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March 31, 1982

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VICE PRESIDENT
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Serial No. 175
PSE&C/brc/BSD/KSB

Docket Nos. 50-280
50-281
License Nos. DPR-32
DPR-37

Gentlemen:

GENERAL DESIGN CRITERIA 17 ANALYSIS
SURRY UNIT NOS. 1 AND 2

In accordance with our letter of December 31, 1981, Serial No. 233A, we are transmitting to you the final results of our GDC-17 analysis. The scope of our analysis is based on all the guidelines and requirements set forth in the NRC's letters of August 8, 1979, entitled "Adequacy of Station Electrical Distribution System Voltages," and June 25, 1980, which included a "Request for Additional Information Regarding the Adequacy of Station Electric Distribution System Voltages".

Our analysis has been conducted assuming that certain operating restrictions will be followed and modifications will be installed. The results of the analysis meet the GDC-17 criteria. The required restrictions and modifications are summarized below.

The operating restrictions include:

(1) The existing load shed, which is initiated when both units load to the Reserve Station Service transformers (RSSTs), will be normally enabled when 1) one unit is on line and the other unit is in startup, 2) both units are on line, and 3) both units are in start up.

(2) A program will be established to ensure station operation is consistent with the assumptions made in the GDC-17 analysis. The program will specify the appropriate corrective actions to be taken if transmission system voltage goes outside the range of 505 KV to 535 KV.

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(3) The disconnects on both sides of the 34.5 KV bus tie breaker will be normally open.

(4) Until the RSST 4 KV cable modification is complete, the station will, whenever practical, limit loads during unit start up and following unit trips. When practical, those loads, which would be tripped by the load shed, will not run during start up and will be tripped in an orderly manner when a unit has tripped.

(5) When one of the 34.5 KV low side breakers on the 230/36.5 KV transformer is closed, the disconnects on the other 34.5 breaker shall be opened.

The modifications include:

(1) Rerate all motor operated valves (MOVs) to assure starting at predicted voltages. Motors on certain MOVs may have to be replaced. (The full scope for MOV rerating/motor replacement is still being developed).

(2) Trip the 34.5 KV reactors in the switchyard when a Safety Injection (SI) or Consequence Limiting Sequence (CLS) event occurs on either unit.

(3) Modify RSST load tap changer (LTC) control to eliminate all delays in LTC response during the first three minutes of a SI or CLS event on either unit and on transfer of unit loads to the RSS system.

(4) Block the auto starting of large non-IE motors when the station service bus feeding the motor is fed from the same source as an emergency bus of a unit experiencing an SI or CLS.

(5) Modify the RSST secondary cables to insure that they do not become overloaded by replacing the existing underground cable with an alternative which will have sufficient capacity for worst case conditions.

(6) Install two additional radiators with fans on each RSST to raise their ratings from 24 MVA to 30 MVA.

(7) Install new IE motor control center control transformers to assure desired operation. (The full scope for motor control center control circuit transformers is still being developed).

(8) Reroute several switchyard control cables to improve separation.

We plan to implement these modifications during currently scheduled maintenance and refueling outages. Completion of all required modifications is anticipated for Unit 1 by the end of the maintenance outage following the 1983 refueling and for Unit 2 by the end of the maintenance outage following its 1983 refueling, presently scheduled for the first quarter of 1984. We will keep you advised of any changes to our modification implementation schedule. The operating restrictions will be implemented by July 1, 1982.

A detailed review of our analysis is provided in Attachment I entitled, "Summary of GDC-17 Analysis Report." We have also included in the report our answers to your December 1, 1981 telecopied questions regarding "Grid Voltage Degradation" and your January 12, 1982 "Diesel Sequencing" verbal questions.

Should you need more information, please contact us.

Very truly yours,

R. H. Leasburg

Attachments

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NRC Office of Inspection and Enforcement
Division of Reactor Operations Inspection
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Summary of General Design Criteria
17 analysis rpt

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SUMMARY OF GDC-17 ANALYSIS REPORT

SURRY POWER STATION

I. ELECTRICAL SYSTEM

We are analyzing the electrical system shown in Appendix A.

The reserve station service system is supplied from two 500/230/36.5 KV autotransformers. The two 34.5 KV buses fed from these transformers supply three 34.4/4.16 KV reserve station service transformers (RSST's), two 34.4/4.16 KV intake structure transformers and four 34.5 KV reactor banks. RSST's A, B, and C supply 4 KV transfer buses D, E, and F, respectively. Transfer bus D supplies emergency bus 1J and station service buses 1A and 2A. Transfer bus E supplies emergency bus 2H and station service buses 1B and 2B. Transfer bus F supplies emergency buses 1H and 2J and station service buses 1C and 2C.

The 230/36.5 KV transformer serves as a back-up reserve station service supply. On loss of either 500/230/36.5 KV autotransformer, the 230/36.5 KV transformer is automatically switched to supply the affected 34.5 KV bus. Electrical acceptability (e.g., lack of electrical faults) of the 34.5 KV bus is a permissive in the automatic transfer logic.

The station service buses are fed through the 22/4.16 KV station service transformers (SST's) when their unit is on-line. During start-ups the station service buses are fed from the RSST's. A unit trip initiates transfer of the station service buses from the SST's to the RSST's.

The transmission system voltage range at the 500 KV switchyard is 505 KV to 535 KV. This range is based on analysis of system voltages for extreme conditions of unit outages and loading. We will establish a system plan, to become Appendix B, which outlines action to be taken to ensure the voltage stays within these values. This plan will be submitted by July 1, 1982.

II. ELECTRICAL EQUIPMENT RATINGS

A. Transformers

The 500/230/36.5 KV autotransformers which feed the RSST's are tapped at 512.5 KV. The high and low voltage windings are rated for 450 MVA at a 55°C temperature rise. The tertiary winding is rated for 97.7 MVA at a 55°C winding rise temperature rise. To fully load all three windings concurrently, the high, low,and tertiary ratings become 450, 360, and 90 MVA, respectively. To achieve the 97.7 MVA tertiary rating, the maximum loading becomes 425/327/97.7 MVA, respectively.

The 230/36.5 KV transformer which provides an alternate feed to either 34.5 KV bus is tapped at 230 KV and is rated for 112 MVA at a 65°C winding temperature rise. It has a load tap changer (LTC) on its secondary winding which is set to maintain 36.5 KV and will provide a ± 10% voltage adjustment over full range operation. This adjustment capability is provided by 32 taps each of which provides a 5/8% voltage adjustment.

The 22/230 KV Unit 1 main step-up transformers are tapped at 230 KV and are rated for 900 MVA at a 55°C winding temperature rise.

The 22/500 KV Unit 2 main step-up transformers are tapped at 500 KV and are rated for 900 MVA at a 55°C winding temperature rise. These taps will be changed to 512.5 KV during the next refueling outage, currently scheduled for May, 1982.

The 34.4/4.16 KV RSST's are tapped at 34.4 KV and are each rated for 24 MVA at a 55°C winding temperature rise. With the addition of two sets of radiators and fans per transformer, each RSST rating will be upgraded to 30 MVA. The RSST's have LTC's on their secondary terminals which are set to maintain a 4300 volt output and which will provide a ± 10% voltage adjustment over full range operation. This adjustment capability is provided by 32 taps, each of which provides a 5/8% voltage adjustment.

The Unit 1 22/4.16 KV SST's are tapped at 20.9 KV and are rated for 22.4 MVA at a 65°C winding temperature rise.

The Unit 2 22/4.16 KV SST's are tapped at 21.422 KV and are rated for 22.4 MVA at a 65°C winding temperature rise. These taps will be changed to 20.9 KV during the next refueling outage, which is currently scheduled for May, 1982.

The 4.16/.48 KV emergency bus load center transformers are tapped at 4260V and 4160V and are rated for 1333 KVA at a 55°C winding temperature rise. These taps will be changed to 4056V.

The data on the main step-up and SST's is provided for information only. The RSST's provide the offsite supply to the reserve system and, as such, the analysis has addressed only RSST supply of the emergency buses.

B. Cables and Bus Duct

The existing feeders from the RSST's to the 4 KV transfer buses (D, E, and F) consist of 4 - 2000 MCM aluminum cables per phase with summertime continuous $90^{\circ}C$ ratings of 1624 A for RSST B and 1684 A for RSST's A and C. The emergency $130^{\circ}C$ ratings are 1940 A and 2008 A, respectively. ICEA S-68-516 Appendix D, 1979, defines an allowable operation at $130^{\circ}C$ as 100 hours per year with a maximum of 500 hours in the lifetime of the cable. During the winter, due to lower earth temperature and lower thermal resistivity of the soil, the continuous $90^{\circ}C$ rating of these cables is 2000 amps. A portion of each of these feeders is located in underground duct while the rest is located in cable tray. The duct portion of each cable run is responsible for these low ampacity ratings.

The 4 KV feeders from the transfer buses to the emergency buses consist of 2 - 3/C 750 MCM aluminum per emergency bus and are rated at 946 amps per phase.

The bus duct between the transfer buses and the unit 2 normal buses is rated for 3000 amps.

C. **4 KV Switchgear**

The 4 KV transfer bus feeder breakers and buses are rated for 3000 amps.

The 4 KV normal bus feeder breakers and buses are rated for 3000 amps.

The 4 KV emergency bus feeder breakers and buses are rated for 1200 amps.

D. **Motors**

The 1E motors are all fed from the emergency buses. The 4KV 1E motors are rated for continuous operation at 4000V ± 10% (3600 to 4400V) and will start with voltages as low as 2800V (70% of 4000V).

The 480V 1E motors are rated for continuous operation at 460V ± 10% (414V - 506V) and will start with voltages as low as 322V (70% of 460V).

E. **Motor Operated Valves**

The 1E Motor Operated Valves (MOV's) are presently rated either for continuous operation at 460V ± 10% and require 90% of 460V to start, or for continuous operation at 440V ± 10% and require 85% of 440V to start.

The MOV vendor has indicated that, based on their records of valve torque requirements, a number of MOV's which start on either Consequence Limiting Safeguard (CLS) or Safety Injection (SI) signals may be rerated for starting at 80% of 460V (368V).

We are pursuing this MOV rerate, which will be discussed in the Motor Operated Valve Analysis (section VI).

F. Contactors

The 1E contactors which are used to start and stop motors fed from motor control centers (MCC's) are rated for 120V ± 10% (103.5V - 126.5V). They will pick-up at 100V (83% of 120V) and will drop out below 60 V (50% of 120 V).

III. ANALYSIS ASSUMPTIONS

A. The 500 KV switchyard voltage is assumed to remain within the 505 KV - 535 KV previously specified. Worst-case transmission system analysis indicates that the maximum switchyard voltage drop caused by either one or both Surry units tripping off-line will not exceed 15 KV. In our analysis, we assumed a 15 KV voltage drop would occur instantaneously with the CLS or other anticipated transient being analyzed. Initially, we analyzed the same accident condition twice, once with a voltage drop from 535 KV to 520 KV and once with a voltage drop from 520 KV to 505 KV. Results for the latter case proved to be the worst. For the results we are submitting to you, we have assumed a switchyard voltage drop from 520 KV to 505 KV upon the occurrence of the condition being analyzed.

B. The LTC tap position just prior to a condition being analyzed is determined by the loading on the RSST's (generally just emergency bus loads) and by assuming 520 KV in the switchyard. At the instant a particular condition occurs, the switchyard voltage is assumed to drop to 505 KV and loading caused by the condition is assumed to occur (e.g., emergency loads starting and station service buses transfering to the RSST's).

Voltages at this instant are calculated based on the LTC tap position prior to the condition occurrence. Final voltages are based on the LTC correcting as required with the switchyard voltage still at 505 KV.

C. For all turbine and reactor trips, with the exception of electrical abnormalities, the generator breakers (the generator breakers refer to the two 230 KV breakers on unit 1 and the two 500 KV breakers on unit 2) will be tripped 60 seconds afterwards. The station service buses transfer from the SST's to the RSST's when the generator breakers of their respective unit are opened. Our studies assume that the station service bus loads are transfered to the RSST's immediately upon the occurrence of the condition being analyzed. This is a conservative approach to the voltage analysis.

D. To ensure worst case motor starting results, all motors receiving an SI or a CLS signal were assumed to be not running just prior to the accident, even if some would be running under normal operation (e.g., a charging pump). At the time of the accident all of these motors were assumed to start. Additionally, worst case station service bus loadings were used in the analysis based on the specific condition in question (e.g., analysis of a unit 2 CLS concurrent with a unit 1 trip requires that the 1B, 1C, 2A, and 2B condensate pumps be modeled as those running at the time of the accident since these pumps are not shed as a result of the installed load shedding scheme).

E. The ampere values used in our analysis are values taken during station measurements. Values not measured (e.g., 480 V emergency bus loading during CLS conditions) were estimated.

F. No manual load shedding or reduction in motor current due to decreased pump load is assumed to occur prior to 1 hour after the occurrence of a condition being analyzed.

G. The only sequential loading assumed is that which is presently designed into the system. The sequenced loads are the auxiliary steam generator feedwater pumps (50 seconds after an SI signal), inside recirculation spray pump (120 seconds after a CLS signal), and outside recirculation spray pump (300 seconds after a CLS signal).

H. The existing load shedding scheme, which is individually initiated on each RSST loading for two unit loading to the RSST's is assumed to operate properly. The affected loads are tripped and locked-out.

With two unit loading on RSST A, the loads shed on Unit 1 bus 1A are the condensate pump, mechanical chiller, training center and low pressure heater drain pump. The loads shed on Unit 2 bus 2A are the feedwater pump, mechanical chiller and low pressure heater drain pump. For approximately 2 minutes after the second unit transfers to RSST A, RSST A's LTC control will wait only 5 seconds after a voltage correction requirement is indicated before initiating corrective action. At the end of the 2 minute period, the delay prior to correction will revert to its normal 30 second setting.

With two unit loading on RSST B, loads shed on Unit 1 bus 1B are the feedwater pump, high pressure heater drain pump, and mechanical chiller. The load shed on Unit 2 bus 2B is the high pressure heater drain pump. For approximately 2 minutes after the second unit transfers to RSST B, RSST B's LTC control will wait only 5 seconds after a voltage correction requirement is indicated before initiating corrective action. At the end of the 2 minute period, the delay prior to correction will revert to its normal 30 second setting.

