WESTINGHOUSE CLASS 3

WCAP-12927

RESIDUAL HEAT REMOVAL SYSTEM AUTOCLOSURE INTERLOCK REMOVAL REPORT FOR VOGTLE ELECTRIC GENERATING PLANT UNITS 1 AND 2 GEORGIA POWER COMPANY

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ABSTRACT

A review and analysis has been performed for the Vogtle Electric Generating Plant, Units 1 and 2, which justified the removal of the autoclosure interlock associated with the Residual Heat Removal System suction/isolation valves. The methodology utilized in the analysis was based on the Westinghouse Owners Group funded generic WCAP-11736, "Residual Heat Removal System Autoclosure Interlock Removal Report for the Westinghouse Owners Group." The only change to the valve interlock and circuitry is to remove the autoclosure portion of the interlock and add a control room alarm to notify the operator of an incorrectly positioned valve. The valve open permissive circuit will not be altered. A probabilistic analysis and an overpressurization analysis were used to demonstrate that the removal of the autoclosure interlock is acceptable from both a core safety and Residual Heat Removal System overpressurization standpoint.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

WP0554:1D/082791

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

EXECUTIVE SUMMARY

This report provides a justification for the removal of the Autoclosure Interlock (ACI) on the Residual Heat Removal System (RHRS) suction/isolation valves for the Vogtle Electric Generating Plant, Units 1 and 2.

A literature review of decay heat removal problems indicated that approximately 28 percent of the recent loss of RHRS events were caused by inadvertent automatic closure of the RHRS suction/isolation valves. In an effort to reduce the frequency of these inadvertent automatic suction/isolation valve closures, several plants have taken one or more of the following steps: 1) power lockout of these valves during plant shutdown, 2) maintenance procedures that require de-energizing these valves in the open position before conducting setpoint calibration or work on the inverters, and 3) modifications to Technical Specification surveillance requirements involving verification of open suction/isolation valves when credit is taken for RHRS relief valves for cold overpressure mitigation. The literature recognizes that corrective actions are necessary to minimize the risk associated with loss of decay heat removal capability caused by actuation of the ACI, as well as highlights concerns associated with intersystem Loss-Of-Coolant Accidents (LOCA), referred to as an Event V, and RHRS relief capacity.

During the 1960s and 1970s, two closed valves in series isolated the RHRS from the Reactor Coolant System (RCS) while the RCS was at normal operating temperature and pressure. Both valves were to have power disconnected via administrative procedures, except when the valves were to be stroked. An Open Permissive Interlock was provided to one of the valves to prevent opening until the RCS pressure was below RHRS design pressure. In 1971, the Atomic Energy Commission requirements had evolved to require an ACI on increasing pressure. A meeting between the industry and the Nuclear

Regulatory Commission (NRC) in 1974 brought about three acceptable methods of preventing RHRS overpressurization while the RHRS is in operation or when returning the RCS to operation: 1) automatic closure interlocks on the RHRS suction/isolation valves, 2) sufficient capacity of the RHRS suction line relief valves to mitigate a pressure transient, or 3) a combination of the two.

This agreement was short lived and in 1975 the NRC required, in its Safety Evaluation Report for RESAR-41, that RHRS suction isolation valves be equipped with the ACI feature. The current NRC position is stated in Branch Technical Position RSB 5-1 of July 1981, which requires that the RHRS suction/isolation valves be interlocked to protect against one or both valves being open during an RCS pressure increase above the RHRS design pressure and that adequate relief capacity shall be provided during the time period while the valves are closing. In 1984, an internal NRC Instrumentation and Control Systems Branch memo recommended that action should be taken to modify the design of the RHRS interlocks. A 1985 NRC internal memo stated that a request by a plant to remove the ACI feature should be substantiated by proof that the change is a net improvement to safety and should, as a minimum, address the following:

1. The means available to minimize Event V concerns.
2. The alarms available to alert the operator of an improperly positioned valve.
3. Adequacy of the RHRS relief capacity.
4. Means other than the ACI to ensure both Motor-Operated Valves (MOVs) are closed (e.g., single switch actuating both valves).
5. Assurance that the function of the open permissive circuitry is not affected by the proposed change.
6. Assurance that MOV position indication will remain available in the control room.
7. Assessment of the affect of the proposed change on the reliability of the RHRS, as well as on Low Temperature Overpressure concerns.

This report provides, for Vogtle Unit 1 and 2, the supporting: 1) RHRS description, 2) current RHRS suction/isolation valve control circuity description, 3) proposed ACI deletion hardware changes, 4) proposed suction/isolation valve alarm circuitry addition, 5) RHRS unavailability analysis, 6) interfacing systems LOCA analysis, 7) overpressurization analysis, 8) RHRS relief valve adequacy analysis, and 9) proposed document changes.

This report references the study performed under the Westinghouse Owners Group (WOG) that justified the deletion of the RHRS ACI for four reference (or lead) plants. This study is documented in WCAP-11736, "Residual Heat Removal System Autoclosure Interlock Removal Report for the Westinghouse Owners Group." In order to perform the plant specific analyses for Vogtle, an analysis was performed that compared Vogtle to its reference plant identified in the WOG report. Once the differences were identified, the reference probabilistic analyses were modified to model Vogtle, Units 1 and 2, specifically.

CONCLUSIONS

This report recommends the deletion of the ACI of the RHRS suction/isolation valves during shutdown. The installation of a control room alarm is recommended to warn the operator that a series suction/isolation valve(s) is not fully closed when RCS pressure is above the alarm setpoint. The results of the intersystem LOCA analysis show that the frequencies of the Event V decreases with the removal of the ACI feature. The results of the RHRS unavailability analysis show that the removal of the ACI feature increases the RHRS availability. The results of the overpressurization analysis show that removal of the ACI feature has a positive impact on the consequences of low temperature overpressure events at Vogtle. The net effect of the ACI feature removal is considered to be a net improvement in plant safety.

1.0 INTRODUCTION

This section presents the objective of this report and provides the background information for the analysis supporting the deletion of the Vogtle, Units 1 and 2, Residual Heat Removal System (RHRS) suction/isolation valve Autoclosure Interlock (ACI) feature. It also presents as background, a description of the Westinghouse Owners Group (WOG) generic topical report upon which this report and the methodology used is based.

1.1 Objective

The Nuclear Regulatory Commission (NRC) and the nuclear industry has expressed interest in the acceptability of removing the ACI on the RHRS suction/isolation valves. This interest is in response to growing concerns about the loss of residual heat removal capability during cold shutdown and refueling operations due to inadvertent isolation of the RHRS caused by failure of the ACI circuitry. Isolation of the RHRS while operating has resulted in a loss of decay heat removal capability at several operating plants. In addition, inadvertent isolation prevents the RHRS from performing its function of Reactor Coolant System (RCS) cold overpressure mitigation and may result in RHRS pump damage.

A literature review of decay heat removal problems indicates that approximately 28 percent of the recent loss of RHRS events were caused by inadvertent automatic closure of the RHRS suction/isolation valves. In an effort to reduce the frequency of these inadvertent automatic suction/isolation valve closures, several plants have taken one or more of the following steps: 1) power lockout of these valves during plant shutdown, 2) maintenance procedures that require de-energizing these valves in the open position before conducting setpoint calibration or work on the inverters, and

3) modifications to Technical Specification surveillance requirements involving verification of open suction/isolation valves when credit is taken for RHRS relief valves for cold overpressure mitigation. The literature recognizes that corrective actions are necessary to minimize the risk associated with loss of decay heat removal capability caused by inadvertent actuation of the ACI, as well as highlights concerns associated with intersystem Loss-Of-Coolant Accidents (LOCA), termed an Event V in WASH-1400 (Reference 1), and RHRS relief valve capacity.

During the 1960s and 1970s, two closed valves in series isolated the RHRS from the RCS while the RCS was at normal operating temperature and pressure. Both valves were to have power disconnected via administrative procedures, except when the valves were to be stroked. An Open Permissive Interlock (OPI) was provided to one of the valves to prevent opening until the RCS pressure was below RHRS design pressure. In 1971, the Atomic Energy Commission's requirements had evolved to require an ACI on increasing pressure. A meeting between the industry and the NRC in 1974 brought about three acceptable methods of preventing RHRS overpressurization while the RHRS is in operation or when returning the RCS to operation: 1) automatic closure interlocks on the RHRS suction/isolation valves, 2) sufficient capacity of the RHRS suction line relief valves to mitigate a pressure transient, or 3) a combination of the two.

This agreement was short lived and in 1975 the NRC required in its Safety Evaluation Report for RESAR-41 (Reference 2) that RHRS suction isolation valves be equipped with the ACI feature. The current NRC position is stated in Branch Technical Position RSB 5-1 (Reference 3) of July 1981, which requires that the RHRS suction/isolation valves be interlocked to protect against one or both valves being open during an RCS pressure increase above the design pressure and that adequate relief capacity shall be provided during the time period while the valves are closing. There have been more recent discussions within the NRC on this issue. In 1984, an internal NRC

Instrumentation and Control Systems Branch memo recommended that action should be taken to modify the design of the RHRS interlocks. A 1985 NRC internal memo (Reference 4) stated that a request by a plant to remove the ACI feature should be substantiated by proof that the change is a net improvement to safety and should, as a minimum, address the following:

1. The means available to minimize Event V concerns.
2. The alarms available to alert the operator of an improperly positioned valve.
3. Adequacy of the RHRS relief capacity.
4. Means other than the ACI to ensure both Motor-Operated Relief Valves (MOVs) are closed (e.g., single switch actuating both valves).
5. Assurance that the function of the open permissive circuitry is not affected by the proposed change.
6. Assurance that MOV position indication will remain available in the control room.
7. Assessment of the affect of the proposed change on the reliability of the RHRS, as well as on Low Temperature OverPressure (LTOP) concerns.

Based on the concerns stated above, the WOG funded the evaluation of the removal of the ACI on the RHRS suction/isolation valves at the following four reference plants: Salem Unit 1, North Anna Unit 1, Callaway Unit 1, and Shearon Harris Unit 1. Other WOG plants participating in the program were categorized into one of four groups led by one of the reference plants based on similar RHRS configuration and design characteristics. It was intended that other members of the WOG could reference the applicable lead plant in the study and provide a difference analysis, should they desire to remove the RHRS ACI.

This report is written in support of deleting the Vogtle ACI feature on the RHRS suction/isolation valves based on the methodology contained in WCAP-11736, "Residual

Heat Removal System Autoclosure Interlock Removal Report For The Westinghouse Owners Group" (Reference 5). A summary description of WCAP-11736 is presented below.

1.2 WOG Program: WCAP-11736

WCAP-11736 was written with the support and funding of the WOG. It provides an evaluation of the removal of the ACI on the RHRS suction/isolation valves at four reference plants: Salem Unit 1, North Anna Unit 1, Callaway Unit 1, and Shearon Harris Unit 1. The WOG plants participating in the program were categorized into one of four groups based on similar RHRS configurations and design characteristics. The plants listed by group are:

<u>Group 1 - Salem Unit 1</u>

Salem Unit 2
D. C. Cook Units 1 & 2
Indian Point Unit 3
McGuire Units 1 & 2
Sequoyah Units 1 & 2
Watts Bar Units 1 & 2
Zion Units 1 & 2

<u>Group 2 - Callaway Unit 1</u>

Braidwood Units 1 & 2
Byron Units 1 & 2
Catawba Units 1 & 2
Comanche Peak Units 1 & 2
Trojan Unit 1
Seabrook Unit 1
Vogtle Units 1 & 2
Wolf Creek Unit 1
Millstone Unit 3
South Texas Units 1 & 2

Group 3 - North Anna Unit 1

H. B. Robinson Unit 2

Turkey Point Units 3 & 4

Beaver Valley Unit 1

Prairie Island Units 1 & 2

North Anna Unit 2

Group 4 - Shearon Harris Unit 1

Farley Units 1 & 2

Beaver Valley Unit 2

V. C. Summer Unit 1

The choice of the four particular reference plants was made based on providing the maximum number of the other WOG members with the best possible fit should they choose to delete the ACI in the future and reference this document. It is expected that, should a plant desire to delete the ACI, a plant-specific difference analysis would still be required, but the resources expended to produce and review it should be substantially less with reference to the WOG WCAP-11736.

WCAP-11736 provides, for each of the four reference plants, the supporting: 1) RHRS description, 2) current RHRS suction/isolation valve control circuity description, 3) proposed ACI deletion hardware changes, 4) proposed suction/isolation valve alarm circuitry addition, 5) RHRS unavailability probabilistic analysis, 6) interfacing systems LOCA probabilistic analysis, and 7) probabilistic overpressurization analysis.

WCAP-11736 addresses each of the seven NRC concerns expressed in the 1985 NRC internal memo for each of the four reference plants and recommends the deletion of the ACI feature for all WOG plants. The installation of a control room alarm is recommended for all plants to warn the operator that a series suction/isolation valve(s) is not fully closed when RCS pressure is above the alarm setpoint. The results of the WOG intersystem LOCA analysis show that the frequencies of the Event V decreases with the removal of the ACI feature. The results of the WOG RHRS unavailability analysis show that the removal of the ACI feature increases the RHRS availability. The results of the WOG overpressurization analysis show that removal of the ACI feature will have no effect on the heat input transients and will result in a slight increase in frequency of occurrence for some categories of the mass input transients with a decrease in others. The net effect of the ACI feature removal is considered to be a net improvement in plant safety.

The basic information presented in WCAP-11736 is applicable for use in the Vogtle, Units 1 and 2, plant-specific effort. The literature review and licensing basis remain the same for all Westinghouse plants. The probabilistic models and data base can be utilized as a basis for the Vogtle plant-specific effort. The recommended changes to the Technical Specifications are also applicable.

The Vogtle plant-specific report builds on the generic work of WCAP-11736. The Vogtle report justifies removal of the ACI based on a safety evaluation of the effect of ACI removal on LTOP, RHRS availability, and interfacing system LOCA potential. Additionally, this report proposes basic logic changes to implement the ACI removal.

1.3 Background

The primary function of the RHRS is to remove residual heat from the core and reduce the temperature of the RCS during the second phase of plant cooldown and during refueling operations. The RHRS also serves as part of the Emergency Core Cooling System (ECCS) during the injection phases of a LOCA. As a secondary function, the RHRS is used to transfer refueling water between the Refueling Water Storage Tank (RWST) and the refueling cavity before and after the refueling operations. In addition to the above functions, the RHRS suction line relief valves are used to provide mitigation of RCS cold overpressure transients.

The RHRS consists of two parallel flow paths. Each path takes a suction from a separate RCS hot leg. Each flow path contains a residual heat removal pump, a residual heat exchanger, associated piping, valves, and instrumentation required for operational control. The return lines are connected to the cold leg of each of the reactor coolant loops.

During system operation, reactor coolant flows from the RCS to the residual heat removal pump, through the tube side of a residual heat exchanger, and back to the RCS. Heat is transferred from the reactor coolant to the Component Cooling Water System (CCWS) circulating through the shell side of the residual heat exchangers.

During normal and emergency conditions, it is necessary to keep low pressure systems, which are connected to the high pressure RCS, properly isolated in order to avoid damage by overpressurization or potential for loss of integrity of the low pressure system and possible radioactive releases. The Vogtle RHRS is a low pressure system, with a design pressure of 600 psig, with an interface to the high pressure RCS, with a normal operating pressure of 2235 psia.

Two motor-operated gate valves in series in each line isolate the two RHRS suction pipes from the RCS hot legs. These motor-operated, gate valves are normally-closed except when the RHRS is in operation and function to keep the low pressure RHRS isolated from the high pressure RCS. Each of these valves is provided with a manual control switch (OPEN/CLOSE) on the Main Control Board and has two automatic interlocks associated with its control circuitry: the ACI and the OPI.

The OPI prevents inadvertent opening of the suction/isolation valves when the RCS pressure is above the design pressure of the RHRS. Each suction/isolation valve on each inlet line is interlocked with an independent RCS wide range pressure signal to provide an OPI feature to these valves. These valves are interlocked to prevent their being opened whenever the RCS pressure is greater than 365 psig.

The ACI ensures that both suction/isolation valves in each RHRS train are fully closed when the RCS is pressurized above the RHRS design pressure. Each valve is interlocked with an independent RCS wide range pressure signal to close automatically before the RCS pressure exceeds 750 psig.

A detailed description of the Vogtle Units 1 and 2 RHRS is provided in Section 2.0 of this report. Figure 2-1 presents a flow diagram of the Vogtle RHRS design.

Note, throughout this report the actual values for the Vogtle OPI (365 psig) and ACI (750 psig) setpoints will not be specified. The OPI setpoint will be referred to as the valve opening setpoint, and the ACI setpoint as the valve closing setpoint.

2.0 VOGTLE RESIDUAL HEAT REMOVAL SYSTEM DESCRIPTION

2.1 General Description

The primary function of the RHRS is to remove decay heat from the core and RCS during plant cooldown and refueling operations. The RHRS transfers heat from the RCS to the CCWS to reduce reactor coolant temperature to the cold shutdown temperature. The cold shutdown temperature is maintained until the plant is started up again.

The RHRS also serves as part of the Safety Injection System (SIS) during the injection mode to provide Low-Head-Safety-Injection emergency core cooling in the event of a break in either the RCS or steam system. As a secondary function, the RHRS is used to transfer refueling water between the RWST and the refueling cavity before and after the refueling operations.

2.2 Residual Heat Removal System

A detailed flow diagram of the RHRS is shown in Figure 2-1. The RHRS consists of two separate RHRS trains of equal capacity, each independently capable of meeting the safety analysis design bases. Each train consists of one heat exchanger, one motor-driven pump, associated piping, valves, and instrumentation necessary for operational control. The inlet line to each train of the RHRS is connected to a reactor coolant loop hot leg, while the return lines are connected to the cold legs of each of the reactor coolant loops. The connection to the cold legs is through the 10-inch accumulator injection lines.

Each RHRS suction line is normally isolated from the RCS by two motor-operated gate valves in series, while the discharge lines are isolated by series check valves in each

RHRS injection path. The RHRS suction/isolation valves, the inlet line pressure relief valve, and the discharge lines downstream of valves HV-8809A/B and HV-8840 are located inside containment, while the remainder of the system is located outside containment.

During normal RHRS operations, reactor coolant flows from the RCS hot legs 1 and 4 to the RHRS pumps, through the tube side of the RHRS heat exchangers, and back to the RCS through the SIS cold leg injection lines. The reactor coolant heat is transferred by the RHRS heat exchangers to the component cooling water that circulates through the shell side of the RHRS heat exchangers.

Coincident with RHRS normal operations, a portion of the reactor coolant flow may be diverted from downstream of the RHRS heat exchangers to the Chemical and Volume Control System (CVCS) low-pressure letdown line for cleanup, and/or pressure control. By regulating the diverted flowrate and the charging flow, the RCS pressure can be controlled during water-solid plant operations. Pressure regulation is necessary to maintain the pressure range dictated by the reactor vessel fracture prevention criteria requirements and by the Reactor Coolant Pump (RCP) No. 1 seal differential pressure and net pump suction head requirements of the RCPs.

The RCS cooldown rate is manually controlled by regulating the reactor coolant flow through the tube side of the RHRS heat exchangers. Instrumentation is provided to monitor system pressure, temperature, and total flow.

System Operation

A discussion of RHRS operation during various reactor operating modes follows:

Reactor Startup

Generally, during cold shutdown, the RHRS operates to remove residual heat from the reactor core. The number of pumps and heat exchangers in service depends on the RHRS heat load at the time.

At initiation of plant startup, the RCS is completely filled, and the pressurizer heaters are energized. At least one RHRS pump is operating with a portion of its discharge directed to the CVCS for purification and/or pressure control via a line that is connected to a cross-connect header downstream of the RHRS heat exchanger. Once a steam bubble is formed in the pressurizer, the RHRS is isolated, and RCS pressure/inventory control are provided by the pressurizer spray, pressurizer heaters, and the normal letdown and charging systems.

Power Generation and Hot Standby Operation

The RHRS is not used during hot standby or power operations when the RCS is at normal pressure and temperature. Under these conditions, the RHRS is aligned for operation as part of the ECCS. Upon initiation of a safety injection signal ("S" signal), the RHRS pumps, taking suction from the RWST, inject borated water into the reactor vessel via the accumulator cold leg injection headers. When the water in the RWST is depleted, the RHRS pumps are aligned to take suction from the containment sump. The sump fluid, which is recirculated by the RHRS pumps, is cooled by the RHRS heat exchangers and delivered to the reactor vessel cold legs. Since the charging pumps and the safety injection pumps do not take suction from the containment sump, the RHRS pumps (low head safety injection) also supply the suction of these pumps during recirculation. Hot leg recirculation is initiated approximately 11 hours after the accident and ECCS initiation. The flow path for hot leg recirculation consists of both RHRS pumps taking suction from the containment sump, discharging through the discharge cross connect valves and common discharge valve to the RCS hot legs 1 and 4.

Reactor Shutdown

With the RCS borated to the cold shutdown concentration, the initial phase of reactor cooldown is accomplished by transferring heat from the RCS to the steam generators and Steam Dump System. When the reactor coolant temperature and pressure are reduced to approximately 350°F and less than 365 psig, the second phase of cooldown starts with the RHRS being placed in operation.

The reactor cooldown rate is limited by RCS equipment cooling rates based on allowable stress limits, as well as the operating temperature limits of the CCWS. As the reactor coolant temperature decreases, the reactor coolant flow through the RHRS heat exchangers is increased to maintain a constant cooldown rate.

As cooldown continues, the pressurizer is filled with water, and the RCS is operated in a water-solid condition. At this stage, pressure is controlled by regulating the charging flow rate and the letdown rate to the CVCS from the RHRS. After the RCS is depressurized, cooled to less than or equal to 140°F, and purged to reduce dissolved hydrogen concentration to a safe level, the reactor vessel head may be removed for refueling or maintenance.

Refueling

During refueling, the RHRS pumps transfer borated water from the RWST to the refueling cavity. During this operation, the isolation valves in the inlet line of the RHRS are closed, and the isolation valves from the RWST are opened. After the water level in the refueling cavity reaches normal refueling level, the inlet isolation valves are opened, the RWST supply valves are closed, and normal RHRS operation resumes.

During refueling, the RHRS remains in service with the number of pumps and heat exchangers in operation as required by the heat load and the Technical Specifications. Additionally, a portion of the RHRS flow is directed to the CVCS for purification and eventual return to the RCS via the charging system.

Following refueling, the RHRS pumps drain the refueling cavity to the top of the reactor vessel flange by pumping water from the RCS to the RWST.

Component Description

This section describes the major components of the RHRS as shown in Figure 2-1.

RHRS Pumps

Two pumps are installed in the RHRS. Each pump is sized to deliver sufficient reactor coolant flow through the RHRS heat exchangers to meet the plant cooldown requirements. The use of two pumps ensures that cooling capacity is only partially lost should one pump become inoperable.

The RHRS pumps are protected from deadheading by miniflow bypass lines, located on the heat exchanger outlet, which divert part of the flow back to the suction of the pump. A control valve located in each miniflow line is regulated by a signal from the flow switch located in each pump discharge header. The control valves open to divert flow back to the pump suction when the discharge flow is less than approximately 751 gpm and close when it exceeds approximately 1405 gpm. This arrangement ensures that the

RHRS pump does not overheat or cavitate when the discharge line is closed or when the RCS pressure exceeds the pump shutoff head during the ECCS injection phase. A pressure transmitter in each pump discharge header provides pressure indication with a high pressure alarm in the Main Control Room.

The RHRS pumps are vertical, centrifugal units with mechanical shaft seals. All pump surfaces in contact with reactor coolant are austenitic stainless steel or equivalent corrosion resistant material.

RHRS Heat Exchangers

Two residual heat exchangers are installed in the RHRS. The heat exchanger design is based on heat load and temperature differences between reactor coolant and component cooling water existing 20 hours after reactor shutdown when the temperature difference between the two systems is small. The installation of two heat exchangers ensures that the heat removal capacity of the system is only partially lost if one heat exchanger becomes inoperative.

