

CONTROL SYSTEMS FAILURES
EVALUATION REPORT

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PREPARED

FOR

GULF STATES UTILITIES COMPANY
RIVER BEND STATION

PREPARED
BY

DR. S. H. SLIVINSKY
D. E. BENNETT
J. Y. FUJITANI

GENERAL ELECTRIC COMPANY, NUCLEAR ENERGY BUSINESS OPERATIONS
San Jose, California 95125

Approved:

Michael A. Smith

M. A. Smith, Manager - Regulatory Compliance Engineering
Nuclear Control and Instrumentation Product Design Operation

E. C. Eckert

E. C. Eckert, Manager - Plant Transient Performance Engineering
Nuclear Power Systems Engineering Department

C. L. Tully

C. L. Tully, Licensing Engineer
Safety and Licensing Operation

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CONTROL SYSTEMS FAILURES
EVALUATION REPORT
FOR THE RIVER BEND STATION

1.0 PURPOSE

The purpose of this evaluation report is to address the following concerns:

- Perform an analysis in response to the concern that the failures of power sources for electrical signals to multiple control systems could result in consequences outside the bounds of the River Bend Final Safety Analysis Report (FSAR) Chapter 15 analyses and beyond the capability of operators or safety systems.
- Provide a positive demonstration that adequate review and analysis has been performed to ensure that despite such failure, the River Bend Station FSAR Chapter 15 analyses are bounding, and no consequences beyond the capability of safety systems would result.

To reach these objectives, a comprehensive approach was developed to analyze the control systems capable of affecting reactor water level, pressure or power in the River Bend plant.

The contents of the report and the attachments were prepared by the General Electric Company* for the Gulf States Utilities Company (GSU) with a significant technical contribution from the Stone and Webster Engineering Corporation (SWEC).

2.0 CONCLUSIONS

The information contained herein, supplemented by the existing FSAR Chapter 15 transient analyses, documents an evaluation of the River Bend Station for system interaction by electrical means. The conclusion of this evaluation is that previously reported limits of minimum critical power ratio (MCPR), peak reactor vessel and main steamline pressures, and peak fuel cladding temperature for the expected operational occurrence category of events would not be exceeded as a result of common power source failures. Although transient category events have been postulated as a result of this study, the net effects have been positively determined to be less severe than those of the original, conservative, Chapter 15 events. It should be noted that this study uses the event - consequence logic of the Chapter 15 analysis, but starts the logic chain from a specific source (e.g., a single bus failure) rather than a system condition (e.g., feedwater pump trip). By approaching the study in this manner, a great deal of confidence can be placed in the study conclusions. The soundness of the total plant design is demonstrated by its tolerance of the interactions identified in the process of performing the analysis.

*Additional GE technical contributors: K. H. Pandya, E. D. Schrull, and L. K. Stapleton.

3.0 ANALYSIS METHODOLOGY

The control systems failure analysis was conducted in the following manner by GE and SWEC.

| <u>ACTIVITY</u> | <u>ASSIGNED TO</u> |
|--|--------------------|
| • DEFINE BUS STRUCTURE | GE |
| • DEFINE CONTROL SYSTEMS | GE & SWEC |
| • IDENTIFY LOADS | GE & SWEC |
| • DETERMINE CRITICAL LOADS | GE & SWEC |
| • SUMMARIZE CRITICAL LOADS | GE |
| • ANALYZE COMBINED EFFECTS | GE |
| • COMPARE RESULTS TO CHAPTER 15 | GE |
| • ANALYZE EXCEPTIONS | GE |
| • MODIFY/AUGMENT CHAPTER 15 IF NECESSARY | GE |

3.1 DEFINE BUS STRUCTURE

Potential sources for system interaction by electrical means were established by formulating bus structure as follows: Bus trees (see Figures 1, 2, and 3) were constructed using one-line diagram information to show power distribution from the highest level previously analyzed (loss of offsite power) down to the lowest level of plant distribution (Motor Control Centers, instrument busses, etc.).

3.2 DEFINE CONTROL SYSTEMS

The scope of control systems to be analyzed was established by first compiling a complete list of River Bend Station systems and subsystems. Next, the list was reviewed to confine the analysis to only those systems with the potential to affect reactor pressure, water level, or power.

In order to ensure that all necessary systems were considered, specific elimination criteria were established as a basis for not analyzing systems further (see Appendix B). If there was any uncertainty as to whether or not a system met the criteria, it was retained for further analysis. Those systems that met the criteria for elimination were removed from the complete system list to produce the final list of control systems for analysis. This final list of systems to be reviewed by GE and SWEC follows:

System DesignatorsSystems

| | |
|-----|--|
| B21 | Nuclear Boiler Process Instrumentation |
| B33 | Reactor Recirculation/Jet Pump |
| C11 | Control Rod Drive/Reactor Manual Control |
| C33 | Feedwater Control |
| C51 | Neutron Monitoring |
| C85 | Steam Bypass and Pressure Regulation |
| D17 | Process Radiation Monitoring |
| E31 | Leak Detection and Isolation |
| G33 | Reactor Water Cleanup |
| N64 | Offgas |
| ARC | Condenser Air Removal |
| CCP | Reactor Plant Component Cooling Water |
| CCS | Turbine Plant Component Cooling Water |
| CNM | Condensate |
| BCS | Bearing Cooling Water |
| CRS | Cold Reheat |
| HRS | Hot Reheat |
| CWS | Circulating Water |
| DET | Turbine Building Equipment Drains |
| DER | Reactor Building Equipment Drains |
| DSM | Moisture Separator Vents and Drains |
| DSR | Moisture Separator RHTR Vents and Drains |
| DTM | Turbine Building Miscellaneous Drains |
| ESS | Extraction Steam |
| FWL | FDW Pump and Drive Lube Oil |
| FWR | FDW Pump Recirculation |
| FWS | Feedwater |
| GML | Generator Leads Cooling |
| GMC | Generator Stator Cooling Water |
| GMM | Generator H ₂ and CO ₂ Purge |
| HDL | High-Pressure FDW Heater Drain |
| HDL | Low-Pressure FDW Heater Drain |
| SAS | Service Air |
| IAS | Instrument Air |
| GMO | Generator Seal Oil |
| MSS | Main Steam |
| SUH | FDW Heater Relief Drains and Vents |
| SWP | Service Water |
| TMA | Turbine Trips |
| TMB | Turbine Generator E.H. Fluid System |
| TME | Turbine Generator Gland Seal and Exhaust |
| TML | Turbine Generator Lube Oil |
| TMR | Turbine Unit Runback |
| TMS | Turbine Generator Exhaust Hood Spray |

3.3 IDENTIFY LOADS

The data base necessary to determine which electrical loads were to be analyzed, was identified as follows. A set of load tables comprised of all electrical loads of the control systems in Paragraph 3.2 was assembled by GE and SWEC, each providing information on the loads within their respective scope of supply. Each component (load) was listed with its

power bus source, its unique Master Parts List number, circuit description, and failure mode on power loss with primary and secondary effects. Samples of load system tables are included in Appendix A.

3.4 DETERMINE CRITICAL LOADS

The analysis was performed by next sorting out the components (loads) whose failure has the potential to initiate events affecting reactor pressure, water level, and power. The elimination criteria established earlier for the system list (Appendix B) was also used in the component review to determine which individual loads required further consideration or could be deleted from the analysis. If there was any uncertainty as to whether or not a load met the elimination criteria it was retained for further analysis. The numerical code associated with an elimination criterion was assigned to each eliminated load in the load tables discussed in Paragraph 3.3.

3.5 SUMMARIZE CRITICAL LOADS

Non-critical loads were deleted from the load tables, and the remaining loads are grouped together by their common power busses. These tables are shown in Appendix C.

3.6 ANALYZE COMBINED EFFECTS

In performing the combined effects portion of the analysis, attention was given to the specific events treated in Chapter 15 of the FSAR. This portion of the analysis provided the basis for determining the worst case combinations of load and system failures that are credible events considering the interconnection by power distribution. Using the combined effects at the lowest level bus as a starting point, the next higher bus was postulated to fail and the total effect of that failure analyzed. This process was continued up to the highest bus level. The combined effects at the lowest bus level are included in the Appendix C tables. Worst case effects at the higher levels are summarized in Section 4. The combined effects at intermediate bus levels less severe than their associated higher bus combined effects were analyzed but not included in Section 4. The intermediate level combined effect analysis is formally represented in the higher bus analysis.

3.7 COMPARE RESULTS TO FSAR CHAPTER 15

The consequences of all potential system interaction events initiated by electrical means were then compared to the results of FSAR Chapter 15. A review of the information in the Appendix C tables was conducted in the course of developing the bus summaries of Section 4. At each bus level of the combined effects analysis, the review evaluated whether effects were bounded by a specific Chapter 15 transient analysis or not. Section 4 includes these evaluations considering the worst case effects.

3.8 ANALYZE EXCEPTIONS

There were no failure scenarios which were not bounded by the FSAR Chapter 15 transient analysis for the River Bend Station.

3.9 MODIFY/AUGMENT FSAR CHAPTER 15 IF NECESSARY

Modification of FSAR Chapter 15 was not necessary in the River Bend Station analysis.

4.0 BUS LOSS SUMMARY RESULTS AND FSAR CHAPTER 15 COMPARISONS

1NPS-SWG1A (Figure 1)

Loss of this bus will result in a loss of recirculation pumps A and B, 1 out of 3 feedwater pumps, 2 out of 3-50% normal service water pumps, 2 out of 3 condensate pumps, 2 out of 3 reactor plant component cooling water pumps, 1 out of 2-100% turbine generator EHC fluid pumps, and 2 out of 4-25% circulating water pumps. In addition, there is a decrease in feedwater heating due to a loss of hot water to the second and third point feedwater heaters, an inability to drain condensate from cooler condensers, and a choke-off of offgas flow. There is a decrease in main condenser vacuum, caused by the stoppage of offgas flow and loss of circulating water. The hot water loss to the heaters would also cause a heater drain pump trip.

The combined overall effect of these losses is a trip of two recirculation pumps transient. The remaining two feedwater pumps provide sufficient flow, such that level 8 is reached which initiates a scram, turbine trip, and feedwater pump trip. This event is bounded by the trip of two recirculation pumps event analyzed in FSAR Chapter 15.

The loss of lower level, associated power buses will result in some of the following effects: loss of some reactor pressure and level signals and inability of the recirculating system to automatically follow system load. The loss of Bus 1NPS-SWG1A envelopes these effects.

1NPS-SWG1B (Figure 1)

Loss of this bus will result in the loss of Recirculation Pumps A and B, 2 out of 3 feedwater pumps, 1 of 3 normal service water pumps, 1 of 3 condensate pumps, 1 of 3 reactor plant component cooling water pumps, 1 of 2 turbine generator EHC fluid pumps, 2 out of 4 circulating water pumps, and the loss of the offgas condenser level and temperature signals. The feedwater flow reduction results in a water level decrease; a Level 3 trip initiates a scram. Locked feedwater control valves increase the probability of tripping the third FW pumps, reaching low level faster.

The combined overall effect of these system losses is a trip of two feedwater pumps and a trip of two recirculation pumps. If Level 8 is reached, which is the unlikely scenario, this transient is bounded by the trip of two recirculation pumps event analyzed in FSAR Chapter 15. However, the most likely scenario is that water level decreases as described above, resulting in an event bounded by the loss of all Feedwater Flow event analyzed in FSAR Chapter 15.

The loss of lower level, associated power buses will result in some of the following effects: loss of feedwater trip logic and activation of Recirculation Pumps A and B low level signal. The loss of Bus 1NPS-SWG1B envelopes these effects.

1ENS*SWG1A Safeguard Bus (DC) (Figure 2)

The loss of this bus results in the loss of RHR and RCIC isolation relays, recirculation pump breaker control power, RHR and RWCU temperature monitors, and a "half-isolation" (MSIVs).

There are no combined effects resulting from these system losses, since alternate logic is available. The loss of lower level safeguard and DC busses is not anticipated due to redundant power sources.

1ENS*SWG1B Safeguard Bus (DC) (Figure 3)

Loss of this bus results in closure of the inboard reactor water cleanup valves, a "half-scrum", and a "half-isolation" (MSIVs).

The combined effects of this bus loss are to isolate the RHR Shutdown Cooling and RWCU systems. These system losses have no effect on the reactor parameters of vessel pressure, reactor power, and vessel water level. The loss of lower level safeguard and DC busses is not anticipated due to redundant power sources.

1NNS-SWG1A

The loss of this bus results in the loss of 2 (1CCS-P1A, P1C) out of 3-50% capacity turbine plant component cooling water pumps, 1 out of 2-100% capacity feedwater heater drain pumps in each heater train, and 1 out of 2 CRD drive water pumps.

Loss of two third point heater drain pumps would cause one feedwater pump to trip on low suction and recirculation runback. Loss of two of three turbine plant component cooling water pumps would result in a turbine trip due to loss of generator stator cooling.

1NNS-SWG1B

The loss of this bus results in the loss of 1 (1CCS-P1B) out of 3-50% capacity turbine plant component cooling water pumps, 1 out of 2-100% capacity feedwater heater drain pumps in each heater train, and of 1 out of 2 CRD drive water pumps.

Loss of two third point heater drain pump would cause one feedwater pump trip on low suction and recirculation runback.