Upon the occurrence of two unit loading on either RSST A or RSST B, both 34.5 KV reactor banks on 34.5 KV bus no. 5 will be tripped and locked-out.

With two unit loading on RSST C, the loads shed on Unit 1 bus 1C are the feedwater pump, high and low pressure heater drain pumps, and the condensate polishing building. The loads shed on Unit 2 bus 2C are the condensate, high and low pressure heater drain pumps, and the condensate polishing building. Both 34.5 KV reactors on 34.5 bus no. 6 will also be tripped and locked out. For approximately 2 minutes after the second unit transfers to RSST C, RSST C's LTC control will wait only 5 seconds after a voltage correction requirement is indicated before initiating corrective action. At the end of the 2 minute period, the delay prior to correction will revert to its normal 30 second setting.

This load shedding scheme was initially installed as a interim modification. Based on our analysis, we believe it should remain as a permanent modification.

I. The RSST's provide the offsite supply to the reserve system. The analysis has addressed only RSST supply to the emergency buses.

J. Additional assumptions that were made concerned anticipated modifications which we incorporated into our analysis. The 4.16/.48 KV emergency transformers will be re-tapped to the 4056V tap and are modeled as such. We will be tripping the 34.5 KV reactors for the conditions studied. In our studies the reactors were considered to be out of service at all times, which provides the worst case LTC tap prior to the condition being analyzed. The LTC's were assumed to begin correction immediately after the occurrence of the analysis condition rather than delaying for the 5 seconds or 30 seconds presently designed into its response.

Our analysis has been directed at identifying and addressing worst case conditions. We have not directly analyzed every possible occurrence. By observation and through the use of engineering judgement, we have ensured that all worst case conditions have been analyzed and the proposed modifications will correct all deficiencies identified as a result of this study.

IV. EQUIPMENT LOADING ANALYSIS

The purpose for this portion of the analysis is to ensure the reserve station service system can adequately handle the safety and nonsafety loads which it is required to supply and to address any overload which might occur due to load transferring to the reserve system. This analysis assumes all sequenced loads are energized and a steady state loading has been achieved. Loads analyzed include the maximum load necessitated by the event and the mode of operation of the plant at the time of the event as well as all loads caused by expected automatic actions and manual actions permitted by administrative procedures. The analysis, rather than taking credit for load diversity of major loads, maximized loading on individual pieces of equipment. Summation of the loads used to analyze a single event would exceed the actual total load of the event because, in actuality, not all of the loads are running at any one time.

The loading conditions analyzed included all combinations of the units at 100% power, start-up, tripping, and tripping with a CLS, with the exception of two units simultaneously in start-up and two units simultaneously tripping with a CLS on each unit. The Equipment Loading Analysis Tabulation, Appendix C, provides results for worst case loading as defined above. While the majority of the equipment will not experience an overload, some of the equipment may possibly become overloaded. The RSST's, 4 KV transfer buses, and feeder cable from the RSST's to the transfer buses, 500/230/36.5 KV autotransformers, 230/36.5 KV transformer and certain emergency 4 KV/480 V transformers may become overloaded under certain situations and are discussed below.

A. Reserve Station Service Transformers

The 24 MVA RSST's may become overloaded only during two unit loading.

The present rating for each RSST with its LTC in the maximum boost position is 2967 amps. If loading is such that the LTC cannot correct the voltage to 4300 V, the LTC will definitely be at maximum boost. For worst case conditions, the LTC maintains approximately 4160 V. For this reason, worst case load currents have been calculated at 4160 V and compared to the 2967A rating.

Maximum 2 unit RSST loading with a CLS on one unit results in loading on RSST's A, B, and C of 3141A, 3340A, and 3487A which are 106%, 113%, and 118%, respectively, of the transformer ratings.

Maximum 2 unit RSST loading in nonaccident conditions results in loading on RSST's A, B, and C of 3141A, 3340A, and 3313A which are 106%, 113%, and 112%, respectively of the transformer rating.

At an 18% overload, based on a 100% preload and a 30°C average ambient temperature, the maximum loss of life due to the overload will not exceed 1.0% in 24 hours.

The RSST's are not overloaded during normal power operations or during single unit loading of the RSST's.

We will install two sets of radiators and fans on each RSST. Each RSST full load rating will become 30 MVA at a 55°C temperature rise. With its LTC at the maximum boost position, each transformer will be rated for 3708A. The maximum loading will be 94% of the rated capacity.

B. 4 KV Cable From The RSST's To The Transfer Buses

The 4-2000 MCM aluminum cables per phase which supply the 4KV transfer buses from the RSST's may be loaded such that their 90°C continuous rating is exceeded. The overload is possible on each set of cables but the most severe case is for the cables from RSST C to transfer bus F. The overload data supplied below pertains to these cables, unless otherwise specified.

Under worst case conditions, the cables may experience loads equal to 167% and 160% of rated capacity during single unit start-up and single unit trip conditions respectively. These percentages are with respect to worst case summer ratings. When compared with the winter 90°C rating, the loads are 141% and 135%, respectively, of rated capacity. The start-up loading may be restricted to allowable values. Cable heat-up to 90°C due to a unit trip following power operation of both units will take at least 6 hours.

The cables may experience maximum loads equal to 207% of rated capacity during 2 unit loading on the RSST's. This loading occurs during a unit start-up while the other unit trips with a CLS. Based on a typical 24 hour start-up, if the second unit tripped at the end of the start-up of the first unit and if the first unit remained on the RSST's, the cable would not reach its 130°C emergency rating for at least 75 minutes. Maximum non-accident two unit loading on the RSST's results in loading equal to 206% of the rated capacity of the cables between RSST B and transfer bus E.

Present operating restrictions limit loading on each RSST to 2000 amps maximum, which is the winter 90°C rating of the cable, whenever possible. For the occasions which that level is exceeded, we are recording the current level and duration of that level. These values are used in determination of the condition of the cable with respect to its allowable overload time.

To correct this situation, each set of feeder cables between the RSST's and the transfer buses will have its underground portion removed from service. The feeders from the RSST's will consist of overhead bus from the transformers to the turbine building wall. From that point, existing cable and/or new cable will be used as a continuation of these feeders in one of three arrangements, which are: 1) the feeders directly supplying each transfer bus as presently exists, 2) the feeders splitting and separately supplying the Unit 2 station service buses and the transfer buses, with Unit 1 station service buses still fed from the transfer buses, or 3) the feeders splitting and separately supplying the Unit 1 station service buses, Unit 2 station service buses, and the transfer buses. The emergency buses will continue to be supplied from the transfer buses regardless of the alternative chosen. We must complete additional engineering review prior to determining which of the alternatives will be implemented.

In the interim period, until completion of the modification discussed above, operating restrictions are required to minimize loss of equipment life due to overloading of the equipment. Based on the cable heat-up times discussed above, operating restrictions have been developed and are included in the Summary of Modifications, Section X, Part A.3.

C. 4 KV Transfer Bus Feeder Breakers and Buses

The 3000 amp, 4 KV transfer bus feeder breakers and buses may become overloaded during two unit loading on the RSST's.

As discussed above, the maximum loads for transfer buses D, E and F are 3141A, 3340A, and 3487A, respectively. Based on present operating restrictions which limit RSST loading to 2000 amps, the maximum 487 amp overload may last for over 29 minutes prior to causing any increased loss of switchgear life due to the overload. Operator action will remove the overload on the switchgear.

Based on the operating restrictions discussed for single unit loading on the RSST's, the maximum preload to a 2 unit RSST loading case will be 1684 amps during the summer. The allowable duration of the 487A overload, without causing increased loss of life, will be over 33 minutes.

With reference to the Summary of Modifications, Section X, Part A.3., operating restrictions will ensure that load reduction to 3000A or below is accomplished within 30 minutes. These operating restrictions will be in effect until completion of the cable replacement modification, at which time the possibility of an overload of the transfer buses will not exist or bus cooling will be installed on each transfer bus.

D. 500/230/36.5 KV Autotransformers

Based on worst case loading, including both intake structure (G Bus) transformers and both 30 MVAR reactor banks, on the autotransformer which supplies RSST's A and B, this autotransformer may become overloaded, during nonaccident conditions only, by 23% based on its 90 MVA tertiary rating. The reactor banks are typically energized during periods of light system load. Using the 97.7 MVA tertiary rating, which is more realistic for the autotransformer loading experienced during a light system load condition, this overload reduces to 13%. The overload on the other autotransformer is approximately 3% based on its 90 MVA rating.

Based on 100% preload and a 30°C average ambient temperature, the maximum loss of life caused by a 23% overload is less than 2% over a 24 hour period. At a 13% overload, the loss of life is less than 0.5% for 24 hours.

Alarms are presently installed to monitor the tertiary of each autotransformer. The alarms alert our System Operator's office to overloads. Surry Power Station is then notified to take suitable action to remove the overload condition.

E. 230/36.5 KV Transformer

Subject to the same maximum loading as the autotransformers, the 230/36.5 KV transformer has a higher continuous rating and a less severe overload possibility. The maximum overload for this transformer is 9%.

The maximum additional loss of life due to a 9% overload will be less than 0.5% over a 24 hour period.

The loading on this transformer is also alarmed as discussed above, with appropriate load reduction following station notification.

F. Emergency 4 KV/480 V Transformers

Review of worst case loadings indicate that only 4 KV/480 V emergency transformers 1H and 2H could possibly be overloaded, under accident conditions only, at a steady state voltage of 451 volts (94% of 480 V) or below. The other emergency transformers will not become overloaded.

Review of the voltage profiles indicates 480 V bus 2H could drop as low as 88.8% in the condition of an autotransformer failure. This would result in a maximum load of 106% of rated capacity. Based on 100% preload and an average ambient of 30°C, the additional loss of life due to an overload is less than 0.25% in a 24 hour period. Based on this negligible loss of life combined with the low occurrence probability, no modification is required for this condition.

Review of the voltage profiles for normal operating arrangements indicates that the steady state voltages for 480 V buses 1H and 2H remain above 451 V.

V. VOLTAGE ANALYSIS

A. Guidelines and Assumptions

We have conducted our voltage analysis on the assumption that no onsite sources of AC power are available. Our intent is to ensure the offsite power system and the onsite distribution system are of sufficient capacity and capability to automatically start as well as operate all required safety loads within their required voltage ratings in the event of (1) an anticipated transient (such as unit trip) or (2) an accident (such as a LOCA) regardless of other actions the electric power system is designed to automatically initiate and without the need for manual shedding of any electric loads.

Specific goals of our analysis are to ensure:

1. All 1E loads receive rated starting and running voltages within the time frame required for proper operation. This includes analysis of voltage drop in cable feeding switchgear, MCC's and motors.

2. No spurious separations from the offsite sources occur. This goal addresses recovery voltages after motor starting and final voltage adequacy to ensure the emergency buses will not separate from the offsite while the offsite has the capability to adequately supply the emergency buses.

3. Final steady-state voltages are within all 1E equipment ratings.

4. Starting voltage and minimum running voltage requirements for all equipment are to be achieved based on the lowest system voltage. Maximum running voltage requirements are to be met based on the highest system voltage.

5. 4KV emergency bus loss of voltage and degraded voltage relaying setpoints adequately protect all 1E loads, including the 480V and 120V loads.

The above goals are to be achieved while analyzing all offsite sources to each emergency bus and specific worst case loading for each possible condition.

After initial analysis indicated certain modifications would be required to prevent possible spurious separation of the emergency buses and to ensure adequate 480V bus voltages, these modifications were incorporated into our analysis and are included in our results. The modifications are as follows:

1. The RSST LTC's presently operate 30 seconds after a voltage correction requirement is indicated. This prevents unnecessary operation during system transients (e.g., system voltage swings and large motor starting). During two unit loading on the RSST's, the 30 second delay is reduced to 5 seconds for a period of 2 minutes. The LTC control will be modified such that for SI

and CLS conditions on either unit, the LTC will provide instantaneous voltage correction for approximately 3 minutes after the accident occurs, and for approximately 1 minute after a unit transfers to the RSST's while an SI or CLS condition is occurring on either unit. Field measurements indicate voltage correction sensing and drive motor acceleration take 2 cycles, and each tap change takes approximately 1.9 seconds. Voltages shown at t = 5 seconds are calculated with either fixed taps (no LTC correction) or with the LTC advanced 2 taps from its position at the time of the accident. The bases for the LTC advancement are the instantaneous correction modification and the timing sequence previously identified.

2. The 34.5 KV reactor banks will be tripped when a unit transfers to the RSST's if an SI or CLS condition is occurring on either unit.

3. The 4.16/.48KV emergency transformers were modeled as being tapped at 4056V rather than the existing taps of 4160V and 4260V.

Although we will modify the 4KV feeds from the RSST's to the emergency and station service buses, all our voltage profile studies have been run based on the existing cable arrangement. These studies should provide results close to those achieved based on our modifications. Once we finalize our cable modification, we will assess the effect of the modifications on our voltage profiles completed to date and will inform you of any negative impact on the conclusions we have reached in this analysis.

Our voltage analysis assumed occurrence of a CLS, which includes all motors started on an SI plus the additional motors required by a CLS, and loading of the RSST's as defined in the Analysis Assumptions (Section III). Unit station service loads are assumed to transfer to the RSST's upon the occurrence of a CLS. For two unit loading of the RSST's, three possibilities of the timing of the second unit load transfer to the RSST's were considered. The station service bus loads of the second unit were assumed to transfer 60 seconds prior to, simultaneous with, and 60 seconds after, the occurrence of a CLS on the first unit. After initial analysis indicated that the second unit transfer at 60 seconds after the CLS provided a worse case than the 60 second transfer prior to the CLS, the offset cases were limited to transfers 60 seconds after the CLS.

The simultaneous cases are the worst cases; however, we believe the probability of their occurrence is sufficiently small that modifications are not required specifically for these cases. The 60 second offset cases were run to analyze events we view as credible. Analysis for the second unit load transfer with a 60 second offset on either side of the first unit CLS is equivalent to analysis of the second unit load transfer at any time greater than 60 seconds.