The heat exchangers are of the shell and U-tube type. Reactor coolant circulates through the tubes, while component cooling water circulates through the shell. The tubes are welded to the tubesheet to prevent leakage of reactor coolant.

RHRS Valves

Two motor-operated gate valves are provided in each inlet line from the RCS. These valves are normally closed, except when the RHRS is in operation. Each of these valves is provided with a manual control (open/closed) on the Main Control Board and will fail in the "as-is" position.

Valves HV-8701A, 8702A, 8701B, and 8702B are currently interlocked with the wide range RCS pressure transmitters PT-438, 418, 408, and 428, respectively. Note, a cross reference key for Westinghouse and Bechtel valve identification is provided in Table 2-1. These transmitters are connected to the sensing of lines the Reactor Vessel Level Indication System outside containment. Each transmitter has a physically and electrically independent power supply to ensure that a single failure does not disable both residual heat removal loops. These interlocks prevent inadvertent opening of the valves when the RCS pressure is above 365 psig (Reference 6). The ACI will cause both valves to close automatically when the RCS pressure is higher than 750 psig. If the RCS has been depressurized to below 365 psig and the valves are open, the ACI will close the valves automatically if the pressure increases above approximately 750 psig.

Interlocks are also provided to prevent opening valves HV-8701A(B) and HV-8702A(B) if any of the following valves are open:

HV-8804A(B) - Valves in recirculation lines from RHRS heat exchanger to charging pump and safety injection pump suctions.

HV-8811A(B) - Containment sump line isolation valves.

HV-8812A(B) - Isolation valves in RHRS pump suction lines from the RWST.

These interlocks are arranged by trains to assure functional separation of the two trains in the RHRS. Accordingly, interlocks are provided between the train A valves, and separately between the train B valves.

Heat Exchanger Flow Control Valves HCV-606 and HCV-607

The reactor coolant flow rate through the RHRS heat exchangers is adjusted by air-operated, butterfly valves HCV-606 and HCV-607. Positioning of these valves from the control room regulates the reactor coolant flow exiting the heat exchangers. These valves are normally full open during power operation.

Bypass Flow Control Valves FCV-618 and FCV-619

Each RHRS heat exchanger is provided with a bypass line containing an air-operated butterfly valve that may be positioned automatically from flow instrument FICA-618 and FICA-619 or manually from the Main Control Room. As valves HCV-606 and HCV-607 are manually adjusted to adjust the heat exchanger tubeside flow and control the cooldown rate, these bypass valves will be automatically modulated by flow controllers FICA-618 and FICA-619 to maintain a constant loop return flow to the RCS. The valves can be manually positioned directly by placing them under manual control at the control board manual/auto station. During power operation when the RHRS is aligned for safety injection, these valves should be in the manual control mode and fully closed.

Miniflow Stop Valves FCV-610 and FCV-611

These normally opened valves are motor-operated gate valves that are located in the RHRS pump miniflow lines. The valves are controlled by flow switches FIS-610 and FIS-611, respectively, which are located in the discharge lines of the RHRS pumps. These valves open when their respective pump is operating and the flow is less than approximately 751 gpm. When the pump flow exceeds approximately 1405 gpm or the RHRS pump stops, the corresponding valve will close.

Crosstie Valves 8716A and 8716B

These motor-operated gate valves, located in the piping crosstie downstream of the RHRS exchangers, must be normally open during normal plant operation when the RHRS is aligned for safety injection. During residual heat removal operation, the valves must be closed to prevent possible control interaction between the two independent trains of residual heat removal. These valves are controlled from the Main Control Board and fail "as is." These valves are used to align the RHRS for the recirculation phases following a LOCA.

Cold Leg Injection Line Check Valves 8818A,B,C,D and 8948A,B,C,D

There are two check valves in each branch of the cold leg injection line to prevent backflow from the RCS.

Gate Valve HV-8809A and HV-8809B

There is a normally-open, motor-operated gate valve in each parallel discharge line from the RHRS pump, downstream of the heat exchanger and discharge crosstie header. These valves are used to isolate the RHRS from the cold legs during hot leg recirculation or during refueling operation when returning water to the RWST.

Crosstie Valves 8734A and 8734B

These two normally-closed, manual valves are used to line up a portion of the RHRS pump discharge to be directed to the CVCS. Throttle valve HCV-128 is used to control this flow. This flow path is used during a plant cooldown and during water solid plant operations when the CVCS is used for RCS pressure control and purification.

Gate Valve HV-8840

During hot leg recirculation the RHRS pumps are aligned to deliver flow through cross-connect valves HV-8716A and HV-8716B, and common discharge valve HV-8840. This realignment is initiated at approximately 11 hours after accident initiation. Hot leg recirculation prevents crystallization of boric acid in the core and quenches the steam bubble in the top of the core.

RWST Isolation Valves 8958A/B and 8812A/B

Check valves 8958A/B and motor-operated gate valves HV-8812A/B isolate the RWST from the suction of each RHRS pump. Gate valves HV-8812A/B are interlocked with the RHRS suction isolation valves HV-8701A/B and HV-8702A/B.

Sump Isolation Valves HV-8811A/B and HV-8820A/B

Check valves HV-8820A/B and motor-operated gate valve HV-8811A/B isolate the RHRS from the containment sump. There is one motor-operated normally closed gate valve (HV-8811A or B) in each line leading from the containment sump to the suction of each RHRS pump. Valves HV-8811A and HV-8811B are interlocked to open automatically, when an "S" signal exists, on a 2/4 "LO" signal from RWST level instrumentation. Interlocks ensure that valves HV-8811A or B cannot be opened remotely from their control board switches unless the associated RWST suction valve HV-8812A/B and their respective residual heat removal loop suction isolation valves HV-8701A/B and HV-8702A/B are closed. A check valve (HV-8820A or B) is located in series with HV-8811A and HV-8811B, also prevents refueling water from flowing backward into the sump.

RHRS to Charging and Safety Injection Pump Suction Isolation Valves HV-8804A/B and 8969A/B

There is one normally closed, motor-operated gate valve (HV-8804A) in the line leading from the discharge side of the RHRS heat exchanger No. 1 to the suction side of the centrifugal charging pumps. The valve is normally closed for cold leg injection, opened by operator action for cold leg recirculation and remains open for hot leg recirculation. Check valve 8969A is located in series with gate valve HV-8804A.

There is one normally closed, motor-operated gate valve (HV-8804B) in the line leading from the discharge side of the RHRS heat exchanger No. 2 to the suction side of the safety injection pumps. This valve is normally closed for cold leg injection, opened by operator action for cold leg recirculation and remains open for hot leg recirculation. Check valve 8969B is located in series with gate valve HV-8804B.

Valves HV-8804A and B are interlocked such that they cannot be opened unless the safety injection pump miniflow valves (8813 or 8920 and 8814) are closed, the alternate charging pump miniflow isolation valves (8508A or 8509B and 8508B or 8509A) are closed, the associated residual heat removal loop suction isolation valves (HV-8701A/B or HV-8702A/B) are closed, and the associated sump valve HV-8811A or B is open.

RHRS Discharge Relief Valves 8856A/B and 8842

A 3/4-inch relief valve is located in each RHRS cold leg and hot leg discharge header. These valves protect against overpressurization of the piping due to any RCS backleakage or thermal expansion of trapped water. The design capacity of these valves is 20 gpm at the setpressure of 600 psig.

Inlet Relief Valves 8708A and 8708B

There is one, 3-inch relief valve (inside containment) in each RHRS suction line from the RCS hot leg. These relief valves prevent RHRS overpressurization and provide cold overpressurization protection by discharging to the Pressurizer Relief Tank (PRT) when pressures within the RHRS suction line exceed 450 psig. These valves have a design capacity of 900 gpm at the 450 psig setpressure.

2.3 Current RHRS Suction Isolation Valve Interlocks and Functional Requirements

The following sections provide a description of the Vogtle suction/isolation valve interlocks and valve control circuits.

2.3.1 Current Interlock

There are two normally closed, motor-operated gate valves in series in each of the two RHRS pump suction lines from the RCS hot legs. The two valves inside the missile barrier (HV-8701B, HV-8702B) are designated as the inner isolation valves, while the two valves outside of the missile barrier (HV-8701A, HV-8702A) are designated as the outer isolation valves. The interlock features provided for the inner isolation valves are identical to those provided for the outer isolation valves.

Each valve is interlocked against opening unless the following conditions are met:

a. The RCS pressure as measured by appropriate pressure channels is less than 365 psig. This assures that the RHRS cannot be overpressurized when aligning it to the RCS and the maximum RCS pressure plus the RHRS pump head will not exceed the RHRS pump discharge design pressure.

b. The corresponding RHRS pump/RWST suction isolation valve is closed. This assures positive isolation of the RWST and RHRS/RWST suction piping before initiating a normal cooldown.

c. The corresponding isolation valve in the recirculation lines to the charging/safety injection pumps is closed. This assures the suction of the safety injection and/or charging pumps cannot be overpressurized by normal cooldown flow via an open recirculation line isolation valve.

d. The corresponding containment sump isolation valve is closed. This assures normal cooldown flow cannot be misdirected to the containment sump via an open sump isolation valve.

Each valve is also currently interlocked to automatically close on increasing RCS pressure greater than 750 psig. This assures that both valves will be closed during a plant startup prior to reaching operating conditions, should one valve have been inadvertently left open by operator omission.

The RCS pressure interlock for both the prevent open and the autoclosure feature on the inner isolation valves is independent and diverse from that provided to the outer isolation valves. This is specifically required to meet NRC criteria applicable to the RHRS design.

Local operation is possible when the REMOTE/LOCAL permissive operation switch at the Local Control Board is in the Local position. Simultaneous operation from both the Main Control Board and the Local Control Board is not possible. An alarm is actuated whenever the REMOTE/LOCAL permissive operation switch is in the Local position.

When operation is from the Local Control Board, manual control is the only capability that exists and this manual control is not restricted by any interlocks.

2.3.2 RHRS Suction/Isolation Valve Description

Description

The RHRS Inlet Isolation Valves are motor-operated gate valves that can be opened or closed from the Main Control Board or the local shutdown panel. The valves will automatically close on increasing RCS pressure (ACI). On decreasing RCS pressure, below the valve opening setpoint, the valve control circuit receives an interlock signal that allows the valve to be opened using the Main Control Board switch (OPI). On RCS pressure above the setpoint, the valve control circuit is disabled and the valve cannot be opened.

The valve control circuit consists of control switches, limit switches, torque switches, contactors, relays, indicating lights, fuses, a 3 phase, 480 VAC motor, and a pressure control loop. Control switches are located in the Main Control Room and at the local shutdown panel. The limit switches are located in the valve motor operator and provide indication of the position of the valve. Relays are used for providing control signals. The two contactors (starters), located in the motor control center, are switched on and off to provide the open and close power to the valve. The contactors also provide contacts that are used in the valve control circuit. There are red and green indicating lights on the Main Control Board and the local shutdown panel to show the position of the valve. The valve motor operator is located at the valve and is used to change the position of the valve. The pressure control loop measures RCS pressure and provides output signals to the valve control circuit based on the system pressure.

The following provides a detailed description of the valve control circuits for HV-8701A (see Figure 2-5). The valve control circuits for valves HV-8701B, HV-8702A, and HV-8702B are similar (see Figures 2-6, 2-7, and 2-8, respectively).

<u>Closing the Valve from the Main Control Room</u>

With the valve in the full open position, the valve can be closed from the control switch in the Main Control Room, as described in the following steps:

1. Placing the control board switch to the CLOSE position will energize the closing contactor coil (42(C)). The control board switch closing contacts are in series with the following contacts:

   - Limit switch contact 33ao/1, which is closed when the valve is open;
   - A torque switch contact (33tc/17) in parallel with limit switch contact 33ao/1; and
   - Contact 42b/(O), which is closed when the opening contactor coil (42(O)), is not energized.

2. With all the contacts in step 1 closed, the Main Control Board switch placed in the CLOSE position will energize the contactor closing coil 42(C) with 120 VAC power from the 480/120 VAC control power step down transformer. The closing contactor contacts 42(C) in the motor circuit close and supply 480 VAC to the valve motor operator and the valve begins to close. The closing contactor simultaneously opens another contact (42b/(C)) in the opening control circuit which prevents the opening contactor relay from picking up while the valve is closing (i.e., the opening control circuit is interlocked with the closing control circuit to prevent both contactor relays from being energized at the same time). An additional closing contactor contact

(42a/(C)) seals-in the closing circuit so that the Main Control Board switch can be released and the valve will continue to close.

As the valve begins to close, the limit switch contact 33bo/3 closes, turning on the green indicating light on the Main Control Board. The red indicating light is controlled by limit switch contact 33ac/15, and is on when the valve is open or during travel (i.e., both the red and green lights are on during travel).

3. Limit switch contacts 33ao/1 open as the valve begins to close, leaving only the parallel torque switch contact (33tc/17) to complete the circuit. The valve continues to close until the valve torque switch contact 33tc/17 opens indicating the valve is fully closed. When the limit switch contact opens, the contactor coil de-energizes and the motor contacts 42(C) open, which in turn de-energize the valve motor. The (42a/(C)) seal-in contacts open, resetting the closing seal-in circuit. The 42b/(C) contact in the opening control circuit closes to allow the valve opening control circuit to be actuated.

   When the valve is fully closed, limit switch contact 33ac/15 opens, which turns off the red indicating light on the Main Control Board, leaving the green indicating light on the Main Control Board to show that the valve is closed through limit switch contact 33bo/3.

Opening the Valve from the Main Control Room

With the valve in the closed position as described above, the valve can be opened from the control switch in the Main Control Room as follows:

1. The opening of the RHRS valve is restricted by the RCS pressure. If the RCS pressure is below the valve opening permissive setpoint, the valve can be opened using the Main Control Board switch as described in steps 2 through 4 below. If the RCS pressure is above the valve opening setpoint, the valve cannot be opened. When the RCS pressure is above the opening setpoint, interlock contact K734 in the valve opening circuit is open. When contact K734 is open, the valve opening contactor circuit cannot be energized and the valve cannot be opened. If the RCS pressure is below the setpoint, the valve will operate as discussed below.

2. If the RCS pressure is below the valve opening setpoint, contact K734 will be closed in the valve opening contactor circuit. Operating the Main Control Board switch to OPEN the valve, will energize the opening contactor relay coil 42(O), provided the contacts listed below are closed. In addition, the control board switch OPEN contacts are in series with the following contacts:

   - RCS pressure interlock contact, K734;
   - Two valve limit switch contacts, 33bo/4 and 33bc/5, which are closed when the valve is closed;
   - A torque switch contact, 33to/18, in parallel with limit switch contact 33bc/5;
   - RWST to RHRS Pump Isolation Valve HV-8812A limit switch contact, 33bc/6, which is closed when the valve is fully closed;
   - Containment Sump to RHRS Pump Isolation Valve HV-8811A limit switch contact, 33bc/13, which is closed when the valve is fully closed; and

- Contact K752, which closes when valve HV-8804A RHRS pumps to Charging Pump Isolation Valve, is fully closed.

3. With all the contacts in Step 2 closed, the opening contactor relay coil (42(O)) is energized with 120 VAC from the control power step down transformer. The opening contactor motor contacts (42(O)) close and supply 480 VAC to the valve motor operator and the valve begins to open. The 42(O) motor contacts connect the three phase power phases such that the motor rotation direction is reversed from the closing direction. The opening contactor simultaneously opens another contact (42b/(O)) in the closing contactor circuit which prevents the closing contactor from picking up while the valve is opening (i.e., the closing contactor is interlocked with the opening contactor to prevent both contactors from being energized at the same time). An additional opening contactor contact (42a/(O)) that is in parallel with the opening Main Control Board switch OPEN contact closes, which seals-in the opening contactor circuit so that the control switch can be released and the valve will continue to open.

   As the valve begins to open, limit switch contact 33bc/5 opens leaving the parallel torque switch contact 33to/5 to complete the circuit. Also, as the valve begins to open, limit switch contact 33ac/15 closes, turning on the red indicating light on the Main Control Board. The green indicating light is controlled by limit switch contact 33bo/3 and is on when the valve is closed or during travel.

4. The valve continues to open until the valve limit switch contact 33bo/4 opens indicating the valve is fully open. When the limit switch opens, the opening contactor relay coil de-energizes and the 42(O) motor contacts open, de-energizing the valve motor. The 42a/(O) seal-in contacts open resetting the opening seal-in circuit. The 42c/(0) closing interlock contact closes, allowing the valve to be closed.

Also, when the valve is fully open, limit switch contact (33bo/3) opens and the green indicating light on the Main Control Board is turned off. The red indicating light on the Main Control Board remains on to indicate that the valve is open through limit switch contact 33ac/15.

During the time the valve is opening, the valve and the valve opening control circuit are protected from an over-torque condition by the torque switch contact 33to/18, which is in series with the seal-in contact 42a/(O).

Automatic Closing of the RHRS Valve

When the RCS pressure is below the valve opening setpoint the valve can be opened or closed from the control switch in the Main Control Room, as described above. When the valve is open, an increasing RCS pressure will automatically close the valve and prevent it from opening, as described below:

An increasing RCS pressure above the valve closing setpoint will close contact K735 in the valve closing contactor circuit. If the valve is open, limit switch contact 33ao/8 and torque switch contact 33tc/17, which are in series with contact K735, will be closed. When contact K735 closes, the valve automatically begins to close. Contact K735, which is in parallel with the seal-in contact (42a/(C)) energizes the valve control circuit in the same manner as described above in the "Closing the Valve From the Main Control Room." The valve will continue to close until the valve is fully closed as described in the referenced section above. When the valve is fully closed, limit switch contact 33ac/8 and torque switch contact 33ta/17 will open preventing the re-actuation of the closing contactor from contact K735 (which will still be closed due to high pressure above the valve closing setpoint). After the valve is fully closed, it cannot be opened because the opening circuit is locked out by pressure greater than the valve opening setpoint, as described above in the "Opening the Valve from the Main Control Room" section.

Process Control Circuitry

Four pressure control channels (PT-408, -418, -428 and -438) provide the control signals to the four RHRS Inlet Isolation Valves (see Figure 2-3 and 2-4). The pressure control channel alignment with the series valves is such that one pressure channel controls only one isolation valve. Therefore, a failure in one pressure channel only results in the failure of a single isolation valve. The following control channel description addresses only the PT-408 loop; the other pressure loops are similar.

The RCS Hot Leg Pressure Channel, PT-408 is used to provide interlock signals for RHRS Inlet Isolation Valve HV-8701B. The pressure signal is used to control two auxiliary relays (K734 for Open Permissive and K735 for Auto Close).

RCS Pressure Control Loops

The PT-408 RCS pressure control loop (Figure 2-4) consists of a pressure transmitter, a channel test card, a loop power supply/current to voltage transformer, a dual circuit signal comparator, a comparator trip switch, two Solid State Protection System (SSPS) relays (K1301 and K1302), which are powered from logic cabinet train C.

The pressure transmitter measures the RCS pressure and provides a current output signal that is proportional to the measured pressure. The loop power supply converts the 4 to 20 mA current signal from the pressure transmitter to a 0 to 10 V proportional voltage signal. The output of the loop power supply is input to the dual comparator.

The dual comparator compares the pressure signal (input voltage) to each of two given setpoints. The two comparator outputs are 0 Vdc or 24 Vdc depending on the signal to setpoint comparison. The comparator outputs control the SSPS relays K1301 and K1302. When the pressure is below the valve opening setpoint, the output of the dual comparator energizes the SSPS relay K1301 and provides a contact permissive to allow opening of valve HV-8701B. When the pressure is above the valve closing setpoint, the output of the dual comparator energizes the SSPS relay K1302 and provides a contact interlock to close valve HV-8701B.

The channel test switch, various test points and jacks and the comparator trip switch are used during maintenance and calibration of the instrument loop.

Control Loop Summary

The following is a description of the RHRS valve closing comparator circuit. Whenever the RCS pressure measured by the pressure loop exceeds the valve closing setpoint, the dual comparator output circuit will close the K1302 relay contact in the valve HV-8701B closing circuit causing the valve to automatically close as discussed above. Whenever the RCS pressure is below the valve closing setpoint, the dual comparator output circuit will open the contacts in the HV-8701B closing circuit allowing it to remain open.

The following is a description of the RHRS valve opening comparator circuit. Whenever the RCS pressure exceeds the valve opening setpoint, the dual comparator output circuit will open the contacts in the valve HV-8701B opening circuit and prevent the valve from being opened as discussed above. Whenever the RCS pressure is below the setpoint, the dual comparator output circuit will close the contacts in the valve opening circuit and permit valve HV-8701B to be opened from the Main Control Board control switch.

2.4 Reference Plant Differences

As discussed in the introduction of this report, the basic information presented in WCAP-11736 is applicable for use in this plant specific effort. However, the aspects that require further review are the differences between Vogtle, Units 1 and 2, and the reference plant for their category. Based on the recommendation of WCAP-11736, the applicable reference plant for the Vogtle Units is the Callaway Unit 1 Plant.

Table 2-2 shows a summary of general characteristics for Vogtle and Callaway.

In order to perform the difference analysis between Vogtle and the reference plant, the following documents were examined:

- Control wiring diagrams for the RHRS suction/isolation valves
- Suction/isolation valve logic diagrams
- RHRS configuration drawings
- Operating Procedures
- Technical Specifications
- FSAR
- RHRS Design Basis Document

Once the differences were identified, those differences that impact the Callaway "reference" probabilistic analyses were re-modeled such that the analyses would represent the Vogtle, Units 1 and 2, specifically.

The following is the plant difference, which required the reference models to be modified:

1. The Vogtle operating procedures include the defeat of the ACI by disconnecting the leads from the ACI circuitry to the valves circuitry per Procedure 54840, "RCA Draindown Modifications: RCS Sightglass, Tygon Tube, and Defeat of RHRS Suction Valve Auto Closure Interlock." The Callaway operating procedures do not include this action. This difference only affects the interfacing system LOCA analysis.

2. The Vogtle ACI logic has an independent pressure transmitter for each valve, for a total of 4 pressure transmitters, such that no single failure will isolate both trains of the RHRS. The Callaway ACI logic has one pressure transmitter shared between two valves, for a total of 2 pressure transmitters. This difference affects all of the analyses.

For details on how the probabilistic analyses were modified, based on the above discussion, refer to Section 4.0 of this report.