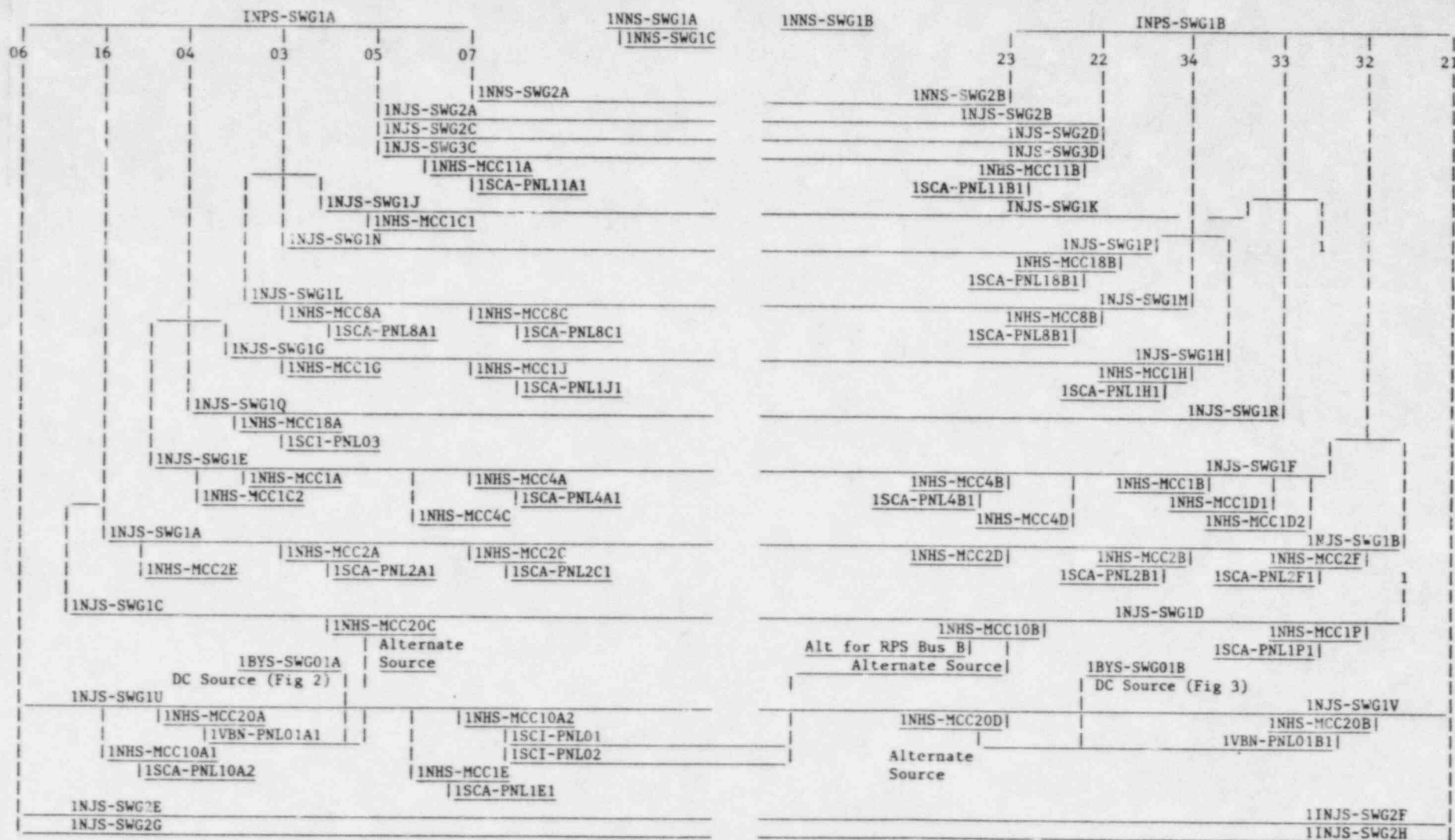


FIGURE 1
AC BUS TREE

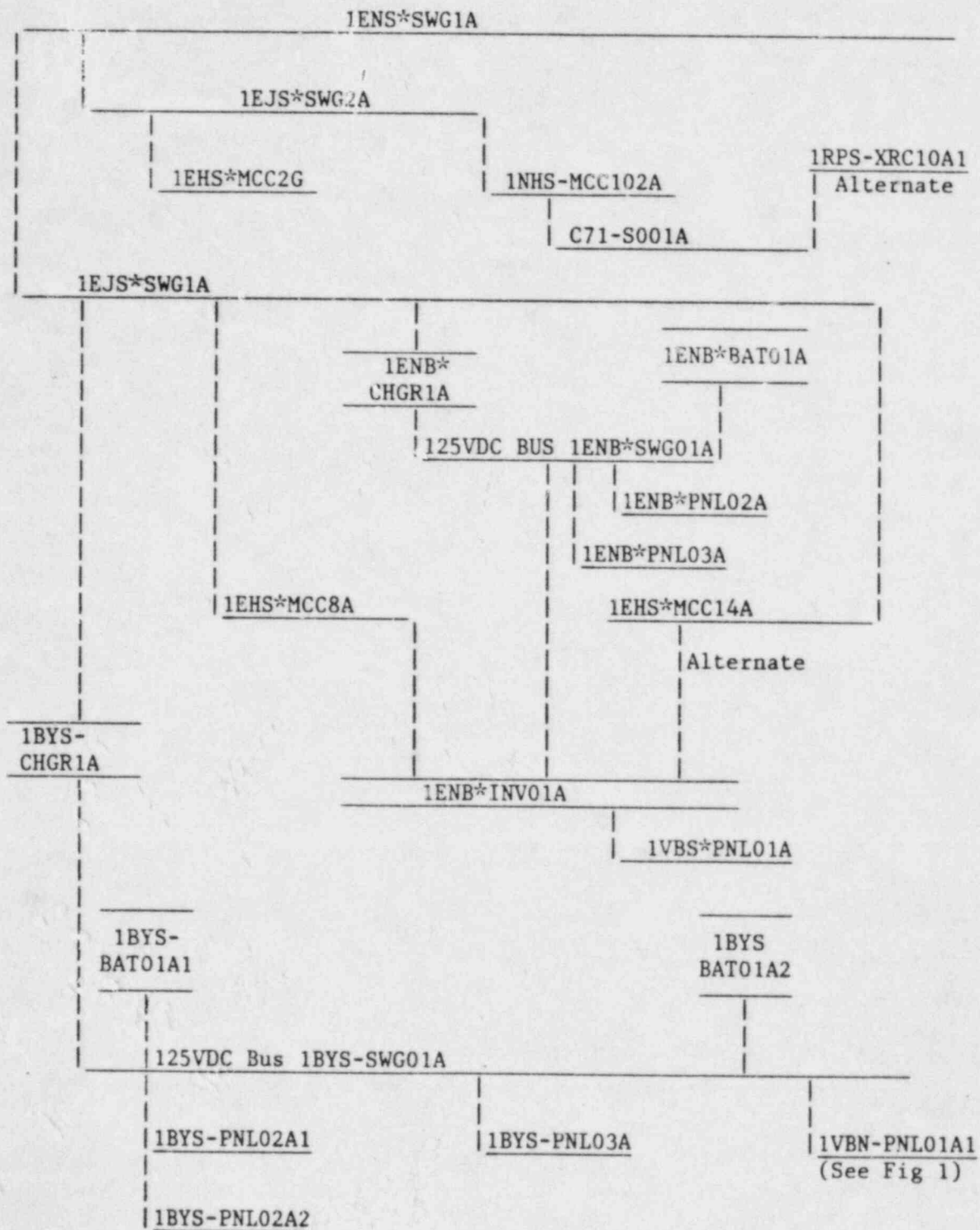


FIGURE 2
SAFEGUARD AND DC BUS TREE "A"

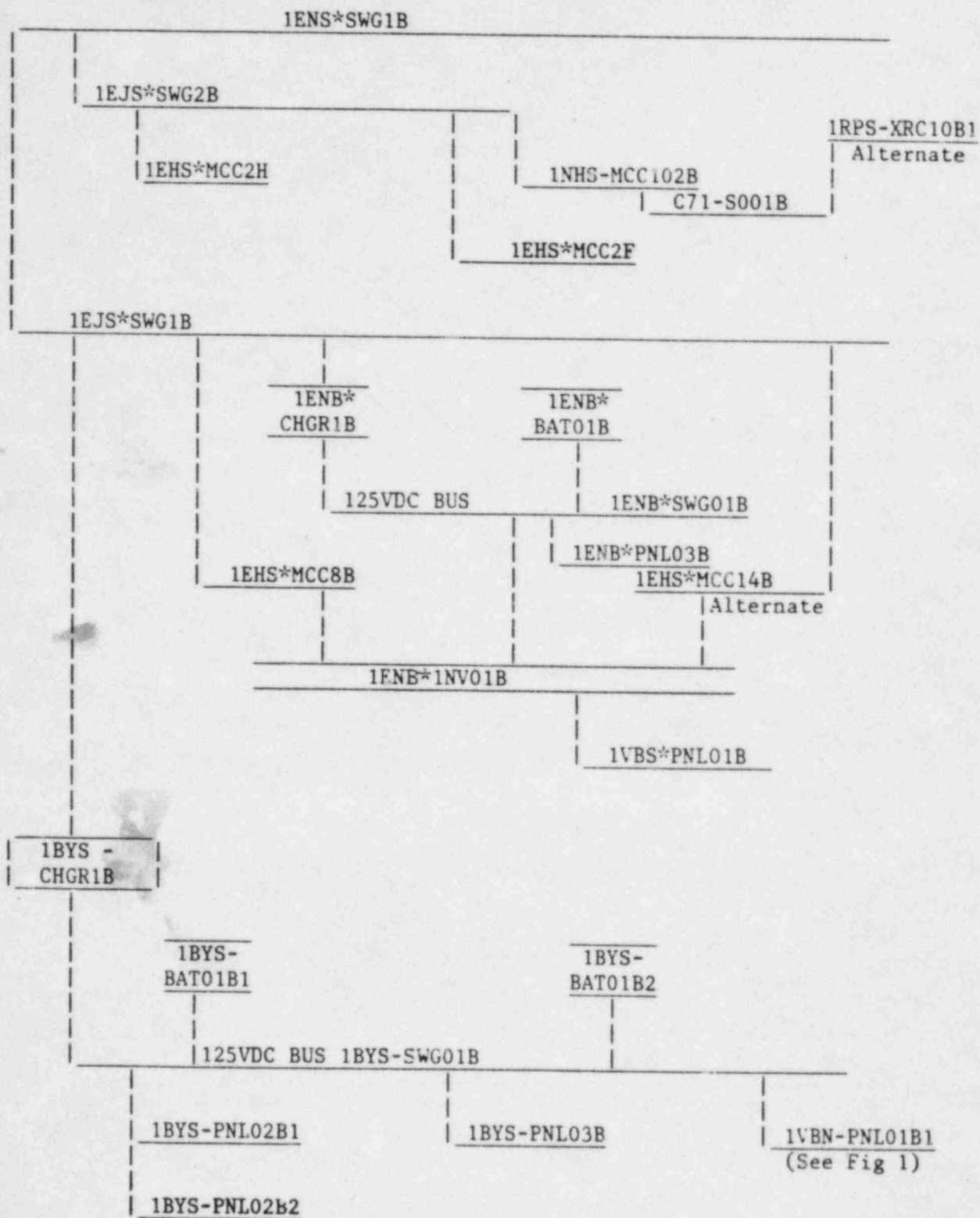


FIGURE 3

SAFEGUARD AND DC BUS TREE "B"

APPENDIX B

CRITERIA FOR ELIMINATION OF SYSTEMS AND COMPONENTS OF SYSTEMS FROM CONTROL SYSTEMS FAILURE ANALYSIS

Elimination Criterion*

Basis

- N1 Non-Electrical Components (i.e., mechanical and structural); however, associated functions that are electrically controlled or controlling (including signal input to electrical systems) may be relevant to the analysis. N1 examples are piping, tanks, and turbines.
- N2 Instrumentation with no direct or indirect controlling function or passive input (such as a permissive) into control logic. Instrumentation and other dedicated inputs to the process computer, as well as the computer itself, may probably be excluded. Operator actions as a result of indications are not considered control functions for the control systems failure analysis.
- N3 Control systems and controlled components (pumps, valves) which have no direct or indirect interaction with reactor operation/parameters. Examples are communications, most unit heaters and controls, lighting controls, ventilation control systems for exterior building, machine shop equipment, refueling or maintenance equipment controls, etc.
- N4 Control systems and controlled components (pumps, valves) that do interact or interface with reactor operating systems but which cannot affect the reactor parameters (water level, pressure or reactivity) either directly or indirectly.
- N5 Systems or components which cannot affect reactor parameters within 30 minutes of the loss of any power bus or combination thereof.
- N6 Systems which are not used during normal power operation. For example, start-up, shutdown or refueling systems not used during normal power operation may be eliminated.
- N7 Electrical components involved in distribution, transformation or interruption of power; however, controls for these components may need to be considered if loss of such control power may lead to failure of other electrical busses.
- N8 Safety systems, except for their response to conditions brought about by control systems failures. Example: A Level 3 scram will be assumed for a loss of feedwater event.

*In some cases, more than one of these criteria may apply.