B. Voltage Profile Summary Sheets

We have included copies of our voltage profile results for those studies which were run after we decided to implement several modifications. Along with initial starting voltages and final steady state voltages, a series of times are shown to indicate the effects of motor starting, motors reaching full speed, LTC corrective action, and load transferring to the RSST's. This transient analysis is used to ensure that spurious separation of the emergency buses will not occur.

The MOV's are modeled as starting loads, drawing locked rotor amps, through the first 5 second time period to reflect their higher starting voltage rating.

The 480 volt buses are listed on the voltage profile summary sheets in a format with the 1H bus always above the 1H1 bus, the 2J bus above the 2J1 bus, etc.

Our voltage profile computer model provides voltages on a per unit basis for all 500KV, 230KV, 36.5KV, 4.16KV and 480V buses, using those voltages as base voltages. The voltages are listed in per unit on the voltage profile summary sheets.

These summary sheets will be individually discussed in Sections G, H, I, J, K, and L which follow.

C. Motor Terminal Voltage Requirements

To ensure all 4KV and 480V loads receive adequate voltage during all conditions, minimum 4KV and 480V bus voltages were calculated based on each motor receiving its minimum required starting and running voltages. This calculation includes voltage drop in all cables feeding the motors. These results are tabulated in Appendix D. This table provides the guidelines for acceptability of the voltage profile results. Note that the starting voltages required at the 480V buses for loads starting from motor control centers (MCC's) are based on MOV's requiring 80% of 460V (368V) to start.

D. 120V Contactor Requirements

Analysis of voltages available to the 120V contactors, which control the load fed from MCC's, was completed in a similar manner. Based on a review of 1E control circuits' lead lengths and burdens, selected worst case circuits were analyzed. The analysis method assumed MCC bus voltages which would occur for worst case voltage profiles. This voltage will supply at least 382 V (80% of 480 V) to the worst case MOV's. The maximum lead lengths which would allow the contactors' coils to receive 100V (83% of 120V) were then calculated.

Five different sizes of control transformers are used in the 1E control circuits. These sizes are 65VA, 120VA, 140VA, 200VA, and 350VA. Three of these sizes are used in the NEMA size 1 starters which supply the MOV's required to start on SI or CLS. These transformer sizes are 65VA, 120VA and 140VA. For worst case conditions (i.e. long lead length and high burden), the impedances of these control transformers are higher than the maximum impedance allowable to ensure the contactor coils receive at least minimum pick-up voltage when minimum starting voltage is available for the MOV's. Replacement of existing control transformers with transformers of suitable characteristics will correct this condition. Investigations of this option and of the less than worst case conditions are still being completed. As a result, the scope of this modificaton has not yet been developed.

E. Emergency Bus Loss of Voltage/Degraded Voltage Protection

The emergency buses each have a two out of three loss of voltage and a two out of three degraded voltage protective scheme. Each scheme consists of three undervoltage relays set to initiate transfer of an emergency bus from its off-site source based on an undervoltage of a certain duration. The loss of voltage setpoints are 75% voltage and 2 seconds. The degraded voltage setpoints are 90% voltage and 7 seconds for an SI or CLS condition or 90% voltage and 60 seconds for non-accident conditions. The setpoints are based on a nominal 4160V bus voltage.

The emergency diesel generators receive starting signals initiated from the degraded voltage 7 second SI timer (for use in accident conditions), from a degraded voltage 50 second timer (for use in nonaccident conditions), and from a 2 second loss of voltage timer.

In the event of an undervoltage on a emergency bus, the emergency bus will separate from its reserve station service source, at the end of one of the previously indicated design times, and will load to the diesel generator. The longest time frame in loading to the diesel generator during an accident is for a degraded voltage condition. Including 7 seconds of sensing time and the 2 second diesel generator breaker closing delay, the emergency bus will load to the diesel generator at approximately 9 seconds. The FSAR requires that the diesel generator be up to speed and accepting load within about 10 seconds. Westinghouse has documented, see Appendix E, that a safety injection flow interruption of approximately 15 seconds, including sequencing of safeguards loads, may be tolerated at any point during an accident. Therefore, the existing timing sequence is acceptable.

The 75% and 90% undervoltage setpoints and associated times are based on protection of the motors. Referral to the motor terminal voltage requirements listed in Appendix D indicates the 90% setpoint adequately protects the 90% continuous rating of the motors. Comparison with the voltage profile results indicates steady state voltages are well above the 90% setpoint.

The 60 second degraded voltage setpoint is sufficient to allow the emergency bus to ride through reactor coolant pump motor starting transients. The degraded voltage 7 second timers ensure the emergency loads are sequenced onto the diesel generator in the same time frame required for loss of voltage. The 2 second loss of voltage timer allows the emergency bus to ride through transients.

The tolerance of the voltage relay setpoints is ± 0.1%. The maximum operating time of the voltage relays is 0.5005 seconds. The 7, 10, 50 and 60 second timers have tolerances of ± 5% of the setting. The 2 second timer has a tolerance of ± 1%. The two types of auxiliary relays used in the protective scheme operate in 0.014 seconds and 0.084 seconds. Based on these tolerances, the maximum time between the occurrence of a degraded voltage condition during an accident and the emergency bus loading to the diesel generator will be 10.2 seconds, which meets FSAR requirements.

The degraded voltages allowed with this protective scheme (e.g., worst case degraded voltage is 76% voltage for 60 seconds) will not cause 1E overload heaters to operate. Fusing is not used either for primary protection of a 1E load or for control transformer protection in 1E control circuits.

Appendix F consists of logic diagrams of the loss of voltage/degraded voltage protective scheme for 4KV buses 1H and 1J. Unit 2 protection is similar.

Appendix G consists of a description of the testability of the loss of voltage/degraded voltage protective scheme.

The Technical Specifications will be modified to include the protective setpoints and allowable values indicated above.

F. LOAD SEQUENCING

The intent of this section is to describe loading caused by accident and loss of offsite power conditions. The loads addressed are the 4KV and load center fed 480V emergency loads. The discussion will address load sequencing, bulk loading, load shedding, protective system bypassing, and the resetting and reinstating of those items.

Loads (i.e. charging pumps) which may be running during normal operation and which also receive safeguards start signals are indicated as starting for the purposes of this discussion.

The loading described below is based on the assumption that the control switch of the "C" charging pump is in the "Pull-to-Lock" position.

1. Safety Injection, Consequence Limiting Safeguards, and Loss of Offsite Power Conditions.

The Unit 1 4KV and load center fed 480V emergency bus loads and diesel generators are listed, in Appendix H, in a tabulation showing what actions are initiated from SI, CLS, and Loss of Offsite Power signals. This tabulation is the basis on which the following scenarios are discussed.

Unit 2 actions are analogous to the Unit 1 actions described.

2. Loss of Offsite Power Concurrent with an SI

The loads starting on each emergency bus for SI signals will be the charging pumps, low head safety injection pumps, and the filter exhaust fans.

Each emergency bus feeder breaker will be tripped, separating the emergency buses from their offsite sources. The stub bus tie breaker, component cooling and residual heat removal pumps will be tripped off each emergency bus. In addition, the bus 1H charging pump will be tripped.

The diesel generators will each receive two start signals. Their breakers will close after the generators are within 95% ± 2% of their rated voltage and 97% ± 2% of their rated speed, but not sooner than 2 seconds after the automatic breaker closure signal is given. Once the emergency bus offsite feeder breaker opens and the diesel generator breaker closes, the loss of voltage/degraded voltage protection scheme is automatically disabled. This is also standard operation for the loss of offsite power scenarios discussed following this one.

The steam generator auxiliary feedwater pump on each emergency bus will start 50 seconds after the SI.

3. Loss of Offsite Power Concurrent with a CLS

For the occurrence of a CLS, the loads which are initiated on SI signals will be initiated in addition to the CLS initiated loads.

Immediate starting signals will be received by the charging pump, low head safety injection pump, filter exhaust fan, containment spray pump, and the diesel generator on each bus.

The emergency bus feeder breaker, stub bus feeder breaker, component cooling pump, residual heat removal pump, and containment recirculation fan are tripped on both emergency buses. The bus 1H charging pump will also be tripped.

The diesel generators will pick up the emergency buses, after the generators attain the required speed and voltage, as discussed in Item F2.

Delayed starting will occur on each emergency bus as follows: 1) at 50 seconds after the CLS, the steam generator auxiliary feedwater pumps will start, 2) at 120 seconds after the CLS, the inside recirculation spray pumps will start, and 3) at 300 seconds after the CLS, the outside recirculation spray pumps will start.

4. Interruption of Offsite Power While an SI is in Progress

The loss of offsite power does not effect the sequencing of the delayed starting SI initiated loads. For an SI at T = 0 seconds and a loss of offsite power at T = 30 seconds, the steam generator auxiliary feedwater pumps still sequence on at T = 50 seconds. The following discussion will concern a loss of offsite power later than 50 seconds after an SI.

Upon the occurrence of an SI, the emergency diesel generator, charging pump, low head safety injection pump and filter exhaust fan on each emergency bus receive immediate start signals. The steam generator auxiliary feedwater pumps are started 50 seconds after the SI.

Upon the occurrence of the loss of offsite power, the emergency bus feeder breaker, stub bus feeder breaker, component cooling pump, and residual heat removal pump are tripped on both buses, while the charging pump is tripped on Bus 1H.

Each diesel generator breaker closes 2 seconds after the loss of offsite power and opening of its respective emergency bus feeder breaker.

5. Interruption of Offsite Power While a CLS is in Progress

The loss of offsite power does not effect the sequencing of the delayed starting CLS initiated loads. For a CLS at T = 0 seconds and a loss of offsite power at T = 100 seconds, the inside recirculation spray pump would start at T = 120 seconds and the outside recirculation spray pump would start at T = 300 seconds. The following discussion will concern a loss of offsite power later than 300 seconds after a CLS.

Upon the occurrence of a CLS, the emergency diesel generator, charging pump, low head safety injection pump, containment spray pump, and filter exhaust fan on each emergency bus receive immediate start signals. The containment recirculation fan on each bus will be immediately tripped.

The steam generator auxiliary feedwater pump will be started 50 seconds after the CLS. The inside and outside recirculation spray pumps will be started 120 and 300 seconds after the CLS, respectively.

Upon the occurrence of the loss of offsite power, the emergency bus feeder breaker, stub bus feeder breaker, component cooling pump,and residual heat removal pump are tripped on both buses. The bus 1H charging pump is also tripped.

Each diesel generator breaker closes 2 seconds after the loss of offsite power and opening of its respective emergency bus feeder breaker.

G. SINGLE UNIT LOADING ON THE RSST's

In this portion of the voltage profile analysis, it is assumed a unit has a CLS and immediately transfers its station service bus loads to the RSST's, while the other unit is operating at 100% power with its station service buses fed from its SST's.

Appendix I consists of Job Numbers 1663 and 2210, which summarize our results for these conditions.

Job 2210, Unit 1 CLS with Unit 2 at 100% power, indicates adequate starting voltages for all motors, spurious separation of an emergency bus will not occur, and adequate steady state voltages are achieved.

Job 1663, Unit 2 CLS with Unit 1 at 100% power, analyzes the effect of the condensate pumps, on buses 2B and 2C, starting after the LTC's had reached their final positions. The voltages on emergency buses 2H and 2J dip, although not severely or for a long duration.

H. TWO UNIT LOADING ON THE RSST's

In this portion of the voltage profile analysis, it is assumed that one unit experiences a CLS and transfers its station service loads to the RSST's at that time. The second unit trips and transfers its station service loads to the RSST's either at the occurrence of the CLS or 60 seconds later.

Appendix J consists of Job Numbers 3478, 3525, 0656, 1313, 0322, 2142, 1575, and 764.

Job 3478, Unit 2 CLS with Unit 1 transferring its station service loads to the RSST's at the same instant the Unit 2 CLS occurs, indicates all initial starting voltages are acceptable with the exception of the 480V bus 2H. The starting voltage requirements for the 480V containment spray pump and low head safety injection pump motors, both fed from bus 2H, are 70.9% and 72.0% voltage at the load center bus, respectively. Acceleration of the 4KV charging pump will ensure adequate starting voltage will be supplied to at least the containment spray pump. Acceleration of the containment spray pump will ensure adequate starting voltage is supplied to the low head safety injection pump. The protective relaying on both 480V motors will not operate before 20 seconds with the motors drawing locked rotor current at 100% voltage. At 70% voltage, the relay operating time is greater than 25 seconds. As a comparative example, the low head safety injection motor starts in under 0.6 seconds at 100% voltage and in approximately 2 seconds at 70% voltage. This fully justifies the starting voltages available for this situation. The voltages shown at T = 5 seconds do not reflect any LTC movement from its initial position. The voltages are adequate to start MOV's rated at 368V starting. Although 4KV bus 2J has adequate voltage at T = 5 seconds, 4KV bus 2H voltage appears low. The 87.7% shown on bus 2H would be approximately 89.6% at 7 seconds if one takes into account an instantaneous LTC signal and the LTC movement times previously specified (taking credit for 3 taps at 5/8% per tap). Based on a 90% degraded voltage setpoint and 7 second timer during accident conditions, bus 2H may spuriously separate from the offsite source and load to the diesel generator. Given the calculation conservatisms, extremely low occurrence probability, and marginality of the calculation results, we do not believe additional modification is required for this occurrence. Examination of the steady state (after LTC has completed its correction) condition indicates acceptable results.

Job 3525, Unit 1 CLS with Unit 2 transferring its station service loads to the RSST's at the same instant the Unit 1 CLS occurs, indicates all starting voltages are acceptable except for 480V bus 1J. The 480V containment spray and low head safety injection pumps, fed from bus 1J, require 73.3% and 73.6% voltage at the load center bus, respectively, to start. Again, based on 4KV charging pump motor acceleration, instantaneous LTC movement, and at least 20 seconds prior to relay operation due to starting current, this is an acceptable starting voltage profile. The 89.5% voltage shown on bus 1J at 5 seconds, will be approximately 91.4% at 7 seconds based on instantaneous LTC movement. The 480V voltages shown at 5 seconds are adequate for 368V starting MOV's. The steady state voltages are adequate.