TABLE 2-1

Vogtle Units 1 and 2

Westinghouse/Bechtel Valve Identification

Cross Reference

Westinghouse Valve Identification	Bechtel Valve Identification
8708A	1205-PSV8708A
8708B	1205-PSV8708B
8724A	1205-019
8724B	1205-020
8730A	1205-009
8730B	1205-010
8734A	1205-021
8734B	1205-022
8735	1205-027
8818A	1204-147
8818B	1204-148
8818C	1204-149
8818D	1204-150
8819A	1204-143
8819B	1204-144
8819C	1204-145
8819D	1204-146
8820A	1204-122
8820B	1204-123
8842	1204-HV8842
8856A	1205-PSV8856A
8856B	1205-PSV8856B
8922A	1204-139
8922B	1204-140
8922C	1204-141
8922D	1204-142
8948A	1204-083
8948B	1204-084
8948C	1204-085
8948D	1204-086
8958A	1205-001
8958B	1205-002

TABLE 2-1

Vogtle Units 1 and 2

Westinghouse/Bechtel Valve Identification

Cross Reference

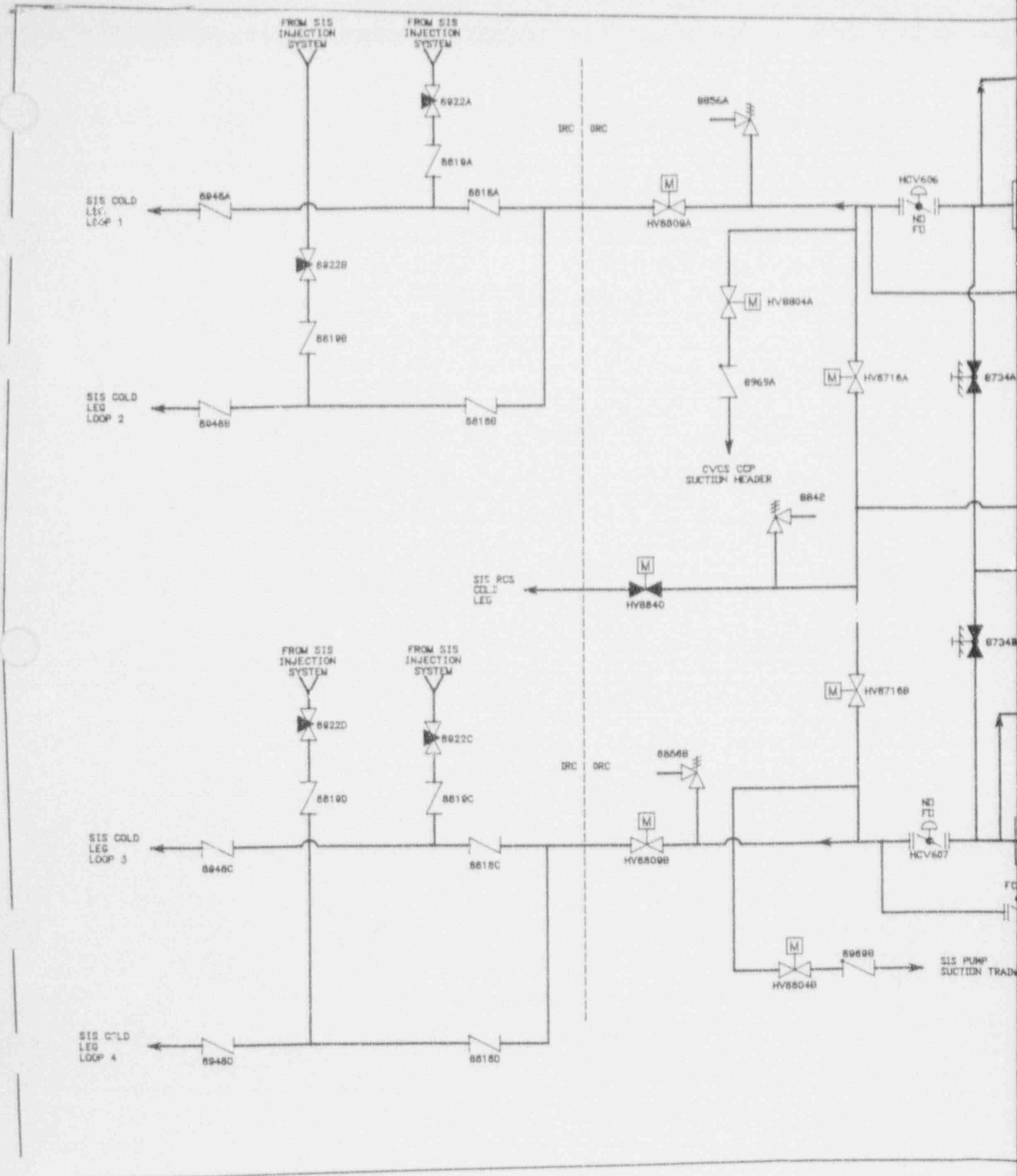
(Continued)

Westinghouse Valve Identification	Bechtel Valve Identification
8969A	1208-436
8969B	1204-163
FCV610	1205-FV610
FCV611	1205-FV611
FCV618	1205-FV618
FCV619	1205-FV619
HCV606	1205-HV606
HCV607	1205-HV607
HV8701A	1201-HV8701A
HV8701B	1201-HV8701B
HV8702A	1201-HV8702A
HV8702B	1201-HV8702B
HV8716A	1205-HV8716A
HV8716B	1205-HV8716B
HV8804A	1205-HV8804A
HV8804B	1205-HV8804B
HV8809A	1204-HV8809A
HV8809B	1204-HV8809B
HV8811A	1205-HV8811A
HV8811B	1205-HV8811B
HV8812A	1205-HV8812A
HV8812B	1205-HV8812B
HV8840	1204-HV8840
NO W TAG #	1205-226

TABLE 2-2

REFERENCE PLANT COMPARISON

Parameter	Vogtle Units 1 and 2	Callaway Unit 1
No. Loops	4	4
No. RHRS Drop Lines	2 (HL Loop 1&4)	2 (HL Loop 1&3)
RHRS Operation Parameters	400 psig, 350°F	425 psig, 350°F
RHRS Isolation Valves	2 MOVS	2 MOVS
Prevent Open Setpoint	365 psig	360 psig
Autoclosure Setpoint	750 psig	682 psig
Relief Valve Design Setpoint	450 psig	450 psig
Relief Valve Design Flowrate	900 gpm	900 gpm
COPS Design Criteria	RHRS Relief Valves	RHRS Relief Valves



?EC-0534
6-27-91
DDG

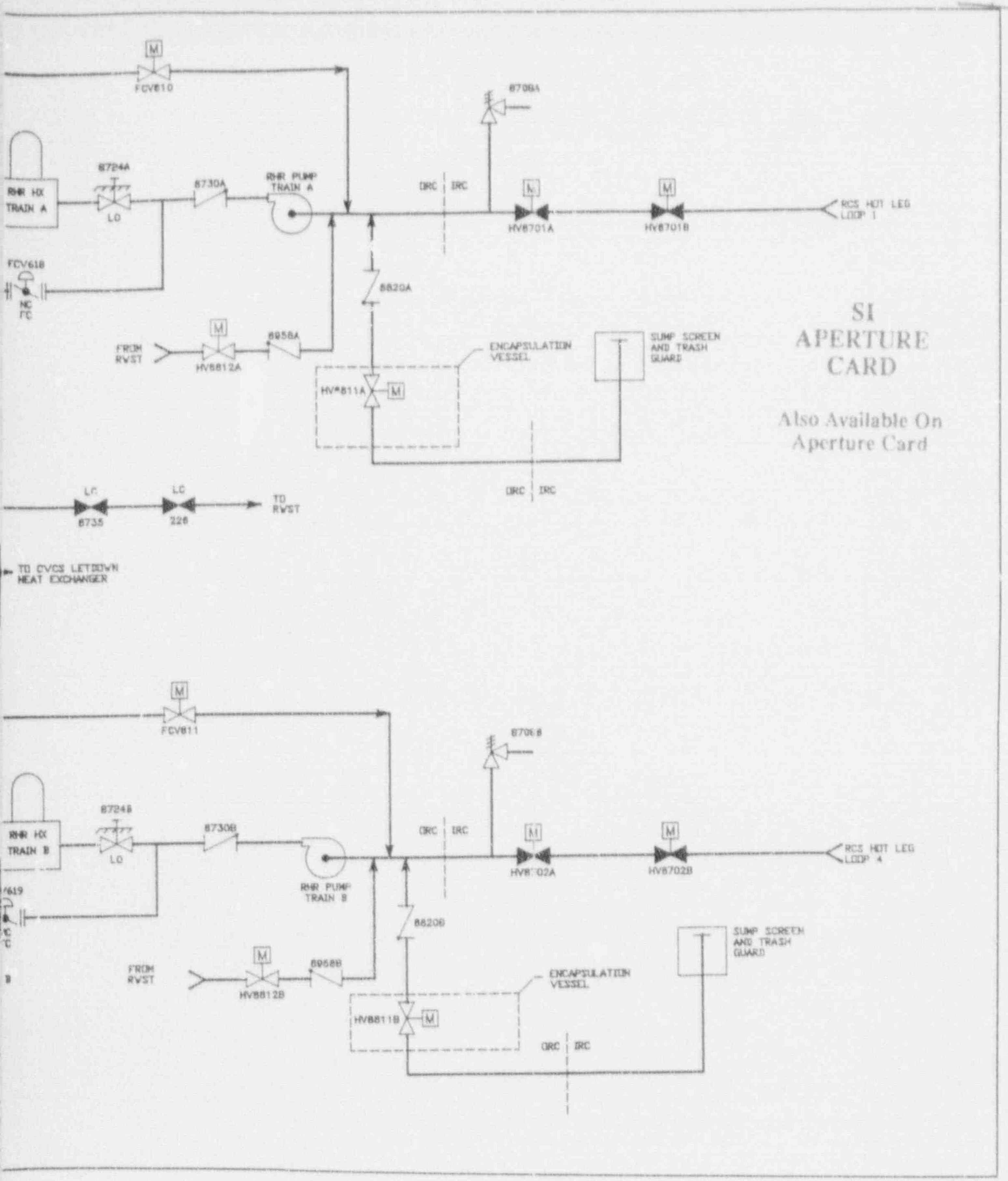


Figure 2-1 Vogtle Residual Heat Removal System

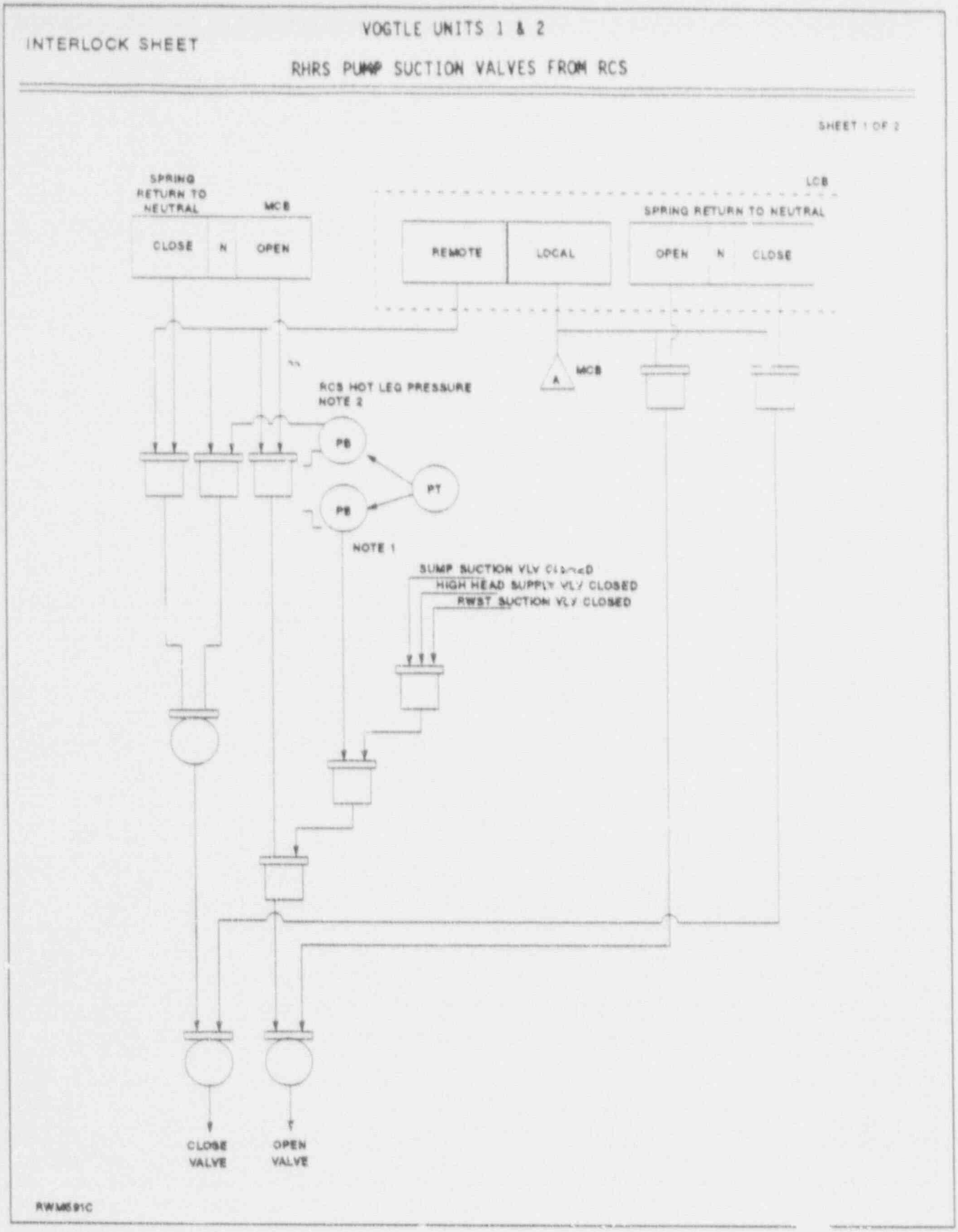


Figure 2-2 Current Interlocks for Valves HV-8701A/B and HV-8702A/B (Sheet 1)

INTERLOCK SHEET

VOGTLE UNITS 1 & 2

RHRS PUMP SUCTION VALVES FROM RCS

SHEET 2 OF 2

INTERLOCK TABLE

WITH \ INTERLOCK VALVE	8701 A	8702 A	8701 B	8702 B
Sump Suction Valve	8811 A LS 1	8811 B LS 2	8811 A LS 2	8811 B LS 1
Hi-head Supply Valve	8804 A LS 1	8804 B LS 2	8804 A LS 2	8804 B LS 1
RWST Suction Valve	8812 A LS 1	8812 B LS 2	8812 A LS 2	8812 B LS 1
PT	438	418	408	428
Train	A	D	C	B

NOTE 1: DE-ENERGIZE BELOW LOW SETPOINT < 365 PSIG

NOTE 2: ENERGIZE ABOVE HIGH SETPOINT > 750 PSIG

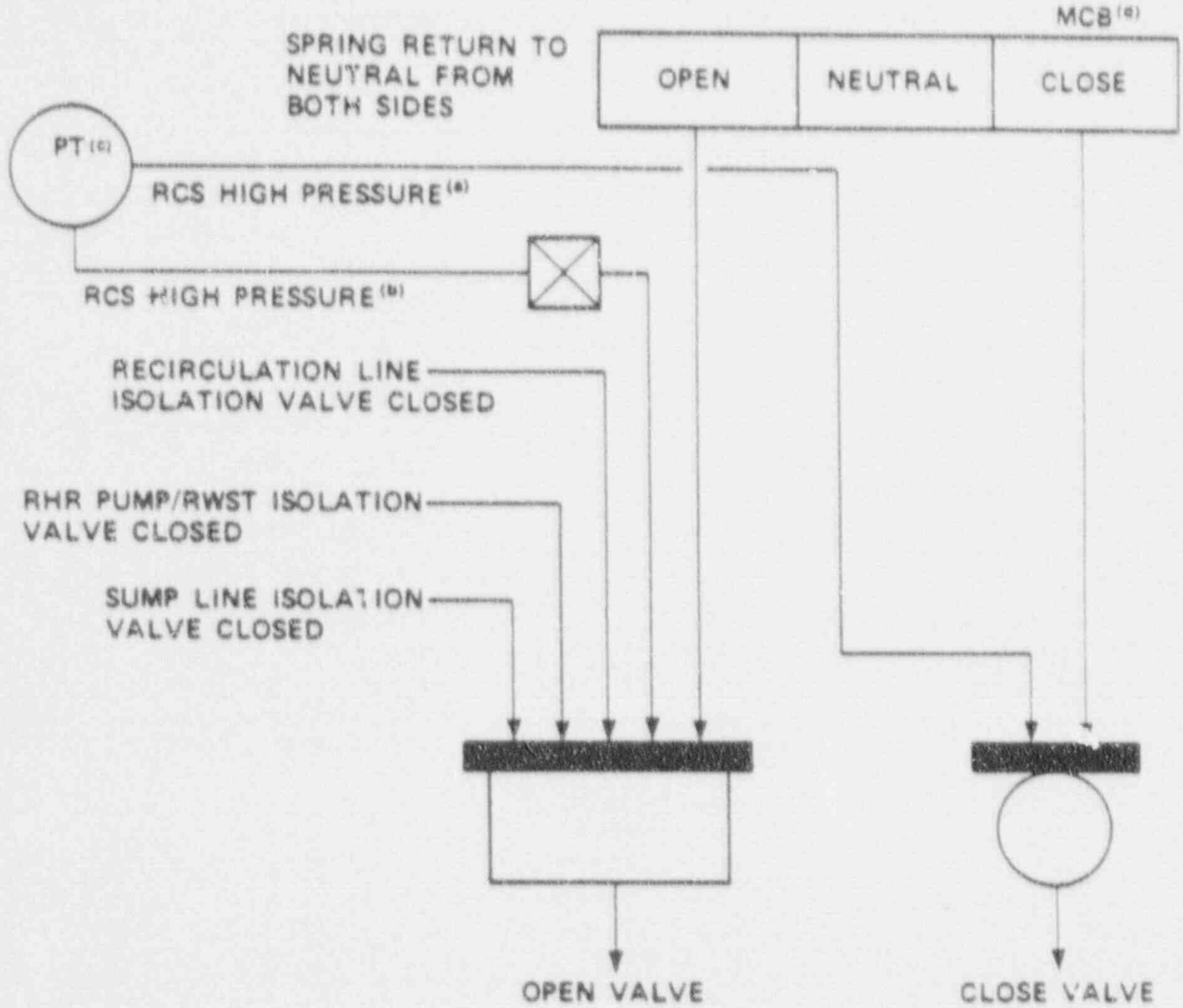
BISTABLE OUTPUT IS LOGIC " 1 " WHEN MEASURED PARAMETER IS GREATER THAN THE SETPOINT VALUE.

BISTABLE OUTPUT IS LOGIC " 1 " WHEN MEASURED PARAMETER IS LESS THAN SETPOINT VALUE.

RWM5918

Figure 2-2 Current Interlocks for Valves HV-8701A/B and HV-8702A/B (Sheet 2)

19232-3



NOTE: LOGIC FOR VALVES IN EACH FLUID SYSTEM TRAIN IS IDENTICAL

a. Automatic close setpoint.
b. Prevent open setpoint.
c. PT-Pressure transmitter.
   PT 406 in MOV 8701 B interlock (for inner valve).
   PT 418 in MOV 8702 A interlock (for outer valve).
   PT 428 in MOV 8702 B interlock (for inner valve).
   PT 438 in MOV 8701 A interlock (for outer valve).
d. MCB - Main control board (local panel not shown).

Figure 2-3 Logic Diagram for the RHRS Isolation Valves

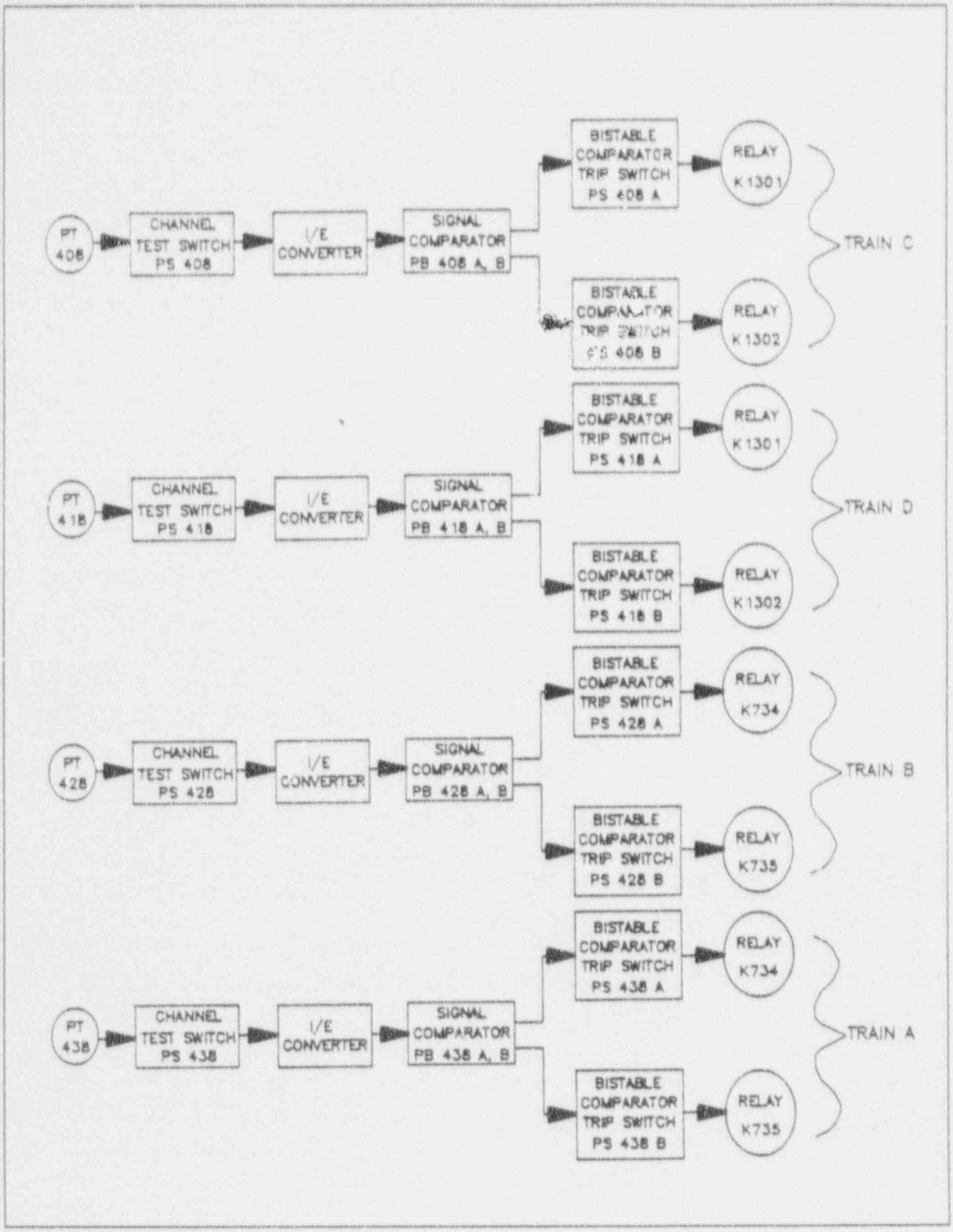


Figure 2-4 RHRS Suction Valve Interlocks Process Control Diagram (Sheet 1)