APPENDIX C
CONTROL SYSTEMS FAILURE
ANALYSIS

APPENDIX C

RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|------------|--------------|---|--|---|--|
| INPS-SWG1A | | | | | |
| CB06 | | | | | |
| | 1NJS-SWG1U | | | | |
| | 1NHS-MCC10A2 | | | | |
| | 1SCI-PNL01 | CCS - Turbine Plant component cooling water | 1MWS - SOV132 - Turbine plant component cooling water surge tank makeup water valve. | Valve fails closed. | None. Loss of makeup water. |
| | | CCP - Reactor Plant Component Cooling Water | 1MWS - SOV134 - Reactor plant component cooling water surge tank makeup water valve. | Valve fails closed. | None. Loss of makeup water. |
| | | DET - Turbine Building Equipment Drains | 1DET - SOV17A,B,C 1DET - SOV16A,B,C | Valves fail closed. Valves fail open. | None. Turbine building sump pump flow diverted from condenser to liquid radwaste. |
| | | FWR - Feedwater Pump Recirculation | 1FWR - SOV2A,B,C (FW Min Flow Valves) | Valves fail open. | Lower FW pump efficiency. Lower FW pump effi- ciency. |
| | | FWL - Feedwater Pump Lube Oil | 1FWL - PS2A-C, PS12A-C | Loss of FW pump speed increaser and pump lube oil pressure. | Unable to trip FW pump on low lube oil pressure. Unable to trip FW pump on low lube oil pressure. |
| | | SVH - Feedwater Heater Relief Drains and Vents | 1SVH - SOV45A,B; 46A,B; 51A,B; 52A,B; 25A,B; 26A,B; 31A,B; 32A,B; 36A,B; 37A,B; 38A,B; thru 43A,B. Start up vent valves for FW heaters and drain coolers. | All valves fail open. | All FW heater and drain coolers are vented to condenser and result in increased flow to condensers. All FW heater and drain coolers are vented to condenser and resulted in increased flow to condensers. |

NOTE: CB06 CONT'D
ON SHEET C-14
1NJS-SWG1U CONT'D
ON SHEET C-6

APPENDIX C

RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--|--|---|---|--|--|
| 1NHS-MCC10A2 ISCI-PNL01 (Cont'd) | C11 Control Rod Drive | C11-K600 +24V DC Power Supply | Loss of power to alarms C11-N600, N652 | None. Activates alarms. | |
| | | C11-SRU1 | Loss of power to xmtrs C11-N007A-D | None Loss of drive water flow indication. | |
| | | C11-SRU2 | Loss of power to xmtrs C11-N009,8,11,5 | None. Loss of indication. | |
| | | C11-SRU3 | Loss of power to xmtrs C11-N004 and controller C11-R600. | Flow control valves F002A,B open. Unable to adjust flow during accumulator charging and scram. | Flow control valves F002A,B open. Unable to adjust flow during accumulator charging and scram. |
| | | Indicating CKT F002A,B | Loss of valve position indication. | None. | |
| | ARC - Condensate Air Removal | IARC - SOV3A,B air removal pump suction valves | Valves fail closed. | None. | |
| | | IARC - SOV1A,B air ejector suction valves | Valves fail open. | None. | |
| | CNM - Condensate | CNM - SOV43A,B,C condensate pump vent valve | Valves fail open. | None. | |
| | | CNM - SOV114 - Condensate min flow recirc valve | Valve fails open. Condensate flow to condenser. | Low condensate flow resulting in feedwater pump trips on low suction pressure. | Feedwater pumps trip. Recirc flow runback, scram. |
| | | 1CNM - SOV119 - Condensate Demin bypass valve | Valve fails closed. | None. | |
| | DSM - Moisture Separator Vents and Drain | 1DSM - SOV75A,B | Valves fail closed. | Loss of hot water supply to third point heaters and loss of some feedwater heating. | This loss plus the loss of supply from second point heater (see HDL on C-4) would cause the third pt htr drain pumps to trip on low level. The loss of the pumps result in loss of ~40% of FW flow and cause FW pump trip - see CNM above. |
| | | 1DSM - SOV78A,B Moisture separator drain receiver normal and high water level control valves | Valves fail open. Loss of normal and backup level control for moisture separator drain receiver. | | |

APPENDIX C

RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|------------------------|--|---|---|---|--|
| ISCI-PLN02 (Cont'd) | DSR - Moisture Separator Reheater Vents and Drains | 1DSR - SOV65A,B. 1DSR - SOV68A,B. Reheater drain receiver normal and high water level control valves. | Valves fail closed. Valves fail open. Loss of normal and backup level control for reheater drain receiver. | Loss of hot water supply to first pt heater and loss of some FW heating. | Loss of hot water supply to first pt heater and loss of some FW heating. |
| | DTM - Turbine Building Miscellaneous Drains | 1TMB-PS-3TM-S101PS4,5 Turbine tripped signal expansion. (EHC emergency trip system fluid pressure <1000 psig). | All extraction line drain valves open to condenser. | Extraction steam line to first, third, and fourth pt heaters. Drains open to condenser. | Decrease main condenser vacuum. |
| | | | Moisture separator shell pocket drain valves open. | None. | |
| | | 1DTM-SOV41AB, 35AB, 32AB, 118AB (1st, 3rd, 4th pt heaters, and steam seal evap and radwaste reboiler). | Main steam control drain valves open. Crossaround line control valves open. | Main steam leads drain through valves as well as restricting orifices and results in slight decrease in feedwater heating. | Slight decrease in feedwater heating. |
| | | Extraction line drain valves. | Crossaround line to 2nd pt heater drain control valve open. Extraction steam to steam seal evap and radwaste reboiler iso valves close. | None - Main steam automatically backs up extraction steam. | |
| | | 1DTM-SOVX187, 189 1DTM-SOVY187, 189 Radwaste reboiler and steam seal evaporator drain normal and high water level control valves. | SOVX valves fail open and SOVY valves fail closed. Causes hot water supply to fourth pt heaters to drain to condenser. | Loss of drain receiver hot water supply to 4th pt htr. Results in decrease in 4th pt heater output. Loss of some feedwater heating. | Loss of some feedwater heating. |
| | | 1DTM-SOV12AB, main steam header drain bypass valve 1DTM-SOV5AB, turbine bypass chest drain valve 1DTM-SOV222, Radwaste reboiler vent valve 1DTM-SOV223 steam seal evaporator vent valve. | All valves fail closed (valves normally closed). | None. | |

APPENDIX C

RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| RUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|------------------------|--|---|---|--|--|
| 1SCI-PNL02 (Cont'd) | ESS - Extraction Steam System | 1ESS-SOV34A,B; 24A,B; 23A,B; 16A,B; 115, 116. (1st - 4th pt Extraction steam line isolation valves.) | Extraction line return valves clappers swing freely for 1st through 4th pt htrs and radwaste reboiler and steam seal evap. | None. | |
| | HDL - High Pressure Feedwater Heater Drain | 1HDH-SOV6A,B; 26AB 1st pt to 2nd pt htr drain and 1st pt htr drain to condenser. | SOV6AB close - causes loss of hot water supply to 2nd pt htr. SOV26AB opens and drains 1st pt htr to condenser. | Loss of some feedwater heating. Reactivity increase. | Loss of some feedwater heating. Reactivity increase. |
| | HDL - Low Pressure Feedwater Heater Drain | 1HDL-SOV5AB - 2nd pt to 3rd pt heater drain 1HDL-SOV25AB, 24AB, 23AB, 22AB htr drain SOV-20AB - 3rd pt htr pump recirc valve. | Valve closes - Loss of hot water to 3rd pt htrs. 2nd pt, 3rd pt, 4th pt, and 5th pt htrs drain to condenser 3rd pt htr pump recirc valve opens. | Loss of feedwater heating capability from 3rd pt htr. Loss of feedwater from 3rd pt heaters. | See DSM Sh C-2. |
| | TMB - Turbine Generator Fluid System | TMB-HF-1FM1,2 turbine gen EH fluid unit heater fan. | Loss of EHS (electro-hydraulic system) electric heater fans. | None. | |
| | TMS - Turbine Generator Exhaust Hood Spray | Turbine exhaust hood high temp. | Loss of turbine trip signal on high turbine exhaust hood temp. | None. | |
| | CS1 - TIP Calibration System | H13-P607 - 120V power | Loss of TIP (Traversing Incore Probe) calibration function. | None. | |
| | B21 - Nuclear Boiler Process Instrumentation | B21-F033 - Stm line inboard drain line B21-F069 - Stm line outboard drain line B21-F071 - Stm line downstream drain | Valve opens - results in loss of steam. Valve closes - valve normally closed. Valve opens - results in loss of steam. | None. None. None. | |
| | N64 Offgas Control | Power supply (PS1A,B) for N64-K602A,B, K620, K610 Transformers T1A,B Recorders N64-R602, 613. | Loss of process information and actuation of alarms. System principal functions not affected. | None | |

APPENDIX C

RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|------------------------|--------------------|---|--|---|---|
| 1SCI-PNL02 (Cont'd) | N64 Offgas Control | N64-F063 bypass line air seal valve. | Valve closes - Loss of bypass line air seal. | None | |
| | | N64-F003A,B recombiner air purge valve. | Valve remains closed. | None | |
| | | N64-F010A,B preheater valve. | Valve opens - Unable to close valve | Excessive consumption of nuclear steam. | Excessive consumption of nuclear steam |
| | | N64-F016AB condenser drain valve. | Valve remains/goes closed. | Offgas condenser fills with water and chokes off offgas process flow. Back pressure on SJAE increases causing a decrease in main conden- ser vacuum. Loss of con- denser vacuum below trip point will trip turbine. | Turbine trip and scram |
| | | N64-F034AB cooler condenser drain valve. | Cooler condensate drain valves remain/goes closed | Unable to drain conden- sate from cooler conden- sers B010A,B. Will even- tually choke off process flow and trip turbine. | Turbine trip and scram |
| | | N64-F023 holdup line drain valve. | Valve closes | None - Flow too low to have any immediate effect. | |
| | | N64-F054 Prefilter inlet drain valve | Valve closes - unable to drain condensate | Would eventually choke off offgas flow. | Turbine trip and scram |
| | | N64-F053A,B Adsorber train discharge valve | Valve remains in open position. | Unable to control process flow. | |
| | | N64-F045, F062 Adsorber train bypass valve | Valves remain in closed position. | None. | |
| | | N64-F060 Offgas discharge to vent | Valves remain in open position. | Unable to isolate offgas on high radiation. | Delayed turbine trip |
| | | N64-F032A,B Cooler condenser inlet valve | Valve A remains open, B goes open. | Process gas with high moisture content will pass through separator D010B and saturate pre- filters and dryers faster | |
| | | N64-F028A,B Recombiner standby flow purge valves. | Valve A remains closed, Valve B goes closed. | None. May result in accumulation of H ₂ in the inactive loop due to loss of air purge flow. | |