Jobs 0656 and 1313, Unit 2 CLS with Unit 1 transferring its station service loads to the RSST's 60 seconds after the Unit 2 CLS, indicate acceptable starting, intermediate, and steady state voltages.

Job 0322, Unit 2 CLS with Unit 1 in start-up, indicates acceptable starting, intermediate, and steady state voltages.

Job 2142, both units tripping simultaneously in nonaccident conditions, indicates acceptable voltage levels.

Job 1575, Unit 1 CLS with Unit 2 station service loads on the RSST, analyzes condensate pumps starting on buses 1A and 2C after a steady state condition had been achieved for the two unit loading of the RSST's. Spurious separation of an emergency bus does not occur and adequate voltages are indicated after the motor accelerates prior to LTC correction.

Job 764, Unit 2 CLS with Unit 1 station service loads transferring to the RSST's at the instant the CLS occurs, is a re-run of Job 3478 but models the G bus tie breaker as closed. To determine the effect of either possible arrangement (i.e. Bus 1G supplying Bus 2G with the 2G feeder breaker open or the reverse arrangement), loading equivalent to both G buses was modeled on both 34.4/4.16KV intake structure transformers.

Comparison of Jobs 764 and 3478 indicates the G bus loading affects the voltage profiles. For buses 1J and 2H, the extra loading decreases voltage by 0.8%, maximum, during the transient conditions and by 2.6%, maximum, at steady state. For buses 1H and 2J, the respective values are 0.6% and 0.5%. The differences result because the offsite train (including RSST's A and B) supplying buses 1J and 2H is more heavily loaded than the other offsite train. In case 3478, the LTC's on RSST's A and B have reached maximum boost while the LTC on RSST C has not. Voltage drop caused by any additional load will be directly reflected on RSST's A and B since they have no additional correction capability. RSST C has additional voltage correction capability which will be used with the addition of a second G bus load. Consequently the voltage differences indicated are not as large.

In analyzing the voltage profile for Job 764, the reasoning presented in Job 3478 analysis is applicable. The voltage at T = 0 seconds is sufficient to start and accelerate the 4KV charging pump. The acceleration of this pump combined with instantaneous LTC movement will provide sufficient voltage to the 480V containment spray pump to accelerate this motor. The low head safety injection pump will begin acceleration no later than the time at which the containment spray pump has accelerated. Given that the protective relaying will not operate for at least 20 seconds, this analysis provides acceptable results. Based on achieving LTC movement of 3 taps at 7 seconds, 4KV bus 2H voltage would be approximately 88.9%. This indicates a spurious separation may occur. Again evaluating the calculation conservatisms and low occurrence probability, we do not believe additional modification is required for this occurrence.

By applying the voltage differences between Jobs 764 and 3478 to the other voltage profiles presented, analysis of the effect of both G buses being fed from one source may be accomplished for all other conditions. Results of this analysis indicate acceptable results.

I. LOSS OF 500/230/36.5KV AUTOTRANSFORMER

In the event of the loss of a 500/230/36.5KV autotransformer, the affected 34.5KV bus is automatically supplied by the 230/36.5KV transformer. Due to system load flow through the remaining autotransformer, this arrangement provides worst case conditions for those emergency buses fed from the remaining autotransformer. Results for buses being fed from the 230/36.5 KV transformer are somewhat better.

Jobs 2299, 1078 and 712, in Appendix K, provide results for buses 1J and 2H being fed (radially) from both the 230/36.5 KV transformer and the remaining 500/230/36.5 KV autotransformer. While this arrangement is a physical impossibility, the studies were completed in this manner because buses 1J and 2H are the worst case buses and these studies would provide a comparison between the two possible methods of supplying these buses with one autotransformer out of service. These jobs list "1J and 2H" columns and "1J' and 2H'" columns. The "1J and 2H" columns model those buses as being fed from the remaining autotransformer. The "1J' and 2H'" columns model those buses as being fed from the 230/36.5 KV transformers. The following analysis is applicable to both arrangements.

Job 2299, Unit 2 CLS with a Unit 1 trip causing its station service loads to transfer to the RSST's at the same instant the CLS occurs, indicates a lower voltage profile than previously indicated with Job 3478. The 4 KV motors will start at T=0. The 480 V motors will not start until the charging pumps have started and will probably require

LTC movement of approximately 5 steps. The 480 V bus 2H1 voltage at T=5 seconds is lower than that required to ensure all MOV's receive adequate starting voltage. The 4 KV bus 2H voltage at T=5 seconds is sufficiently low enough that, even with an additional LTC tap, at T=7 seconds the emergency bus will probably spuriously separate from its offsite source and load to the diesel generator. Based on the low occurrence probability for this scenario we do not see a need for modification to improve these results, which are conservatively calculated.

Job 712 and 1078, Unit 2 CLS with unit 1 station service buses transferring to the RSST's 60 seconds after the CLS indicates acceptable starting, intermediate, and steady state results.

Applying the results of the G bus transfer case, Job 764, to the two scenarios discussed above will provide the results for lower probability occurrences but will not measurably change the conclusions. The simultaneous case will be somewhat worse than the above analysis indicates. The 60 second offset cause will still provide acceptable results.

J. Overvoltage Analysis

Based on 535KV in the switchyard, no load on the RSST's or intake structure (G bus) transformers, no transformer losses, and the 34.5 KV reactor banks in a de-energized state, the LTC's correct to 4331v or 108% of the nominal rating of the 4kv motors and 103% of the nominal PT rating. At the 480V buses, the maximum voltage will be 513v or 112% of the nominal ratings of the 480V motors and 107% of the nominal PT ratings. The maximum voltage on the 120V motor starting circuits will be 139V, or 116% of the starter coil nominal rating. The overvoltages indicated are strictly for unloaded, lossless analysis. As loading is added to the RSST system, the overvoltages will cease to exist due to voltage drops across transformers and cables.

To simulate a light load on the RSST's, Job 3379, summarized in Appendix L, analyzes Unit 1 at 100% power and Unit 2 in refueling. Unit 1 loading on the RSST's consists of emergency bus loads only. Unit 2 loading on the RSST's consists of emergency bus loads and some 480V loads fed from the station service buses. The voltages for this condition are within the equipment ratings.

K. Large Nonsafety Motor Starts

Three nonsafety motors, condensate (3000HP), high pressure heater drain (2000 HP), bearing cooling (700 HP) and a fourth, component cooling (600 HP), located on each emergency bus, receive nonaccident automatic start signals, which conceivably could occur during an accident. Jobs 1575 and 1663 provided results for condensate pump starts after all CLS loads were operating and steady state voltages achieved. Acceptable results will also be achieved with the other three pumps since these have smaller motors than that of the condensate pump. If one of these motors started prior to the steady state condition, it could possibly cause the spurious separation of an emergency bus.

We will modify the automatic starting circuits of the condensate, high pressure heater drain, bearing cooling, and component cooling pumps to disable the automatic starts for approximately 60 seconds after an SI or CLS to ensure sufficient voltage is available to start the motors without causing emergency bus separation. These blocking features will be initiated such that blocking will not occur in cases which will not affect an emergency bus.

Manual starts of these pumps and of the reactor coolant and steam generator feedwater pumps will not be restricted during accident conditions. The operators will be informed that starting these pumps may cause emergency bus separation and they will only start the motors if necessary.

This spurious separation problem only exists on an emergency bus under SI or CLS conditions. Spurious separation does not occur for NON-SI and NON-CLS conditions.

L. Instrumentation Circuits

The 120V plant vital bus loads, including instrumentation, are fed either from uninterruptible power supplies or from regulating transformers and are not affected by system voltage fluctuation. For loss of A.C. power, the uninterruptible power supplies have the capability to supply the vital buses normally fed from the regulating transformers.

M. Control Circuits

The breaker control circuits for the 4,160 V bus and 480 V load center bus loads are supplied by the station batteries and are independent of system voltage.

The MCC control circuits, fed from 480 V/120 V control transformers, are not fused. As such, they are not affected by system voltage fluctuations.

VI. MOTOR OPERATED VALVE ANALYSIS

Our initial investigations indicated all MOV's required to start on either SI or CLS signals were rated at 460V ± 10% for starting and running. Further investigations with the MOV vendor have indicated a number of MOV's may be rerated for 368V (80% of 460V) starting, while others may not be rerated. Several MOV's are actually rated for continuous operation at 440V ± 10% and will start at 374V (85% of 440V). In addition, some MOV's are still being investigated for rerating. Out of a total of 82 MOV's on Units 1 and 2, 32 may be rerated for 368v (80% of 460V) starting, 36 are rated for 414v (90% of 460V) starting only, and 14 are still being investigated. The 440V MOV's are being investigated for starting capability at or below 368V. The 6V difference between their present rating and the re-rating value is fairly negligible.

Along with providing rerating values, the MOV vendor also recommended we contact the valve manufacturer to ensure the valve torque requirements on which the MOV vendor based his reratings are indeed the valve torque requirements as defined by the valve manufacturer. We are in the process of making this confirmation. Our present schedule estimates 3 months until the valve manufacturer's review is completed.

The acceptability of our voltage profile results is based on rerating the MOV's to 368V starting. Review of the voltage profile results indicates that MOV's rated for 368V starting will probably start before and definitely no later than 5 seconds after the initial accident for all conditions with the exception of job 2299 which analyzes the loss of an autotransformer and simultaneous 2 unit loading on the RSST's at the instant CLS occurs. The MOV's which cannot be sufficiently rerated will be replaced with MOV's rated at 368V voltage starting.

We are presently field verifying the overload heater settings for these MOV's to ensure the heaters will not operate under these conditions. Overload heaters which do not allow adequate MOV starting time will be modified or replaced. Investigations to date indicate acceptable results (i.e. the overload heaters do not operate during MOV starting).

Prior to wholesale replacement of MOV's rated above 368V starting, we have several alternatives to investigate in an effort to minimize MOV replacement. The first alternative is to analyze the specific voltage drops to each MOV rather than using worst case voltage drops. In less than worst case conditions, a rating higher than 368V may be sufficient. The second alternative is to compare the torque required by the MOV in its worst case operating condition versus the torque value on which the valve manufacturer is basing his analysis. The procurement document may have specified that several MOV's have the same capabilities although they may be operating under different conditions.

The scope of this modification is presently undetermined. The rerating may require installation of new torque switch limiter plates to ensure the units will "torque out" at the maximum operating output of the unit. We are pursuing this investigation with the MOV manufacturer. The MOV's on which the MOV vendor has not yet provided a rerating capability present an unknown scope. Additionally, the reply from the valve manufacturer will affect the scope of this modification.

It should be noted that the ability to rerate an MOV to 368V starting is based on the torque developed at that voltage versus the torque requirements of the valve. The MOV manufacturer has certified, based on his record of valve torque requirements, that the existing MOV's which may be rerated are capable of starting at 368V. This certification provides documentation that the MOV's are presently starting at 368V. The torque limiter plate modification is simply to provide better protection of the MOV.

VII. COMPUTER MODEL VERIFICATION

To verify our computer model and to ensure that our voltage analysis results are valid, we performed a voltage profile test, in which Unit 1 station service loads were fed from RSST's. System voltages, RSST load tap changer (LTC) positions, and 4.16 KV (emergency and normal) and 480 volt (emergency) bus voltages and currents were recorded. The system voltages, RSST's LTC positions, and the bus current values were input into the computer model to calculate bus voltages. Appendix M contains tabulations of the recorded and calculated values.

Review of 4KV buses 1A, 1B, 1C, 1H, 2H, and 2J, and of 480V buses 1H1 and 1J1 indicates acceptable model results with errors in the conservative direction when compared with values measured during the test.

Review of 4KV bus 1J indicates a low 4KV bus voltage and an error in the non-conservative direction. However, the measured value is in error. The following tabulation lists voltages read from voltmeters at the time of the test to compare with the measured values:

4KV Bus	Measured	Voltmeter Reading	% Error
1A	4135	4320	4.5
1B	4330	4280	1.2
1C	4245	4250	0.1
1H	4205	4280	1.8
1J	3855	4320	12.1
2H	4285	4250	0.8
2J	4245	4300	1.3

The voltmeter readings agree very closely with the measured values in all cases but 1J. Buses 1A and 1J are fed from the same RSST and Bus 1J is the more lightly loaded of the two. The measured voltages should be closer than indicated. Based on this and the 4KV voltage calculated based on 480V bus 1J1 measured voltage (addressed later), the 4K bus 1J measured value is in error and should be ignored. The computer calculated voltage is conservative when compared to the voltmeter reading.

Review of 480V bus 1H indicates a much higher measured 480V bus voltage (555V) than predicted by the model. Based on the 4205V measured on 4KV bus 1H and the existing 4.16/.48KV transformer tap (4260V), the maximum voltage on 480V bus 1H would be 474V. This maximum voltage would change to 511V by retapping the transformer to provide the maximum voltage boost (tap 3950V). The 480V bus 1H1 measured voltage of 495V is close to the maximum voltage calculated (485V) based on existing transformer taps and 4205V on bus 1H. Based on this analysis, the 480V on bus 1H measured voltage is incorrect. The voltage predicted in the model (450V) is a conservative estimate of the actual voltage for 480V bus 1H.

Review of 480V bus 1J indicates a higher measured voltage (530V) than predicted (457V). To achieve 530V based on the existing transformer tap (4260V), the minimum voltage required on 4KV bus 1J is 4704V. Changing the tap to its maximum boost position (3950V) would reduce this minimum requirement to 4361V. Both these values exceed the voltmeter reading (4320V). The 490V measured on 480V bus 1J1 requires a minimum of 4247V on 4KV bus 1J, further substantiating the errors in measurement of 4K bus 1J and 480V bus 1J. The computer calculated voltage for 480V bus 1J is a conservative estimate of the actual voltage.

The maximum and minimum voltages indicated above are based on unloaded, lossless transformers.

These results justify the use of our computer model in predicting voltages during worst case analysis.

VIII. REVIEW FOR SIMULTANEOUS OR CONSEQUENTIAL LOSS OF OFFSITE POWER SOURCES

We have reviewed our electrical distribution system to determine its compliance with GDC-17 and whether or not any events or conditions exist which could result in the simultaneous or consequential loss of both required circuits to the offsite network. With the exception of a few minor modifications, the design of our offsite power supply is in full compliance with GDC-17. The modifications are required to comply with the requirement concerning the simultaneous or consequential loss of both offsite sources. These modifications are addressed below.