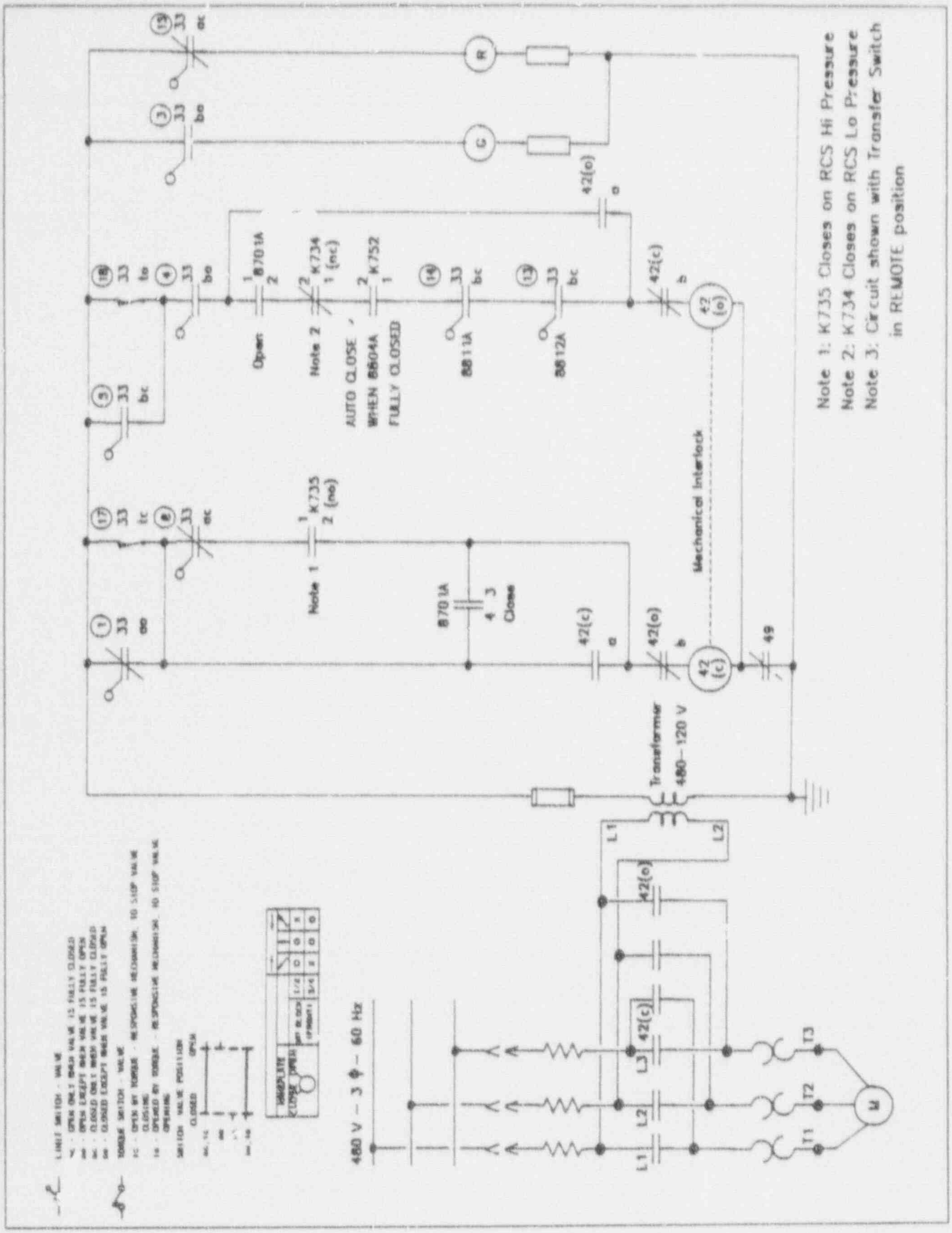


Figure 2-5 RHRS Suction Valve HV-8701A Control Circuit

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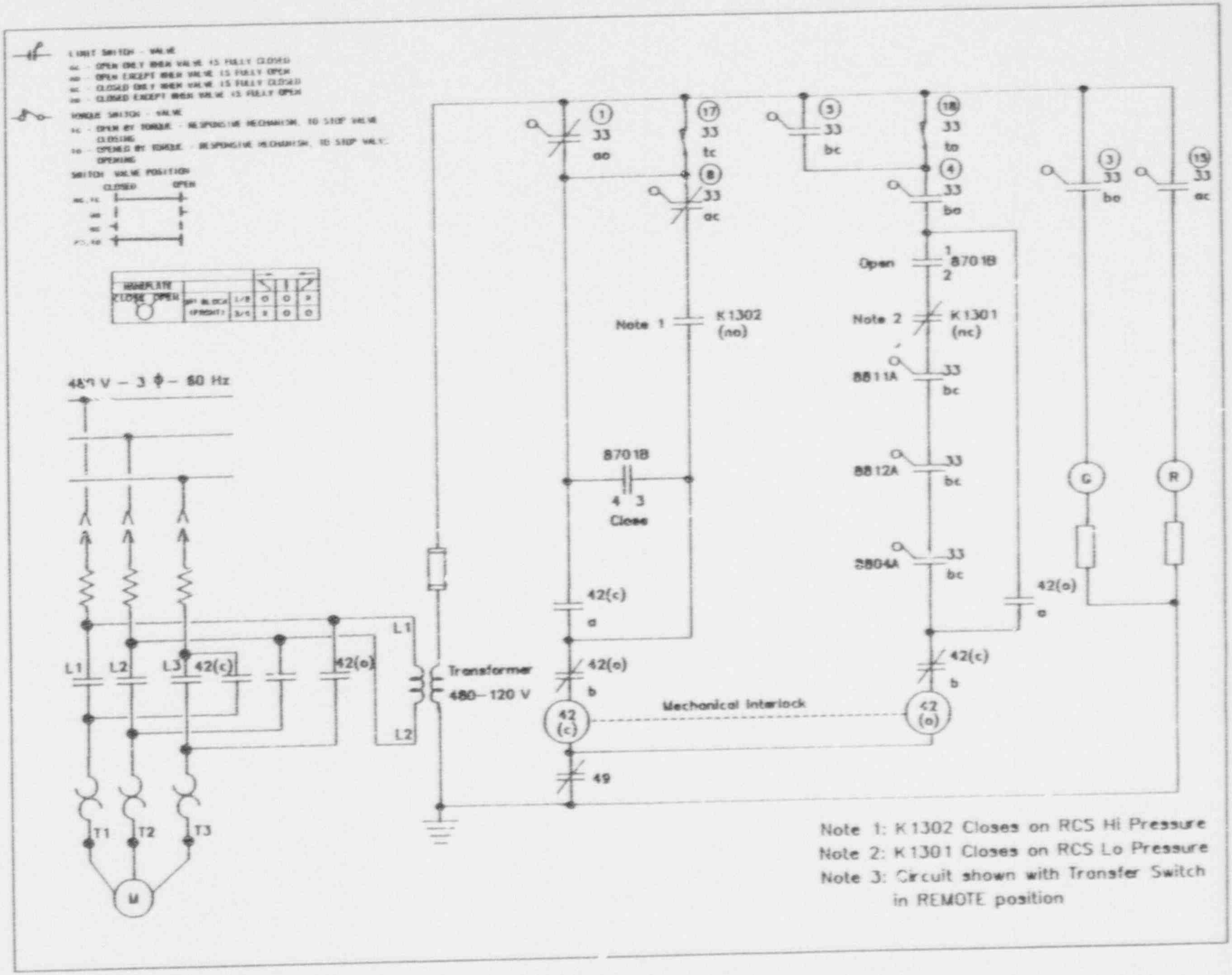

Figure 2-6 RHRS Suction Valve HV-8701B Control Circuit

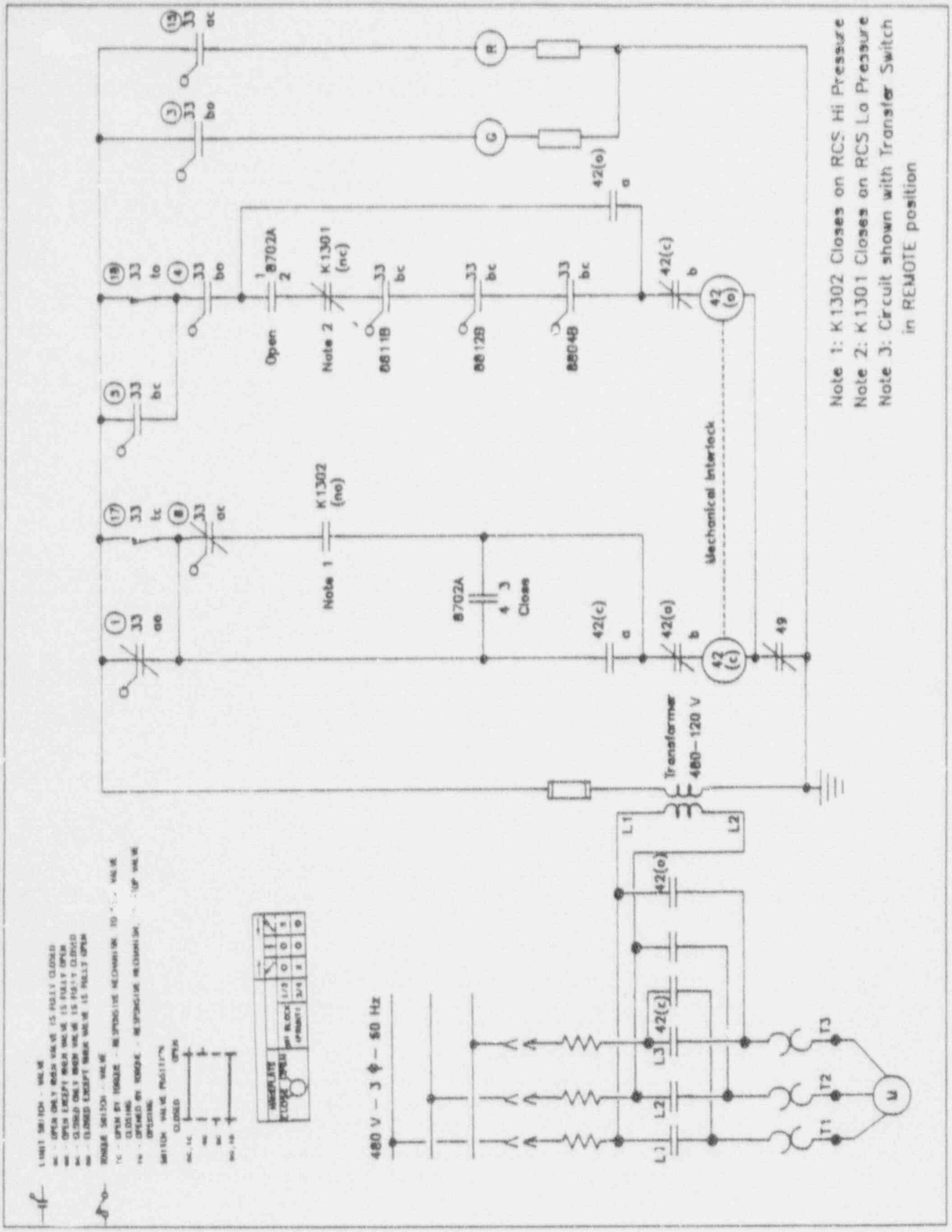

Figure 2-7 RHRS Suction Valve HV-8702A Control Circuit

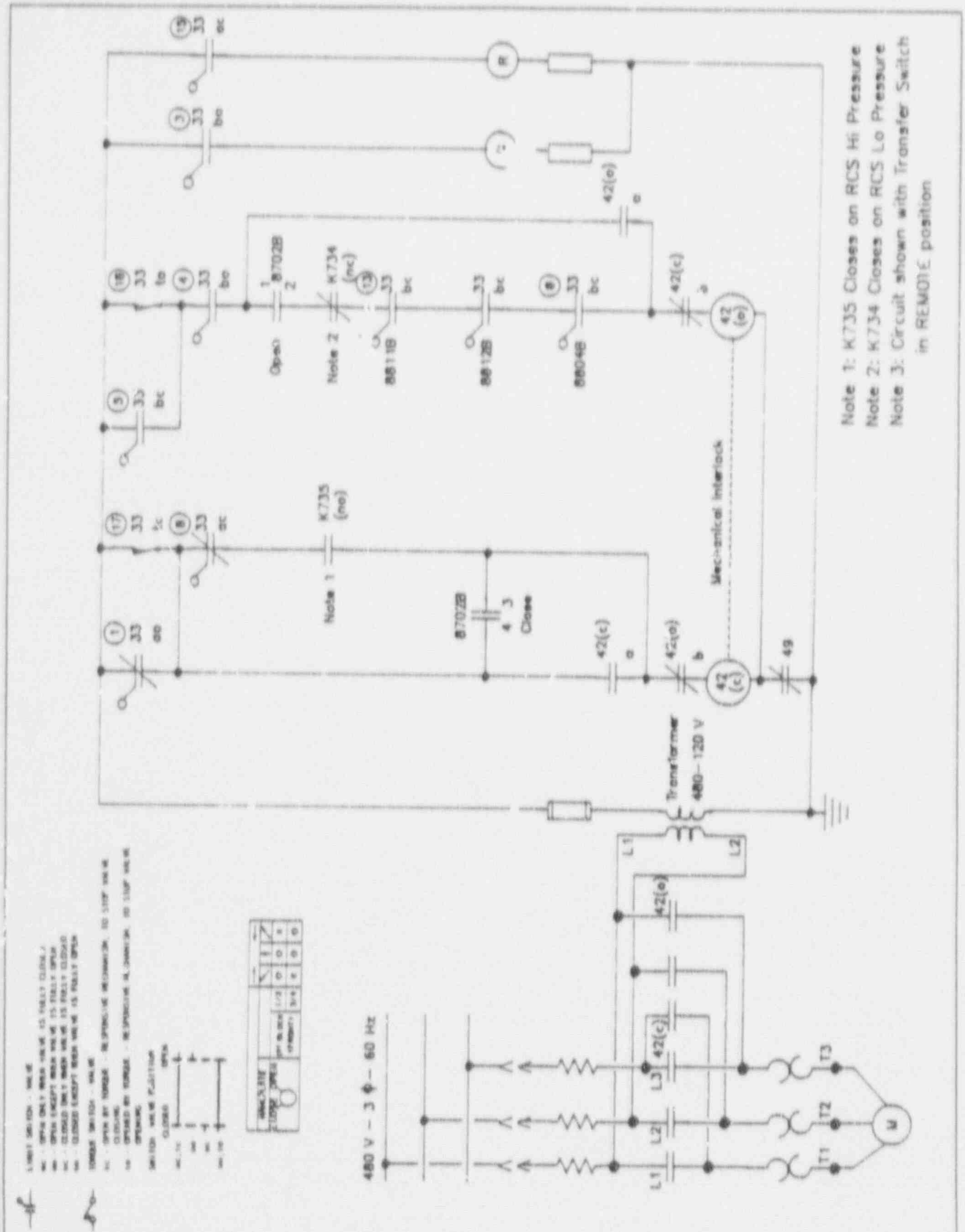

Figure 2-8 RHRS Suction Valve HV-8702B Control Circuit

WP0554:1D/082791

3.0 PROPOSED BASIC LOGIC CHANGE

The proposed interlock changes for Vogtle, Units 1 and 2, removes the ACI feature from the RHRS suction/isolation valves (HV-8701A/B, HV-8702A/B). With removal of the ACI feature, valves HV-8701A/B and HV-8702A/B will not close automatically on increasing RCS pressure greater than the valve closing setpoint. Alarms will be added (for each RHRS suction/isolation valve) that actuate in the main control room given a "VALVE NOT FULLY CLOSED" signal in conjunction with a "RCS PRESSURE-HIGH" signal. The intent of the alarms is to alert the operator that a RCS-RHRS suction/isolation valve(s) is not fully closed, and that double valve isolation from the RCS to the RHRS is not being maintained. Valve position indication to the alarm must be provided from the valve limit switches, and power to the limit switches must not be affected by power lockout to the valve.

The proposed interlocks for valves HV-8701A/B and HV-8702A/B are shown functionally on Figure 3-1. In addition, the proposed valve interlock changes for Vogtle Unit 1, are shown on the elementary wiring diagrams in Figures 3-2 through 3-5. The proposed valve interlock changes for Vogtle Unit 2 are identical and therefore, have not been included. The only change to the valve interlock and circuitry is to remove the autoclosure portion of the interlock and add a control room alarm. The valve open permissive circuit will not be altered.

In summary, the proposed Vogtle interlock changes provide deletion of the ACI feature from the RHRS suction/isolation valves, while still meeting the regulatory requirements to retain the open permissive portion of the interlock. In addition, the change provides a control room alarm to alert the operator if a RHRS suction/isolation valve is not fully closed. The annunciator for the alarm will be located next to the existing RHRS alarms.

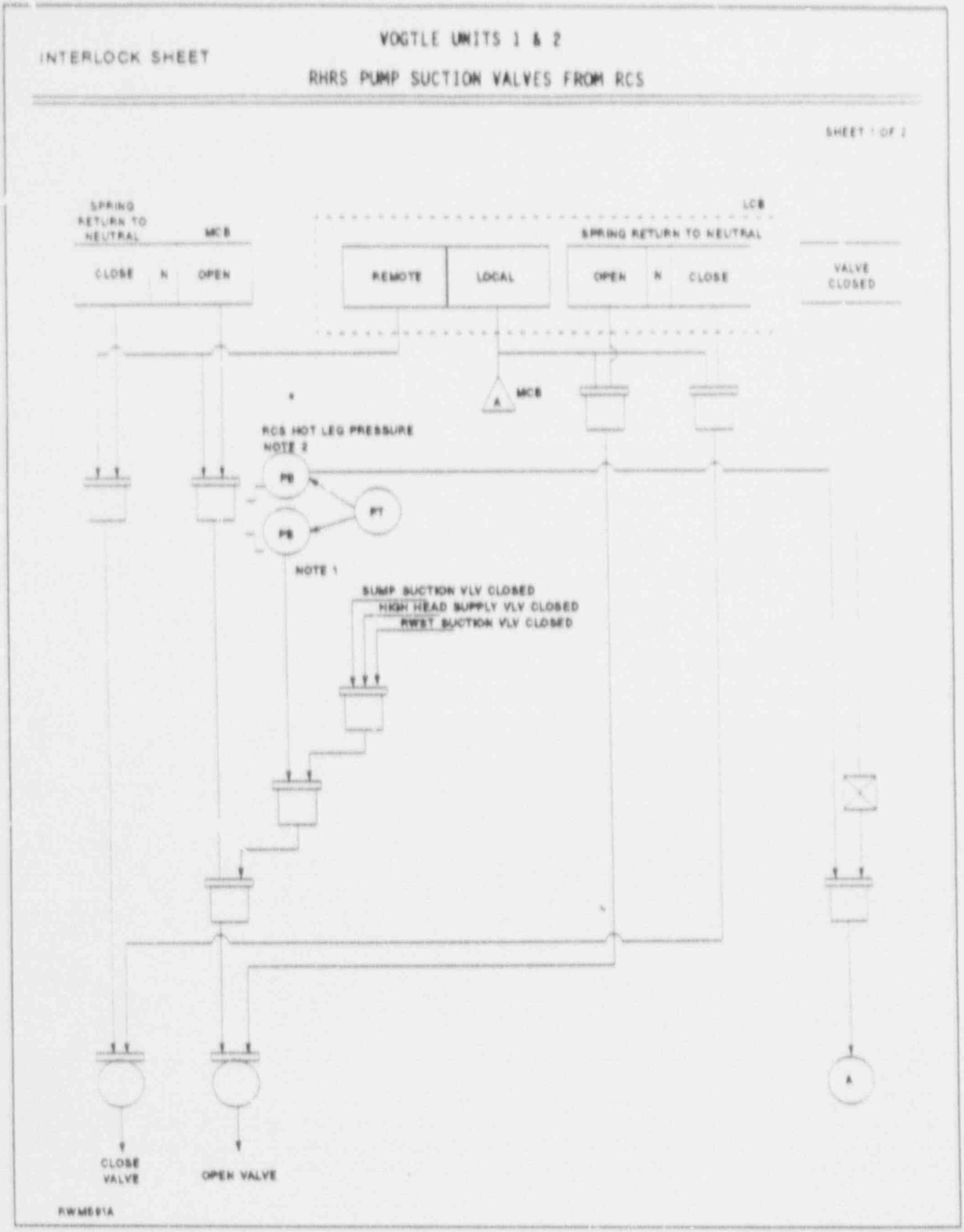

Figure 3-1 Proposed Interlocks for Valves HV-8701A/B and HV-8702A/B (Sheet 1)

WP0554:1D/082791

INTERLOCK SHEET

VOGTLE UNITS 1 & 2

RHRS PUMP SUCTION VALVES FROM RCS

INTERLOCK TABLE

INTERLOCK VALVE / WITH	8701 A	8702 A	8701 B	8702 B
Sump Suction Valve	8811 A LS 1	8811 B LS 2	8811 A LS 2	8811 B LS 1
Hi-head Supply Valve	8804 A LS 1	8804 B LS 2	8804 A LS 2	8804 B LS 1
RWST Suction Valve	8812 A LS 1	8812 B LS 2	8812 A LS 2	8812 B LS 1
PT	438	418	408	428
Train	A	D	C	B

NOTE 1: DE-ENERGIZE BELOW LOW SETPOINT < 365 PSIG

NOTE 2: ENERGIZE ABOVE HIGH SETPOINT ≥ 750 PSIG

BISTABLE OUTPUT IS LOGIC " 1 " WHEN MEASURED PARAMETER IS GREATER THAN THE SETPOINT VALUE.

BISTABLE OUTPUT IS LOGIC " 1 " WHEN MEASURED PARAMETER IS LESS THAN SETPOINT VALUE.

[illegible]

Figure 3-1 Proposed Interlocks for Valves HV-8701A/B and HV-8702A/B (Sheet 2)

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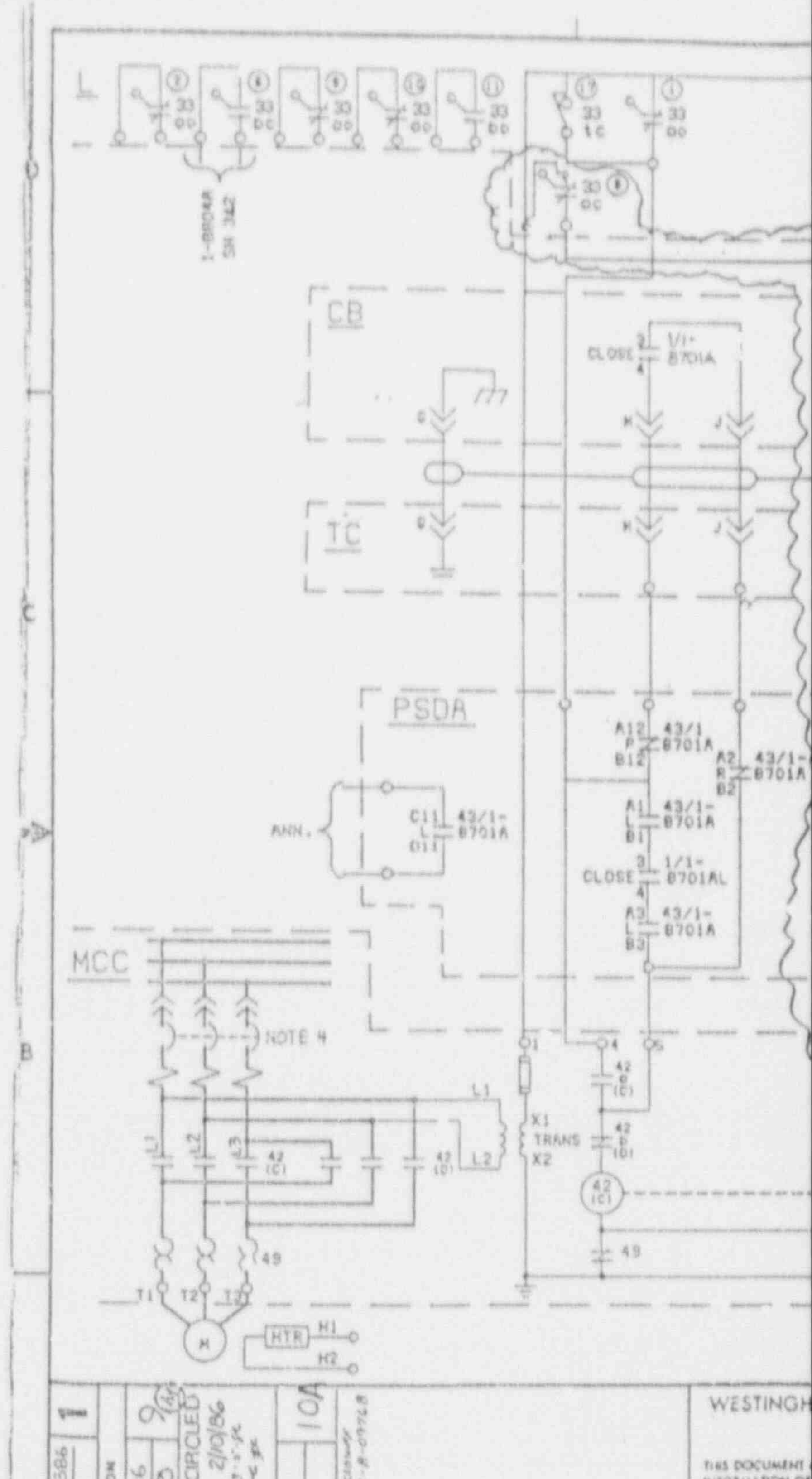