APPENDIX C

RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|------------------------------|--|--|--|---|------------------|
| 1NJS-SWG1U (Cont'd from C-1) | | | | | |
| 1NHS-MCC10A1 | | | | | |
| | 1SCA-PNL10A2 MSS - Main Steam | 1HRS-PS124 Pressure switch | Loss of reheat steam isolation (1MSS-MOV111, 112) upon less than 10% turbine load. | None - Loss of moisture separator drain receiver backup level control. No effect on normal control. | |
| | | 1HRS-PS125 Pressure switch | None | None - Loss of reheater drain receiver backup level control. | |
| 1NHS-MCC1E | | | | | |
| | 1SCA-PNL1E1 GMH - Generator Hydrogen and CO ₂ | 1GMH-SOV101 Hydrogen supply shutoff valve | Valve fails closed. Hydrogen pressure decreases. Low pressure alarm. | None - If long term will cause turbine runback or trip. | |
| CB452 | | | | | |
| | TMB - Turbine Generator EHC Fluid System | ITMB-HFPM-1A Turbine generator EHC fluid pump | Loss of 1 of 2 100% capacity pumps. Redundant pump starts automatically. | None. | |
| 1NHS-MCC20A | | | | | |
| | 1VBN-PNL01A1 B21 Nuclear Boiler Process Instr Sys | B21-R643 Recorder | Loss of recorder functions | None - Loss of data only | |
| | | B21-N601A Temp xmtr | Loss of "A" steamline temp measurement. | None - Loss of data only | |
| | | B21-N601B Temp xmtr | Loss of "B" steamline temp measurement. | None - Loss of data only | |
| | | B21-N602A Temp xmtr | Loss of "A" feedwater flow temp measurement. | None - Loss of data only | |
| | | B21-N602C Temp xmtr | Loss of "A" feedwater flow temp measurement. | None - Loss of data only | |
| | | B21-N602B Temp xmtr | Loss of "B" feedwater flow temp measurement. | None - Loss of data only | |
| | | B21-N602D Temp xmtr | Loss of "B" feedwater flow temp measurement. | None - Loss of data only | |
| | B33 - Reactor Recirculation System | B33-R604 Temp recorder | Loss of recorder function. A and B recirc loop temp recording. | None. | |
| | | B33-R601 Temp recorder | Loss of recorder function. A and B recirc pump motor temp recording. | None. | |
| | | LC1A-1 Power supply (HPU) logic controller and ind. Modicon I/O module #1, 2, 3, 4, and 6. | Loss of "A" recirc loop HPU (Hydraulic Power Unit) 1 and 2 power and functions. | None - Recirc flow control valve F060A locks up at power failure position. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|--|--|--|--|---|
| 1VBN-PNL01A1 (Cont'd) | B33 - Reactor Recirculation System (CONT'D) | PS1A +24 VDC Power supply of for modicon I/O module #5 and recirc flow analog cont equip in rack 1 (H13-P634). | Loss of "A" recirc loop. HPU 1 and 2, flow control func, logic and signals, valve position and speed, loop flow rate inputs. | None - Loss of HPU 1 and 2 logic and flow control signals and ability to operate in load following mode. | |
| | | D003A HPU servos 1 and 2 | Loss of HPU servo 1 and 2 power and functions. | None - Inability to load follow. | |
| | | PS2A +24 VDC Power supply for: | Loss of output power. | | |
| | | SRU3 (Signal Resistor Unit) | Loss of input power - Loss of output signals. | Initiation of ATWS recirc pumps B33-C001A,B trip. | Initiation of ATWS recirc pumps B33-C001A,B trip. |
| | | B21-N058A Press xmtr | Loss of reactor press sig. | None - Loss of data. | |
| | | -N058F Press xmtr | Loss of reactor press sig. | None - Loss of data. | |
| | | B21-N099A Level xmtr | Loss of reactor level sig. | None - Loss of data. | |
| | | -N099F Level xmtr | Loss of reactor level sig. | None - Loss of data. | |
| | | <u>Instrument power for:</u> | | | |
| | | B21-N658A Press Ind/Sw | Reactor pressure ind downscals. | ATWS trip signal. | Recirc pump B33-C001A,B trips. A two recirc pump trip transient occurs. |
| | | -N658F Press Ind/Sw | Reactor pressure ind downscals. | ATWS trip signal. | |
| | | B21-N699A Level Ind/Sw | Reactor level ind downscals. | ATWS trip signal. | |
| | | -N699F Level Ind/Sw | Reactor level ind downscals. | ATWS trip signal. | |
| | C11 Control Rod Drive - Rod Control and Information System | Rod gang drive cabinet. P653 power supply (+5 VDC). | Loss of power output. | None. | |
| | | -BJM01 thru 13 and all HCUs | Loss of rod motion control power. | None - Loss of rod control for reactor power change. | |
| | | -F007A thru 007D stabilizing valves | Loss of power to stabilizing valves. | None - Valves fail closed. Cooling header flow reduced. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|---|---|--|--|-------------------------------|
| IVBN-PNL01A1 (Cont'd) | CS1 Neutron Monitoring - Power Range | H13-P69 Power supplies P ⁺ ± 20 VDC V _{R20} +15 VDC PS23 +5 VDC (Used for process rad monitor "A" analog signals below) | Loss of power and signals for: APRM CHs A&E, 1. Indications 2. Recorder and comp inputs 3. Annunciators 4. Logic circuits and relays 5. Recirc flow rate ref setpoint 6. Isolator AR6 7. APRM A for recirc | Inability to properly monitor reactor neutron flux using APRM Channels A and E analog signals. (Other neutron monitoring channels available. Scram trip channels not affected.) Recirculation flow control valves goes to max open. | Increase in reactor power. |
| | | | Loss of power and signals for: SRM CH A and IRM CHs A&E, 1. Indications 2. Recorder and comp inputs 3. Annunciators 4. Logic circuits and relays 5. Isolators AR6 and AR7 | None - (SRM & IRM channels not used during reactor power operation). | |
| | | H13-P671 Power supplies PS22 ± 20 VDC VR20 +15 VDC PS23 +5 VDC (Also used for process rad monitor "C" analog signals below). | Loss of power and signals for: APRM CH C&G, 1. Indications 2. Recorder and comp inputs 3. Annunciators 4. Logic circuits and relays 5. Recirc flow rate ref setpoint 6. Isolator AR6 | None - Inability to properly monitor reactor neutron flux using APRM Channels C and G analog signals. (Other neutron monitoring channels available. Scram trip channels not affected.) | |
| | | | Loss of power and signals for: SRM CH A and IRM CHs C&G, 1. Indications 2. Recorder and comp inputs 3. Annunciators 4. Logic circuits and relays 5. Isolators AR6 and AR7 | None - (SRM & IRM channels not used during reactor power operation). | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|----------------------------------|--|--|--|------------------|
| 1VBN-PNL01A1 (Cont'd) | D17 Process Radiation Monitoring | Power supplies H13-P669 PS23 (Cont'd) ± 20 VDC +5 VDC Located as part on power range monitor in panel. | Loss of output power. Loss of main steam line "A" radiation monitor analog signals and indications. Actuates annunciators: 1. Main steam line Div 1&2 high-high radiation or inop. 2. Main steam line "A" high radiation. | None - Inability to monitor main steam line "A" analog signals. Trip and isolation signal not affected. | |
| | | H13-P671 PS23 (Cont'd) ± 20 VDC +5 VDC Located as part of power range monitor. | Loss of main steam line "C" radiation monitor analog signals and indications. Actuates annunciators: 1. Main steam line Div 1&2 high-high radiation or inop. 2. Main steam line "C" high radiation. | None - Inability to monitor main steam line "C" analog signals. Trip and isolation signal not affected. | |
| | C85 Steam Bypass Reg Sys | Power supplies: PS11 ± 22 VDC PS12 ± 24 VDC | Loss of power output. | None - A15-LISPS provides redundant current sharing opera- tion with PS21 and PS22 power supplies. | |
| | | PS1 (AR10Z102) ± 15 VDC | Loss of power output and startup signal for system "A". | None - startup signal not used at power levels. | |
| | | PS2 (AR10Z102) ± 15 VDC | Loss of power output turb interface. Amp "A" in- operative and signals for sys "A" load demand and turb flow ref and flow demand lost. | None - system "B" load demand and turbine flow signal available. | |
| | | PS1 (AR10Z105) ± 15 VDC | Loss of power output and load demand error signal to the recirc system. | None - Loss of recirc sys automatic load flowing if recirc controller is in auto. Otherwise no effect. Unable to load follow. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|--|--|---|--|------------------|
| IVBN-PNL01A1 (Cont'd) | C85 - Steam Bypass Reg Sys (Cont'd) | F001-1 Fast open sol valve. | Loss of power to valves. Backup power available to open valves. | None. | |
| | | F002-1 Fast open sol valve. | | | |
| | E31 Leak Detection Sys | 5 Bus Switching Unit P637. | Power failure, transfers to bus "B" power. | None. | |
| | | Sump relays and logic circuits H13-P632 | Actuation power lost to relays and timers, R605 and R606 | None - Inability to perform drywell equip drain sump fill and pump- out operations. | |
| | | K10 Relay | R605 and R606 | | |
| | | K11 Relay | R605 and R606 | | |
| | | K12 Relay | R605 and R606 | | |
| | | K13 Relay | R607 and R610 | None - Inability to perform containment equip drain sump fill and pump- out operations. | |
| | | K14 Relay | R607 and R610 | | |
| | | K15 Relay | R607 and R610 | | |
| | | K19 Relay | R601 and R602 | None - Inability to perform containment area drain sump fill and pump- out operations. | |
| | | K20 Relay | R601 and R602 | | |
| | | K21 Relay | R601 and R602 | | |
| | | R613A Ind switch | Loss of power to R613A ind switch, N023A flow xmtr, N023A-1 preamplifier. | None - Actuates annunci- ator for refueling bellows leakage. | |
| | | AT12 Analog isolator AT13 Analog isolator assembly | Loss of signal from K605A main cond flow and K602A recirc suction flow. | None - RWCU inlet flow ind G33-N600 signal lost. Actuate low pump flow annunciator. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|-----|--|--|--|---|---------------------|
| | 1VBN-PNL01A1 G33 Reactor Water Cleanup (Cont'd) | Cleanup pump logic circuit K4 and K5 relays. | Loss of relay power inhi- bits starting pumps. | None - operation not affected. | |
| | | Power supply K600 +24 VDC for: | | | |
| | | <u>SRU1 (Signal Resistor Unit)</u> | | | |
| | | R610 Flow meter | Loss of reactor bottom head drain flow indicator. | None. | |
| | | R600 Press meter | Loss of regenerative heat exch inlet press indication. | None. | |
| | | R606 R/W control station | Loss of controller output to K001 I/O converter | None - Valve F033 closes, preventing main condenser blowdown operations. No effect, not used dur- ing reactor power operation. | |
| | | | Loss of output power for: | | |
| | | R611 Recorder | Reactor recirc and cont rod drive water dissolved | None. | |
| | | R605A Alarm units R606B Alarm units | O ₂ recording and high dissolved O ₂ concentration alarms inoperative. | None. | |
| | | R601 Recorder | Filter demin influent conductivity recording | None. | |
| | | N602A Alarm units N602B Alarm units | and high/low conductivity alarms inoperative. | None. | |
| | | R603 Recorder | Filter demin effluent conductivity recording and | None. | |
| | | N603A Alarm unit N603B Alarm unit | high/low alarms inoper- ative. | None. | |
| | | R604 Recorder | Condensate storage water conductivity recording and | None. | |
| | | N604 Alarm unit | high/low alarms inoper- ative. | | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|--------------------------------------|-----------------------|--|--|------------------|
| IVBN-PNL01A1 (Cont'd) | G33 - Reactor Water Cleanup (Cont'd) | | Loss power to: | | |
| | | N600 Alarm unit | Cleanup sys inlet flow hi/low alarm trips pumps COG1A&B or inhibits pump startup. | None - Loss of RWCU flow from pumps COG1A&B. None, flow not needed for reactor power operation. | |
| | | R613 Recorder | Jet pump total flow and reactor core plate D/P recording inoperative. | None. | |
| | | CTX1 Power Supply 24V | Loss of output power for recorder chart & pen drive. | | |
| | | R611 Recorder | CRD O ₂ Chart and pen drive Recirc O ₂ Chart & pen drive. | None. None. | |
| | | R601 Recorder | Filter in conductivity drive. | None. | |
| | | R603 Recorder | Filter out conductivity drive. | None. | |
| | | R604 Recorder | CST conductivity drive. | None. | |
| | | | Loss of output power for recorder chart & pen drive. | None, recording loss only. | |
| | | CS1A-R602A Recorder | SRM A log count rate drive. | None, recording loss only. | |
| | | CS1A-R602B Recorder | SRM B log count rate drive. | None, recording loss only. | |
| | | CS1A-R603A Recorder | IRM and APRM Ch A/E output drive. | None, recording loss only. | |
| | | CS1A-R603B Recorder | IRM and APRM Ch B/F output drive. | None, recording loss only. | |
| | | CS1A-R603C Recorder | IRM and APRM Ch C/G output drive. | None, recording loss only. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|--|---|--|---|------------------|
| 1VBN-PNL01A1 (Cont'd) | G33 - Reactor Water Cleanup (Cont'd) | C51A-R603D Recorder | IRM and APRM Ch D/H output drive. | None - Recording loss only. | |
| | | C51B-R614 Recorder | Recirc flow loop A/B output drive. | None - Recording loss only. | |
| | | C33-R607 Recorder | Feedwater/steam total flow drive. | None - Recording loss only. | |
| | | C33-R608 Recorder | Narrow/upset RPV level drive. | None - Recording loss only. | |
| | | C33-R609 Recorder | Turb 1st stage and reactor pressure drive. | None - Recording loss only. | |
| | | B21-R615 Recorder | Fuel zone RPV level drive. | None - Recording loss only. | |
| | | B21-R622 Recorder | Feedwater turbidity drive. | None - Recording loss only. | |
| | CCP - Reactor Plant Component Cooling Water System | 1CCP-PT127 Press xmtr | Loss of auto start signal to idle CCP pump and loss of header press indication. | None - Control room alarm low CCP press. No effect on plant operations. | |
| | | 1CCP-LT120 Level xmtr | Loss of CCP surge tank level ind for makeup water. | None - CCP surge tank low level alarm actuated. No effect on plant operations. | |
| | CCS - Turbine Plant Cooling Water System | 1CCS-PT116 Press xmtr | Loss of press signal. | None - Low header pressure Initiation of auto start for CCS pump. | |
| | | 1CCS-LT113 Level xmtr | Make up water valve closes. | None - CCS surge tank low level alarm actuated. Make up water lost. | |
| | CNM Condensate System | 1CNM-PT70A Press xmtr | Loss of feedwater pump suction press indication and low pressure trip operation. | None - Only low FW pump suction pressure alarm actuated. | |
| | | -70B Press xmtr -70C Press xmtr (ESX70) | | | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------------------|---|------------------------------------|--|--|--|
| IVBN-PNL01A1 (Cont'd) | CNM Condensate System (Cont'd) | 1CNM-FT68 Flow xmr (ES68) | Loss of feedwater pump suction flow indication and low flow alarm and cont operation | None - Only low FW pump suction flow alarm actuated. | |
| | | | Loss of reactor recirc runback signal on low FW pump suction flow. | Loss of reactor recirc runback upon low FW flow. | Loss of reactor recirc runback upon low FW flow. |
| | | | | None - Loss of FWR-SOV2A min flow valve control signal. No effect on plant operation. | |
| | ESS - Extraction Steam System | 1_LSS-PDT111 D/P Xmr | Loss of 3rd pt extraction steam to main steam diff press signal | None - Low diff pressure indicator in control room actuated. MOV111 and 112 valves fail to close. Close on low 3rd pt extraction steam to main steam Δ/P. Loss of main steam supply for radwaste reboiler and steam seal evaporator. | |
| | MSS - Main Steam System | 1MSS-FT13A,B Flow Xmr | Loss of 2nd stage air ejector steam flow signal. | None - Low 2nd stage air ejector steam flow alarm actuated. Air ejector suction valve opens. | |
| | TMB - Turbine Generator EH Fluid System | 1TMB-10837-1TMRN06 Load Signal Xmr | High turbine gen load. Signal alarm and loss of signal. | None - Loss of turbine runback signal to 70% upon removal of one string of low press heaters. | |
| CB06 (Cont'd from C-1) INJS-SWG2E | CWS - Circulating Water | 1CWS-FN1BA Cooling tower fan | Loss of 1 of 8 fans. | None - Loss of 4 of 8 fans. No short term effects. | |
| | | 1CWS-FN1BC Cooling tower fan | Loss of 1 of 8 fans. | None. | |
| | | 1CWS-FN1BE Cooling tower fan | Loss of 1 of 8 fans. | None. | |
| | | 1CWS-FN1BG Cooling tower fan | Loss of 1 of 8 fans. | None. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|----------------------------------|------------------------------------|---|--|--|---|
| CB06 (Cont'd) 1NJS-SWG2G | CWS - Circulating Water | 1CWS-FN1DA Cooling tower fan | Loss of 1 of 8 fans. | None - Loss of 4 of 8 fans. No short term effects. | |
| | | 1CWS-FN1DC Cooling tower fan | Loss of 1 of 8 fans. | None. | |
| | | 1CWS-FN1DE Cooling tower fan | Loss of 1 of 8 fans. | None. | |
| | | 1CWS-FN1DG Cooling tower fan | Loss of 1 of 8 fans. | None. | |
| CB14 | CNM - Condensate | 1CNM-F1A Condensate pump | Loss of 1 of 3 50% capacity pumps. | Recirculation flow run-back on loss of two condensate pumps and feedwater pumps trip on low suction. | Loss of 2 of 3 condensate pumps. Recirculation flow runback. Feedwater pumps trip on loss of suction. |
| CB15 | CNM - Condensate | 1CNM-P1C Condensate pump | Loss of 1 of 3 50% capacity pumps. | | |
| CB12 | FWS - Feedwater System | 1FWS-P1A Feedwater pump | Loss of 1 of 3 FW pumps. | Water level decrease results in recirc flow runback. | |
| CB16 1NJS-SWG1A 1NHS-MCC2E | WCS - Reactor Water Cleanup | 1WCS-P5A Reactor water cleanup backwash pump. | None - Backup pump 1WCS-P5B available. | None. | |
| | G33 - Reactor Water Cleanup (RWCU) | G33-F:07 - Regen heat exch bypass valve. | Valve fail as is - Valve normally closed. | None. | |
| | | G33-F031 - Drain flow orifice bypass (blow-down) valve. | Valve fail as is - Valve normally closed. | None. | |
| | B33 - Recirculation System | B33-D003A oil pumps and fan motors subloop 1&2. | Loss of hydraulic power in loop "A". | None - Flow control valve B33-F060A locks up | |
| 1NHS-MCC2A | B21 - Nuclear Boiler | B21-F001 Reactor head vent valve | Loss of valve control and position indication valve. Fail as is. | None - valve normally closed. | |