The first modification concerns the 34.5KV tie breaker between the two 34.5KV buses which supply the redundant offsite power supplies. This tie breaker would normally be open and only automatically closes upon the loss of supply power to either 34.5KV bus when both 34.5KV feeder breakers from the 230/36.5 KV transformer are in manual operation only. To eliminate any possibility of simultaneous loss of both offsite sources due to tie breaker failure, we will incorporate operating procedures to leave both 34.5KV disconnects open (one disconnect is installed on each side of the breaker).

This principle will also be applied when the 230/36.5 KV transformer is supplying a 34.5 KV bus. The normally closed 34.5KV disconnects on either side of the open breaker, which could supply the other 34.5KV bus from the 230/36.5 KV transformer, will be opened.

The third modification concerns routing of RSST control cables from the 500/230/34.5 KV switchyard to the turbine building. Our review indicates that although the control cables for RSST's A and B are routed separately from the control cables for RSST C, several areas of cable trough exist where the occurrence of a fire could possibly cause the loss of all three RSST's. We are presently reviewing methods by which we will remove this possibility. Modifications will be completed in a schedule consistant with the other identified modifications.

IX. TECHNICAL SPECIFICATIONS

Based on the results of our GDC-17 analysis, there are no Technical Specification revisions required.

Technical Specifications will be submitted to address the loss of voltage/degraded voltage protective scheme.

X. SUMMARY OF MODIFICATIONS

A. Operating Restrictions

1. The existing load shedding scheme, which automatically occurs on two unit loading to the RSST's, will be normally enabled when 1) one unit is on line and the other unit is in start-up, 2) both units are on line, and 3) both units are in start-up.

2. Adherence to the transmission system voltage regulation action plan.

3. The following operating restrictions are required until the underground portion of the 4 KV cable between the RSST's and the transfer buses is replaced. The restrictions are required to ensure the 4 KV transfer bus switchgear and 4 KV cables feeding the transfer buses from the RSST's do not endure overloads longer than industry standards will allow. The transfer buses are each rated for continuous operation at 3000 amps. The 4 KV feeder cables from RSST's A and C are each rated for continuous operation at 1684 amps. The 4 KV cables from RSST B are rated for continuous operation at 1624 amps. These cable ratings are for worst case (summer) conditions. The following operating procedures shall be followed to minimize the reduction in expected equipment life due to overload. The procedures are:

    a. Single Unit Loading on the RSST's

        i. Start-up

            a. Those loads which are shed as a part of the existing load shed scheme should not be running during start-up.

b. The operators must monitor the loading on each RSST and maintain loading below the continuous ratings noted above. The operator has a number of redundant pumps (e.g., charging, component cooling and bearing cooling) which he should arrange to minimize RSST loads. Additionally, 480V transformer loading may be adjusted. Start-ups with one condensate pump may be required. The amount of loading restriction required will depend on how much load current the operating pumps are drawing.

ii. Unit Trip

a. Within one hour after a unit trips, RSST loading must be reduced as indicated in "Start-up", discussed above.

b. Two Unit Loading on the RSST's

i. One Unit in Start-up - One Unit Tripped

a. After the second unit transfers to the RSST's, loading must be reduced to at least 3000 amps on each RSST within 30 minutes.

b. Within 60 minutes after the second unit transfers to the RSST's, RSST loading must be reduced to the 1684A and 1624A ratings previously specified.

ii. Two Unit Trip

a. The restrictions identified for the one unit start-up, one unit trip condition apply to this case.

c. For instances in which any RSST loading exceeds the applicable 90°C rating of its 4 KV feeder cable, the amount of load current and its duration shall be recorded. A cumulative total will be kept for comparison with the allowable overload times.

The restrictions for unit trips apply for nonaccident and accident conditions.

The guidelines expressed in these restrictions are applicable for use with the 2000 amp rating of the cable during the winter. The operator will use 2000 amps as the maximum allowable load rather than 1624 amps and 1684 amps.

4. Disconnects on both sides of the 34.5KV bus tie breaker will be normally open.

5. With regard to the two 34.5 KV breakers supplying the two 34.5 KV buses from the 230/36.5 KV transformer, disconnects on both sides of the open 34.5 KV breaker will be opened after the other 34.5 KV breaker is closed.

B. MOV Re-Rate and Replacement

1. Rerate all MOV's with the capability to be rerated to 368V starting. This may require installation of new torque limiter plates on these MOV's.

2. Replace all other MOV's with MOV's rated for 368V starting.

C. Automatic Tripping of the 34.5 KV Reactor Banks

1. All 34.5 KV reactor banks will be tripped, following an SI or CLS on either unit, when a unit's normal buses load to the RSST's.

D. Instantaneous LTC Voltage Correction

1. The RSST LTC voltage correction mechanism will be given a signal to provide instantaneous voltage correction upon the occurrence of an SI or CLS on either unit. This signal will last for approximately 3 minutes.

2. The LTC voltage correction mechanism will be given a signal to provide instantaneous voltage correction when a unit transfers to the RSST's during an SI or CLS. This signal will last for approximately 1 minute.

E. Blocking Automatic Starting of Large Non 1E Motors

1. Block condensate, high pressure heater drain, bearing cooling, and component cooling pumps from automatic starting for approximately 60 seconds after an SI or CLS occurs.

F. 4KV Cable Replacement

1. The existing underground portion of the 4KV cable from the RSST's to the transfer buses will be removed from service.

2. The exact cable replacement modification has not yet been determined. Most probably, 4KV overhead bus will be installed from the RSST's to the turbine building wall. From that point, feeders will go either directly to the transfer buses, or split and separately supply the transfer buses and the Unit 2 station service buses, or split and separately supply each station service bus and transfer bus. The emergency buses will continue to be supplied from the transfer buses.

G. Increase Cooling Capacity of RSST's

1. Add 2 radiators with fans to each RSST to increase their 55°C rise ratings to 30 MVA per transformer.

H. Replacement of Control Transformers

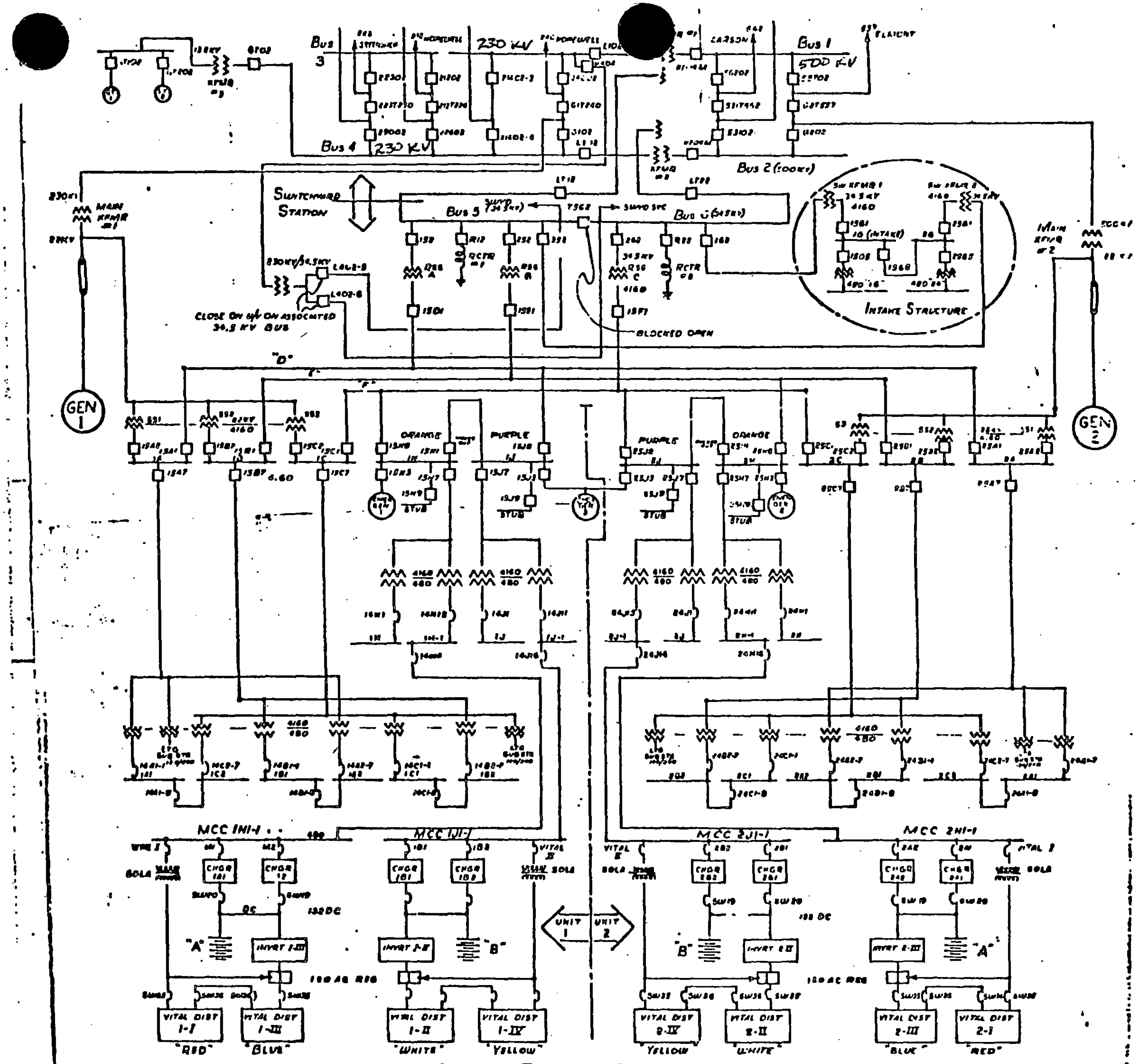
1. Control transformers (480V/120V), which have impedance characteristics such that they provide unacceptable voltages to the MOV contactor coils, will be replaced.

I. Re-tap emergency 4KV/480V transformers to the 4056 tap.

J. Modification of RSST control cable routing.

K. Possible modification or replacement of MOV overload heaters, depending on the outcome of field verification.

APPENDIX A



SURRY POWER STATION

ELECTRICAL POWER DISTRIBUTION, ONE LINE, INTEGRATED, SCHEMATIC

S.RS. 2A

L.A. JOHNSON 10-13-75 REV: 8-10-76 REV: 8-19-76 REV: 6-23-77 REV: 1-8-80

APPENDIX B

This appendix is for our transmission system voltage regulation action plan which will be submitted by July 1. 1982.

APPENDIX C

EQUIPMENT LOADING ANALYSIS TABULATION

EQUIPMENT	EQUIPMENT RATING	MAXIMUM LOAD PRIOR TO MODIFICATIONS	PERCENTAGE OF EQUIPMENT RATING	MAXIMUM LOAD AFTER MODIFICATIONS	PERCENTAGE OF EQUIPMENT RATING
1. 500/230/36.5 KV Autotransformers	450/360/90 MVA Tertiary rated at 1424 Amps at 36.5 KV	1424 Amps	100%	1424 Amps	100%
2. 230/36.5 KV Transformer	112 MVA 1772 Amps at Neutral Position 1610 Amps at Maximum Boost	1610 Amps	100%	1610 Amps	100%
3. 34.4/4.16 KV RSST's	24 MVA 3336 Amps at Neutral Position 2967 Amps at Maximum Boost	3487A at 4.16KV	118%		
	30 MVA 4170 Amps at Neutral Position 3709 Amps at Maximum Boost			3487 A at 4.16KV	94%
4. 4.16/.48KV Emergency Bus Load Center Transformers	1333 KVA 1603 Amps at 480V	1698 Amps at 426V	106%	1698 Amps at 426V	106%
5. 4-2000 MCM Al. Cables/Phase RSST's to Transfer Buses	Summer 1684 Amps at 90°C 2008 Amps at 130°C	3487 Amps at 4.16KV	207%	Modification not finalized at this point; however, 4 KV feeder ampacity will be such that worst case 2 unit loading will be within its capability.	
			174%		
	Winter 2000 Amps at 90°C				
6. 2-3/C 750 MCM Al. Cables/Phase Transfer Buses to Emergency Buses	946 Amps	478 Amps at 4.16KV	51%	478 Amps at 4.16KV	51%

EQUIPMENT LOADING ANALYSIS TABULATION (Con't.)

EQUIPMENT	EQUIPMENT RATING	MAXIMUM LOAD PRIOR TO MODIFICATIONS	PERCENTAGE OF EQUIPMENT RATING	MAXIMUM LOAD AFTER MODIFICATIONS	PERCENTAGE OF EQUIPMENT RATING
7. 4-KV Emergency Bus Feeder Breakers	1200 Amps	478A at 4.16KV	40%	478A at 4.16KV	40%
8. 4-KV Transfer Bus Feeder Breakers	3000 Amps	3487 Amps at 4.16KV	116%	3000 A	100%

Notes:

1. Voltages expressed are based on conservative approximations of worst case steady state voltages (i.e., the LTC is not able to fully correct to 4317V).
2. The maximum load is based on proper operation of the existing load shedding scheme.

APPENDIX D

MINIMUM REQUIRED BUS VOLTAGES FOR CLASS 1E LOADS

Bus		Minimum Voltage Required At Bus			
		Starting		Running	
Nominal Voltage	Bus	Volts	% of Nominal	Volts	% of Nominal
4160	1H	2812	67.6	3607	86.7
	1J	2816	67.7	3611	86.8
	2H	2816	67.7	3611	86.8
	2J	2820	67.8	3611	86.8
480 (Load's fed directly from load center)	1H	344	71.6	419	87.3
	1H1	*	*	*	*
	1J	353	73.6	418	87.1
	1J1	*	*	*	*
	2H	346	72.0	422	88.0
	2H1	*	*	*	*
	2J	353	73.5	419	87.3
	2J1	*	*	*	*
480 (Loads fed from MCC's)	1H	*	*	*	*
	1H1	384	80.0	434	90.4
	1J	*	*	*	*
	1J1	383	79.8	428	89.2
	2H	*	*	*	*
	2H1	391	81.4	432	90.0
	2J	*	*	*	*
	2J1	394	82.1	432	89.9

Notes:

1. Starting voltage requirements are based on those loads which start immediately with SI or CLS signals.

2. MCC loads' starting requirements are based on MOV's starting with a minimum of 368V (80% of 460V).

3. * indicates no loads of the specified type (e.g., fed from MCC's) are fed from the bus indicated.