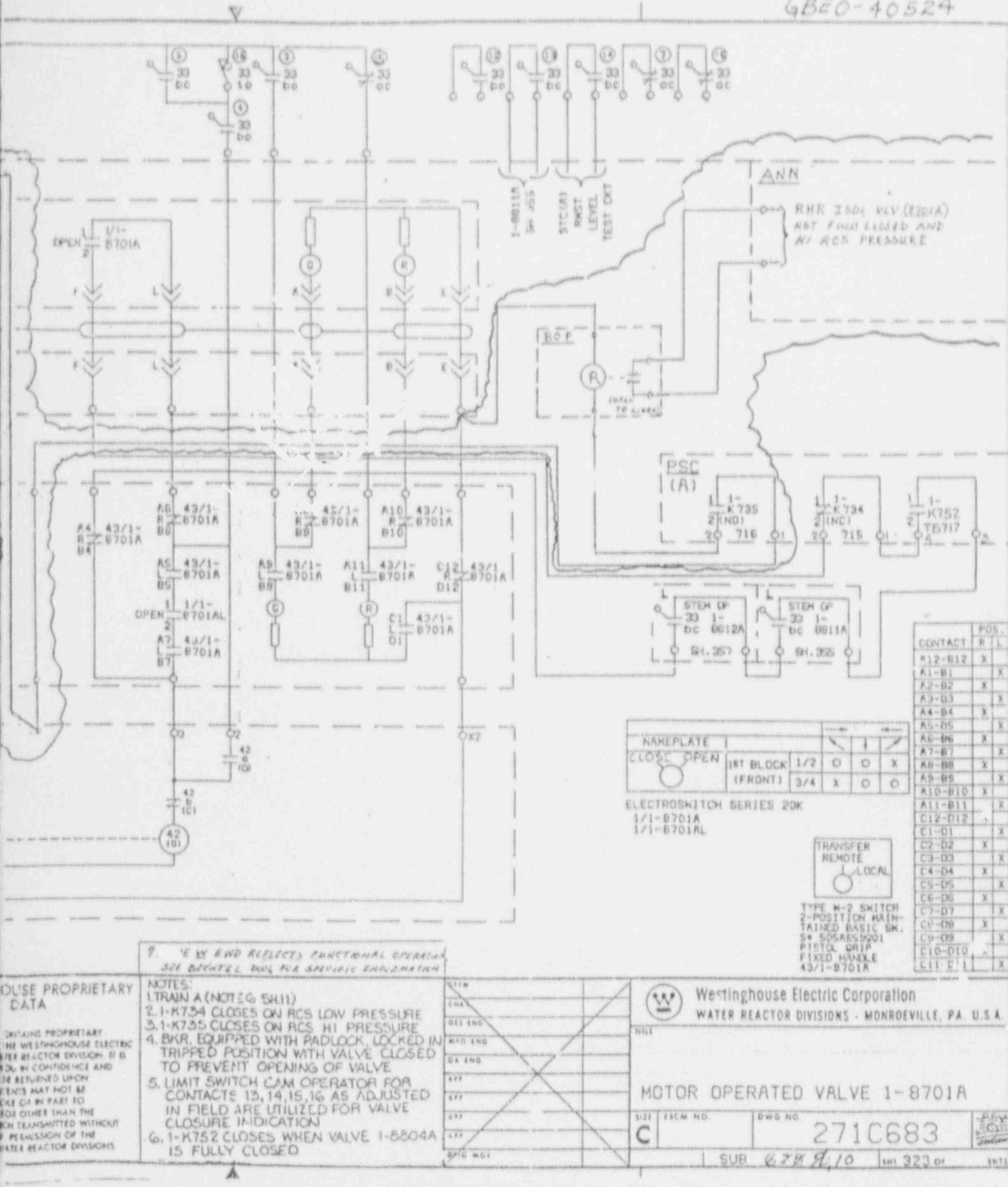

Figure 3-2 RHRS Suction Valve HV-8701A Proposed Interlock Control Circuit

9112020037-02

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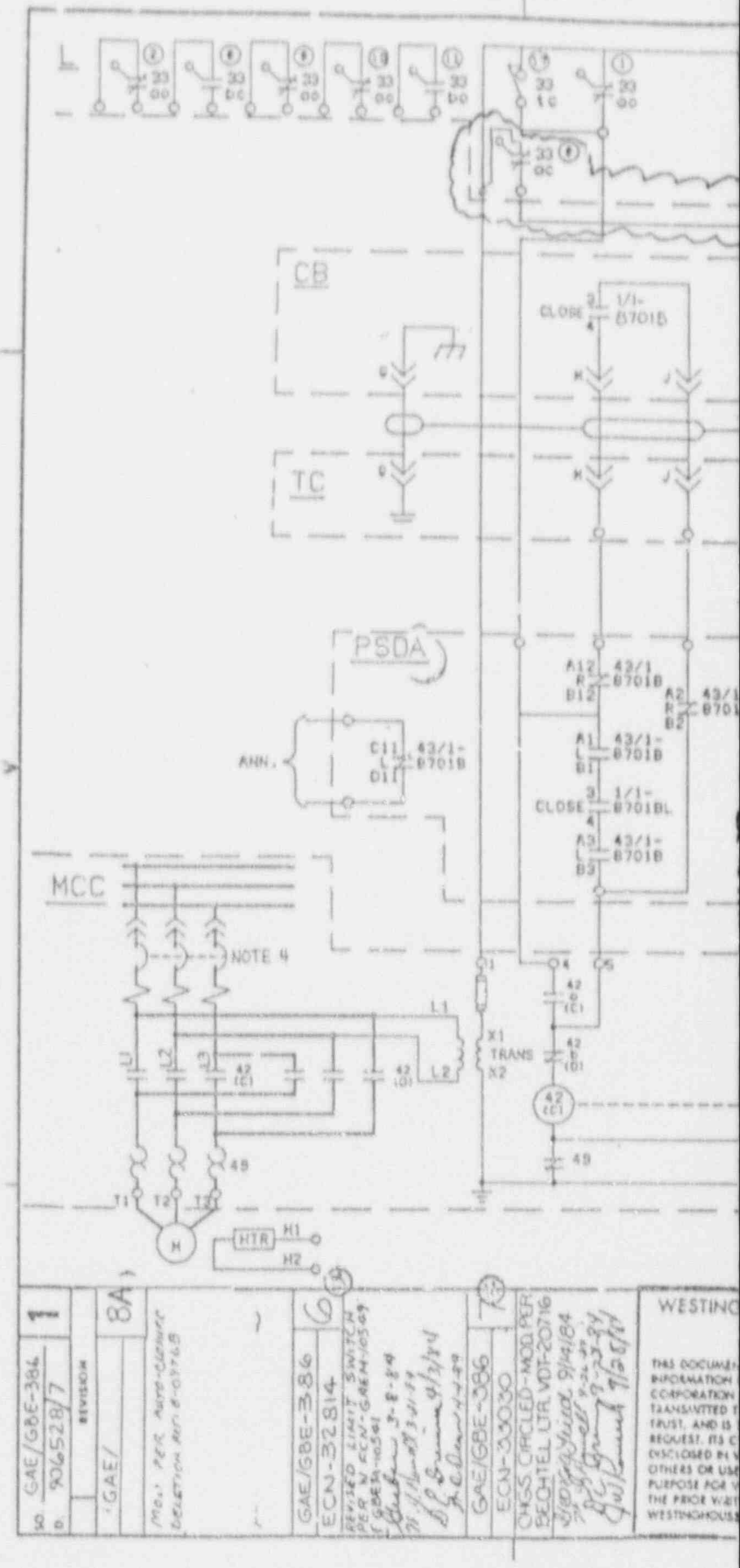
Aperture Card



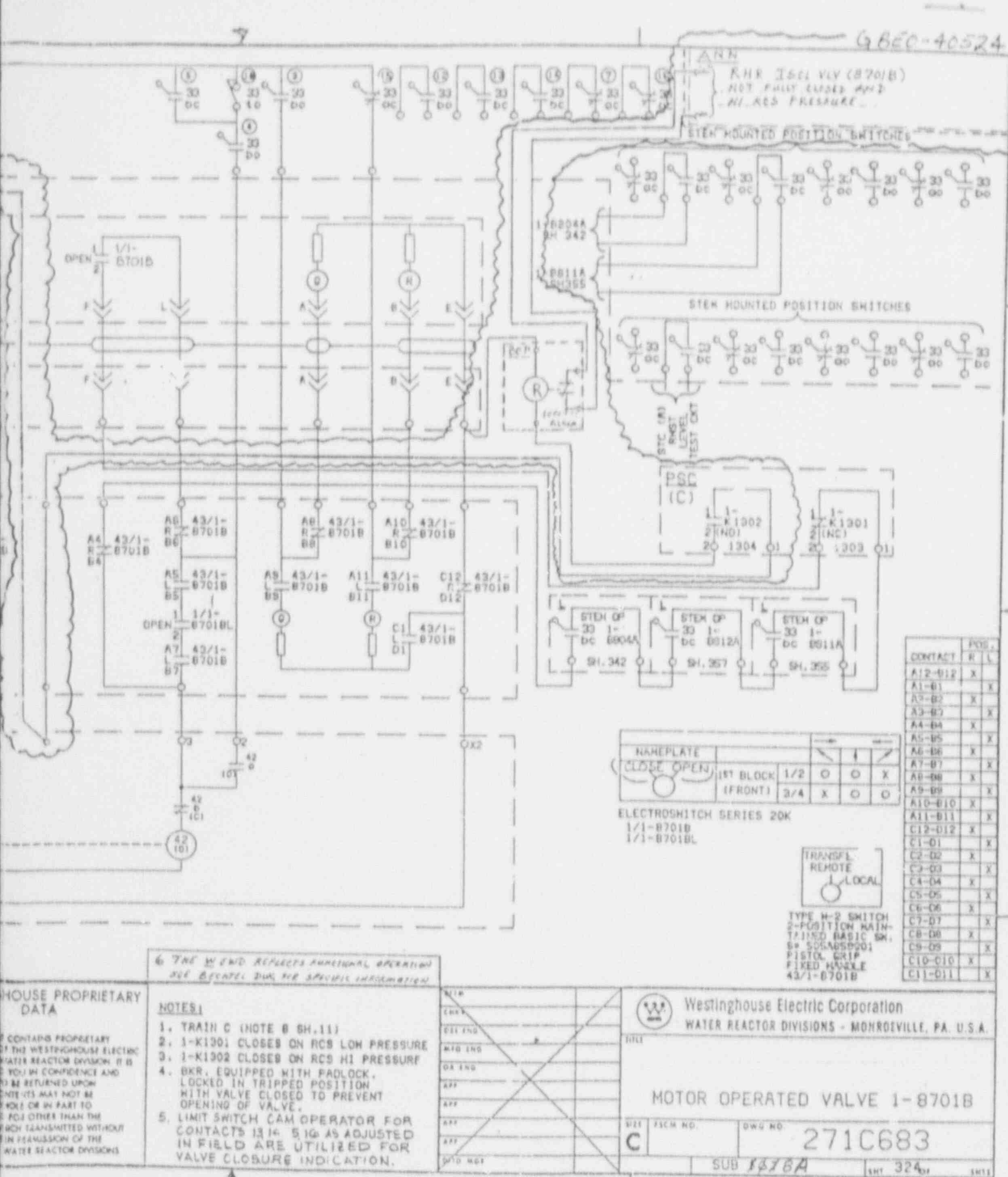


Figure 3-3 RHRS Suction Valve HV-8701B Proposed Interlock Control Circuit

9112020037-03

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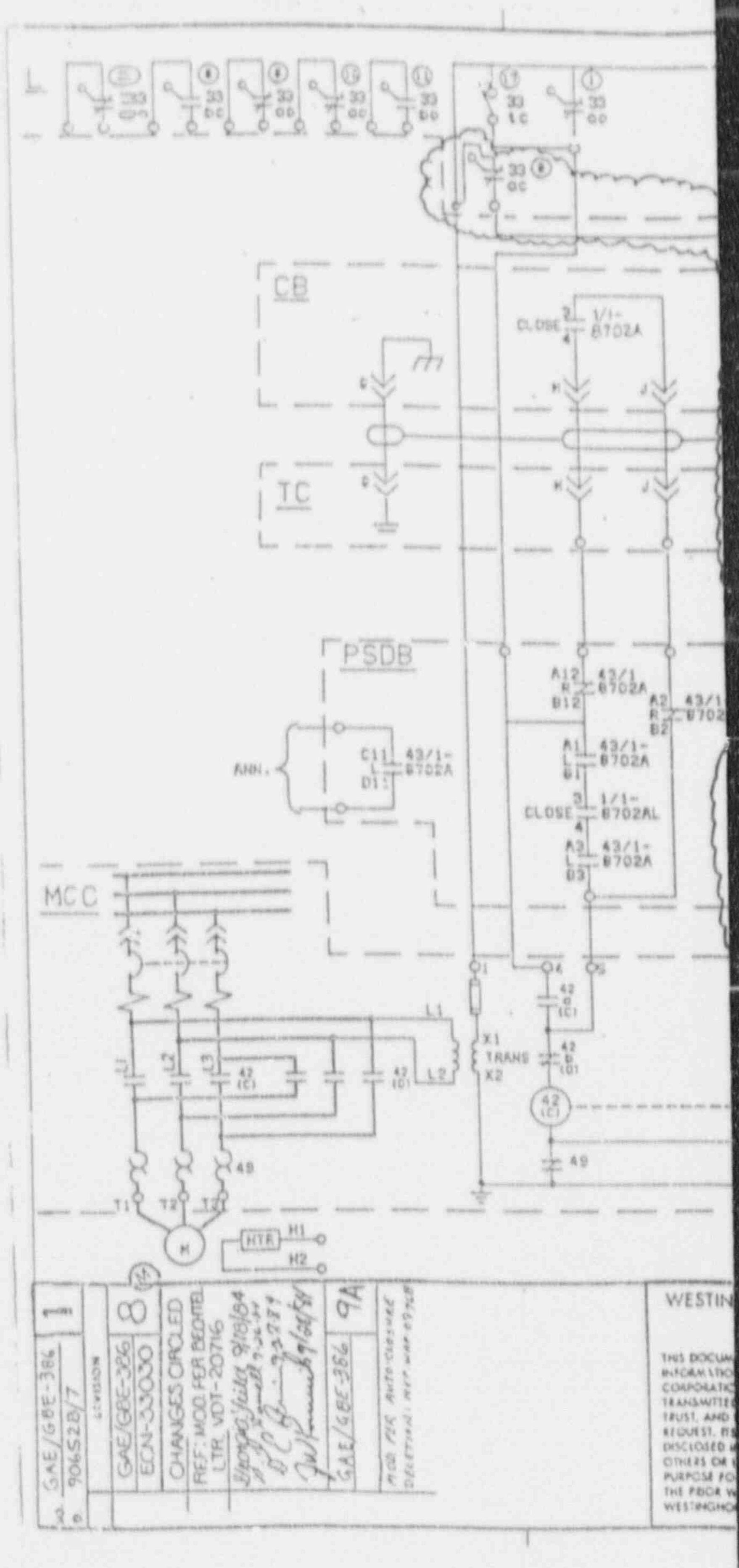
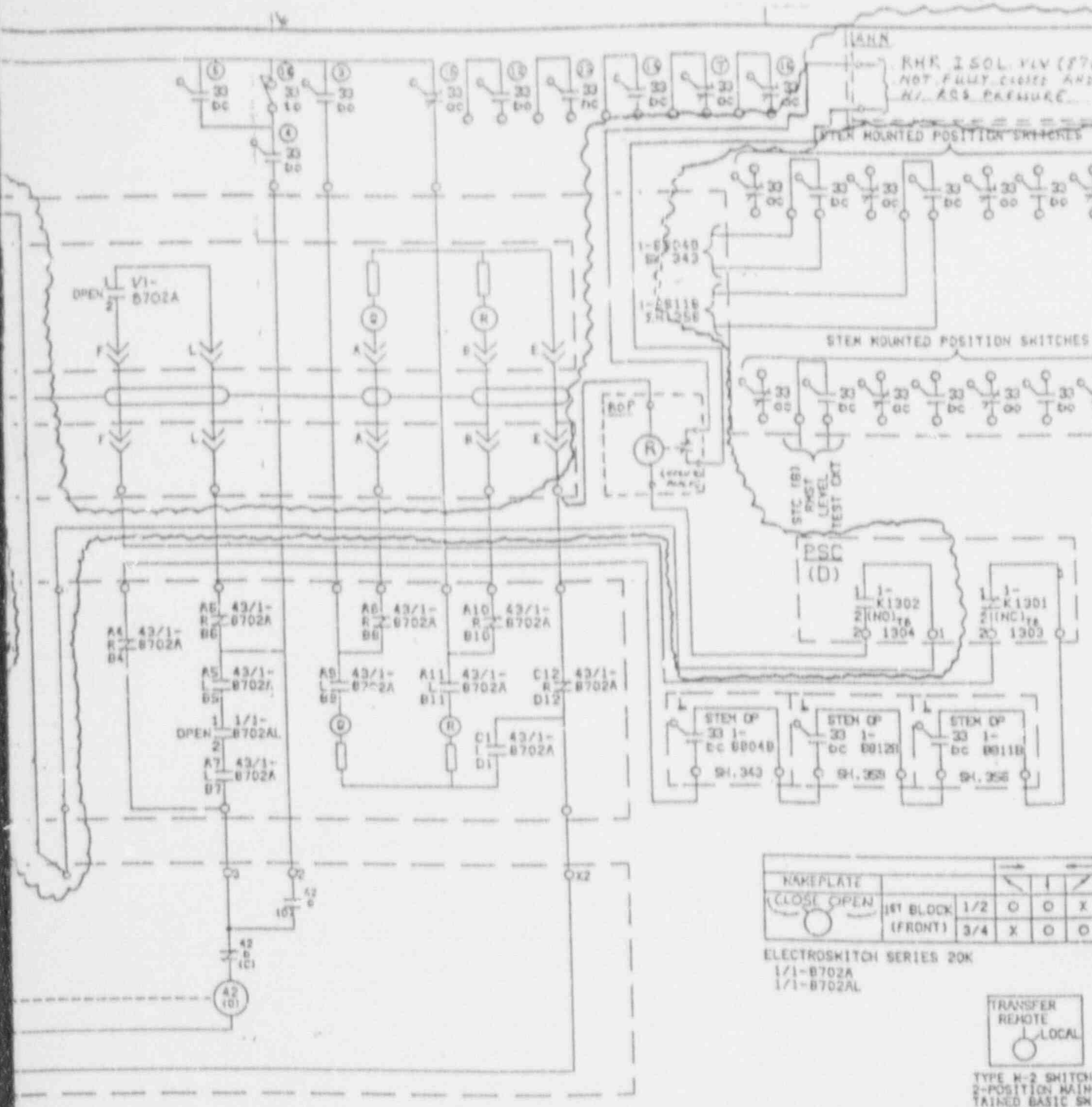
Also Available On
Aperture Card



GBEO-4052



CONTACT	POS. R	POS. L
A12-B12	X	
A1-B1		X
A2-B2	X	
A3-B3		X
A4-B4	X	
A5-B5		X
A6-B6	X	
A7-B7		X
A8-B8	X	
A9-B9		X
A10-B10	X	
A11-B11		X
C12-D12	X	
C1-D1		X
C2-D2	X	
C3-D3		X
C4-D4	X	
C5-D5		X
C6-D6	X	
C7-D7		X
C8-D8	X	
C9-D9		X
C10-D10	X	
C11-D11		X

NOTES:

1. TRAIN D (NOTE 6 SH. 11)
2. 1-K1301 CLOSES ON RCS LOW PRESSURE.
3. 1-K1302 CLOSES ON RCS HI PRESSURE.
4. LIMIT SWITCH CAM OPERATOR FOR CONTACTS 13, 14, 15 16 AS ADJUSTED IN FIELD ARE UTILIZED FOR VALVE CLOSURE INDICATION.
6. THE W DWG REFLECTS FUNCTIONAL OPERATION SEE BECHTEL DWG FOR SPECIFIC INFORMATION

Westinghouse Electric Corporation
WATER REACTOR DIVISIONS · MONROEVILLE, PA. U.S.A.