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|---------------------|---|--|---|--|---|
| INJS-SWG1A (Cont'd) | | | | | |
| INHS-MCC2A (Cont'd) | B33 - Reactor Recirculation | B33-F023A Recirc loop "A" suction valve. | Loss of valve control and position indication. Valve fails as is. | None - valve normally open. Unable to close off recirc loop "A". | |
| | | B33-F067A Recirc loop "A" discharge block valve. | Loss of valve control and position indication. Valve fails as is. | None - valve normally open. Unable to close off recirc loop "A". | |
| | G33 - Reactor Water Cleanup | G33-F102 RWCU Suction Line Valve. | Loss of valve control and position indication. Valve fails as is. | None - valve normally open. | |
| | | G33-F106 RWCU Suction from recirc loop "B". | Loss of valve control and position indication. Valves fail as is. | None - valve normally open. | |
| ISCA-PNL2A1 | G33 - Reactor Water Cleanup | G33-F033 Blowdown flow control valve. | Loss of valve control. Valves fail closed. | None - not used during normal operation. | |
| | | G33-N003 Temp xmtr | Loss of regen and nonregen heat exchanger process temp. | None. | |
| CB06 | CCP - Reactor Plant Component Cooling Water | 1CCP-P1A CCP Pump "A". | Loss of 1 of 3 50% capacity pumps. | None - Auto startup of idle pump. | None. Loss of 2 of 3 pumps causes auto start of the standby service water sys pumps and isolate CCP heat exchangers from SWP. This results in loss of cooling to the recirc pumps and trips CRD pumps. |
| CB07 | | 1CCP-P1C CCP Pump "C". | Loss of 1 of 3 50% capacity pumps. | None - Auto startup of idle pump. | |
| INHS-MCC2C | G33 - Reactor Water Cleanup | G33-F046 RWCU drain to main condenser valve. | Loss of valve control. Valve fail as is. | None. | |
| | B21 - Nuclear Boiler | B21-F020 Sta line Inbd drain valve. | Loss of valve control. Valve normally closed. | None - Not used during normal power operation. | |
| | C51 Startup Range Det Drive Cont Sys | C51-S001A,B,C,D,E,F,G,H,J,L,M Motor module. | Loss of detector drive power. | None. | |
| ISCA-PNL2C1 | C51 Startup Range Det Drive Cont Sys | H22-P008 120 VAC | Loss of control power for detector drives. | None. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|---|--|---|---|---|------------------|
| INPS-SWG1A (Cont'd) CB04 INJS-SWG1E INHS-MCC4A ISCA-PNL4A1 INHS-MCC1A INHS-MCC1C2 INHS-MCC4C | ISCA-PNL2C1 (Cont'd) | C51-1060 Traversing Incore Probe Calib Sys | Statrol 4 - Drive mech C51-J001D. | Unable to calibrate APRM | None. |
| | D17 - Process Radiation Monitoring | D17-J013 Offgas post treatment sample panel P1 and P2 vacuum pumps. | Unable to monitor offgas - alternate monitoring by plant exhaust duct monitor. Annunciator actuated. | None. | |
| | | D17-J013 Heater | Loss of heating. | None. | |
| | | D17-J013 Purge solenoid valves. | Loss of calibration capability. | None. | |
| | N64 - Offgas | N64-N012A Hydrogen analyzer | Loss of "A" H ₂ analyzer operation | None - alternate analyzer "B" available. | |
| | ARC - Condenser Air Removal System | 1ARC-P2A Condenser air removal recirculation seal pump | Unable to establish vacuum during startup. | None - not used during power operation. | |
| | FWL - Feedwater Pump and Drive Lube Oil | 1FWL-P5A Feedwater pump gear increases aux oil pump | Loss of backup pump. Actuation of control room annunciator. | None - shaft driven oil pump 1FWL-P4A normally in use not affected. | |
| | GML - Generator Leads Cooling | 1GML-FN1 Isol phase bus duct cooling fan motor | Loss of fan power and operation. Indication in control room. | None - backup fan 1GML-FN2 available. | |
| | N64 - Offgas | N64-S001A Heater transformer | Loss of power to temp controller N64-R002A. | None if sys "A" in opera- tion. If sys "B" is operating, will not main- tain sys "A" temp high enough to allow switching to sys "A". | |
| | | N64-Z001 Glycol cooler refrigeration mach 6A | Loss of 1 of 3 machines | None - 6B & 6C machines available. | |
| | | N64-Z001 Glycol cooler condenser pump | Loss of 1 of 3 pumps | None - 7B & 7C pumps available. | |

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|--|---|---|--|---|------------------|
| CKT04 (Cont'd) 1NHS-MCC4C (Cont'd) | N64 - Offgas | N64-Z002A Dryer heater train "A" | Unable to regenerate train "A" dryer N64-D030A. | None - alternate train "B" available. | |
| | | N64-Z002A Regenerator blower "A", train "A" | Unable to cool or regenerate dryer N64-D030A if train "A" is not processing. | None - alternate train "B" available. | |
| | | N64-Z003 Control power train "A". | Unable to regenerate SV08A inlet valve. Fails as is. SV15A outlet valve fails as is. SV09A and 14A regeneration valves fail closed. SV16A fails open. | None. If train "A" is in operation or in standby | |
| 1NJS-SWG1G | N64 - Offgas | N64-B012A Vault refrigeration unit compressor 1HVT-C1A. | Loss of one of two compressors. | None - backup unit capable of maintaining vault temp. | |
| | ABC - Condenser Air Removal | 1ARC-P1A - Cond air removal pump motor. | Cannot establish condenser vacuum. | None - not used during normal operation. SJAE used normally. | |
| | IAS - Instrument Air | 1IAS-C1A - Instrument air compressor. | Loss of 1 of 3 compressors | None - two compressors normally in load/unload mode. Remaining one in auto standby. | |
| 1NHS-MCC1J ISCA-PN11J1 | CSS - Turbine Plant Component Cooling Water | 1CCS-SOV13A,B,C -SOV31A,B,C | All valves fail open to allow cooling water to circulate continuously. | None. | |
| 1NHS-MCC1G | IAS - Instrument Air | 1IAS-DRY1A Instrument Air Dryer. | Loss of one of two 100% capacity dryers. | None - Dryer 1IAS-DRY1B available | |

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|--|--|--|---|---|------------------|
| CB04 (Cont'd) 1NJS-SWG1Q 1NHS-MCC18A 1SCI-PNL03 | DTM - Turbine Building Miscellaneous Drains | 1DTH-SOV128 Sol valve 1DTH-SOV129 Sol valve 1DTH-SOV206 Sol valve 1DTH-SOV207 Sol valve 1DTH-SOV204 Sol valve 1DTH-SOV205 Sol valve | Loss of valve control Valve fails closed Valve fails closed Valve fails closed Valve fails closed Valve fails open Valve fails open | None - Regenerative evaporator reboiler and waste evaporator boiler drain receiver drains diverted to radwaste. | |
| 1NPS-SWG1A (Cont'd) CB05 1NJS-SWG2A | CWS - Circulating Water | 1CWS-FN1AA 1CWS-FN1AC Fan, cooling tower. 1CWS-FN1AE 1CWS-FN1AG | Loss of 4 of 8 fans in the associated cooling tower. | None - four backup fans remain available. | |
| 1NJS-SWG2C | CWS - Circulating Water | 1CWS-FN1CA 1CWS-FN1CC Fan, cooling tower. 1CWS-FN1CE 1CWS-FN1CG | Loss of 4 of 8 fans in the associated cooling tower. | None - four backup fans remain available. | |
| 1NJS-SWG3C 1NHS-MCC11A 1SCA-PNL11A1 | BCS - Bearing Cooling Water System | 1BCS-F1A Pump bearing cooling water. 1BCS-STR1A Strainer bearing cooling water. | Loss of pump indication in control room. Loss of one of two strainers. | None - backup pump train available. None - backup pump strainer available. | |
| CB03 1NJS-SWG1J 1NHS-MCC1C1 | DET - Turbine Building Equipment Sump | 1DET-P1C Pump, turbine building equip sump. 1DET-P1E Pump, turbine building equip sump. | Loss of one of two full capacity pumps. Control room indication. Loss of one of two full capacity pumps. Control room indication. | None - pump 1DET-F1F available. None - pump 1DET-P1B available. | |

APPENDIX C

RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|---------------------------|---|--|--|---|--|
| CB03 (Cont'd) | | | | | |
| 1NNS-MUCIC1 (Cont'd) | FWL - Feedwater Pump and Drive Lube Oil | 1FWL-P1A Feedwater pump and oil pump. | Loss of one of two AC oil pumps. | None - backup AC pump 1FWL-P2A and DC pump 1FWL-P3A available. | Loss of both AC pumps Backup DC pump 1FWL-P3A available. |
| | | 1FWL-P2A Feedwater pump and aux oil pump. | Loss of one of two AC oil pumps. | None - backup DC pump available (1FWL-P3A). | |
| 1NJS-SWG1L 1NNS-MCCRA | C11 - Control Rod Drive Hydraulic | 1C11-F003 Pressure control valve | Unable to adjust drive cooling water flow | None - valve remains in last position | |
| 1SCA-PNLBA1 | B33 - Reactor Recirculation System | 1B33-P001A LFNG "A" aux equipment and voltage regulator. | Unable to operate recirc sys "A" at low speed. | None - not used at full power. | |
| CB305 | B33 - Reactor Recirculation System | 1B33-S001A LFNG "A" drive motor. | Unable to operate recirc sys "A" at low speed. | None | |
| 1NNS-MCCRC 1SCA-PNLBC1 | C11-1060 - Control Rod Hydraulic System | 1C11-C001A Aux oil pump | Cannot start hyd pump C11-C001A if aux oil pump not operating. | None - direct coupled lube oil pump provides lubrication during normal operation. | |
| CB07 1NNS-SWG2A | SWP - Service Water | 1SWP-P1A Service water pump | Loss of one of three 50% capacity pumps annunciated in CR. | Annunciated in control room. | Loss of two of three 50% capacity pumps. Standby service water pumps SWP-P2A,B,C,D available. Loss of cooling to turbine plant component heat exchanger results in a turbine trip. |
| | | 1SWP-P1C Service water pump | Loss of one of three 50% capacity pumps annunciated in CR. | Annunciated in control room. | |
| | CWS - Circulating Water | 1CWS-P1A Circulating water pump | Loss of 25% of circ water capacity. Annunciated in CR. | Loss of some condenser vacuum. | Loss of 50% capacity will result in turbine trip on low condenser vacuum. |
| | | 1CWS-P1C Circulating water pump | Loss of 25% of circ water capacity. Annunciated in CR. | Loss of some condenser vacuum. | |
| CB13 | B33 - Recirculation System | 1B33-C001A Recirc pump | Loss of pump A. Pump coasts down to stop. | Feedwater flow decreases. | Reactor power decreases. |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|---------------------------|--------------------------------|--------------------------------|---|---|-----------------------------------|
| 1NPS-SWG1B CB22 | | | | | |
| 1NJS-SWG2B | CWS - Circulating Water System | FN1AB Cooling tower fan | Fan motive power lost: Control room light indication. | None. | Four backup fans remain operable. |
| | | FN1AD Cooling tower fan | Control room light indication. | None. | |
| | | FN1AF Cooling tower fan | Control room light indication. | None. | |
| | | FN1AH Cooling tower fan | Control room light indication. | None. | |
| 1NJS-SWG2D | CWS - Circulating Water System | FN1CB Cooling tower fan | Fan motive power lost: Control room light indication. | None. | Four backup fans remain operable. |
| | | FN1CD Cooling tower fan | Control room light indication. | None. | |
| | | FN1CF Cooling tower fan | Control room light indication. | None. | |
| | | FN1CH Cooling tower fan | Control room light indication. | None. | |
| 1NJS-SWG3D 1NHS-MCC11B | BCS - Bearing Cooling System | PIB Bearing cooling water pump | Pump motive power lost. Control room light indication. | None, backup pump available | |
| 1SCA-PNL11B1 | | STR1B Strainer | Strainer disabled, control room light indication. Backwash and flush function lost. | None, backup strainer and backwash and flushing pump train available. | |
| CB21 | CNM | 1CNM-PIB Condensate pump | Loss of 1 of 3 50% capacity pumps. | None. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|---|-----------------------------|---------------------------------|--|---|--|
| INPS-SWG1B (Cont'd) CB23 INNS-SWG2B | CWS - Circulating Water | P1B Circ water pump | Pump disabled. Control room unannounced. | Loss of 25% of circulating water flow. Main turbine condenser vacuum lost, actuating alarms. | 50% condenser cooling water flow lost results in loss of condenser vacuum and turbine trip actuation and eventual scram. |
| | | P1D Circ water pump | Pump disabled. Control room unannounced. | Loss of 25% of circ water flow. Main turbine condenser vacuum lost, actuating alarm. | |
| | SWP - Service Water | P1B Normal service water pump | Pump disabled. Control room unannounced. | Loss of 50% capacity pump. 1 of 3 pumps. | |
| CB34 INJS-SWG1M INNS-MCC8B ISCA-PNL8B1 | C11 - Control Rod Drive | Aux oil pump for CRD pump C001B | Loss of pump operation. | None, not required for power operation, only for pump startup. | |
| INJS-SWG1P INNS-MCC18B ISCA-PNL18B1 | WCS - Reactor Water Cleanup | SOV101 Solenoid valve | Loss of valve operation for receiving tank backwash. | None - Valve fails closed. Required for power operation. | |
| | | SOV102 Solenoid valve | Loss of valve operation for receiving tank backwash. | None - Valve fails closed. Required for power operation. | |
| | | SOV103 Solenoid valve | Loss of valve operation for receiving tank backwash. | None - Valve fails closed. Required for power operation. | |
| | | SOV110 Solenoid valve | Loss of valve operation for receiving tank backwash. | None - Valve fails closed. Required for power operation. | |
| CB30 | B33 - Recirculation System | B33-C001B Recirc pump | Loss of Pump A. Pump coasts down to stop. | Feedwater flow decreases. | Reactor power decreases. |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|---|---|---|--|---|------------------|
| *ISCA-PNL18B1 (Cont'd) | WCS - Reactor Water Cleanup (Cont'd) | SOV171 Solenoid valves | Loss of valve operation for receiving tank backwash. | None - Valve fails closed. Required for power operation. | |
| INPS-SWG1B (Cont'd) CB33 INJS-SWG1D | IAS - Instrument Compressed Air System | Instrument air compressor IAS-C1C. | Loss of 1 of 3 instrument air compressors. One standby air compressor is available to supply air demand. | None. | |
| INHS-MCC1P | DET - Turbine Building Equipment Drains | Turbine building equipment sump pumps 1DET-P1A and 1DET-P1D. | Unable to pump TK1A sump fluid to condenser hotwell or liquid radwaste system. | None - Possible extreme high sump level alarm in control room. | |
| ISCA-PNL1P1 | DET - Turbine Equipment Drain Sumps | Conductivity instruments for sump TK1A and TK1C; 1DET-CITS135 and 1DET-CITS137. | Loss of ability to transmit high conductivity signal for sumps 1A and 1C. Instruments fail low scale. | None - Loss of automatic diversion of fluid from sumps 1A and 1C from condenser hotwell to liquid radwaste upon high conductivity in discharge. | |
| CB32 INJS-SWG1F | GML - Generator Leads Cooling | 1GML-FN2 Isolated phase bus duct cooling fan. | None - backup fan 1GML-FN1 available. Ann of trouble in CR. | None. | |
| INHS-MCC1B | ARC - Condenser Air Removal | 1ARC-P2B Condenser air removal recirculation seal water pump. | None - not used during normal operation. | None. | |