APPENDIX E

VPU(RRK)-46

J.M. Davis

Westinghouse Electric Corporation

Water Reactor Divisions

Nuclear Commercial
Operations Division

Box 355
Pittsburgh Pennsylvania 15230

November 20, 1980

Mr. B. Stewart
Virginia Electric and Power Company
P. O. Box 26666
Richmond, VA 23261

Dear Mr. Stewart:

VIRGINIA ELECTRIC AND POWER COMPANY
SURRY & NORTH ANNA POWER STATION

LHSI Flow Interruption

On the Surry and North Anna plants, Westinghouse was asked by VEPCo to determine the effect on the plant safety analyses of a short duration delay (2.0 or 4.2 seconds respectively) in safety injection flow following a blackout. A related issue was evaluated extensively by the NRC during 1976 and was documented in NUREG-0138 (issue Number 4). Although the main emphasis in the NRC position stated in NUREG-0138 related to loss of power following reset of safety injection, the NRC made the following statement:

> "Analyses in the Reactor Safety Study, WASH-1400, indicated the likelihood of a LOCA to be about one chance in 1000, per reactor year. The probability of the loss of offsite power in a one-hour period following a LOCA would be about one chance in 50,000. The combined probability of this sequence of events is very low.
>
> Routine ECCS evaluations by the staff have not required consideration of interruption of flow to the core because the fundamental design basis for mitigating the consequences of a LOCA has been that a single failure or single operator error should not cause a loss of ECCS function. The staff had identified no such failure and, therefore, analyses of interruptions of core flow during a LOCA were not considered to be warranted."

Based on the above evaluation, safety analyses have not been required to incorporate flow interruptions due to loss of power. However, Westinghouse has evaluated the effect of flow interruptions occurring during the time frame that LOCA peak clad temperatures are calculated (i.e. prior to safety injection reset). A typical flow interruption, resulting from loss of offsite power, with a time duration of approximately 15 seconds, including sequencing of safeguards loads has been investigated. The effect of this short duration flow interruption is more than offset by performing the safety analyses with consistent assumptions, e.g. RCP running during the blowdown phase of a LOCA. A sensitivity study has been submitted to the NRC (attached letter NS-TMA-1928 from T. M. Anderson of Westinghouse to T. H. Novak of NRC dated September, 1978) which qualifies the reduction in peak clad temperature with offsite power available. This reduction more than offsets a temperature increase due to a safety injection flow interruption.

The addition of the 2.0 (or 4.2) second delay to the other delays that will occur due to sequential loading of the safeguards equipment onto the diesel generators for Surry and North Anna falls within the 15 second envelope described above. Therefore, Westinghouse concludes that the impact of the additional delay will not invalidate the results of the Surry and North Anna safety analyses. Based on the above discussion, Westinghouse does not believe that it is appropriated to perform plant specific analyses, nor would it be productive to speculate on maximum time allowable to meet safety criteria without performing significant safety analyses.

Would you please send me a copy of any correspondence you send to or receive from the NRC on this subject.

Very truly yours,

Richard R Kent

Richard R. Kent
Project Engineer
Vepco Projects

/rcc
Attachment

B. Stewart 1L, 1A

cc: G. Smith (VEPCo) 1L, 1A
R. Berryman (VEPCo) 1L, 1A
J. Davis (VEPCo) 1L, 1A
F. Walker (S&W) 1L, 1A
W. R. Cartwright (VEPCo-North Anna) 1L, 1A
J. Wilson (VEPCo-Surry) 1L, 1A

Attachment to NS-TMA-1928

Case			PCT
1	LOP	RCP-T	1950 °F
2	OPA	RCP-R	1707 °F
3	OPA	RCP-T	1932 °F

NS-TMA-1923

inghouse Electric Corporation Power Systems

Box 355
Pittsburgh Pennsylvania 15230

September 6, 1978

Mr. Thomas H. Novak
U. S. Nuclear Regulatory Commission
Phillips Building
7920 Norfolk Avenue
Bethesda, Maryland

Dear Mr. Novak:

Recently a question has been raised by your staff on the assumptions made by Westinghouse with regards to offsite power and how that is interprated with regards to containment systems actuations following a LOCA. The Westinghouse position has been that the set of assumptions yielding the highest peak clad temperature is loss of offsite power and reactor coolant pumps tripped. Inherent in this set of assumptions is the fact that there is a delay time assumed for the start-up of emergency diesels for on-site power. These are the assumptions used in a design Westinghouse ECCS analysis.

These assumptions were justified by Westinghouse sensitivity studies performed and presented to the staff in 1974. Unfortunately, these studies have never been formally documented by either Westinghouse or the staff. Also, the staff's recollection of those studies is different than that of Westinghouse. Therefore, we repeated part of that study. The details follow.

The plant analyzed was a typical 4-loop, 3411 Mwt plant with a 12' core and 17 x 17 fuel assemblies. The cases investigated were:

1. Westinghouse design case: Loss of offsite power (LOP) and reactor coolant pumps tripped (RCP-T).

2. Consistent offsite power available case: Offsite power available (OPA) and reactor coolant pumps running (RCP-R).

3. Inconsistent case: Offsite power available (OPA) and reactor coolant pumps tripped (RCP-T).

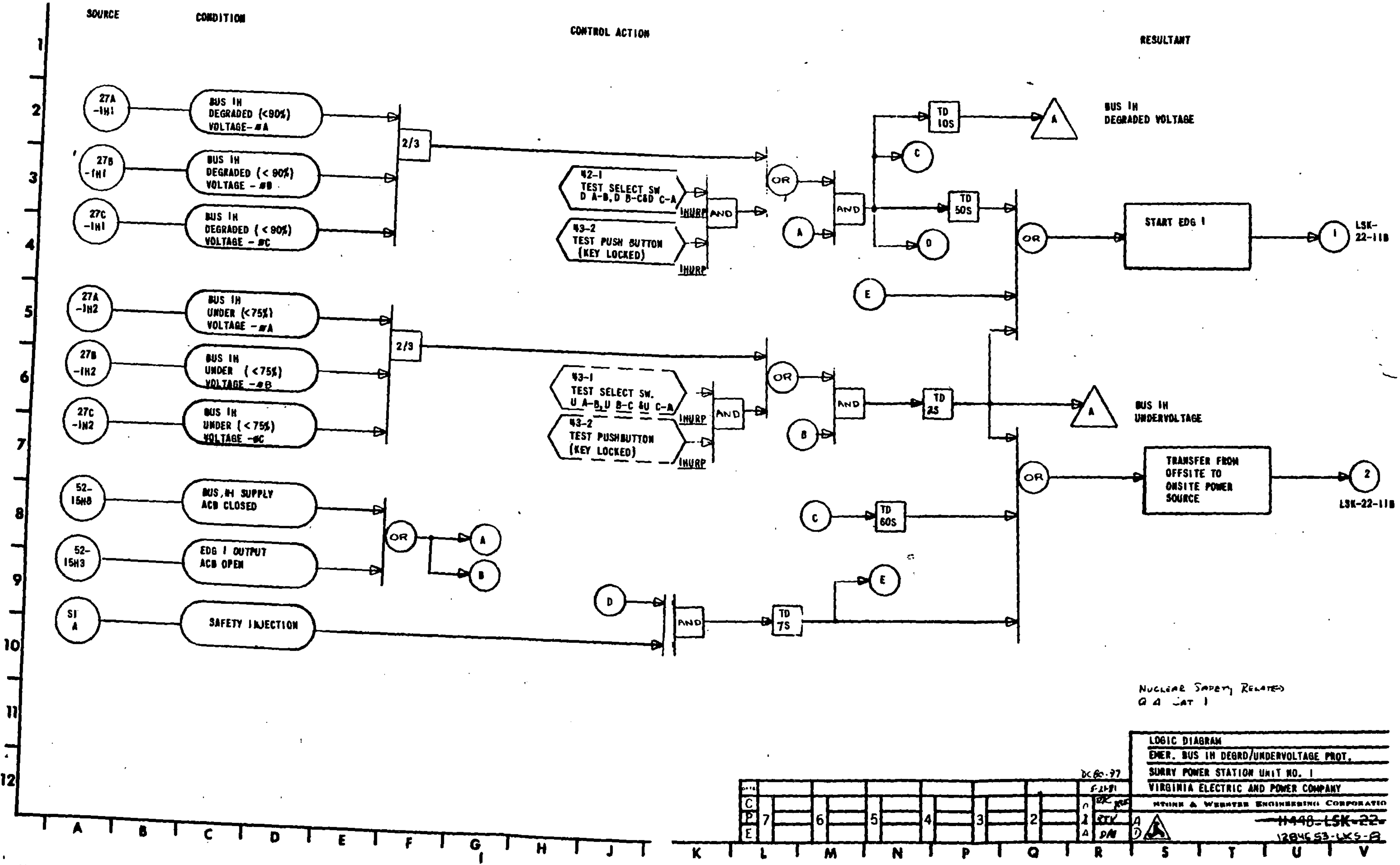
The results are summarized in the attachment. They confirm that the Westinghouse design assumptions are conservative. These results were reported to you on the telephone during the past week. It is our understanding that the Westinghouse design basis assumptions are acceptable for all Westinghouse design NSSS including the 414 design despite some misunderstanding with respect to the wording of the NRC 1974 Status Report on the Westinghouse ECCS Evaluation Model.

Very truly yours,

T. M. Anderson, Manager
Nuclear Safety Department

RAH/ls

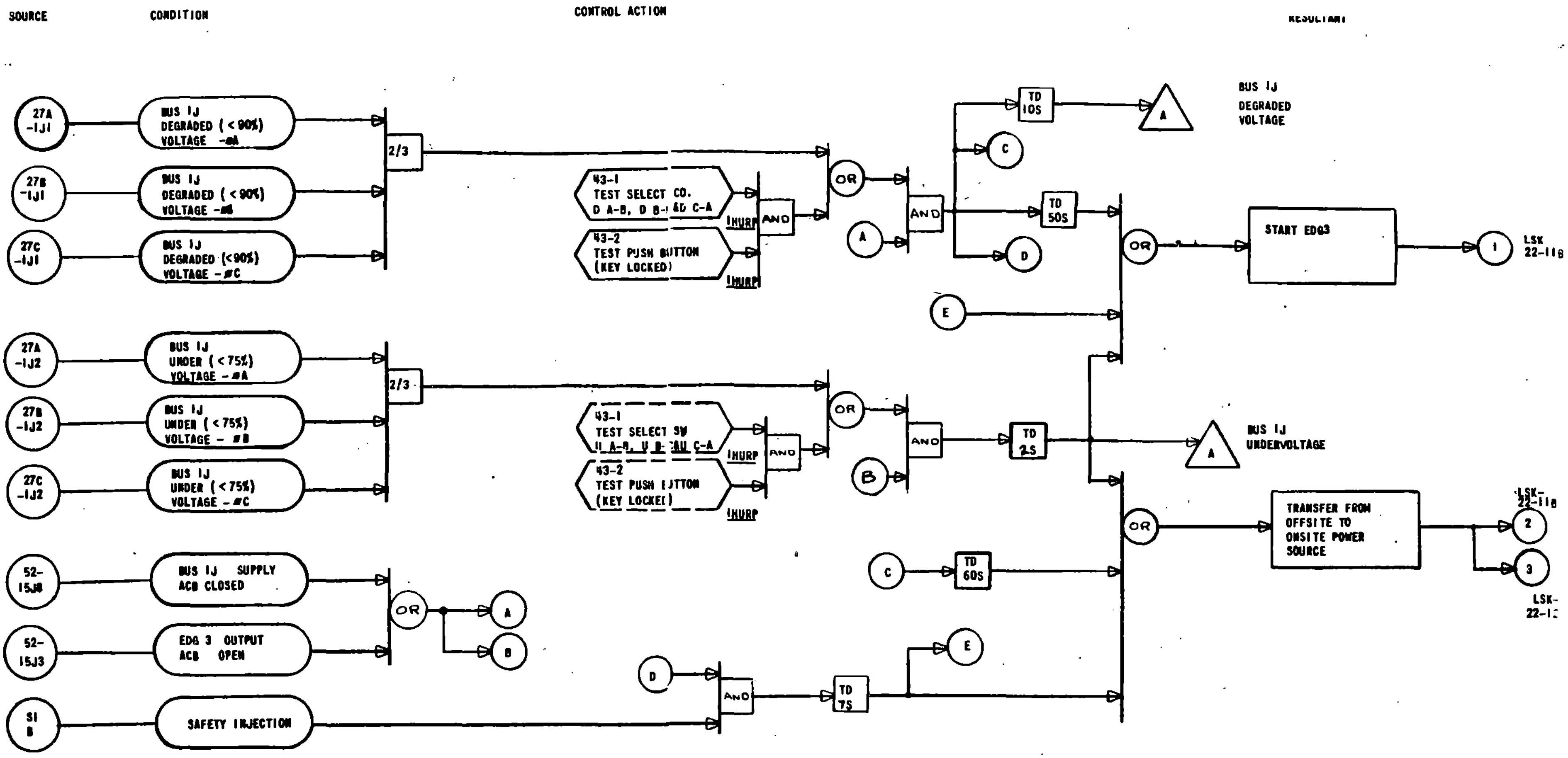
APPENDIX F



NUCLEAR SAFETY RELATED
QA CAT 1

LOGIC DIAGRAM
EMER. BUS 1H DEGRD/UNDERVOLTAGE PROT.
SURRY POWER STATION UNIT NO. 1
VIRGINIA ELECTRIC AND POWER COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
~~11448-LSK-22~~
12845 53-LKS-B

DC 80-97
5-21-81



Nuclear Safety Related
Q A Cat 1

LOGIC DIAGRAM
EMER. BUS 1J DEGRD/UNDERVOLTAGE PROT.
SURRY POWER STATION UNIT NO. 1
VIRGINIA ELECTRIC AND POWER COMPANY
STONE & WEBSTER ENGINEERING CORPORATI

DATE							5-21-81
C	7	6	5	4	3	2	0
P							1
E							A

DC 80-97

~~11448-LSK-22~~
12846.53-LKS-1

A 99608

APPENDIX G

ATTACHMENT III
PRELIMINARY TESTING PROCEDURE
EMERGENCY BUS
DEGRADED/UNDERVOLTAGE PROTECTION SYSTEM
SURRY POWER STATION
VIRGINIA ELECTRIC AND POWER COMPANY

Two sets of three undervoltage relays are provided for each 4,160 V emergency bus. Each of the relays is interlocked through auxiliary relays to create a two out of three tripping logic matrix. Operation of any two of the three relays will energize output devices which will initiate the protective action.