TITLE: MOTOR OPERATED VALVE 1-8702A

SIZE C | FSCM NO. | DWG NO. 271C683

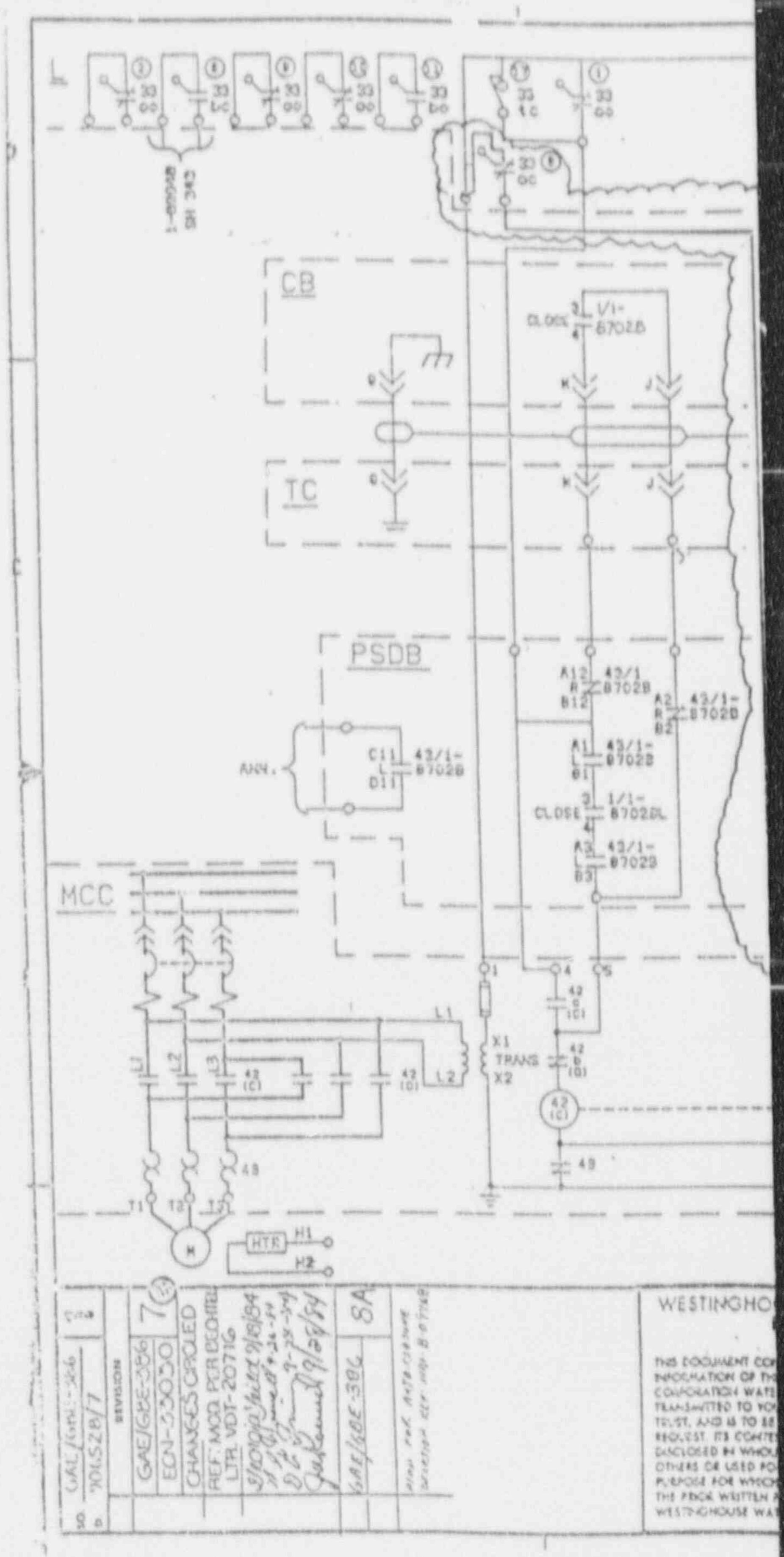
SUB 6789A | SHT 325 OF

Figure 3-4 RHRS Suction Valve HV-8702A Proposed Interlock Control Circuit

9112020037-04

SI
APERTURE CARD

Also Available On
Aperture Card



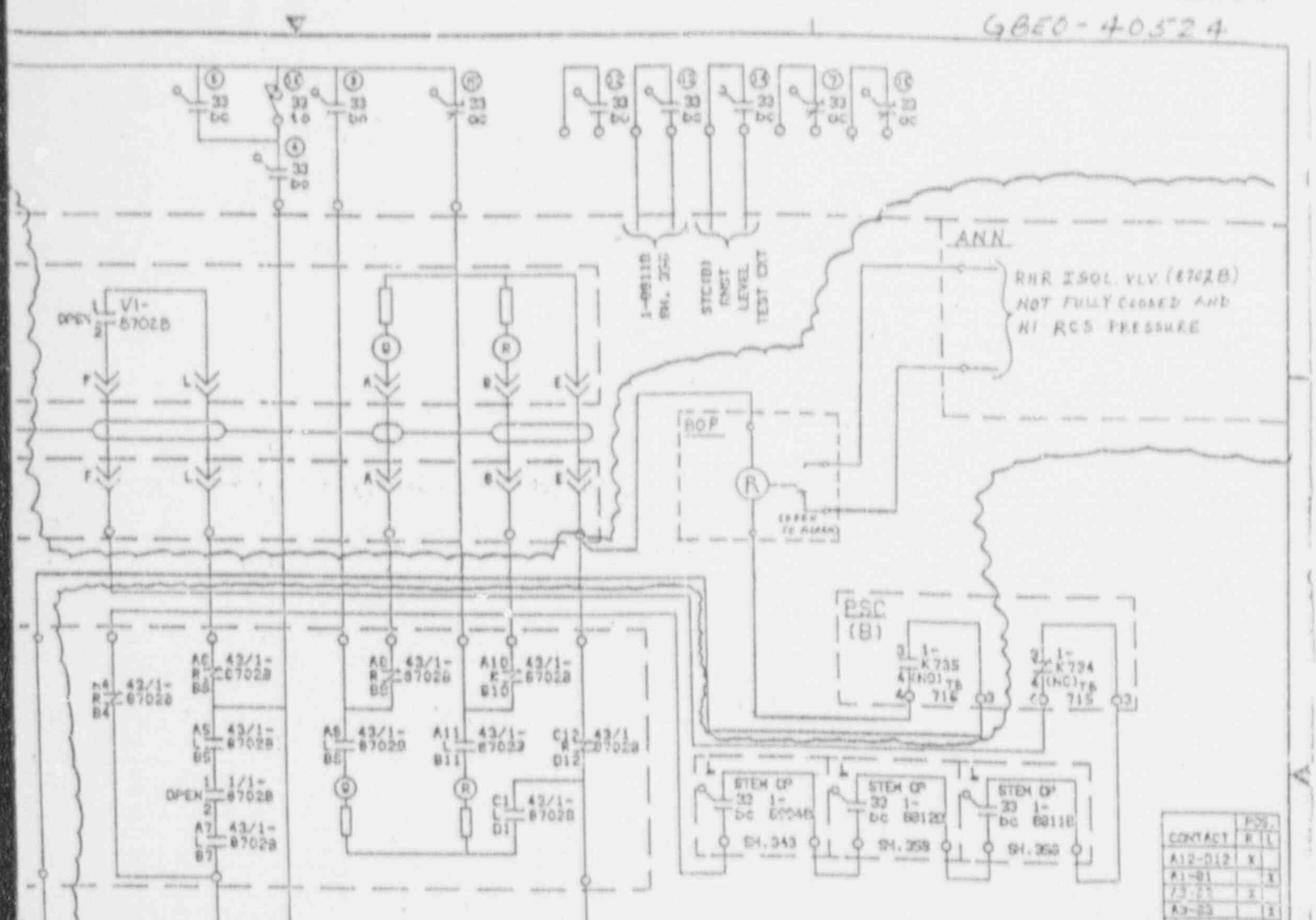


Figure 3-5 RHRS Suction Valve HV-8702B Proposed Interlock Control Circuit

9112020037-05

4.0 PROBABILISTIC ANALYSIS

4.1 Introduction

This section describes the probabilistic analysis performed to justify removal of the ACI from the RHRS suction isolation valves for Vogtle, Units 1 and 2. Three different areas were examined in this analysis: 1) the likelihood of an interfacing system LOCA; 2) RHRS availability, and 3) low temperature overpressurization concerns. Each of the three areas was analyzed utilizing the current control circuitry configuration and then with the proposed modification to the control circuitry. The net change in each area was determined, and the detriments and benefits were weighed to determine the acceptability of removal of the ACI from a probabilistic standpoint.

4.2 Data

The data used in this analysis was derived primarily from two documents - NUREG/CR-2815 Rev. 1, "Probabilistic Safety Analysis Procedures Guide" (Reference 7) and IEEE-500, "IEEE Guide to the Collection and Presentation of Electrical, Electronic, Sensing Component, and Mechanical Equipment Reliability Data for Nuclear-Power Generating Stations" (Reference 8). The component failure data is presented in Table 4-1.

Testing information was obtained from the Technical Specifications, while maintenance information was extracted from the "Individual Plant Evaluation Methodology for Pressurized Water Reactors," (Reference 9).

The mean human error probabilities were calculated utilizing the medians and error factors from NUREG/CR-1278 (Reference 10) and assuming a log normal distribution.

Each human error calculation is explained in the individual analysis and is shown in the Appendices.

4.3 Interfacing Systems LOCA Analysis

An interfacing systems LOCA, referred to as an Event V in WASH-1400, is a breach of the high pressure RCS boundary at an interface with the low pressure piping system. This breach has the potential to cause a LOCA in which the containment and containment safeguards radionuclide protective barriers are bypassed.

An RHRS LOCA is classified as a non-mitigable LOCA outside containment. It is assumed to occur if the valves in the RHRS suction line fail open when the RCS is at normal operating pressure (2235 psia). Since the RHRS is designed for a much lower pressure (600 psig), the result of both suction/isolation valves failing open is overpressurization of the RHRS, which is assumed to lead to gross failure of the RHRS boundary. Since most of the RHRS is located outside of containment, gross failure of the RHRS boundary is assumed to result in an uncontained LOCA.

In this section, the frequency of an interfacing system LOCA is calculated for the RHRS-RCS interface for two cases: 1) with the present interlock configuration, and 2) with the proposed control circuitry modification. Appendix A provides the detailed calculations.

Typically, RHRS suction paths are the dominant V-sequence source. Usually there are two motor-operated gate valves in series on the RHRS suction line from the RCS. Failure of these normally closed valves during power operation (at high pressures) would expose the low pressure piping downstream of the valves to the existing RCS pressure.

In this analysis, several failure combinations are considered which would result in both suction valves being in the "OPEN" position. These failure modes are defined as: 1) rupture of the two motor-operated gate valves, in series, in the RHRS suction line, and 2) failure to have closed one suction valve (or spurious opening of the valve) and subsequent rupture of the other valve. The latter failure mode actually includes two combinations - the failure to close the valve closer to the RCS (or spurious opening of the valve) and subsequent rupture of the valve closer to the RHRS and vice versa. Failure to close both RHRS suction valves during startup is not considered a credible failure mode because the condition would become apparent and corrective action would be taken. (The RHRS relief valve would lift as the RCS pressure increased, an alarm would sound, and the RCS pressure would increase more slowly than if the suction valves were closed.)

The general expression used to calculate the frequency of an Event V (F(VSEQ)) utilizing the above failure modes is:

$$F(VSEQ) = X \left[(g)_2 \, Q(V_1) + (g)_1 \, Q(V_2) + (g)_2 \, Q(V_1R) \right]$$

where

X	=	the number of RHRS suction lines (1 or 2)
$(g)_2$	=	failure rate of RHRS valve closest to the RCS (due to rupture)
$(g)_1$	=	failure rate of valve closest to the RHRS (due to rupture)
$Q(V_1)$	=	probability that RHRS valve is open
$Q(V_2)$	=	probability that RCS valve is open
$Q(V_1R)$	=	probability of rupture of RHRS valve

The following boundary conditions and assumptions were applied in each of the analyses:

1. The calculation is based on an occurrence when the plant is in Mode 1, 2, or 3.

2. The valve closest to the RCS is at RCS pressure and the valve closer to the RHRS is at RCS pressure only if the valve closest to the RCS fails open.

3. No common cause rupture of the valves is considered. This is based on the fact that no common cause ruptures of these valves have actually occurred.

4. The frequency of valve rupture is that of catastrophic internal leakage. The failure rate is the same for either valve given that the valve is exposed to RCS pressure.

5. All electrical power to the control circuitry (i.e., 480 V AC bus) is assumed to be available with a probability 1.0.

6. A refueling outage occurs approximately every 18 months (assumed to be the only time at which the plant will be in cold shutdown, on average).

Fault trees were developed to determine the probability that one of the RHRS suction valves is open at power conditions ($Q(V_1)$ or $Q(V_2)$). These fault trees (shown in Appendix A) were developed in detail to show the failures down to the control circuitry component level. The scenarios examined in the fault tree for the case with the ACI are: 1) the operator fails to remove power to the valve by racking out the circuit breaker, and subsequently the valve spuriously opens during power operation, or 2) the operator fails to close the valve during startup (or the operator attempts to close the valve but due to some component failure, the valve does not close), and the ACI fails to perform its function and does not close the valve, and an operator fails to detect that the valve is not closed during startup or power operation.

For the case with the ACI removed, the scenarios developed in the fault tree are: 1) the operator fails to remove power to the valve by racking out the circuit breaker, and subsequently the valve spuriously opens during power operation, or 2) the operator fails to close the valve during startup (or the operator attempts to close the valve but it does not close), and the operator fails to detect that the valve is not closed via the presence of an alarm (or the alarm fails to operate).

The probabilities generated from the fault trees were input into the equation for the frequency of an interfacing system LOCA for Vogtle. The frequencies were calculated for the case with the ACI present and without the ACI and with an alarm (the proposed change). The frequencies are shown in Table 4-2 along with the percent change in the frequency.

The frequency of an Event V decreases with removal of the ACI. The main contributor to the frequencies in each case is a rupture of the RCS valve followed by rupture of the RHRS valve (frequency of 5.76E-07/year). The deletion of the ACI has no impact on this contributor. The other dominant contributor (the rupture of one valve while the other valve has failed open) does not contribute as significantly in the ACI deletion case as it does in the ACI available case. This causes an overall reduction in the frequency of an Event V when ACI is deleted.

Furthermore, several factors were not considered in the analyses, but are worth mentioning:

1. The suction valves have OPIs that prevent the valves from being opened whenever the RCS pressure is greater than the setpoint of the open permissive. Thus, an operator error in which he inadvertently opens the valves is not very likely.

2. It is highly unlikely that a suction valve could move against the high differential pressure across the valve when the plant is in Modes 1, 2, or 3 because the valve motor size is inadequate to open the valve given the high differential pressure.

3. If an Event V should occur, the RHRS relief valve would operate. This relief valve discharges inside containment to the PRT. This relief valve would decrease the consequences of an Event V.

Thus, from a probabilistic standpoint, the deletion of the ACI and the inclusion of a control room alarm is beneficial in reducing the frequency of an interfacing systems LOCA and the potential for a significant radionuclide release outside containment.

4.4 Residual Heat Removal System Unavailability Analysis

The availability of the RHRS during cold shutdown has been of increasing concern in the nuclear industry. Many events have occurred in which the ability to remove decay heat has been lost, either because of a loss of flow in the RHRS or because of a loss of the heat sink. Abnormal events that occur shortly after initiation of RHRS operation, while the decay heat generation rate is high, can cause bulk boiling conditions if decay heat removal is lost and not restored by the operator in a time period as short as twenty minutes. The Vogtle RHRS was analyzed to determine the unavailability of the system to remove decay heat and the impact of removal of the ACI on this unavailability due to spurious closure of the suction valves. Appendix B provides the detailed description of the analysis.

The availability of the RHRS to remove decay heat is considered in three phases in this analysis. First, the RHRS must be placed into service and go through a warm-up period in order to minimize the thermal shock to the system. Secondly, during the initial phase of cooldown, the decay heat load is high. For this phase, the two trains of the RHRS (two pumps and two heat exchangers) are assumed to be in operation for 72 hours. The final phase of cooldown is long term decay heat removal. The decay heat load is low and only one train of the RHRS (one pump and one heat exchanger) is assumed to be in operation. Six weeks was the time period assumed for this phase (based on the average refueling outage time period).

Fault trees were constructed for each of the three phases. The components in the RHRS were modeled in the fault tree. Separate fault trees were developed, with and without the RHRS suction/isolation valves ACI, in order to show the change in RHRS unavailability due to the removal of the ACI. These RHRS suction/isolation valves from the RCS hot legs were modeled in detail down to the control circuitry level in order to show the change in unavailability.

The following boundary conditions and assumptions were utilized in the analysis.

1. Both trains of the RHRS are operating, injecting into two of four cold legs for 72 hours following initiation of RHRS operation (short term phase).

2. One train of RHRS is operating, injecting into two of four cold legs for the long term RHRS cooldown phase of 6 weeks (representative of the time of a refueling outage).

3. No testing or maintenance operations are assumed to occur during the initial phase of cooldown using the RHRS (first 72 hours).

4. During the warm-up period of the RHRS, both RHRS pumps are started and must run for approximately two hours before injection into the RCS cold legs.

5. All electric power (AC and DC) is assumed to be available with a probability of 1.0.

6. For long term cooling, it is assumed that the Train A pump is operating and the Train B pump is in standby, and thus, must start and run should the Train A pump fail. No switching of trains during long term cooling is assumed.

7. No common cause failure of components is considered.

The three phases of cooldown are described below:

<u>Failure to Initiate RHRS Operation</u>

A single fault tree was developed for this phase of RHRS operation to identify those faults that could impact the initiation of RHRS operation, which is defined as being approximately the first two hours of operation. An additional fault tree was not developed because this phase of operation is not dependent on the ACI, but on the OPI, which has remained unchanged.

The basis for the fault tree development for this phase was provided by the operating procedures for initiating decay heat removal by the RHRS. Each of the steps modeled in the RHRS initiation fault tree involved an operator error or a component failure or both, as appropriate.

Failure of Short Term Cooling

The fault trees developed for this phase of cooldown reflect that both RHRS trains are assumed to be in operation. Injection into two of four RCS cold legs is required for success in this phase, or more precisely, failure to supply cooling flow from the two RHRS trains to at least two cold legs constitutes RHRS failure. The short term cooling fault tree primarily features spurious closing of various valves, failure of check valves to open, and failure of the RHRS pumps to run over the 72 hour period. Spurious closure of the RHRS suction/isolation valves due to the ACI is explicitly modeled in the fault trees.

Failure of Long Term Cooling

Only one RHRS train is assumed to operate for six weeks in the long term cooling phase to provide adequate cooling. Injection into any two of four RCS cold legs is required for success in this phase, or inversely, failure to supply cooling flow from either of two RHRS trains to the cold legs results in RHRS failure.

The long term cooling fault tree shows spurious closing of various valves over the six week period along with failure of the operating pump to continue running, and upon failure of the running pump, failure of the second RHRS pump to start, run or be otherwise unavailable due to test or maintenance.

Results

The fault trees for each phase were quantified to determine the unavailabilities. The results are shown in Table 4-3.

For the failure of the initiation fault tree, the dominant failure modes are the RHRS pumps failing to start and the operator error in which the operator fails to open the suction valves. The deletion of the ACI has no impact on the failure probability for RHRS initiation.

The failure probabilities for the short term cooling phase are reduced by approximately 26 percent with the deletion of the ACI for Vogtle. The dominant failure mode for each case is the failure of either pump to run for 72 hours (both pumps are assumed to be required for success in this phase). For the case with the ACI, failures of components associated with the ACI contribute approximately 4.5E-05 to the failure probability.

In the long term cooling phase, the failure of both pumps to run for six weeks is the dominant contributor to the system unavailability. For the deletion of the ACI, the failure probability is reduced by approximately 40 percent. For the case with the ACI present, the failure of a component associated with the ACI such as the power supplies, signal comparators, comparator trip switches or pressure transmitters in combination with failure of one of the pumps to run contributes approximately 7.2E-03 to the system unavailability.

The results of the quantification of the Vogtle RHRS unavailability fault trees show that deletion of the ACI reduces the number of spurious closures of the suction valves, and thus, increases the availability of the RHRS.

4.5 Low Temperature Overpressurization Analysis

A number of plants have experienced pressure transients in which the temperature - pressure limits for the reactor vessel as specified in the Technical Specifications have been exceeded. A majority of these events have occurred during startup or shutdown conditions and have been caused by equipment malfunction, procedural deficiencies, or incorrect operator action. These pressure transients are of concern because the RHRS may be subject to overpressurization, and since the reactor vessel material is more brittle at relatively low temperatures than at operating temperatures, the requirements of 10CFR50 Appendix G may be exceeded.

The effect of an overpressure transient at cold shutdown conditions will be altered by removal of the ACI. With removal of the interlock, the RHRS may also be subject to overpressurization. However, the RHRS relief valve(s) will be available to mitigate the transient. The trade-offs between these two effects must be considered in the analysis of the RHRS ACI.

The overpressurization analysis uses event trees to model the mitigating actions (both automatic and manual) following the occurrence of LTOP events. These mitigating actions affect the severity of the overpressurization events and reduce the possibility of damage to the plant. The analysis is divided into two parts: 1) determination of the frequency of cold overpressure events; and 2) the effect of mitigation on the transients. Each part is discussed below. More detail is provided in Appendix C.

4.5.1 Initiating Events

M...ny past reports have characterized the different types of transients possible at cold shutdown. The following lists the overpressure transients that have been examined:

1. Premature opening of the RHRS (i.e., RHRS operation prior to reaching RHRS operating parameters).
2. Rod withdrawal.
3. Failure to Isolate RHRS During Startup.
4. Actuation of Pressurizer Heaters.
5. Startup of Inactive Loop. (Startup of a RCP.)
6. Loss of RHRS Cooling Train.
7. Opening of Accumulator Discharge Isolation Valves.
8. Letdown Isolation
   a) RHRS operable
   b) RHRS isolated.
9. Actuation of Charging/Safety Injection Pump.

The transients described above were researched in order to determine the frequency of these events based on past experience. Appendix D of the WOG analysis (WCAP-11736) details the events that have occurred and the quantification of the frequencies of these transients. Table 4-4 lists the transients and the frequencies calculated based on operating experience.

These events have been grouped into two general categories that describe their effect on the plant: 1) events that affect the balance between mass addition and mass letdown; and 2) events that affect the heat input/heat removal balance. These types of events have actually occurred and the NRC has expressed concern over the frequency of these events. The heat transients and mass input transients, along with their effect on the RHRS, are described in the WOG WCAP-11736.

4.5.2 Analysis

HEAT INPUT ANALYSIS

Based on the discussion of LTOP initiating events in WCAP-11736, only the mass input analysis needed to be conducted to determine the impact of ACI removal. The heat input analysis, provided in WCAP-11736, showed no effect caused by ACI removal since the heat input transients occur quickly and the RHRS would be subjected to the high pressures before the RHRS suction/isolation valves could close.

MASS INPUT ANALYSIS

In order to depict the mass input transients, which are slower than the heat input transients, event trees were utilized to model the mitigating actions that occur following the transients. Operator actions and mitigating systems are included in the event trees.

The effect of the mass input overpressure transients identified in the WOG analysis was evaluated utilizing event trees (charging/safety injection pump actuation and letdown isolation). Each mitigating system and operator action was modeled as a top node on the event tree for the given transient. The following describes the event tree structure, the success criteria defined for each transient, and the nodal probabilities utilized in the quantification and the results.

The safety functions (i.e., the event tree top events or nodes) for the Vogtle event trees are defined below:

1. Initiating Event (IE): The mass input initiator that could lead to overpressurization and/or possible RHRS damage, either charging pump actuation or letdown isolation (both with the RHRS operable and with the RHRS isolated). The safety injection pumps are not included with the charging pumps since their breakers are racked out, however, the positive displacement pump is included.

2. RHRS isolated (RI): The RHRS will be isolated during certain periods of shutdown dictating whether or not the RHRS relief valves are available to mitigate the transient and if the possibility exists for damage to the RHRS. The event tree allows for both trains of RHRS to be isolated, one train or no trains.

3. RHRS Suction Relief Valve Lifts (RV): If the RHRS is not isolated, the spring loaded relief valves will open at the setpoint pressure. If one train of RHRS is isolated, only one RHRS relief valve is available and if both trains are isolated, there are no RHRS relief valves available to mitigate the transient.

4. COPS Operates: The Cold Overpressure Protection System (COPS) consists of two redundant and independent systems utilizing the Power Operated Relief Valves (PORVs) of the pressurizer. When the system is energized and reactor coolant temperature is below 350°F, a high pressure signal (above the COPS setpoint) will trip the system automatically and open a PORV until the pressure drops below the reset value. For Vogtle, the COPS has a variable setpoint. An auctioneered system temperature is continuously converted to an allowable pressure and then compared to the actual RCS pressure. The system logic will first annunciate a Main Control Board alarm whenever the measured pressure approaches within a predetermined amount of the allowable pressure. On a further increase in measured pressure, an actuation signal is transmitted to the

PORV. For this analysis, it was assumed that the COPS would actuate at its lowest setpoint (505 psig).

5a. RHRS Suction/Isolation Valves Automatically Close (RSV): When the pressure increases to the autoclosure setpoint, the ACI receives a pressure signal that actuates the circuitry and closes the motor-operated gate valves. This node is addressed in the case with the ACI only.

5b. Operator Detects Overpressure Alarm and Isolates the RHRS (OD): For the modification case, an alarm would sound when the pressure reached the alarm setpoint. Through a revision in operating procedures, it is assumed that the operator will detect the overpressure and isolate the RHRS before the pressure reaches 150 percent of the RHRS design pressure.

6. Operator Secures Running Pump (OA1): Given an alarm caused when the RHRS relief valves open to the PRT and actuate one of its alarms, or from the operation of at least one train of COPS or from the high pressure alarm on the RHRS suction valves (in the modification case only), the operator will stop the extra running pump (either an SI or charging pump). If the operator stops the running pump, the overpressure event is halted.

7. Operator Opens a PORV (OA2): Given an alarm, if no or one relief valve operates successfully and the pressure still continues to rise, the operator may open a PORV in order to reduce the pressure. The operator may also open a PORV if he fails to stop the running pump in order to increase the time available to mitigate the transient.

8. RHRS Relief Valve Reseats (RVR): Given that the RHRS relief valves successfully operate and the transient is terminated, the relief valves must reseat or coolant would be lost to the PRT. If the transient is not stopped, the relief valves will cycle open and closed and are assumed to eventually fail open.

9. Pressurizer PORV Reseats (POR): Given that a PORV has opened and the transient has been stopped, the PORV must close in order to avert a loss of coolant condition.

For each of these nodes, failure probabilities were calculated. These nodal probability calculations for Vogtle are shown in Appendix C.

The success criteria for the event trees were determined based on conservative estimates of the flow rates and relieving capacities of the relief valves. For the charging pump actuation case, it was assumed that either two PORVs or two RHRS relief valves, or both one PORV and one RHRS relief valve are required to mitigate the transient, since the maximum flow rate to the RHRS from the two charging pumps and the positive displacement pump is 1208 gpm (conservative assumption that all three pumps operate at their maximum flow rates; 555, 555, and 98 gpm). The maximum flow rate calculated by Westinghouse for the charging pumps actuation case for the Vogtle LTOP Analysis was 673 gpm at 495 psia. However, the 1208 gpm flow rate is being conservatively used to maintain consistency with the WOG WCAP-11736 methodology. The following assumptions were also utilized in the analysis of the charging mass input transient.

1. No credit is taken for venting via the Reactor Vessel Head Vent System.

2. A failure detection time of 24 hours was assumed to detect RHRS suction valve failures, while a detection time of six weeks (1008 hours) was assumed to detect

PORVs and block valves (assumed to be representative of a refueling outage). These times were conservatively determined from the monitoring frequency of the valves.

The event trees for these cases are presented in Appendix C.

The results from the quantification of the event trees for Vogtle show that most of the overpressure consequence categories remain unchanged with the deletion of the ACI. Table 4-5 described the consequence categories. The results from the quantification of the event trees for Vogtle are shown in Tables 4-6 to 4-8.

For the charging pump actuation case, the frequency of the consequence categories MSFO and MSCO increased insignificantly by 3.76E-12 and 2.35E-12/shutdown year. The HOPV category decreased slightly.