*NOTE: CB34 continued on sheet C-29

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RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|------------------------------------|---|--|--|---|------------------|
| INJS-SWG1F (Cont'd) INHS-MCC1D1 | FWL - Feedwater Pump and Drive Lube Oil | 1FWL-P1C Feedwater pump normal main oil pump. | None - backup AC or DC pumps starts automatically on low oil pressure. | None. | |
| | | 1FWL-P1B Feedwater pump normal main oil pump. | Same as above. | None. | |
| | DET - Turbine Building Equipment Drain | 1DET-P1F Turbine bldg equipment sump pump. | None - other full capacity pump P1C available. | None. | |
| | | 1DET-P1B Turbine bldg equipment sump pump. | None - full capacity pump P1E available. | None. | |
| INHS-MCC1D2 | FWL - Feedwater Pump and Drive Lube Oil | 1FWL-P5C Feedwater pump gear increaser aux oil pump. | None - pump used for startup and not used during normal operation. | None. | |
| | | 1FWL-P2B Feedwater pump pump aux oil pump. | None - DC pump starts on low oil pressure. | None. | |
| | | 1FWL-P5B Feedwater pump gear increaser aux oil pump. | None - not used during normal operation. | None. | |
| | | 1FWL-P2C Feedwater pump aux oil pump | None - DC pump starts on low oil pressure. | None. | |
| INHS-MCC4B ISCA-PNL4B1 | D17 - Process Rad Mon | D17-J014 Offgas post-treatment vial sampler. | Loss of vacuum pump and sample control valves. | None. Unable to obtain sample. | |
| | | D17-J034 Offgas combination pretreat sample panel. | Loss of vacuum pump and sample control valves. Loss of heater. | None. Unable to get grab sample Plate out of lines increases. | |

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RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|----------------------|--------------|---|---|--|---------------------|
| ISCA-PNL4B1 (Cont'd) | | | | | |
| | N64 - Offgas | N64-N012B Hydrogen analyzer. | Loss of one of two independent sys activate ann. | None - Sys A available. | |
| | | N64-K026A,E MV/I. | Loss of absorber temp monitoring. | None. | |
| | | N64-N033A,B Flow transmitter. | Loss of train A & B outlet flow monitoring. | None - total flow on FR N64-R620. | |
| | | N64-N029 Temp transmitter. | Unable to monitor vault inlet air temp. | None. | |
| | | N64-N013 Temp transmitter. | Unable to monitor outlet temp of moisture separators A & B. | None. | |
| | | N64-N014 Temp transmitter. | Loss of refrigeration vault outlet air temp recording. | None - temp available of TIC R037AB. | |
| | | N64-N015 Temp transmitter | Unable to record glycol tank outlet temp (TRS-R630). | None - temp available on TIC 17B & 18B. | |
| | | N64-F051A,B Absorber train gas cooler inlet valves | Valves remain open. | None - valves normally open. | |
| | | N64-F051C,D Absorber train gas cooler bypass valves | Valve goes open. Flow divided between cooler and bypass line. | None - Increase in process gas temp to charcoal absorbers. | |
| | | N64-F011, N64-N062 (Flow transmitters). | Unable to record absorber column discharge flow on recorder FR-620. | None. | |
| | | N64-PS2 Power supply | | | |
| | | N64-R035-1 | | | |
| | | N64-R036-1 Alarm | Activate absorber column disch flow alarms. | None. | |
| | | N64-N011-1 | | | |
| | | N64-N062-1 MV/I | Loss of absorber column discharge flow signal to FR620. | None. | |
| | | N64-AR6 Ind/amp | Loss of absorber column discharge flow indication. | None. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|----------------------|--------------|--|--|---|-------------------------|
| 1SCA-PNL4B1 (Cont'd) | | | | | |
| | N64 - Offgas | N64-K024AB Power supply N64-SRU3, R005AB, N008AB, AR5, SRU4, R006-1 | Loss of process level and temp signal of the offgas condenser. Valves N64-F016AB go/remain closed. | Offgas fills with water and chokes-off process flow. Back pressure on SJAЕ increases and results in a decrease in main condenser vacuum and results in a turbine trip. | Turbine trip and scram. |
| | | N64-N009-1 Temp transmitter | Loss of offgas condenser outlet temp. | None. | |
| | | N64-F007A,B Preheater inlet drain valve | None - normally open valves fail open. | None. | |
| | | N64-F029 Holdup line drain loop seal disch valve. | None - normally open valves fail open. | None. | |
| | | N64-F044 Cooler condenser drain loop seal disch valve. | None - normally open valves fail open. | None. | |
| | | N64-N063-1 Temp xmtr | Loss of offgas condenser cooling water disch temp. | None. | |
| | | N64-F048 Prefilter inlet drain loop seal disch valve. | None - normally open valve fails open. | None. | |
| | | N64-K002A, K003A MV/I converter | Loss of catalytic recom- biner inlet and outlet process temp. | None. | |
| | | N64-R002A Temp controller. Voltage control for recombiner heater. | None - heater not used during normal operations. Used in standby. | None. | |
| | | N64-K002B, K003B MV/I converter | Loss of catalytic recom- biner inlet and outlet process temp. | None. | |
| | | N64-R002B Temp controller. Voltage control for recombiner heater. | None - used in standby only. | None. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|-----------------------------------|--------------|--|---|--|---|
| INJS-SWG1F (Cont'd) INHS-MCC4D | N64 - Offgas | N64-Z001 Glycol cooler refrig machine 6B. | Loss of 1 of 3 refrig machines. | None - alternate refrig machines 6A and 6C available. | None - more than one machine (2) required for 12 hours per 72 hours of regeneration. |
| | | N64-Z001 Glycol cooler refrig machine 6C. | Loss of 1 of 3 refrig machines. | None - alternate refrig machines 6A and 6B available. | |
| | | N64-Z001 Glycol cooler condenser glycol pump 7C. | Loss of one of three glycol pumps. | None - alternate pumps 7A and 7B available. | None - more than one pump (2) required 12 for hours per 72 hours of regeneration. |
| | | N64-Z001 Glycol cooler condenser glycol pump 7B. | Loss of one of three glycol pumps | None - alternate pumps 7A and 7C available. | |
| | | N64-B012B Vault refrig unit control power. | Loss of one of two vault temp control sys. | None - alternate refrig unit B021A available. | |
| | | N64-Z002B Dryer heater train B. | Unable to regenerate train B. | None - not used during processing offgas. | |
| | | N64-Z002B Regenerator blower B. | Unable to regenerate train B. | None - not used during processing offgas. | |
| | | N64-Z003 Gas dryer control power train B | Unable to regenerate. Inlet valve SV04B and outlet valve SV15B remain in last position, regener- ation valves SV14B and SV09B fail close, SV16B fails open. | None - not used during processing offgas. | |
| | | N64-S001B Heater transformer | Loss of heater power to temp controller N64-R002B. None if Sys B in operation. Unable to maintain temp if B in standby. | None - unable to switch process to train B if train A in operation. No effect if train B in operation. | |
| | | N64-B012B Vault refrig unit | Loss of one of two vault refrigeration units. | None - alternate unit N64-B012A available. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|-----------------------------|---|--|--|---|------------------|
| CB32 (Cont'd) 1NJS-SWG1B | CCP - Reactor Plant Component Cool Water | 1CCP-P1B Reactor plant comp cool wtr pump. | Loss of 1 of 3 half capacity pumps. Pump disabled. Annunciator actuated. | None, remaining CCP pumps 1CCP-P1A and P1C can meet 100% cooling water demand. | |
| | B33 - Reactor Recirc Water LFMG Set "B" | LFMG set "B" motor. | Loss of LFMG set "B". No effect at full power operation. | None. No effect at full power operation. Used for recirc loop B flow control below 25% power. | |
| | G33 - Reactor Water Cleanup | G33-C001B Reactor water cleanup pump "B" | Loss of 50% reactor water cleanup capacity. No effect unless reactor water quality was borderline. | Loss of water cleanup capacity is annunciated. | |
| 1NHS-MCC2B | B21 - Nuclear Boiler System | B21-F002 Head vent valve. | Loss of valve control and position. No effect. Vlv normally closed. | None. | |
| | G33 - Reactor Water Cleanup (RWCU) | G33-F100 Recirc loop "A" cleanup valve. | Valve power lost. Fails open. | None, valve is normally open. | |
| | | G33-F101 Bottom head drain valve. | None. Valve fails as is, i.e., closed. | None. | |
| | | G33-F042 Regen heat exchanger outlet valve. | None. Valve fails as is, i.e., open. | None. | |
| | | G33-F044, Cleanup filter demin bypass valve | None. Valve fails as is, i.e., closed. | None. | |
| ISCA-PNL2B1 | C51 - TIP Calibration APRM | Statrol, TIP drive/encoder. | Loss of calib function | None. | |
| 1NHS-MCC2D | B33 - Reactor Recirc Water LFMG Set "B" Auxiliaries | LFMG Set B - panel lights, space heaters, voltage reg. | No effect at full power. Recirc system cannot operate below 25% power. | None. | |
| | B33 - Reactor Recirc Water System | B33-F067B Recirc loop "B" pump disch block valve. | None. Valve normally open. Would not be able to isolate pump. | None. | |
| | | B33-F023B Recirc loop "B" pump suction valve. | None | None. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|---------------------------------------|---|---|--|--|------------------|
| 1NHS-MCC2D (Cont'd) | G33 - Reactor Water Cleanup | G33-F035 Drain to rad-waste valve. | None. Valve fails as is, i.e., closed. | None. | |
| | B21 - Nuclear Boiler System | B21-F005 Head vent valve. | Loss of valve cont and position indication. No effect. Valve normally closed. | None. | |
| 1NHS-MCC2F | G33 - Reactor Water Cleanup (RWCU) | 1WCS-P5B Reactor water cleanup backwash pump | None. Backup pump available. | None. | |
| | | G33-F104 Water cleanup heat exchanger bypass valve. | None. Valve fails as is, i.e., normally closed. System cannot be used during hot shutdown. | None. | |
| | B33 - Recirculation System | B33-D003B HPU oil pump and fan motors, subloop 1&2. | Loss of Loop "B" hydraulic power and valve control. | None - Flow control valve B33-F060B locked in last position. | |
| 1SCA-PNL2F1 | C51 - TIP Calibration System | Statrol 1, 2, and 3 | None. | None. | |
| CB34 (Cont'd from C-23) 1NJS-SWG1B | ARC - Condenser Air Removal | 1ARC-P1B Condenser air removal pump. | Cannot establish condenser vacuum on startup. No effect at normal operation. Air ejectors maintain vacuum. | "Disabled" indication in control room. | |
| | IAS - Instrument Air System | 1IAS-C1B Instrument air compressor. | Loss of one of three air compressors. Normally two compressors run in load/unload mode and one in auto standby. In worst case (loss of bus 1NPS-SWG1B) two compressors will be out of service. | "Disabled" annunciation in control room. | |
| 1NHS-MCC1H 1SCA-PNL1H1 | DET - Turbine Building Equipment Drains | 1DET-CITS136. | Loss of auto diversion of high conductivity water from tank TK1B. No effect. Water will be cycled into cond. | None. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--|---|--|--|---|---------------------|
| ISCA-PNL1H1 (Cont'd) | IAS - Instrument Air System | IIAS-DRY1B Instrument air dryer. | Loss of one of two air dryers. No effect. Standby dryer IIAS-DRY1A accomplishes function. | "Disabled" indication. | |
| INPS-SWG1B (Cont'd) CB21 | | | | | |
| INJS-SWG1V | 1TMB - Turbine Generator EH Fluid System | 1TMB-HFPM-B Turbine gen, EH fluid pump | Pump disabled, annunciated in control room. | None - loss of 1 out of 2 100% capacity pumps Redundant pump starts automatically. | |
| INHS-MCC20B ¹ 1VBN-PNL01B1 | B21 - Nuclear Boiler Process Instr | B21-K615 Power Supply: R622 Recorder R615 Recorder | Loss of recording FW turbidity, RPV level. | None. | |
| | | N606 Alarm units | Loss of elect power alarm. | None. | |
| | | SRU2: TBIT 15 xmtr, | Loss of FW turbidity signal and comp input B21-NA007. | None. | |
| | | SRU1: N027 RPV level xmtr. | Loss of RPV level: Ind shutdown rgn. | None. Redundant indication available. | |
| | | R605 RPV level ind. | Ind shutdown rgn. | None. | |
| | | N044C RPV level xmtr. | Ind fuel zone rgn. | None. | |
| | | N044D RPV level xmtr. | Ind fuel zone rgn. | None. | |
| | | R610 RPV level ind. | Ind fuel zone rgn. | None. | |
| | | MV/I Converters K616 RPV head flange temp. | Loss of RPV temp: Indication to R643. | None. None. | |
| | | K617 RPV bottom head temp. | Indication to R643. | None. | |
| | | K618 Shell Floor Temp. | Indication to R643. | | |

