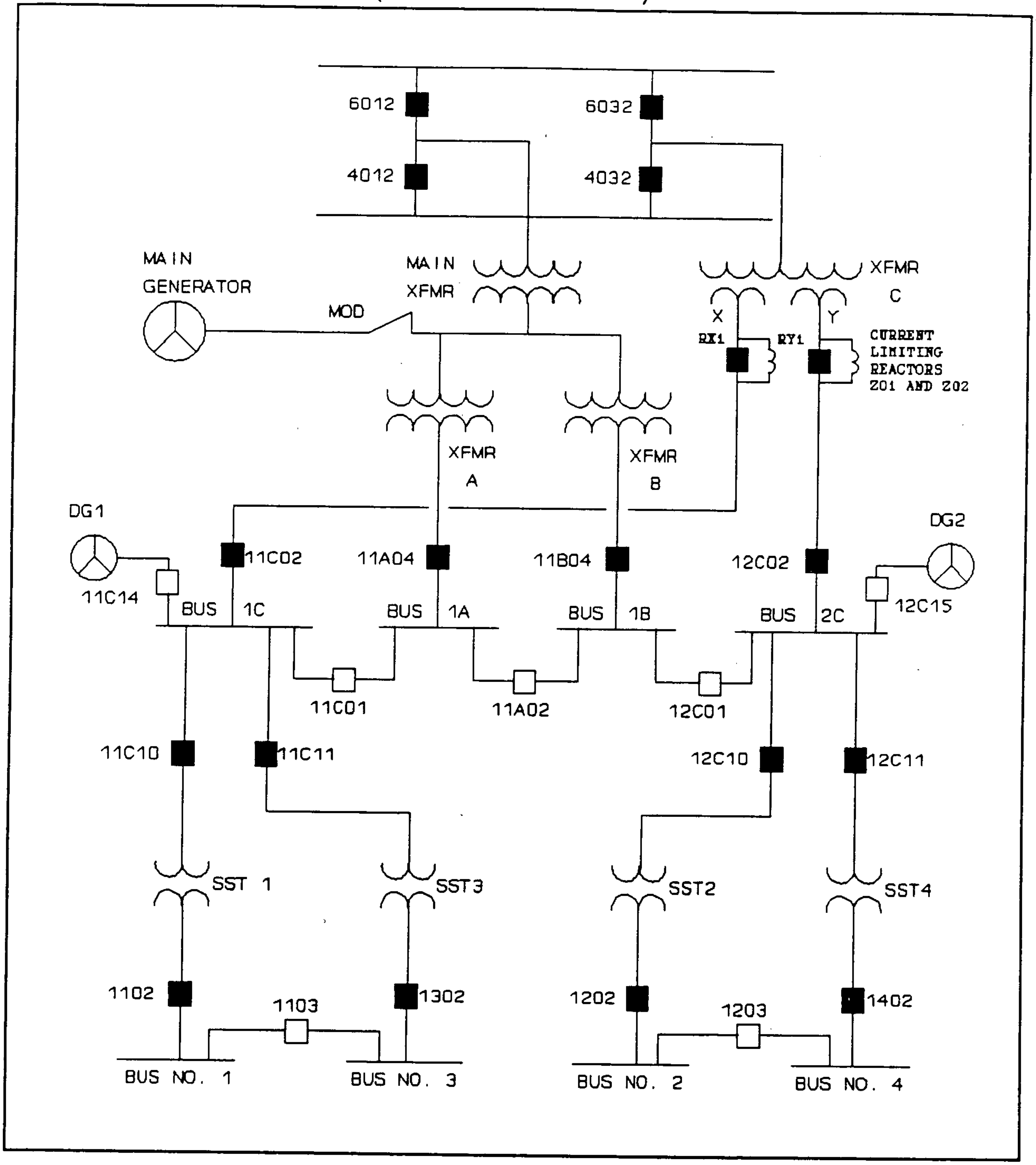
FIGURE 1: (OLD) THREE 480-V BUS CONFIGURATION
(Prior To Modification)



NOTE: NORMAL BUS ALIGNMENT [CLOSED BREAKERS ARE SHOWN SHADED]

ENCLOSURE

FIGURE 2: (NEW) FOUR 480-V BUS CONFIGURATION
(After The Modification)



NOTE: NORMAL BUS ALIGNMENT [CLOSED BREAKERS ARE SHOWN SHADED]