One set of three relays monitors phases A, B, and C potential for 90 percent or less of nominal bus voltage. This set operates when the voltage falls below the 90 percent trip point and provides an annunciation of degraded voltage in the main control room after a 10 second time delay, starts the diesel generator if the condition continues for 50 seconds and initiates the transfer from offsite to on-site power after 60 seconds. If a Safety Injection signal is received coincident with a degraded voltage signal, the normal 10, 50, and 60 second time delays are bypassed; instead, after a 7 second time delay, the diesel generator is started and the transfer from the offsite to the on-site power source is initiated.

The relays will reset and the protective action will be stopped should the voltage level rise above the 90 percent trip point at any time during the 60 second or the 7 second time delay period prior to transfer to the on-site power source. The diesel generator will be stopped manually by the operator after the degraded voltage relays have been reset.

The second set of three relays monitor phases A, B, and C potential for 75 percent or less of nominal bus voltage. This set operates when the voltage falls below the 75 percent trip point and, after a 2 second time delay, provides an annunciation of undervoltage in the main control room, starts the diesel generator and initiates the transfer from the offsite to the on-site power source.

The relays will reset and the protective action will not be initiated if the voltage level rises above the 75 percent trip point during the 2 second time delay. However, the degraded voltage relays were tripped as the voltage fell below the 90 percent trip point, and this sequence will continue until completed or stopped by a continued voltage rise above the 90 percent trip point within the 60 second time delay period associated with this protective scheme.

Once the transfer has been completed and the diesel generator output circuit breaker is closed, the timing relays are reset and interlocking contacts prevent operation of the protective scheme when the diesel generator is supplying power to the emergency bus. The "J" emergency bus diesel generator circuit breaker is also interlocked to open if it has been closed due to a degraded/undervoltage condition on one unit and the other unit experiences a SI or a CLS condition. The protective scheme will be reinstated if the diesel generator output circuit breaker is opened for any reason while the diesel generator is supplying power to the emergency bus.

The degraded and undervoltage relays, auxiliary relays, time delay relays, and associated test equipment will be mounted in a separate relay panel located near the emergency bus switchgear.

The test equipment provided includes:

I. knife switches for each degraded/undervoltage relay to allow testing and calibration of the individual relays

II. "test select switch" to select the degraded or undervoltage logic matrix and the phase relays actuating the matrix

III. "test" key-lock push button to initiate the test and provide administrative control of the test function

IV. indicating lights to indicate operation of the degraded/undervoltage relays

V. auxiliary relays and timers

Testing the individual relays for operation on loss of voltage can be accomplished by opening the knife switch in the input to the relay as shown on ESK-11AA or 11AD. Opening the knife switch removes voltage from the relay, and the relay should operate.

This can be verified by observing the status light on the relay and by the indicating light on the door of the panel being extinguished. This testing can be performed while the circuit is in operation, but care should be exercised to open only one knife switch at a time. The relay operation during the test will put the logic matrix in a one out of three condition and opening a second knife switch will complete the two out of three condition necessary to operate the logic matrix and, hence, the entire protective scheme.

The relays can be calibrated when the bus is shutdown. The relays are disconnected by opening the knife switch in the input line to the relay, and the knife switch in the ground line. A calibrated variable AC voltage source and voltmeter should be connected across a relay and the voltage slowly varied until the relay operates. The voltmeter will indicate the voltage at the point of relay operation and, if necessary, the relay can be adjusted to the proper dropout voltage setting.

During normal operation, the indicating lights mounted on the door of the undervoltage relay panel will be lit. These lights are extinguished during the testing and operation when the potential being sensed falls to the trip point of the relay.

The degraded/undervoltage protection system can be tested for logic operation when the reactor is in a cold shutdown condition. This procedure will describe the testing of the emergency bus "1H" degraded/undervoltage system. The testing of the emergency bus "1J" degraded/undervoltage system is similar.

The following equipment must be available for tests and the circuit breakers racked to the "test" position:

	Equipment	Circuit Breaker
1.	Emergency Generator 1	ACB 15H3
2.	Charging Pump 1A	ACB 15H5
3.	Charging Pump 1C (H Bus)	ACB 15H6
4.	Feed from Transfer Bus "F"	ACB 15H8
5.	Stub Bus	ACB 15H9
6.	Component Cooling Pump	ACB 15H10
7.	Residual Heat Removal Pump	ACB 15H11
8.	Charging Pump 1B	ACB 15J5

In order to perform this testing, the "H" bus will be supplied from the "J" bus by closing the tie breaker ACB 15H1.

Prevent emergency diesel generator 1 from starting by lifting and taping wires 1EGS1 at terminal 5; 1EGS1A at terminal 6; 1EGS2 at terminal 7; and 1EGS2A at terminal 8 of device "PL" located on the door of cubicle 15H3A. The diesel generator should be started once during this testing. If several degraded and undervoltage tests are to be performed, the diesel generator should be started during the last test.

Prevent circuit breaker 15F1 from tripping due to the operation of the bus "1H" degraded/undervoltage protection relaying by lifting and taping wires 15F1T at terminal 1 and 15F1T2 at terminal 2 of device "PJ" in the door of cubicle 15H3A.

Prevent circuit breaker 15J5 from closing on low discharge pressure by lifting and taping wire 15J5C at point 8 on terminal board 18 located in miscellaneous relay rack 1F.

Prevent circuit breaker 15J5 from closing on circuit breakers 15H5 and 15H6 opening by lifting and taping wire 15J5C3 at point 7 on device "AE" located in cubicle 15H6.

Circuit breaker 15J2 should be in the disconnected position.

The following circuit breakers should be in the closed position:

15H5
15H6
15H8
15H9
15H10
15H11

Two test switches are provided on the bus "1H" undervoltage relay panel. One, marked "test select switch," is used to select whether the testing is to be performed on the degraded or the undervoltage matrix and which phases are to be tested. The second switch is a key locked push button marked "test" and is used to initiate the test by actuating a relay when depressed.

With the test select switch in the "D B-C" position, a test of phases B and C degraded voltage relays is designated. Turning the test select switch to the "U B-C" position will set up a test of phases B and C undervoltage relays.

The locking push button has been provided to prevent inadvertent or unauthorized actuation of this testing scheme. The push button should be unlocked only when it is being used to conduct a test and should remain locked when not in use. This push button must be held depressed during the timing period of the auxiliary timing relay.

The relay which is actuated when the "test" push button is depressed will operate to open contacts which will remove voltage from the selected degraded voltage or undervoltage relays. With no voltage, these relays will de-energize and cause a two out of three logic matrix to be completed. This matrix will actuate timers which have been set to sequence the action of the output relays.

The testing of the degraded voltage matrix will proceed in the following manner once the "test" push button is depressed and held:

After 10 seconds at degraded voltage, a timer contact will close to initiate an alarm in the main control room.

After 50 seconds at degraded voltage, a second timer contact will operate to initiate the start of the diesel generator set through output relay 27X1-1H1.

After 60 seconds at degraded voltage, a third timer contact will operate to initiate output relays 27X2-1H1 and 27X3-1H1. These output relays will cause the following actions:

1.	Trip breaker	15F1:	Reserve station service transformer "C" to transfer bus "F"
	Trip breaker	15H8:	Normal feed from transfer bus "F"
2.	Close breaker	15H3:	Emergency generator 1 - This action will be delayed by the time set for residual voltage decay.
3.	Trip breaker	15H5:	Charging pump 1A
	Trip breaker	15H6:	Charging pump 1C (if "1A" does not open)
	Trip breaker	15H9:	Stub bus
	Trip breaker	15H10:	Component cooling pump
	Trip breaker	15H11:	Residual heat removal pump
4.	Close breaker	15J5:	Charging pump 1B

The time delays and output actions should be verified before terminating the tests. Operation of the contact closure to open breaker 15F1 can be verified at device "PJ" in the door of cubicle 15H3A by measuring resistance between terminals 1 and 2. A low resitance will indicate that the contact has closed.

The circuit breakers can be reset to their initial positions, and the test can be repeated to verify the operation of the remaining portions of the degraded voltage logic matrix.

The undervoltage logic matrix can be tested in the same manner as described above. The output relays will be energized after a 2 second time delay.

A simultaneous safety injection signal can be simulated by installing a jumper between terminal points 8 and 9 on terminal block "TB" in the bus 1H undervoltage relay panel. The output relays should operate after a 7 second time delay for this test.

At the conclusion of the testing, the test select switch should be rotated to the "off" position, and the "test" push button should be locked. All other equipment should be returned to the normal position.

APPENDIX H

			SI			CLS			LOSS OF OFFSITE POWER(LOOP)[4]		
VOLTAGE	BUS	LOAD	START	TRIP	NO CHANGE OF STATE	START	TRIP	NO CHANGE OF STATE	START	TRIP	NO CHANGE OF STATE
4KV	1H	Emergency Diesel Generator 1	X			X			X		
		Emergency Diesel Generator 1 Breaker			X			X	X		
		Steam Generator Auxiliary Feedwater Pump	50"			50"			X[7]		
		Charging Pump	X			X			Bus 1J[3] LOOP	X	
		Stub Bus Tie Breaker			X			X		X	
		Component Cooling Pump			X			X		X	
		Residual Heat Removal Pump			X			X		X	
		Emergency Bus Feeder Breaker			X			X		X	
480V	1H	Pressurizer Heaters			X			X			X
		Low Head Safety Injection Pump	X			X					X
		Inside Recirculation Spray Pump			X	120"					X
		Outside Recirculation Spray Pump			X	300"					X
		Containment Spray Pump			X	X					X
		Containment Recirculation Fan			X		X				X
480V	1H1	Filter Exhaust Fan[8]	X or Unit 2 SI			X or Unit 2 CLS					X

			SI			CLS			LOSS OF OFFSITE POWER(LOOP)[4]		
VOLTAGE	BUS	LOAD	START	TRIP	NO CHANGE OF STATE	START	TRIP	NO CHANGE OF STATE	START	TRIP	NO CHANGE OF STATE
KV	1J	Emergency Diesel Generator 3	X			X			X		
		Emergency Diesel Generator 3 Breaker		Unit 2[2] SI	X		Unit 2[2] CLS	X	X		
		Steam Generator Auxiliary Feedwater Pump	50"			50"			X[7]		
		Charging Pump	X			X			Bus 1H[3] LOOP		X
		Stub Bus Tie Breaker	X					X		X	
		Component Cooling Pump	X					X		X	
		Residual Heat Removal Pump	X					X		X	
		Emergency Bus Feeder Breaker	X					X		X	
480V	1J	Pressurizer Heaters			X			X			X
		Low Head Safety Injection Pump	X			X					X
		Inside Recirculation Spray Pump			X	120"					X
		Outside Recirculation Spray Pump			X	300"					X
		Containment Spray Pump			X	X					X
		Containment Recirculation Fan			X		X				X
480V	1J1	Filter Exhaust Fan [8, 9]	X or Unit 2 SI			X or Unit 2 CLS					X

NOTES:

1. X's indicate immediate action caused by condition on same unit.
2. "Unit 2" indicates action caused by condition on opposite unit.
3. "Bus 1H" or "Bus 1J" indicate action caused by a condition on an opposite emergency bus of the same unit.
4. Loss of Offsite Power is defined as loss of voltage or degraded voltage of sufficient duration to cause separation of an emergency bus from its offiste source due to operation of the undervoltage protection.
5. Those pumps receiving SI starts will be automatically started for CLS conditions also, and are indicated as starting for CLS conditions.
6. Delayed action is indicated by the time in seconds (e.g. 120" indicates 120 seconds delay from the occurence of a CLS until the inside recirculation spray pump receives a start signal).
7. For loss of offsite power concurrent with either an SI or CLS, the instantaneous auxiliary feedwater pump loop start is defeated and starting occurs at 50 seconds after the accident.
8. Starting of this fan is somewhat delayed because it is based on a pressure change which is caused by SI signals.
9. Provides normally open alternate feed to Unit 2 supplied filter exhaust fan.

brc/1337/57

APPENDIX I

CALCULATION SHEET

▲5010.61

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SUBJECT/TITLE	QA CATEGORY/CODE CLASS
CONFIRMATORY ANALYSIS	I

JOB 1663

SUMMARY

DESCRIPTION

UNIT 1 – 100% POWER }
UNIT 2 – TRIP WITH CLS } NO LOAD SHED

RUN 107 B

(CONDENSATE PUMPS STARTING AFTER LTC CORRECTION)

	1H	1J	2H	2J
4160 V	0.930	0.995	0.929	0.930
480 V	0.889	0.960	0.870	0.876
480 V-1	0.897	0.979	0.908	0.931

	2B	2C
4160 V	0.927	0.928

RUN 107 C

(CONDENSATE PUMPS RUNNING)