For the letdown isolation - RHRS operable case, the frequency of the consequence category MOPI decreased insignificantly by 1.00E-16/shutdown year, while the HOPV category increased by 4.30E-17/shutdown year.

For the letdown isolation - RHRS isolated case, the frequency of all the impacted consequence categories decreased due to the reduction in the initiating event frequency (i.e., the reduction in the loss of letdown due to spurious closure of the RHRS suction valves).

The conclusion to be drawn from the overpressure analysis is that removal of the ACI has a positive impact on the consequences of LTOP events for Vogtle.

It should be understood that the ACI was not installed to mitigate overpressure transients. The RHRS suction valves are slow-acting and take approximately two minutes to close. The ACI will not protect the RHRS from a fast-acting overpressure transient such as the startup of a RCP.

The major impact with respect to overpressure concerns is that removal of the ACI will significantly reduce the number of letdown isolation transients.

TABLE 4-1
COMPONENT FAILURE RATE DATA

COMPONENT	FAILURE MODE	FAILURE RATE	SOURCE
Air operated valve	Failure to operate	1.0E-05/hr	2815
Check valve	Failure to open	2.0E-07/hr	2815
Check valve	Failure to close	2.0E-06/hr	2815
Motor operated valve	Failure to open	1.0E-05/hr	2815
Motor operated valve	Fail to remain open	2.0E-07/hr	2815
Motor operated valve	Fail to close	1.0E-05/hr	2815
Motor operated valve	Catastrophic	1.0E-07/hr	2815
Manual valve	Failure to operate	2.0E-07/hr	2815
Motor driven pump	Failure to start	1.0E-05/hr	2815
Motor driven pump	Failure to run	1.0E-04/hr	2815
Thermal Overload	Premature open	1.5E-07/hr	Fuse Rate
Diode (Std quality)	All	7.56E-09/hr	MIL HDBK
Resistor (Std quality)	All	4.90E-09/hr	MIL HDBK
Relay	All	8.7E-08/hr	MIL HDBK
Bistable	High Output	2.40E-06/hr	MIL HDBK
Bistable	Low Output	1.65E-06/hr	MIL HDBK
Pressure Sensors	All	2.80E-06/hr	MIL HDBK
Loop Power Supply	All	5.80E-06/hr	MIL HDBK
Comparator	All	2.90E-06/hr	MIL HDBK
Annunciator	All	4.25E-06/hr	IEEE
Torque Switch	Failure to operate	2.00E-07/hr	2815
Current Transformer	All	3.50E-07/hr	IEEE
Relay Contacts	Fail to transfer	1.00E-06/hr	2815
Relay Coil	All	3.00E-06/hr	2815
Circuit Breaker	Fail to close	3.00E-08/hr	IEEE
Circuit Breaker	Fail to open	2.00E-08/hr	IEEE
Circuit Breaker	Open w/o command	1.00E-08/hr	IEEE
Push button switch	All	1.22E-06/hr	IEEE
Rotary switch	All	8.10E-07/hr	IEEE
Toggle switch	All	2.33E-07/hr	IEEE
Fuse	All	1.50E-07/hr	IEEE
Limit switch	All	7.22E-06/hr	IEEE
Motor Starter contacts	Spurious operation	3.00E-08/hr	IEEE

TABLE 4-1
COMPONENT FAILURE RATE DATA
(Continued)

COMPONENT	FAILURE MODE	FAILURE RATE	SOURCE
Relay Contacts	Spurious operation	2.00E-08/hr	IEEE
Relief Valve	Fail to open	3E-04/demand	IPE
Relief Valve	Fail to close	3E-02/demand	IPE
I-E Converter	All	2.00E-07/hr	IEEE
Isolator E-E converter	All	4.8E-07/hr	IEEE
Pressure Transmitter	All	1.73E-06/hr	IEEE
Comparator Trip Switch	All	5.80E-07/hr	IEEE
Amplifier	All	7.0E-07/hr	IEEE
RTD Sensor	All	8.6E-06/hr	MIL HDBK
DC Controller	All	2.41E-06/hr	IEEE

Notes:
IEEE - Reference 8
2815 - Reference 7
MIL HDBK- Reference 14
IPE - Reference 9

TABLE 4-2
INTERFACING SYSTEM LOCA FREQUENCIES
WITH AND WITHOUT AUTOCLOSURE INTERLOCK

WITH AUTOCLOSURE INTERLOCK	WITHOUT AUTOCLOSURE INTERLOCK	PERCENT CHANGE
2.28E-06/YEAR	1.48E-06/YEAR	-35

TABLE 4-3
RHRS UNAVAILABILITY RESULTS

	WITH AUTOCLOSURE INTERLOCK	WITHOUT AUTOCLOSURE INTERLOCK	PERCENT CHANGE
RHRS INITIATION	1.05E-01	1.05E-01	0
SHORT TERM COOLING	1.96E-02	1.46E-02	-25.5
LONG TERM COOLING	1.96E-02	1.18E-02	-39.8

TABLE 4-4
FREQUENCY OF OVERPRESSURE TRANSIENTS

	TOTAL NUMBER OF OCCURRENCES	FREQUENCY (EVENTS/SHUTDOWN YEAR)
OPENING OF ACCUMULATOR DISCHARGE ISOLATION VALVES	4	3.56E-02
STARTUP OF INACTIVE LOOP	11	9.79E-02
ISOLATION OF LETDOWN WHILE CHARGING CONTINUES	14	1.25E-01
CHARGING/SAFETY INJECTION	14	1.25E-01
ISOLATION OF LETDOWN WHILE CHARGING CONTINUES RHRS ISOLATED	50	4.45E-01
TOTAL	93	8.27E-01

TABLE 4-5
TRANSIENT EVENT OUTCOME DESCRIPTIONS

CATEGORY	OUTCOME DESCRIPTION
LSFO	Low pressure with small loss of coolant and the RHRS is open to the RCS. The running pump has been stopped but one of the relief valves has failed to reseat. The operator must take action to reseat the valve or isolate it and then must add makeup.
LSFI	Low pressure with small loss of coolant and the RHRS is isolated from the RCS. The running pump has been stopped but one of the relief valves has failed to reseat. The operator must take action to reseat the valve or isolate it and then must add makeup. He must also reinitialize RHRS operation.
LSCO	Low pressure with small loss of coolant and the RHRS is open to the RCS. The running pump has not been stopped and coolant is exiting via one relief valve. The operator must take action to stop the running pump or isolate it and then must check that the relief valves have reseated completely.
LSCI	Low pressure with small loss of coolant and the RHRS is isolated from the RCS. The running pump has not been stopped and coolant is exiting via one relief valve. The operator must take action to stop the running pump or isolate it and then must check that the relief valves have reseated completely.
LLFO	Low pressure with large loss of coolant and the RHRS is open to the RCS. The running pump has been stopped but two or more of the relief valves have failed to reseat. The operator must take action to reseat the valves or isolate them and then must add makeup.
LLFI	Low pressure with large loss of coolant and the RHRS is isolated from the RCS. The running pump has been stopped but two or more of the relief valves have failed to reseat. The operator must take action to reseat the valves or isolate them and then must add makeup. He must also reinitialize RHRS operation.

TABLE 4-5
TRANSIENT EVENT OUTCOME DESCRIPTIONS
(Continued)

CATEGORY	OUTCOME DESCRIPTION
LLCO	Low pressure with large loss of coolant and the RHRS is open to the RCS. The running pump has not been stopped and coolant is exiting via two or more relief valves. The operator must take action to stop the running pump or isolate it and then must check that the relief valves have reseated completely. The operator must also be aware of possible deadheading or air entrainment of the RHRS pumps.
LLCI	Low pressure with large loss of coolant and the RHRS is isolated from the RCS. The running pump has not been stopped and coolant is exiting via two or more relief valves. The operator must take action to stop the running pump or isolate it and then must check that the relief valves have reseated completely.
MSFO	Medium pressure with small loss of coolant and the RHRS is open to the RCS. The running pump has been stopped but one of the relief valves has failed to reseat. The operator must take action to reseat the valve or isolate it and then must add makeup. He must also reduce the RCS pressure and check on the integrity of the RHRS.
MSFI	Medium pressure with small loss of coolant and the RHRS is isolated from the RCS. The running pump has been stopped but one of the relief valves has failed to reseat. The operator must take action to reseat the valve or isolate it and then must add makeup. He must also reduce the RCS pressure and then reinitialize RHRS operation.
MSCO	Medium pressure with small loss of coolant and the RHRS is open to the RCS. The running pump has not been stopped and coolant is exiting via one relief valve. The operator must take action to stop the running pump or isolate it and then must check that the relief valves have reseated completely. He must also reduce the RCS pressure and check on the integrity of the RHRS.

TABLE 4-5
TRANSIENT EVENT OUTCOME DESCRIPTIONS
(Continued)

CATEGORY	OUTCOME DESCRIPTION
MSCI	Medium pressure with small loss of coolant and the RHRS is isolated from the RCS. The running pump has not been stopped and coolant is exiting via one relief valve. The operator must take action to stop the running pump or isolate it and then must check that the relief valves have reseated completely.
MLFO	Medium pressure with large loss of coolant and the RHRS is open to the RCS. The running pump has been stopped but two or more of the relief valves has failed to reseat. The operator must take action to reseat the valves or isolate them and then must add makeup. He must also reduce the RCS pressure and check on the integrity of the RHRS.
MLFI	Medium pressure with large loss of coolant and the RHRS is isolated from the RCS. The running pump has been stopped but two or more of the relief valves has failed to reseat. The operator must take action to reseat the valves or isolate them and then must add makeup. He must also reduce the RCS pressure and then reinitialize RHRS operation.
MLCO	Medium pressure with large loss of coolant and the RHRS is open to the RCS. The running pump has not been stopped and coolant is exiting via two or more relief valves. The operator must take action to stop the running pump or isolate it and then must check that the relief valves have reseated completely. The operator must also be aware of possible deadheading or air entrainment of the RHRS pumps. He must also reduce the RCS pressure and check on the integrity of the RHRS.
MLCI	Medium pressure with large loss of coolant and the RHRS is isolated from the RCS. The running pump has not been stopped and coolant is exiting via two or more relief valves. The operator must take action to stop the running pump or isolate it and then must check that the relief valves have reseated completely. He must also reduce the RCS pressure.

TABLE 4-5
TRANSIENT EVENT OUTCOME DESCRIPTIONS
(Continued)

CATEGORY	OUTCOME DESCRIPTION
MOPI	Medium overpressure with the RHRS isolated from the RCS. The [illegible]ning pump has been stopped but no relief valves have actuated. The [illegible]or must reduce the RCS pressure and then reinitialize RHRS [illegible]
HOPI	[illegible] ure with the RHRS isolated from the RCS. The running [illegible] pped but no relief valves have actuated. The operator [illegible] S pressure, possibly through the RCS vents or pr[illegible] es.
HOPV	High overpressu[illegible] ith the RHRS open to the RCS. The running pump has not been stopped and no relief valves have actuated. The RHRS integrity is assumed to be lost and an interfacing systems LOCA has occurred. The operator must attempt to isolate the RHRS.

TABLE 4-6

VOGTLE
CHARGING ACTUATION
RESULTS

CONSEQUENCE CATEGORY	FREQUENCY WITH ACI	FREQUENCY WITHOUT ACI	FREQUENCY CHANGE
SUCCESS	8.667E-02	8.667E-02	0
LSFO	2.761E-04	2.761E-04	0
LSCI	0.00	0.00	0
LSCO	0.00	0.00	0
LLFO	4.671E-03	4.671E-03	0
LLCO	3.171E-02	3.171E-02	0
LLCI	1.661E-03	1.661E-03	0
LSFI	0.00	0.00	0
LLFI	2.412E-07	2.412E-07	0
MSFO	1.479E-13	3.906E-12	+3.758E-12
MLFO	0.00	0.00	0
MSFI	1.355E-05	1.355E-05	0
MLFI	0.00	0.00	0
MSCO	9.238E-14	2.439E-12	+2.347E-12
MSCI	7.739E-06	7.739E-06	0
MLCO	0.00	0.00	0
MLCI	0.00	0.00	0
MOPI	5.821E-07	5.821E-07	0
HOPI	2.245E-06	2.244E-06	0
HOPV	2.836E-16	7.488E-15	-7.204E-15
TOTAL	1.25E-01	1.25E-01	

WP0554:1D/082791

TABLE 4-7

VOGTLE
LETDOWN ISOLATION RHRS OPERABLE
RESULTS

CONSEQUENCE CATEGORY	FREQUENCY WITH ACI	FREQUENCY WITHOUT ACI	FREQUENCY CHANGE
SUCCESS	8.613E-02	8.613E-02	0
LSFO	1.649E-06	1.649E-06	0
LSCI	5.786E-13	5.786E-13	0
LSCO	2.003E-05	2.003E-05	0
LLFO	5.494E-03	5.494E-03	0
LLCO	3.336E-02	3.336E-02	0
LLCI	0.00	0.00	0
LSFI	5.177E-17	5.177E-17	0
LLFI	0.00	0.00	0
MSFO	0.00	0.00	0
MLFO	0.00	0.00	0
MSFI	0.00	0.00	0
MLFI	0.00	0.00	0
MSCO	0.00	0.00	0
MSCI	0.00	0.00	0
MLCO	0.00	0.00	0
MLCI	0.00	0.00	0
MOPI	5.213E-13	5.212E-13	-1.00E-16
HOPI	3.255E-13	3.255E-13	0
HOPV	1.693E-18	4.470E-17	+4.30E-17
TOTAL	1.25E-01	1.25E-01	

TABLE 4-8

VOGTLE
LETDOWN ISOLATION RHRS ISOLATED
RESULTS

CONSEQUENCE CATEGORY	FREQUENCY WITH ACI	FREQUENCY WITHOUT ACI	FREQUENCY CHANGE
SUCCESS	3.261E-01	1.627E-01	-1.634E-01
LSFO	0.00	0.00	0
LSCI	1.402E-03	6.994E-04	-7.026E-04
LSCO	0.00	0.00	0
LLFO	0.00	0.00	0
LLCO	0.00	0.00	0
LLCI	1.174E-01	5.856E-02	-5.884E-02
LSFI	1.016E-07	5.069E-08	-5.091E-08
LLFI	1.701E-05	8.488E-06	-8.522E-06
MSFO	0.00	0.00	0
MLFO	0.00	0.00	0
MSFI	0.00	0.00	0
MLFI	0.00	0.00	0
MSCO	0.00	0.00	0
MSCI	0.00	0.00	0
MLCO	0.00	0.00	0
MLCI	0.00	0.00	0
MOPI	0.00	0.00	0
HOPI	1.339E-04	6.682E-05	-6.708E-05
HOPV	0.00	0.00	0
TOTAL	4.45E-01	2.22E-01	

5.0 ADEQUACY OF THE RHRS RELIEF VALVE CAPACITY

The Vogtle RHRS is protected from inadvertent overpressurization by ASME Code relief valves located in each RHRS pump's suction line from the RCS hot leg, downstream of the inlet isolation valves. The main purpose of the RHRS relief valves are to protect the RHRS from overpressurization during residual heat removal operation. In addition, the RHRS relief valves have been qualified as an acceptable RCS Overpressure Protection System required by Appendix G to 10CFR50.

Originally, the Westinghouse sizing basis for the valves provided RHRS overpressure protection for the potential overpressure transient caused by the mismatch between the charging and letdown systems while the RCS is water-solid. This event was chosen as the original design basis since operating procedures and precautions were in place to prevent other, more severe, RHRS overpressurization events (e.g., inadvertent RCP restart or inadvertent safety injection). Based on this condition, the relief valves were sized to relieve the combined flow of all three charging pumps at the relief valve setpressure. The Procurement/Equipment Specification requirements of the valves indicate that the original valve design assumed a single design condition at the valve setpressure of 450 psig, plus 10 percent accumulation:

inlet temperature = 400°F
relieving rate = 900 gpm
maximum backpressure = 50 psig

It is noted that actual backpressure developed in the discharge piping layout at the rated flow and temperature will exceed the 50 psig design limit.

The maximum backpressure will equal the maximum PRT pressure (100 psig) plus piping losses. This discrepancy was previously discussed in Westinghouse letter GP-14838 (Reference 11).

An analysis was performed by Westinghouse to calculate actual valve capacity at maximum relieving backpressures. Westinghouse letter GP-14896, (Reference 12) reported the results of this evaluation. It was concluded that the rated relief capacity was achieved even when assuming 100 psig PRT backpressure, piping losses, and the potential for two phase flow.

The Vogtle Technical Specification 3.4.9.3 specifies that two RHRS suction relief valves represent an acceptable Cold Overpressure Protection System. This requires that the RHRS relief valves have adequate capacity to mitigate the design basis mass and heat injection events over the entire RCS temperature range for which cold overpressure protection is necessary.

Assuming a single failure, one RHRS relief valve has adequate capacity to mitigate the design basis heat injection event for a primary-to-secondary delta-T of up to 50°F for an indicated RCS temperature up to 200°F. For RCS temperatures from 200°F to 350°F, one RHRS relief valve has adequate capacity to mitigate the heat injection event for a primary-to-secondary delta-T that varies linearly with RCS temperature. Therefore, as noted in Reference 12, certain procedural restrictions are required to qualify the RHRS relief valves as an acceptable Cold Overpressure Protection System. Given these administrative restrictions, which are reflected in the Technical Specifications, it is concluded that the relief valves have adequate capacity to mitigate the affects of an LTOP event.

6.0 PROPOSED DOCUMENT CHANGES

The following sections show the proposed changes to the Vogtle Technical Specifications and Final Safety Analysis Report (FSAR) that would be recommended for the removal of the ACI of the RHRS isolation valves.

6.1 Technical Specifications

In general, the RHRS ACI removal has the potential to impact the Technical Specifications in the following two places:

1. The Surveillance Requirement, which is required to demonstrate ECCS subsystem OPERABILITY.

2. The Surveillance Requirement in the Overpressure Protection Systems specification for those plants, such as Vogtle, which take credit for the RHRS suction relief valves as a means of cold overpressure protection.

For Vogtle, Surveillance Requirement 4.5.2.d.1 is required to demonstrate ECCS subsystem OPERABILITY. The surveillance requires that the automatic isolation and interlock function of the RHRS suction/isolati valves be demonstrated OPERABLE on an 18 month interval.

However, with the removal of the ACI function, there is no longer a need to retain this surveillance requirement. Figure 6-1 shows the proposed change to Surveillance Requirement 4.5.2.d.1.

Note, the removal of the RHRS ACI does not affect the OPI. However, it is recommended that the OPI setpoint be modified to address available margins in instrumentation and piping system elevation considerations.

Additionally, the 12 hour surveillance interval of specification 4.4.9.3.2.a and 4.4.9.3.2.b should be changed to be consistent with the surveillance interval of specification 4.4.9.3.1.c for verifying that the PORV isolation valves are open when the PORV is used for overpressure protection. The change is shown in Figure 6-2.

6.2 Final Safety Analysis Report

Figures 6-4 through 6-7 illustrate the proposed changes to the Vogtle FSAR that would result from the removal of the ACI of the RHRS isolation valves. The affected pages were copied from the FSAR and annotated to show the proposed changes.

The sections that were affected include:

1. RHRS, Design Bases - Section 5.4.7.1.

2. RHRS, System Design, Schematic Piping, and Instrumentation Diagrams - Section 5.4.7.2.1,

3. RHRS, System Design, Control - Section 5.4.7.2.4, and

4. Interl ck Systems Important to Safety, Residual Heat Removal Isolation Valves - Section 7.6.2.

In addition, a change is proposed for Figure 7.6.2-1 (shown in Figure 6-8). The current logic diagram shown in this figure should be replaced with the proposed logic diagram shown in Figure 6-9.

Note, the removal of the RHRS ACI does not affect the OPI. However, it is recommended that the OPI setpoint be modified to address available margins in instrumentation and piping system elevation considerations.

SURVEILLANCE REQUIREMENTS

4.5.2 Each ECCS subsystem shall be demonstrated OPERABLE:

a. At least once per 12 hours by verifying that the following valves are in the indicated positions with power lockout switches in the lockout position:

Valve Number	Valve Function	Valve Position
HV-8835	SI Pump Cold Leg Inj.	OPEN
HV-8840	RHR Pump Hot Leg Inj.	CLOSED
HV-8813	SI Pump Mini Flow Isol.	OPEN
HV-8806	SI Pump Suction from RWST	OPEN
HV-8802A, B	SI Pump Hot Leg Inj.	CLOSED
HV-8809A, B	RHR Pump Cold Leg Inj.	OPEN*

b. At least once per 31 days by:

1) Verifying that the ECCS piping is full of water by venting the ECCS pump casings and accessible discharge piping high points, and

2) Verifying that each valve (manual, power-operated, or automatic) in the flow path that is not locked, sealed, or otherwise secured in position, is in its correct position.

c. By a visual inspection which verifies that no loose debris (rags, trash, clothing, etc.) is present in the containment which could be transported to the Containment Emergency Sump and cause restriction of the pump suctions during LOCA conditions. This visual inspection shall be performed:

1) For all accessible areas of the containment prior to establishing CONTAINMENT INTEGRITY, and

2) Of the areas affected within containment at the completion of each containment entry when CONTAINMENT INTEGRITY is established.

d. At least once per 18 months by:

1) Verifying automatic isolation ~~and interlock~~ action of the RHR system from the Reactor Coolant System by ensuring that, w

~~a)~~ With a simulated or actual Reactor Coolant System pressure signal greater than or equal to ~~377~~ 365 psig the interlocks prevent the valves from being opened. ~~and~~

~~b) with a simulated or actual Reactor Coolant System pressure signal less than or equal to 750 psig the interlocks will cause the valves to automatically close.~~

2) A visual inspection of the Containment Emergency Sump and verifying that the subsystem suction inlets are not restricted by debris and that the sump components (trash racks, screens, etc.) show no evidence of structural distress or abnormal corrosion.

*Either valve may be realigned in Mode 3 for testing pursuant to Specification 4.4.6.2.2.

Figure 6-1 Proposed Change to Vogtle Technical Specification 4.5.2.d

REACTOR COOLANT SYSTEM

OVERPRESSURE PROTECTION SYSTEM

SURVEILLANCE REQUIREMENTS

4.4.9.3.1 Each PORV shall be demonstrated OPERABLE by:

a. Performance of an ANALOG CHANNEL OPERATIONAL TEST on the PORV actuation channel, but excluding valve operation, within 31 days prior to entering a condition in which the PORV is required OPERABLE and at least once per 31 days thereafter when the PORV is required OPERABLE;

b. Performance of a CHANNEL CALIBRATION on the PORV actuation channel at least once per 18 months; and

c. Verifying the PORV isolation valve is open at least once per 72 hours when the PORV is being used for overpressure protection.

4.4.9.3.2 Each RHR suction relief valve shall be demonstrated OPERABLE when the RHR suction relief valves are being used for cold overpressure protection as follows:

a. For RHR suction relief valve PSV-8708A by verifying at least once per ~~12~~ 72 hours that RHR RCS suction isolation valves HV-8701A and HV-8701B are open;

b. For RHR suction relief valve PSV-8708B by verifying at least once per ~~12~~ 72 hours that RHR RCS suction isolation valves HV-8702A and HV-8702B are open; and

c. Testing pursuant to specification 4.0.5.

4.4.9.3.3 The RCS vent(s) shall be verified to be open at least once per 12 hours* when the vent(s) is being used for overpressure protection.

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*Except when the vent pathway is provided with a valve which is locked, sealed, or otherwise secured in the open position, then verify these valves open at least once per 31 days.

VOGTLE UNITS - 1 & 2 3/4 4-36

Figure 6-2 Proposed Change to Vogtle Technical Specification 4.4.9.3.1

WP0554:1D/090591

REACTOR COOLANT SYSTEM

COLD OVERPRESSURE PROTECTION SYSTEMS

LIMITING CONDITION FOR OPERATION

3.4.9.3 At least one of the following Cold Overpressure Protection Systems shall be OPERABLE:

a. Two power-operated relief valves (PORVs) with lift settings which vary with RCS temperature and which do not exceed the limits established in Figure 3.4-4a (Unit 1), Figure 3.4-4b (Unit 2), or

b. Two residual heat removal (RHR) suction relief valves each with a setpoint of 450 psig ± 3%, or

c. The Reactor Coolant System (RCS) depressurized with an RCS vent capable of relieving at least 670 gpm water flow at 470 psig.