(1) Worst case is assumed, i.e., loss of 1BYS-INV01B with bus loss

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|-----------------------------|---|---|--|---|------------------|
| INSTR - PNL01B1 (Cont'd) | B21 - Nuclear Boiler Process Instrument (Cont'd) | K620 bottom head Drain temp. | Indication to R643 | None. | |
| | | <u>Alarm Unit</u> | | | |
| | | N648 Loss of elect pwr | RPV temp low annunciation | None. | |
| | | N649 Loss of elect pwr | RPV temp low annunciation | | |
| | | N650 Loss of elect pwr | RPV temp low annunciation | | |
| | | N652 Loss of elect pwr | RPV temp low annunciation | | |
| | B33 - Reactor Recirc Sys Jet Pump Instr Sys | <u>Indicator</u> | | | |
| | | R008 Temp | Loss of steamline drain temp measurements downscale. | None. | |
| | | B33-K606 Power supply for SRU1,2,3,4,9 | Loss of jet pump flow xmtr signals and information. | None. Loss of jet pump flow information. Does not affect reactor operation. | |
| | | B33-R613 Recorder core D/P - flow. | Loss of jet pump flow xmtr signals and information. | None. | |
| | | B33-K608A-D -K609 JP1-20 Square root convs | Loss of jet pump flow xmtr signals and information. | None. | |
| | | B33-K610A-D Summers -K611A,B Summers -K614A,B Summers -K612 Summers -K613 Summers | Loss of jet pump flow xmtr signals and information. No controlling action affected. | None. | |
| | | Temp xmtrs - Rtd chassis Z1 B33-N601A -N601B -N601C -N601D | Loss of recirc pump suction water temp signals/indications to computer system. | None. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|--|---|---|---|---|
| 1VBN-PNL01B1 (Cont'd) | B33 - Reactor Recirculation Jet Pump Instrument System | B33-K600 Power supply for: | | | |
| | | SRU1 | Loss of recirc pump seal water press signals/ indication to recorders. | None. | |
| | | SRU2 | Loss of recirc pump diff press signals and indications to recorders. | None. | |
| | | B33-PS2B Power supply for SRU4 B21-N699B -N658B -N699E -N658E | Loss of reactor level and press signals. ATWS trips recirc pumps C001A and C001B. Level and press inds downscale. Redundant inds available. | Two recirc pump transient. | Recirc pumps B33-C001A,B tripped. Reactor power level decreases. Reactor scr ² ed. |
| | | B33-LC1B-1 Power supply - modicon logic control I/O modules #1 thru 6. | Recirc flow control valve (F060B) control lost. Remains at failure position, will not load follow. | None - HPU-B loop 1&2 inoperable. FCV inoperable, recirc loop "B" flow remains at failed rate. Lose recirc loop B flow control. | |
| | | B33-D003 HPU-B loops 1&2 servos | Lose loop 1&2 servos. Lose flux estimator indication on pnl H13-680. | None - HPU-B loop 1&2 inoperable. FCV inoperable, recirc loop "B" flow remains at failed rate. Lose recirc loop B flow control. | |
| | C33 - Feedwater (FW) Control Sys | Reactor high level trip logic "A". | Loss of trip logic power, 1 out of 2 ($\frac{1}{2}$) trip of FW pump and main turbine | None, redundant logic B available. | |
| | | Level 3 setpoint, setdown logic. | Loss of setdown logic power and setdown capabilities. | None, used during startup only. | |
| | | DS 3 level signal failure indicator. | Loss of level signal failure indication power. | None. | |

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RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|-------------------------------------|--|---|--|---|
| 1VRN-PNLO1B1 (Cont'd) | C33 - Feedwater (FW) Control Sys | F001A Flow cont valve control signal failure interlock logic 1FWSA20. | Loss of control signal failure logic power, locks FW control valve F001A. | None. | |
| | | F001B Flow cont valve. control signal failure interlock logic 1FWSB20. | Loss of control signal failure logic power, locks up FW control valve F001B. | None. | |
| | | F001C Flow cont valve Control signal failure interlock logic circuit 1FWSC20. | Loss of control signal failure logic power locks up FW cont valve F001C. | None. | |
| | | Reactor level channel availability logic circuit 1FWSN20. | Loss of channel availabil- ity logic power limits auto mode level to "A" level signal. "Level out-of- service" indicators inoperative. | None. | |
| | | K611 Power supply for: | | | |
| | | K605A Sq rt converters K605B Sq rt converters K605C Sq rt converters | Loss of power for steam flow control signals. "A", "B", and "C" indications downscale. | Steam vs FW flow mismatch runs FW flow back, decreasing reactor inventory. | Flow control valves A, B, and C lock up and maintain FW flow. De- creased recirc flow causes reactor pwr level decrease result- ing in increasing water level. Sustained increase in level results in level 8 trip. |
| | | K606B Sq rt converters | Loss of power for FW flow; signal "B" indications downscale. | Steam vs FW flow mismatch increases FW flow and reactor inventory. | |
| | | K607B Alarm unit | Annunciators for valve control signal failure. | Signal failure interlock locks up F001B FW flow control valve at failed position and flow rate. | |
| | | K626A Alarm unit K626B Alarm unit | Reactor low level trips A and B actuated. | Recirc pumps A and B transferred to LFMC set power. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|-------------------------|--|---|---|--|
| 1VBN-PNL01B1 (Cont'd) | C33 - Feedwater Control | K648A Alarm unit K648B Alarm unit K648C Alarm unit K648D Alarm unit | Low "A", "B", "C", and "D" steam line flow annunciators actuated in NH proc inst sys. | None. | |
| | | K611 Power supply for: | | | |
| | | K650-1 Alarm unit K650-2 Alarm unit | Reactor water level signal failure ann actuated | None. | |
| | | K649 Dynamic comp | Loss of FW control lag lead signal. | Would run FW to max flow if controller set for reverse; to min flow if controller set for direct. | Would run RW to max flow if controller set for reverse; to min flow if controller set for direct. |
| | | K613-1 M/A station K613-2 M/A station K613-3 M/A station | Loss of FW flow control signal to valve F001B. | Locks up valve F001B at failure flow position and rate. | Locks up valve F001B at failure flow position and rate. |
| | | SRU1 | Loss of steam flow signals A, B, and C and power for xmtrs C33-N003A,B,C. | Steam vs FW flow mismatch, runs back FW pumps and flow. Steam flow signals/inds downscale. | None, decreasing water level precluded by FW flow control valve lockup and decreasing reactor power level. |
| | | K612 Power supply for: | | | |
| | | K605A Sq rt converter K616 Summer R600-1-3 St pt station R601A-1-3 Bias M/A sta | Loss of power and signals for 3 element FW flow control. | FW flow control valves F001A,B,C lock up at signal failure position. | Reactor water level increases with decreases in reactor power level. |
| | | K607A Alarm unit | FW cont valve F001A signal failure ann actuated. | Valve F001A locks up at signal failure position. | Reactor water level increases with decreases in reactor power level. |
| | | K624A Alarm unit | High reactor water level ann actuated. | None. | |
| | | K602 1-3 setpt M/A station | Startup set pt bias inoperative. | None. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|-------------------------|---------------------------------|--|---|--|
| IVBN-PNL01B1 (Cont'd) | C33 - Feedwater Control | K612 Power supply for: | | | |
| | | SRU2 | Loss of power to and signal from: N003D STM fl xmtr N007 Press xmtr N008 Press xmtr | Loss of "D" steam line Flow signal mismatch runs back FW flow. Loss of turbine first stage press and reactor press signals to R609 recorder. | None, water level decrease precluded by FW flow control valve lockup and reactor power level decrease. |
| | | SRU4 | Loss of power to and signal from: N004A Rx lev xmtr. | Water level signal failure ann actuated. "A" reactor level causing indicator downscale. FW flow increase. | None, same as above. "A" reactor level causing indicator down- scale. FW flow increase. |
| | | | N005 Rx press xmtr. | Loss of Rx press signal to recirc. Wide range press ind downscale. | None. |
| | | | N002A FW fl xmtr. | "A" FW flow signal downscale causing FW-vs- steam flow mismatch to increase FW flow. | None, water level increase is limited by FW flow control valve lockup. |
| | | K613 power supply for: | Loss of power signals for: | | |
| | | K602 Summer | Summing FW flows | FW vs steam flow mismatch increases or decreases | None, water level control change is precluded by FW flow control valve lockup and decreasing reactor power level. |
| | | K602 Summer | Totaling FW flow | FW flow depending on FW control flow bias setting and degree of mismatch. | |
| | | K603 Summer | Totaling FW flow | | |
| | | K605D Sq rt converter | "D" steam line flow signal lost. | | |
| | | R600-1 St pt M/A sta | Loss of FW flow control signal to valve F001C. | Signal failure interlock locks up F001C valve at failed position and flow rate. | Reactor water level increases with decreases in reactor power level. |
| | | R600-2 St pt M/A sta | | | |
| | | R600-3 St pt M/A sta | | | |
| | | K653 Proportional delay unit | Loss of FW flow. Post scram setpoint adjustment. | None during reactor operation or if FW pumps shut down. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|--------------------------------------|-----------------------------|--|--|--------------------------------|
| 1VBN-PNL01B1 (Cont'd) | C33 - Feedwater Control | K607C Alarm unit | Signal failure and actuation. | Signal failure interlock locks up F001C valve at failed position. | None. |
| | | K618A Alarm unit | Low FW flow "A" trip | Recirc pumps A and B transferred to LFMG set power, recirc flow decreases. | Reactor power level decreases. |
| | | K618B Alarm unit | Low FW flow "B" trip recirc pump speed transfer actuated. | | |
| | | K613 power supply for: | | | |
| | | K635 Alarm unit | Loss of power/signals. Reactor high/low water level ann actuated. | None. | |
| | | K636 Alarm unit | Reactor high press ann actuated. | None. | |
| | | K659-3 Alarm unit | Rx water level signal failure ann actuated. | None. | |
| | | R607 Recorder ampl | Loss of FW and steam flow signals. | None - FW and steam flow inds downscale. | |
| | | R608 Rec amplifier | Loss of Rx level sig. | None - Rx level indicator downscales. | |
| | | R609 Rec amplifier | Loss of turbine flow and reactor press signals. | None - Turbine flow and Rx press signals and inds downscale. | |
| | C85 - Steam Bypass and Press Reg Sys | Power supplies: | | | |
| | | PS21 ± 22 VDC | Input/output power lost. | None - LISPS (A15) provides redundant current operation from PS11 and PS12 power supplies. | |
| | | PS22 ± 24 VDC | Input/output power lost. | | |
| | | PS1 (AR20Z102) ± 15 VDC | Input/output power lost. Startup signal for system "B" lost. | None, startup sig not used at power levels. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|---|---|--|--|---------------------|
| 1VBN-PNL01B1 (Cont'd) | C85 - Steam Bypass and Press Reg Sys | PS2 (AR20Z102) ± 15 VDC | Input/output power lost. Turb interface amps "B" and signals lost. "B" loop load demand, turb flow ref and flow demand signals lost. | None, redundant "A" power supplies provided. | |
| | | F001-1 Fast open sol valve | Lose alt power for valves only. Primary valve power not affected. | None. | |
| | | F002-1 Fast open sol valve | | | |
| | C51 - Neutron Monitoring | A25 Bus switching unit | Loss of switching for alt fast open sol valve power. Loss of power to A13 indicator panel. | None, primary power not affected. | |
| | | H13-P670 panel power supplies PS22 ± 20 VDC PS25 ± 24 VDC VR20 ± 15 VDC PS23 ± 20 VDC, ± 5 VDC AR6 Isolator | Loss of power and signals for APRM Ch B and F: 1. Indications. 2. Recorder and computer inputs. 3. Annunciators. 4. Logic circuits and relays. 5. Flow rate ref. For SRM Ch B and IRM Ch B and F: 1. Indications. 2. Recorder and computer inputs. 3. Annunciators. 4. Logic circuits and relays. 5. Isolators AR6 and AR7. | None - Inability to pro- perly monitor reactor neutron flux using APRM Ch B and F. Other chan- nels available. Channel trips not affected. None, SRM and IRM Ch B and F not used during power operation. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--------------------------|------------------------------------|---|---|---|---------------------|
| 1VBN-PNL01B1 (Cont'd) | C51 - Neutron Monitoring | H13-P672 Panel Power supplies PS22 ± 20 VDC PS25 ± 24 VDC VR20 ± 15 VDC PS23 ± 20 VDC, ± 5 VDC AR6 Isolator | Loss of power and signals for APRM Ch D and H: 1. Indications. 2. Recorder and computer inputs. 3. Annunciators. 4. Logic circuits and relays. 5. Flow rate ref. For SRM Ch D and IRM Ch D&H 1. Indications. 2. Recorder and computer inputs. 3. Annunciators 4. Logic circuits and relays. 5. Isolators AR6 and AR7. | None - Inability to pro- perly monitor reactor neutron flux using APRM Chs D&H. Other channels available. Channel trips not affected. None - SRM and IRM Chs D&H not used during power operation. | |
| | D17 - Process Radiation Monitor | Power supply PS23 ± 20 VDC ± 5 VDC located in H13-P670 power range monitor panel for: Main steam radiation monitor | Loss of output power. Loss of analog output signal: 1. Main steam line "B" rad monitor indicator downscales. 2. Div 384 high-high rad or inop annunciator actuated. 3. Main steam line "B" high rad annunciator actuated. | None - Loss of analog signal indicators and annunciators only. Iso- lation trip circuit not affected. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|-----------------------------|---------------------------------|---|--|--|---|
| 1VBN-PNL01B1 (Cont'd) | D17 - Process Radiation Monitor | PS23 ± 20 VDC ± 5 VDC located in H13-P672 power range monitor panel for main steam line "D" radiation monitor | Loss of analog output signal 1. Main steam line "D" radiation indicator downscale. 2. Div 364 high-high radiation or inop ann actuated. 3. Main steam line D high radiation ann actuated. | None - Loss of analog signal indicators and annunciators only. Isolation trip circuit not affected. | |
| GB21 (Cont'd) 1NJS-SWG2F | CWS - Circulating Water System | FN1BB Cooling tower fan FN1BD Cooling tower fan FN1BF Cooling tower fan FN1BH Cooling tower fan | Loss of fan power disables fan. Loss of fan power disables fan. Loss of fan power disables fan. Loss of fan power disables fan. | None - Four remaining cooling tower fans are able to keep circulating water temp cool, except during hottest weather when condenser vacuum may decrease. | None - Decreasing reactor power level - scram precludes turbine trip on loss of condenser vacuum. |
| 1NJS-SWG2H | | FN1DB Cooling tower fan FN1DD Cooling tower fan FN1DF Cooling tower fan FN1DH Cooling tower fan | Loss of fan power disables fan. Loss of fan power disables fan. Loss of fan power disables fan. Loss of fan power disables fan. | None - Four remaining cooling tower fans are able to keep circulating water temp cool, except during hottest weather when condenser vacuum may decrease. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--|-------------------------------|--|---|---|---|
| 1ENS*SWG1A 1EJS*SWG1A 1ENB*SWG1A ¹ 1ENB*PNL03A | B33 - Reactor Recirculation | C001A/B Recirc pumps 3A/B Circuit breaker TC-1 (RPT) | Breaker control power lost, unable to trip breaker on RPT trip. | None - Division 2 trip available. | |
| 1ENB*PNL02A | E21 - Low Pressure Core Spray | PS1/PS2 Power supplies Power to C11-N602A,C | Output power lost for: Z6 trip unit files scram discharge vol trip, level indication lost. | None - Trips valves F093A and F104A closed. Trips 1st stage turbine pressure. Initiates rod block. | |
| 1EHS*MCC8A ¹ 1VBS*PNL01A | E31 - Leak Detection | N612A thru N627A Temp and diff temp switches | Loss of RWCU area temp monitoring and temp trips. | Isolate RWCU outboard isolation valves G33-F004, F034, F039, and F054. | Isolate RWCU and RHR outboard isolation valves. Trip one of two isolation logic for MSIVs and main steam line drains. |
| | | N600A, N608A, N610A, N611A Temp and diff temp switches | Loss of RHR equipment area temp monitoring and temp trips. | Isolate RHR outboard isolation valves E12-F008, F025, F040, and F075AB. | |
| | | N604A and N605A temp and diff temp switches | Loss of main steam line pipe tunnel temp monitoring and temp trips. | Trip one of two isolation logic for MSIVs and main steam line drains. | |
| | | N602A and N603A Temp and diff temp switches | Loss of RCIC Div 1 equipment area temp monitoring. | Unable to isolate RCIC. Div 2 RCIC isolation available. | |
| | | N604E and N605E Temp and diff temp switches | Loss of RCIC Div 1 main steam tunnel temp monitoring. | Unable to isolate RCIC. Div 2 RCIC isolation available. | |
| | | Relay logic | Unable to isolate RCIC on Div 1 logic. | Isolate RWCU and RHR outboard isolation valves. Trip one of two isolation logic for MSIVs and main steam line drains. | |

(1) Loss of the lower level bus is not anticipated when the AC bus is lost. The AC bus is listed to show the primary source of power. Analysis shows what happens if the lower level bus is lost.