	1H	1J	2H	2J
4160 V	1.021	1.029	1.022	1.021
480 V	0.989	0.998	0.974	0.977
480 V-1	0.996	1.016	1.007	1.026

	2B	2C
4160 V	1.022	1.020

CALCULATION SHEET

STONE & WEBSTER ENGINEERING CORPORATION

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JOB 2210

SUMMARY

DESCRIPTION

1 UNIT TRIP FROM 100% POWER

UNIT 1 - TRIP WITH CLS }
UNIT 2 - 100% POWER } NO LOAD SHED

		1H	1J	2H	2J
RUN 631 t=0 SEC					
(ALL MOTORS STARTING FIXED TAP)	4160v	0.915	0.906	0.918	0.915
	480v	0.761	0.757	0.875	0.872
	480v-1	0.846	0.853	0.883	0.893
RUN 632 t=5 SEC					
(MOV'S STARTING FIXED TAP LARGE MOTORS @ SPEED)	4160v	0.942	0.933	0.928	0.942
	480v	0.925	0.919	0.886	0.902
	480v-1	0.884	0.905	0.894	0.922
RUN 630 t=∞					
(STEADY STATE AFTER LTC COMPLETES MOVEMENT)	4160v	1.025	1.026	1.026	1.025
	480v	0.978	0.983	0.994	0.993
	480v-1	1.005	1.012	1.001	1.011

APPENDIX J

CALCULATION SHEET

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JOB 3478

SUMMARY

DESCRIPTION

2 UNIT TRIP FROM 100% POWER
UNIT 1 - TRIP WITH NO CLS
UNIT 2 - TRIP WITH CLS

RUN 617 t=0 SEC

(ALL MOTORS STARTING
FIXED TAP)

	1H	1J	2H	2J
4160V	0.891	0.868	0.851	0.890
480V	0.891	0.870	0.706	0.744
480V-1	0.859	0.839	0.787	0.861

RUN 616 t=5 SEC

(MOV'S STARTING
FIXED TAP
LARGE MOTORS @ SPEED)

	1H	1J	2H	2J
4160V	0.916	0.878	0.877	0.916
480V	0.918	0.880	0.854	0.900
480V-1	0.887	0.850	0.822	0.887

RUN 600 t=∞

(STEADY STATE
AFTER LTC COMPLETES
MOVEMENT)

	1H	1J	2H	2J
4160V	1.023	1.005	1.002	1.022
480V	1.029	1.014	0.953	0.979
480V-1	1.002	0.988	0.987	1.028

CALCULATION SHEET

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CONFIRMATORY ANALYSIS	I

JOB 3525

SUMMARY

DESCRIPTION

2 UNIT TRIP FROM 100% POWER
UNIT 1 - TRIP WITH CLS
UNIT 2 - TRIP WITH NO CLS

		1H	1J	2H	2J
RUN 627 t=0 SEC					
(ALL MOTORS STARTING FIXED TAP)	4160V	0.879	0.868	0.867	0.879
	480V	0.730	0.724	0.866	0.882
	480V-1	0.808	0.813	0.841	0.878
RUN 628 t=5 SEC					
(MOV'S STARTING FIXED TAP LARGE MOTORS @ SPEED)	4160V	0.905	0.895	0.877	0.906
	480V	0.885	0.878	0.877	0.909
	480V-1	0.844	0.866	0.852	0.905
RUN 625 t=∞					
(STEADY STATE AFTER LTC COMPLETES MOVEMENT)	4160V	1.021	1.023	1.005	1.021
	480V	0.974	0.980	1.011	1.030
	480V-1	1.000	1.009	0.990	1.027

CALCULATION SHEET

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CONFIRMATORY ANALYSIS	I

SUMMARY

JOB 0656
JOB 1313

DESCRIPTION

UNIT 1 - 100% POWER } NO LOAD SHED
UNIT 2 - TRIP WITH CLS

RUN 105C t=0		1H	1J	2H	2J
(ALL MOTORS STARTING	4160V	0.917	0.926	0.903	0.917
FIXED TAP)	480V	0.874	0.883	0.751	0.766
	480V-1	0.882	0.904	0.841	0.888

RUN 105D t=5 SEC					
(MOV'S STARTING	4160V	0.943	0.935	0.929	0.943
LARGE MOTORS AT SPEED	480V	0.903	0.894	0.911	0.930
FIXED TAP)	480V-1	0.911	0.915	0.878	0.915

RUN 105A t=59 SEC					
(STEADY STATE	4160V	1.025	1.027	1.025	1.025
AFTER LTC COMPLETES	480V	0.993	0.995	0.979	0.982
MOVEMENT)	480V-1	1.000	1.013	1.012	1.031

DESCRIPTION

UNIT 1 - TRIP NO CLS } LOAD SHED
UNIT 2 - TRIP WITH CLS

RUN 105F t=60 SEC		1H	1J	2H	2J
(NO MOTORS STARTING	4160V	0.962	0.956	0.933	0.961
UNIT 1 LOAD	480V	0.965	0.962	0.777	0.809
PICKED UP)	480V-1	0.936	0.935	0.873	0.933

RUN 105E t=∞					
(STEADY STATE	4160V	1.023	1.005	1.002	1.022
AFTER LTC COMPLETES	480V	1.029	1.014	0.953	0.979
MOVEMENT)	480V-1	1.002	0.988	0.987	1.028

CALCULATION SHEET

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STONE & WEBSTER ENGINEERING CORPORATION

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CONFIRMATORY ANALYSIS	I

JOB 0322

SUMMARY

DESCRIPTION

UNIT 1 - STARTUP
UNIT 2 - TRIP WITH CLS

		1H	1J	2H	2J
RUN 452 $t = 0$ SEC (ALL MOTORS STARTING FIXED TAP)	4160V	0.914	0.906	0.888	0.913
	480V	0.870	0.861	0.738	0.763
	480V-1	0.878	0.883	0.825	0.884
RUN 453 $t = 5$ SEC (MOV'S STARTING FIXED TAP LARGE MOTORS @ SPEED)	4160V	0.942	0.917	0.917	0.942
	480V	0.901	0.874	0.898	0.928
	480V-1	0.909	0.895	0.865	0.914
RUN 450 $t = \infty$ (STEADY STATE AFTER LTC COMPLETES MOVEMENT)	4160V	1.022	1.003	1.002	1.022
	480V	0.990	0.969	0.952	0.979
	480V-1	0.997	0.988	0.986	1.028

CALCULATION SHEET

▲5010 61

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CONFIRMATORY ANALYSIS	I

JOB 2142

SUMMARY

DESCRIPTION

2- UNIT TRIP FROM 100% POWER

UNIT 1 - TRIP NO CLS
UNIT 2 - TRIP NO CLS

505KV @ SWYD

RUN 701 t=0		1H	1J	2H	2J
(FIXED TAP NO MOTORS STARTING)	4160V	0.909	0.874	0.869	0.909
	480V	0.910	0.876	0.868	0.909
	480V-1	0.878	0.846	0.843	0.909

RUN 700 t=∞		1H	1J	2H	2J
(STEADY STATE AFTER LTC COMPLETES MOVEMENT)	4160V	1.022	1.003	0.998	1.022
	480V	1.029	1.011	1.003	1.028
	480V-1	1.002	0.986	0.982	1.028

CALCULATION SHEET

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JOB 1575

SUMMARY

DESCRIPTION

UNIT 1 TRIP WITH CLS
UNIT 2 TRIP NO CLS

RUN 108 B

(CONDENSATE PUMPS STARTING AFTER LTC CORRECTION)

	1H	1J	2H	2J
4160V	0.905	0.907	0.958	0.905
480V	0.842	0.849	0.961	0.909
480V-1	0.874	0.883	0.939	0.905

	1A	2C
4160V	0.908	0.902

RUN 108 C

(CONDENSATE PUMPS RUNNING)

	1H	1J	2H	2J
4160v	1.004	1.007	0.999	1.005
480v	0.955	0.962	1.004	1.013
480v-1	0.982	0.991	0.983	1.009

	1A	2C
4160v	1.008	1.004

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE ____

RUN 60C
JOB 764
3/18/82

SUMMARY OF RESULTS

2 UNIT TRIP FROM 100% POWER
(2 UNITS INTAKE STRUCTURE LOADS ON EACH 34.5kv BUS)
UNIT 1 TRIP (NO CLS), UNIT 2 TRIP WITH CLS

1) t=0, ALL MOTORS STARTING, (FIXED TAPS)

	1H	1J	2H	2J
4160V	.886	.860	.843	.885
480V	.886	.862	.699	.739
480V-1	.853	.831	.779	.855

2) t=5 SECS, LARGE MOTORS ACCLD, MOVS STARTING (FIXED TAPS)

	1H	1J	2H	2J
4160V	.912	.870	.870	.912
480V	.913	.872	.846	.896
480V-1	.882	.842	.815	.883

3) t=∞, STEADY STATE (LTC CORRECTED)

	1H	1J	2H	2J
4160V	1.018	.982	.979	1.018
480V	1.025	.989	.927	.974
480V-1	.998	.963	.962	1.024

COMMENT: MINIMUM VOLTAGE REQUIREMENT NOT MET ON 480V BUS 2H

LTC AT MAX BOOST IN STEADY STATE ON ALL 3 RSST.

APPENDIX K

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

CASE 60A

A 5010

N IDENTIFICATION NUMBER

CALCULATION NO. 11393C.C9-E

OPTIONAL TASK CODE

PAGE ____

RUN 60A
JOB 2299

SUMMARY OF RESULTS

UNIT 1 TRIP; UNIT 2 TRIP WITH CLS
(ONE AUTOTRANSFORMER REPLACED WITH 230/36.5 KV TRANSFORMER)

1) t=0; ALL MOTORS STARTING (FIXED TAP)

	1J	2H	1J'	2H'
4160V	.822	.807	.835	.819
480V	.822	.668	.835	.679
480V-1	.789	.740	.803	.753

2) t=5 SECONDS; LARGE MOTORS ACCLD; MOVS STARTING (TAPS ADV 2 STEPS

	1J	2H	1J'	2H'
4160V	.847	.846	.858	.858
480V	.848	.821	.860	.833
480V-1	.816	.790	.829	.802

3) t=∞; STEADY STATE (LTC CORRECTED)

	1J	2H	1J'	2H'
4160V	.948	.945	1.022	1.021
480V	.959	.888	1.031	.974
480V-1	.927	.925	1.006	1.007

NOTE: PRIMED BUSES (1J', 2H') ARE FED FROM 230/36.5KV TRANSFORMER

COMMENT: MINIMUM VOLTAGE REQUIREMENTS NOT MET ON BUS 2H & 2H'.

@ t=∞ { LTC ON RSST A & B REACH MAX BOOST (FED FROM AUTOTRANSFORMER)
" ON 230/36.5 KV XFRMR REACHES MAX BOOST
LTC ON RSST A' & B' REACH 4300V (FED FROM 230/36.5 KV XFMR)

▲5010 65

CALCULATION IDENTIFICATION NUMBER

	CALCULATION NO. 13930.09-8	OPTIONAL TASK CODE	PAGE ____

RUN 61A
JOB 712
& JOB 1078

SUMMARY OF RESULTS

UNIT 2 CLS, UNIT 1 TRIP 60 SECONDS LATER
(ONE AUTOTRANSFORMER REPLACED WITH 230/36.5 kV TRANSFORMER)

	1J	2H	1J'	2H'
1) t=0 ; ALL MOTORS STARTING (FIXED TAP)				
4160V	.891	.870	.897	.876
480V	.844	.722	.851	.728
480V-1	.866	.806	.873	.813
2) t=5 SECONDS ; LARGE MOTORS ACCL'D ; MOVS STARTING (TAPS ADV 2 STEPS)				
4160V	.915	.911	.920	.916
480V	.872	.891	.877	.896
480V-1	.893	.858	.899	.863
3) t=59 SECONDS ; PRIOR TO UNIT 1 TRIP & TRANSFER (LTC CORRECTS)				
4160V	1.027	1.025	1.027	1.025
480V	.995	.979	.995	.979
480V-1	1.013	1.012	1.013	1.012
4) t=60 SECONDS ; UNIT 1 TRANSFERS TO RSST (FIXED TAP)				
4160V	.949	.945	.987	.990
480V	.954	.889	.995	.939
480V-1	.927	.926	.968	.974
5) t=∞ ; STEADY STATE (LTC CORRECTS)				
4160V	.948	.945	1.022	1.021
480V	.954	.888	1.031	.974
480V-1	.927	.925	1.006	1.007

PRIMED BUSES (1J' & 2H') ARE FED FROM 230/36.5KV TRANSFORMER.

APPENDIX L

CALCULATION SHEET

▲5010.61

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JOB 3379

SUMMARY

DESCRIPTION

UNIT 1 - 100% POWER
UNIT 2 - REFUELING

RUN 50		1H	1J	2H	2J
(OVERVOLTAGE CHECK)	4160V	1.032	1.032	1.033	1.032
	480V	1.000	1.001	1.040	1.039
	480V-1	1.007	1.019	1.040	1.039

(MOTORS)
4160 x 1.033 = 4297V < 4000 x 1.1 = 4400V
480 x 1.040 = 499 V < 460 X 1.1 = 506 V

(PT'S)
4160 x 1.033 = 4297V < 4200 x 1.1 = 4620V
480 x 1.040 = 499 V < 480 x 1.1 = 528 V

APPENDIX M

A501061

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SUBJECT/TITLE MODEL CONFIRMATION		QA CATEGORY/CODE CLASS	

TOB 1647

V. CONCLUSIONS

BUS	*MEASURED	CALCULATED	% DIFF
4KV-BUS 1A	4135 V	4106 V	0.7 %
4KV-BUS 1B	4330 V	4019 V	7.18 %
4KV-BUS 1C	4245 V	4064 V	4.26 %
4KV-BUS 1H	4205 V	4064 V	3.35 %
4KV-BUS 1J	3855 V (1)	4106 V	6.51 %
4KV-BUS 2H	4285 V	4014 V	6.32 %
4KV-BUS 2J	4245 V	4064 V	4.26 %
480V-BUS 1H	555 V	450 V	18.92 % (2)
480V-BUS 1H1	495 V	464 V	6.26 %
480V-BUS 1J	530 V	457 V	13.77 % (2)
480V-BUS 1J1	490 V	469 V	4.29 %

$$\% \text{ DIFF} = \frac{|\text{MEASURED} - \text{CALCULATED}|}{\text{MEASURED}} \times 100$$

NOTES:

(1) READING APPEARS INCORRECT - VOLTAGE SHOULD BE CLOSE TO BUS 1A MEASUREMENT

(2) ACTUAL LOAD FOR BUS NOT AVAILABLE - CALCULATED INPUT WAS USED FOR MODEL

* FROM GENERAL ELECTRIC STUDY (SEE ATTACHMENT "B")