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RIVER BEND CONTROL SYSTEMS FAILURE ANALYSIS

| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--|------------------------------------|---|---|---|----------------------------|
| 1VBS*PNL01A (Cont'd) | E31 - Leak Detection | K600 Power supply | Loss of: | | |
| | | | RWCU diff flow monitoring | RWCU isolation | RWCU isolation |
| | | | RHR flow monitoring | Loss of RHR A flow control | Loss of RHR A flow control |
| | | | Standby liquid control tank level and pump pressure | None | |
| | | | Loss of annunciators | None | |
| | | R608, R611 Temp recorder | Loss of area temp recording | None | |
| 1BYS-SWG01A ¹ 1BYS-PNL02A1 | B33 - Reactor Recirculation | AT3 Isolators | Loss of annunciators | None | |
| | | AT13 Isolator power supply AT12 isolator | Loss of computer signals | None | |
| | | C001A Recirc pump | Breaker control power lost, unable to trip breaker on ATWS. Loss of vibration monitoring. | None, at normal power level. Alternate breakers available to trip pump. | |
| | | 5A Circuit breaker | | | |
| | | | | | |
| | | | | | |
| 1BYS-PNL02A2 | B33 - Reactor Recirculation | Pump A Breakers 3A and 4A (TC-2) indication and control | Loss of normal breaker control for Pump A. | None - alternate trips available. | |
| | D17 - Process Radiation Monitoring | Inverter K699A Offgas Post Treat Monitor K601A | Offgas post treat hi rad trip. | Close offgas charcoal bypass valves. | |
| 1BYS-PNL03A | B33 - Reactor Recirculation | LFMG Breaker 1A control, relay logic and protecting relay | None - at 100% lower unable to transfer to low speed. Loss of MG set protection. | None. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|---|---|--|---|---|---|
| 1ENS*SWG1A (Cont'd) 1EJS*SWG2A 1NHS-MCC-102A ¹ C71-P001 | C51-1080 Power Range and C51-1070 Startup Range Neutron Monitoring System | H13-P699 Div 1 Power Supplies | Loss of APRM Ch A&E. Loss of SRM Ch A. Loss of IRM Ch A&E. | Rod block. RPS half scram. Loss of APRM signal to recirc flow control. Recirc valves go full open for max recirc flow. | Rod block. RPS half scram. Recirc flow increase to max flow. Increase in reactor power. |
| | | H13-P671 Div 3 Power Supplies | Loss of APRM Ch C&C. Loss of SRM Ch C. Loss of IRM Ch C&G. | Rod block. RPS half scram. | |
| | D17-1050 - Process Radiation Monitoring | Steam Line Rad Monitor "C" (D17-K610C) | Main steam line hi rad trip of logic "C" | Trip one of two isola- tion logic for MSIVs and main steam line drains. | Trip one of two isola- tion logic for MSIVs and main steam line drains. |
| | | Stm Line Rad Monitor A (D17-K610A) | Main steam line hi rad trip of logic "A" | Trip one of two isola- tion logic for MSIVs and MSL drains. | |
| | E31-1050 - Leak Detection System | E31-N605C Temp Sw -N604C Temp Sw, M2C Meter Module, Relay Logic | Trip of temp sensor | Trip one of two isola- tion logic for MSIVs and MSL drains. | |
| 1EHS*MCC2G | B21 - Nuclear Boiler Process Instrumentation | Feedwater Inlet Shutoff Valve B21-F065A,B | Loss of valve control | None. | None. |
| 1ENS*SWG1B 1EJS*SWG1B 1BYS-SWG01 ¹ 1BYS-PNL02B1 | B33 - Reactor Recirculation | C001B Recirc pump 5B circuit breaker | Breaker control power lost unable to trip breaker on RPV low level or high pressure (ATWS). Loss of vibration monitoring. | None, alternate circuit breaker trips available to trip pump. | None. |
| 1BYS-PLN02B2 | B33 - Reactor Recirculation | Pump B Breakers 3B and 4B (TC-2) indication and control | Loss of normal breaker control for Pump B. | None, alternate trips available. | None. |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--|------------------------------------|--|---|--|--|
| 1BYS-PNL02B2 (Cont'd) | D17 - Process Radiation Monitoring | Inverter K699B offgas post treat monitor (D17-K601B). Power supply (D17-K614). | Offgas post treat hi rad trip. Loss of offgas pretreat and carbon bed vault rad monitoring. | None - Close offgas charcoal bypass valves. | |
| 1BYS-PNL03B | B33 - Reactor Recirculation | LFMG "B" relay logic and protecting relaying | Loss of transfer capability and MG set protection. | None. | |
| | | LFMG Breaker 1B control | None at 100% power unable to transfer to low speed. Loss of MG set protection. | None. | |
| 1EHS-MCC8B ¹ 1VBS-PNL01B | E31 - Leak Detection | N612B thru N627B Temp and diff temp switches | Loss of RWCU area temp monitoring and temp trips. | Isolate RWCU inboard isolation valves G33-F001, F028, F040, and F053. | Isolate RWCU and RHR inboard isolation valves. Trip one of two isolation logic for MSIVs and main steam line drains. |
| | | N600B, N608B, N610B, N611B Temp and diff temp switches | Loss of RHR equipment area temp monitoring and temp trips. | Isolate RHR inboard isolation valves E12-F009, F049, and F060AB. | |
| | | N604B and N605B Temp and diff temp switches | Loss of main steam line pipe tunnel temp monitoring and temp trips. | Trip one of two isolation logic for MSIVs and main steam line drains. | |
| | | N602A and N603A Temp and diff temp switches | Loss of RCIC Div 2 equipment area temp monitoring. | Unable to isolate RCIC. Div 1 RCIC isolation available. | |
| | | N604F and N605F Temp and diff temp switches | Loss of RCIC Div 2 main steam tunnel temp monitoring. | Unable to isolate RCIC. Div 1 RCIC isolation available. | |
| | | Relay Logic | Unable to isolate RCIC on Div 2 logic. | Isolate RWCU and RHR inboard isolation valves. Trip one of two isolation logic for MSIVs and main steam line drains. | |

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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|--|--|--|---|--|---|
| 1VBS*PNL01B (Cont'd) | E31 - Leak Detection | K600 Power supply | Loss of: | | |
| | | | RWCU diff flow monitoring. | RWCU isolation. | RWCU isolation. |
| | | | RHR flow monitoring. | Loss of RHR B flow control. | Loss of RHR B flow control. |
| | | | Loss of annunciator. | None. | |
| | | R609 Indicator switch | Loss of drywell air cooler drain flow indication. | None. | |
| 1ENB*SWG01B ¹ 1ENB*PNL03B | B21 - Nuclear Boiler Process Instrumentation | AT6, 7, and 9 isolator | Loss of annunciators. | None. | |
| | | | Feedwater inlet check valves B21-F032A,B | None. Solenoid deenergization causes negligible restriction of flow. | None. |
| | | | | | |
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| | | | | | |
| 1EJS*SWG2B 1NHS-MCC102B ¹ C71-S001B | B33 - Reactor Recirculation | C001A/B Recirc Pumps 4A/B Circuit Breaker TC-1 (RPT) | Loss of RPT breaker control power. Unable to trip pump. | None. Div 1 trip available. | |
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| | C51-1070 - Startup Range Neutron Monitoring | H13-P670 Div 2 SRM/IRM Power Supplies | Loss of SRM/IRM Ch B, IRM Ch F. | Rod block RPS half scram. | Rod block. RPS half scram. |
| | | | Loss of SRM/IRM Ch C, IRM Ch G. | Rod block RPS half scram. | Trip of one of two isolation logic for MSIVs and main steam line drain. |
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| | C51-1080 - Power Range Neutron Monitoring | H13-P670 Div 2 Power Supplies | Loss of APRM Ch B&F. Loss of Recirc Flow Ref B&F. | Rod block RPS half scram. | |
| | | | Loss of APRM Ch D&H. Loss of Recirc Flow Ref D&H. | Rod block RPS half scram. | |
| | | | | | |
| | | | | | |
| | | | | | |
| | E31-1050 - Leak Detection System | N605D, N604D, M2D, and Relay Logic | Loss of temp monitoring. Temp trips. | Trip one of two isolation logic for MSIVs and main steam line drain. | |
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| BUS | SYSTEM | COMPONENT DESCRIPTION | PRIMARY EFFECT | SECONDARY EFFECT | COMBINED EFFECTS |
|-----------------------|--|---|---|--|--|
| C71-S001B (Cont'd) | D17-1050 - Process Radiation Monitoring | Steam Line Radiation Monitor B&D (K610B and K610D) | Main steam line hi rad trip B&D. | RPS half scram. Trip one of two isolation logic for MSIVs and main steam line drain. | RPS half scram. Trip one of two isolation logic for MSIVs and main steam line drain. |
| 1EHS*MCC2H | B21 - Nuclear Boiler Process Instrumentation | Main Steam Shutoff Valves B21-F098A-D | Loss of valve control. | None. | |
| 1EHS*MCC2F | B21 - Nuclear Boiler Process Instrumentation | Main Steam Line Drain Valves B21-F085, F086 | Loss of valve control. | None. | |
| 1NNS*SWG1A | C11 - Control Rod Drive | C11-C001A CRD Drive Water Pump "A" | Unable to move rods with the rod control system. | None. | |
| | HDL - Low Pressure Feedwater Heater Drain | 1HDL-P1A, 3rd Point Heater Drain Pump Train "A" | Loss of condensate from 3rd point heater. Heater level increase opens drain valve to condenser. A further increase in level would result in closure of the incoming drain valves from the 2nd point heater and moisture separator drain receiver. | If incoming valves are closed, 3rd point heating is lost. This results in loss of feedwater heating and an increase in reactivity and power. | Loss of condensate from 3rd point heaters train A and B. Feedwater pump trip on low suction recirc transfer to LFHG. Reduction in power. |
| | | 1HDL-P1C 3rd Point Heater Drain Pump Train "B" | Loss of condensate from 3rd point heater. Heater level increase opens drain valve to condenser. A further increase in level would result in closure of incoming drain valves from the 2nd point heater and moisture separator drain receiver. | If incoming valves are closed, 3rd point heating is lost. This results in loss of feedwater heating and an increase in reactivity and power. | |
| | CCS - Turbine Plant Component Cooling Water | 1CCS-P1A Turbine Plant Component Cooling Water Pump | Loss of one of three 50% capacity pumps. | None. Standby pump starts automatically. | Loss of two of three CCS pumps. Increasing stator cooling temperature causes turbine runback. A further increase in temperature results in a turbine trip. |
| 1NNS*SWG1C | CSS - Turbine Plant Component Cooling Water | 1CCS-P1C Turbine Plant Component Cooling Water Pump | Loss of one of three 50% capacity pumps. | None. Standby pump starts automatically. | |

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|------------|--|---|--|--|--|
| 1NNS*SWG1B | C11 - Control Rod Drive | C11-C001B CRD Drive Water Pump "B" | Unable to move rods with the rod control system. | None. | |
| | HDL - Low Pressure Feedwater Heater Drain | 1HDL-P1B, 3rd Point Heater Drain Pump Train "A" | Loss of condensate from 3rd point heater. Heater level increase opens drain valve to condenser. A further increase in level would result in closure of the incoming drain valves from the 2nd point heater and moisture separator drain receiver. | If incoming valves are closed, 3rd point heating is lost. This results in loss of feedwater heating and an increase in reactivity and power. | Loss of condensate from 3rd point heaters train A and B. Feed- water pump trip on low suction recirc transfer to LFNG. Reduction in power. |
| | | 1HDL-P1D 3rd Point Heater Drain Pump Train "B" | Loss of condensate from 3rd point heater. Heater level increase opens drain valve to condenser. A further increase in level would result in closure of of incoming drain valves from the 2nd point heater and moisture separator drain receiver. | If incoming valves are closed, 3rd point heating is lost. This results in loss of feed- water heating and an increase in reactivity and power. | If incoming valves are closed, 3rd point heating is lost. This results in loss of feedwater heating and an increase in reac- tivity and power. |
| | CCS - Turbine Plant Component Cooling Water | 1CCS-P1B Turbine Plant Component Cooling Water Pump | Loss of one of three 50% capacity pumps. | None. Standby pump starts automatically. | |