APPLICABILITY: MODES 4, 5, and 6 with the reactor vessel head on.

ACTION:

a. With one PORV and one RHR suction relief valve inoperable, either restore two PORVs or two RHR suction relief valves to OPERABLE status within 7 days or depressurize and vent the RCS as specified in Specification 3.4.9.3.c, above, within the next 8 hours.

b. With both PORVs and both RHR suction relief valves inoperable, depressurize and vent the RCS as specified in Specification 3.4.9.3.c, above, within 8 hours.

c. In the event either the PORVs, the RHR suction relief valves, or the RCS vent(s) are used to mitigate an RCS pressure transient, a Special Report shall be prepared and submitted to the Commission pursuant to Specification 6.8.2 within 30 days. The report shall describe the circumstances initiating the transient, the effect of the PORVs, the RHR suction relief valves or RCS vent(s) on the transient, and any corrective action necessary to prevent recurrence.

d. The provisions of Specification 3.0.4 are not applicable.

VOGTLE UNITS - 1 & 2 3/4 4-34

Figure 6-3 Vogtle Overpressure Protection Systems Technical Specification 3.4.9.3

WP0554:1D/090591

a control room alarm will alert the operators if a valve is open and the RCS pressure exceeds a preset value.

365

line. Each motor-operated valve is interlocked to prevent its opening if RCS pressure is greater than approximately ~~425~~ 365 psig and ~~to automatically close before RCS pressure exceeds 750 psig.~~ a control room alarm will alert the operators if a valve is open and the RCS pressure exceeds a preset value. The RHRS is isolated from the RCS on the discharge side by two check valves in each return line. Also provided on the discharge side is a normally open motor-operated valve downstream of each RHRS heat exchanger. (These check valves and motor-operated valves are not considered part of the RHRS; they are shown as part of the ECCS. See figure 6.3.1-1.)

Each inlet line to the RHRS is equipped with a pressure relief valve designed to prevent RHRS overpressurization assuming the most severe overpressure transients. These relief valves protect the system from inadvertent overpressurization during plant startup, shutdown, and cold shutdown decay heat-removal operations.

Each discharge line from the RHRS to the RCS is equipped with a pressure relief valve designed to relieve the maximum possible backleakage through the valves isolating the RHRS from the RCS.

These valves are considered part of the ECCS, as depicted in figure 6.3.2-1, sheet 3. Relief capacity of these valves is given in table 6.3.2-2.

The RHRS is designed for a single nuclear power unit and is not shared between units.

The RHRS is designed to be fully operable from the control room for normal operation. Manual operations required of the operator are opening the suction isolation valves, positioning the flow control valves downstream of the residual heat exchangers, and starting the residual heat removal (RHR) pumps. By nature of its redundant design, the RHRS is designed to accept all major component single failures, with the only effect being an extension in the required cooldown time. There are no motor-operated valves in the RHRS that are subject to flooding following a secondary side break or a LOCA. Although considered to be of low probability, spurious operation of a single motor-operated valve can be accepted without loss of function as a result of the redundant two-train design.

Missile protection, protection against dynamic effects associated with the postulated rupture of piping, and seismic design are discussed in section 3.5 and subsections 3.6.2 and 3.7.N.2, respectively.

5.4.7-2

Figure 6-4 Proposed Vogtle FSAR Change - Section 5.4.7.1

The RHRS is also used for filling the refueling cavity before refueling. After refueling operations, the RHRS is used to pump the water back to the refueling water storage tank until the water level is brought down to the flange of the reactor vessel. The remainder of the water is removed via a drain connection at the bottom of the refueling canal.

When the RHRS is in operation, the water chemistry is the same as that of the reactor coolant. Provision is made for the process sampling system to extract samples from the flow of reactor coolant downstream of the residual heat exchangers. A local sampling point is also provided on each RHR train between the pump and heat exchanger.

The RHRS also functions, in conjunction with the high-head portion of the ECCS, to provide injection of borated water from the refueling water storage tank into the RCS cold legs during the injection phase following a loss-of-coolant accident (LOCA).

In its capacity as the low-head portion of the ECCS, the RHRS provides long-term recirculation capability for core cooling following the injection phase of the LOCA. This function is accomplished by aligning the RHRS to take fluid from the containment sump, cool it by circulation through the residual heat exchangers, and supply it to the core directly as well as via the centrifugal charging pumps and safety injection pumps.

The use of the RHRS as part of the ECCS is more completely described in section 6.3.

The RHR pumps, in order to perform their ECCS function, are interlocked to start automatically on receipt of a safety injection signal (section 6.3).

The RHRS suction isolation valves in each inlet line from the RCS are separately interlocked to prevent both of them from being opened when RCS pressure is greater than approximately ~~425~~ psig and ~~to automatically close before RCS pressure exceeds~~
365 ~~750 psig~~. These interlocks are described in more detail in paragraph 5.4.7.2.4 and subsection 7.6.2.

The RHRS suction isolation valves are also interlocked to prevent their being opened unless the isolation valves in the following lines are closed:

A. Recirculation lines from the residual heat exchanger outlets to the suctions of the safety injection pumps and centrifugal charging pumps.

a control room alarm will alert the operators if a valve is open and the RCS pressure exceeds a preset value.

Figure 6-5 Proposed Vogtle FSAR Change - Section 5.4.7.2.1

WP0554:1D/090591

5.4.7.2.4 Control

Each inlet line to the RHRS is equipped with a relief valve to prevent RHRS overpressurization during plant startup, shutdown, and cold shutdown decay heat-removal operation. Each valve has a relief capacity of 900 gal/min at a set pressure of 450 psig. An analysis has been conducted to confirm the capability of the RHRS relief valve to prevent overpressurization in the RHRS. All credible events were examined for their potential to overpressurize the RHRS. These events included normal operating conditions, infrequent transients, and abnormal occurrences. The analysis confirmedthat one relief valve has the capability to maintain the RHRS maximum pressure within code limits. The above capacities of the RHRS suction line relief valves are adequate to provide relief protection necessary for the RHRS and the RCS as part of the cold overpressure mitigating system. For a discussion of the cold overpressure mitigating system and the overpressure events examined, refer to WCAP-10529.

Each discharge line from the RHRS to the RCS is equipped with a pressure relief valve to relieve the maximum possible back-leakage through the valves separating the RHRS from the RCS. Each valve has a relief flow capacity of 20 gal/min at a set pressure of 600 psig. These relief valves are located in the ECCS (figure 6.3.1-1).

The fluid discharged by the suction side relief valves is collected in the pressurizer relief tank. The fluid discharged by the discharge side relief valves is collected in the recycle holdup tank.

The design of the RHRS includes two motor-operated gate isolation valves in series on each inlet line between the high-pressure RCS and the lower pressure RHRS. They are closed during normal operation and are opened only for RHR during a plant shutdown after the RCS pressure is reduced to approximately 400 psig or lower and RCS temperature is reduced to approximately 350°F. During a plant startup, the inlet isolation valves are shut after drawing a bubble in the pressurizer and prior to increasing RCS pressure above 425 psig. These isolation valves are provided with independent and diverse "prevent-open" ~~and "auto-closure"~~ interlocks which are designed to prevent possible exposure of the RHRS to normal RCS operating pressure. The two inlet isolation valves in each RHR subsystem are independently interlocked with diverse pressure signals to prevent their being opened whenever the RCS pressure is greater than approximately ~~377~~ 365 psig. Additionally, ~~the valves are independently interlocked with diverse pressure signals to automatically shut before RCS pressure increases to 750 psig during a plant startup.~~ a control room alarm will alert the operators if a valve is open and the RCS pressure exceeds a preset value.

Figure 6-6 Proposed Vogtle FSAR Change - Section 5.4.7.2.4

7.6.2 RESIDUAL HEAT REMOVAL ISOLATION VALVES

7.6.2.1 Description

The residual heat removal system (RHRS) isolation valves are normally closed and are only opened for residual heat removal (RHR) after system pressure is reduced to approximately 425 psig and system temperature has been reduced to approximately 350°F.

There are two motor-operated valves in series in each of the two RHR pump suction lines from the reactor coolant system (RCS) hot legs. The two valves nearest the RCS (valves HV8701B and HV8702B) are designated as the inner isolation valves, while the two valves nearest the RHR pumps (valves HV8701A and HV8702A) are designatnd as the outer isolation valves. The interlock logic provided for the isolation valves is shown in figure 7.6.2-1. Logic for the outer valves is identical to that provided for the inner isolation valves, except that equipment diversity is employed by virtue of the fact that the pressure transmitter set used for valve interlocks on the inner valves is manufactured differently from the pressure transmitter set used for the outer valve interlocks.

Each valve is interlocked so that it cannot be opened at the main control board unless the RCS pressure is below a preset pressure. This interlock prevents the valve from being opened at the main control board when the RCS pressure plus the RHR pump pressure would be above the RHRS design pressure. A ~~second pressure interlock is provided to close the valve automatically if the RCS pressure subsequently increases to above a preset value~~.

The interlock table for the inner and outer isolation valves is shown in table 7.6.2-1. Inner isolation valve HV8701B (in train C) and outer isolation valve HV8702A (in train D) are interlocked by valve position signals derived from stem-mounted switches on valves in the opposite train. The valves themselves are identified in table 7.6.2-1. These switches (designated limit switches No. 2) are operated by the position of the valve stem and are separate from the switches supplied with the valve motor operator (designated No. 1). The motor-operated limit switch on each valve is connected to the same electrical train as the valve motor with which it is interlocked.

RCS pressure control during low temperature operation is discussed in paragraph 5.2.2.10.

control room alarm will alert the operators if a valve is open and the RCS pressure exceeds a preset value.

Figure 6-7 Proposed Vogtle FSAR Change - Section 7.6.2

WP0554:1D/090591

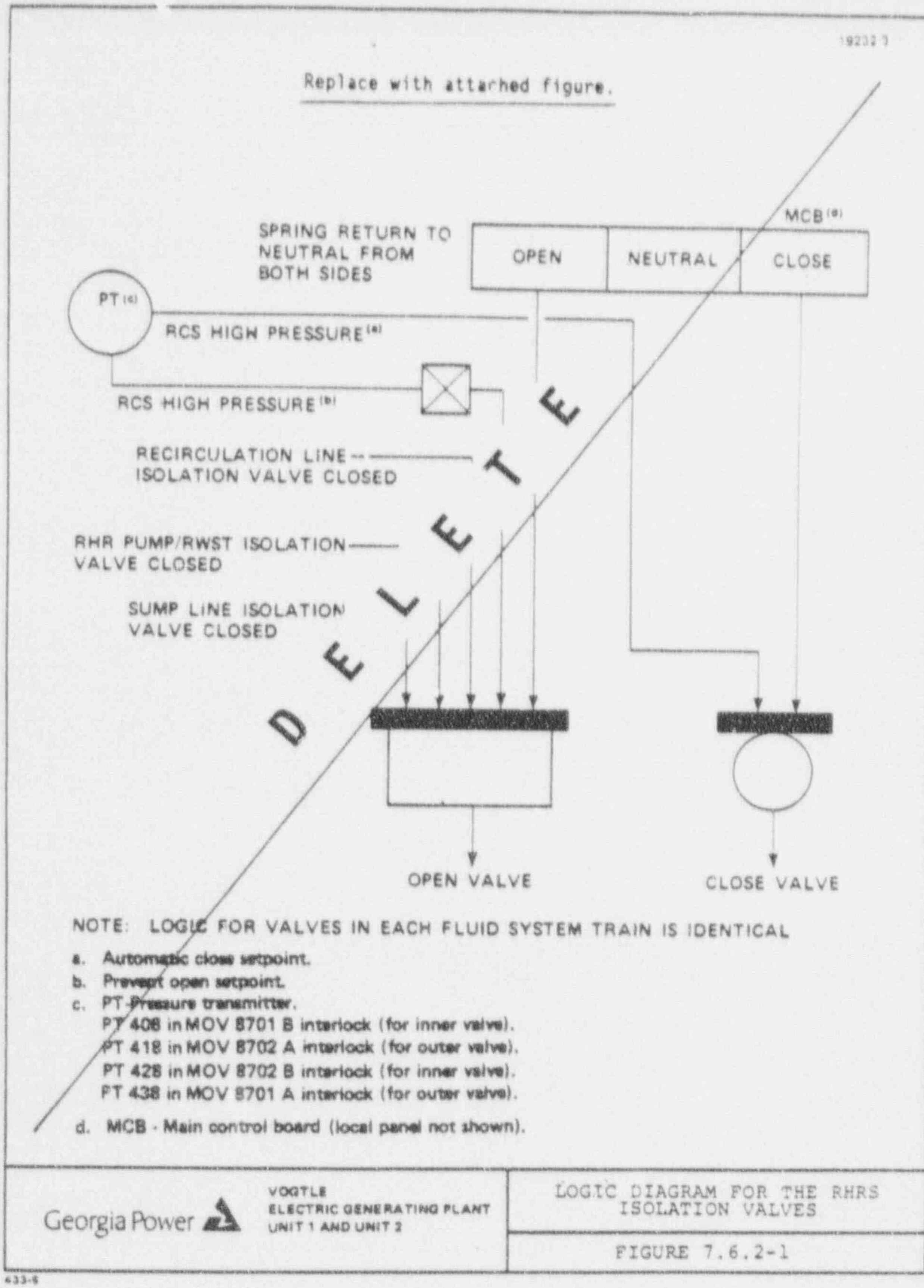

Figure 6-8 Vogtle FSAR Figure 7.6.2-1

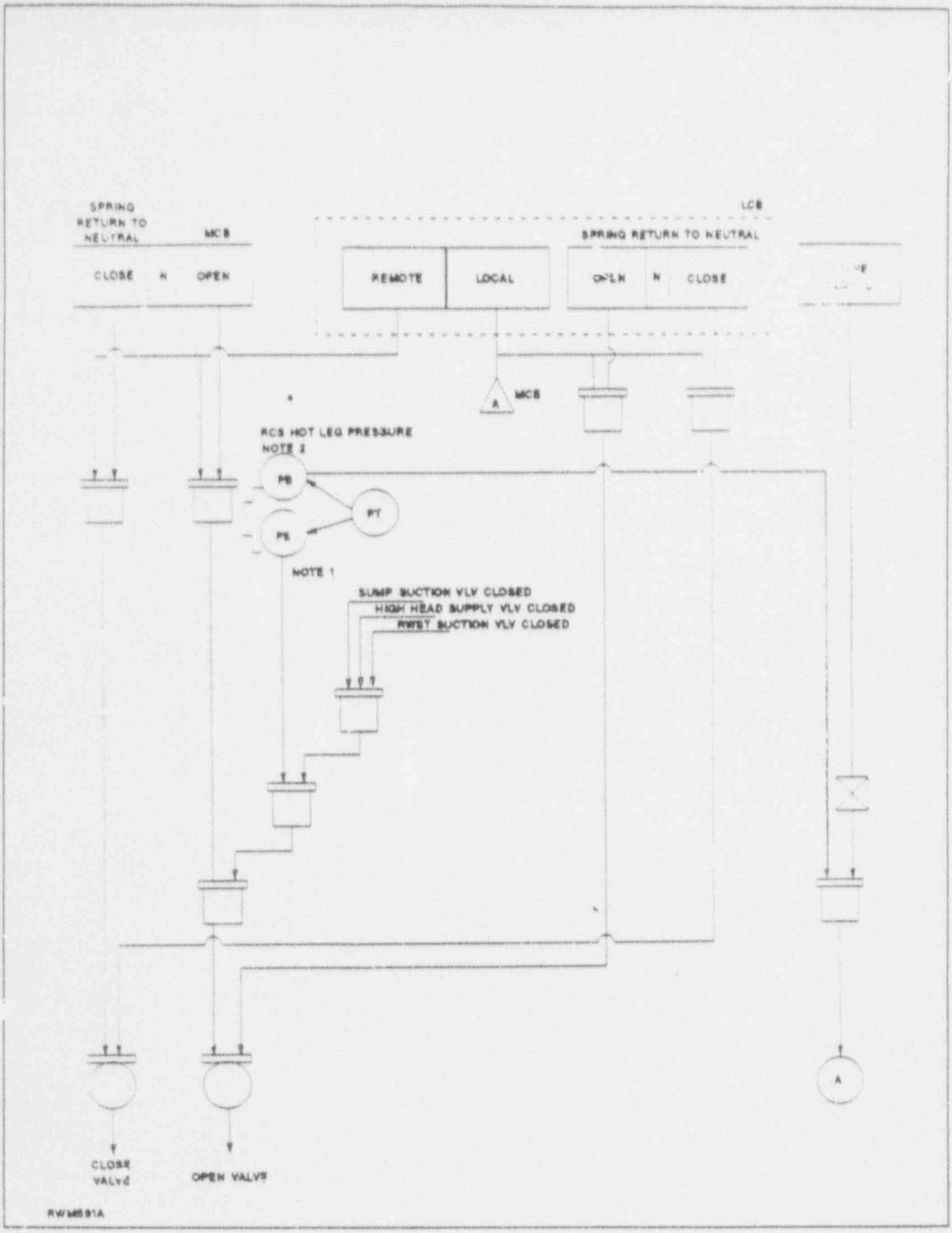

Figure 6-9 Proposed Revision for Vogtle FSAR Figure 7.6.2-1

7.0 CONCLUSIONS AND RECOMMENDATIONS

This section addresses the seven concerns expressed in the NRC internal memorandum (Reference 4) of January, 1985 stating the NRC Reactor Systems Branch position on requests for removal of the RHRS ACI. The memorandum stated that any proposal to remove the ACI should be substantiated by proof that the change is a net improvement in safety and should assess, as a minimum, the following:

1. The means available to minimize Event V concerns.

2. The alarms to alert the operator of an improperly positioned RHRS MOV.

3. The RHRS relief capacity must be adequate.

4. Means other than the ACI to ensure both MOVs are closed (e.g., single switch actuating both valves).

5. Assurance that the function of the open permissive circuitry is not affected by the proposed change.

6. Assurance that MOV position indication will remain available in the control room regardless of the proposed change.

7. Assessment of the affect of the proposed change on the reliability of the RHRS, as well as on LTOP concerns.

Each of the seven items above will be commented on separately and reference will be made to supporting analysis contained in this report, where applicable.

Means Available To Minimize A LOCA Outside The Containment

An interfacing systems LOCA, referred to as an Event V in WASH-1400, is a breach of the high pressure RCS pressure boundary at an interface with the low pressure piping system. An RHRS LOCA is classified as a non-mitigable LOCA outside containment. It is assumed to occur if the isolation valves in the RHRS suction line fail open when the RCS is at normal operating pressure (2235 psia). Since the RHRS is designed for a much lower pressure (600 psig), the result of both suction/isolation valves failing open is overpressurization of the RHRS. The Vogtle RHRS is located outside of containment. Thus, a gross failure of the RHRS pressure boundary is assumed to result in an uncontained LOCA.

The Vogtle RHRS has two motor-operated gate suction/isolation valves on each hot leg suction line from the RCS. These valves on each suction line serve as the primary RCS pressure boundary. They are remotely operated from the Main Control Room, and are powered by separate Class 1E electrical power sources. Power to these valves is manually locked out in Modes 1, 2, and 3. Plant operating procedures instruct the operator to isolate the RHRS during plant heatup, so the likelihood of these valves being left open is remote. Additionally, this report recommends the installation of a Main Control Room alarm to alert the operator if a RHRS suction/isolation valve is not fully closed in conjunction with a "RCS PRESSURE HIGH" signal (see Section 3.0).

Should a pressure peak occur in the RCS, the pressure effect on the low pressure RHRS would be mitigated by the RHRS suction line relief valves. These relief valves discharge inside containment to the PRT. A discharge would be detected by high temperature, level, and pressure alarms in the PRT.

The results of the interfacing systems LOCA probabilistic analyses (Table 4-2) for Vogtle showed a 35 percent reduction in frequency with the deletion of the RHRS ACI.

In conclusion, sufficient means are available to minimize a LOCA outside of containment, and removal of the ACI feature is desirable in that it reduces the frequency of an interfacing systems LOCA in Modes 1, 2, and 3.

<u>Alarms To Alert The Operator Of An Improperly Positioned RHRS Isolation Valve</u>

With the proposed interlocks and functional requirements for Vogtle, it is recommended that an alarm be added for each suction/isolation valve, which will actuate in the Main Control Room given a "VALVE NOT FULLY CLOSED" signal in conjunction with a "RCS PRESSURE-HIGH" signal. The proposed Elementary Wiring Diagram modifications to the individual valve control circuitry are presented in Section 3. The intent of the alarms is to alert the operator that a RCS-RHRS, suction/isolation valve(s) in series is not fully closed, and that double valve isolation of the RHRS from the RCS is not being maintained. Valve position indication to the alarm should be provided from the valve limit switches, and power to the limit switches must not be affected by removal of power to the valve.

The alarm meets the intent of the requirements of Regulatory Guide 1.139, (Reference 13) "Guidance For Residual Heat Removal," which states that it is the regulatory position on RHRS isolation that alarms in the control room should be provided to alert the operator if either valve is open when the RCS pressure exceeds RHRS design pressure.

Verification Of The Adequacy Of RHRS Relief Valve Capacity

The proposed design change as described in Section 3.0 of this report has no impact on the performance and/or design basis assumption used in the original sizing of the valve. As such, the RHRS relief valves perform adequately to meet their original design basis criteria as described in Section 5.0.

Means Other Than Autoclose Interlocks to Ensure Both Isolation Valves Are Closed (e.g., Single Switch Actuating Both Valves)

Current Vogtle operating instructions, along with redundant position indication and the proposed alarm, are sufficient to insure isolation. The addition of a single switch to close both valves would prevent the cycling of individual suction/isolation valves. This would require Vogtle to lift leads and add jumpers during valve maintenance. The location of the existing control switches for the train A valves (HV-8701A and HV-8702A) are side by side on the Main Control Board. The train B valves (HV-8701B and HV-8702B) are located below the train A valves. Layout of switches were human factored to ensure timely operator action in the event the valves needed to be closed. Additionally, assurance that the valves will remain closed is better obtained by procedural controls, such as removing power to the valves before conducting the surveillance leak tests required on both valves during startup. This procedural control would provide positive assurance that the valves remain closed during pressurization to normal operating conditions.

Assurance That the Open Permissive Circuitry is Neither Removed or Affected by the Proposed Change

The proposed design change, as described in Section 3.0 of this report, leaves the OPI circuit intact. Hardware changes are limited to removal of the ACI portion of the valve control circuitry and the addition of an alarm. Neither one of these changes affect the operation of the RHRS OPI.

Assurance That Isolation Valve Position Indication Will Remain Available in the Control Room Regardless of the Proposed Change

With the proposed design change, as described in Section 3.0 of this report, the valve position indication at the Main Control Board is still provided.

Assessment of the Affect of the Proposed Change on Availability of the RHRS, As Well as Low Temperature Overpressure Protection

RHRS UNAVAILABILITY ANALYSIS

The availability of the RHRS to remove decay heat was considered in three phases for the RHRS Unavailability Analysis. The first phase covers the period during which the RHRS is placed into service and goes through a warm-up period needed to minimize the thermal shock to the system and insure boron mixing. The second phase covers the initial period of cooldown when the decay heat load is high. During this phase, two trains of RHRS (two pumps and two heat exchangers) are assumed to be in operation for 72 hours. The third phase covers the final long-term period of cooldown when the heat load is smaller. For this phase only one train of RHRS (one pump and one heat exchanger) is assumed to be in operation. Six weeks was the time period assumed for this phase (based on the average refueling outage time period). The results of the quantification of the Vogtle RHRS unavailability fault trees, discussed in Section 4.4, show that deletion of the ACI reduces the number of spurious closures of the suction valves and thus increases the availability of the RHRS. These results are summarized below:

	Percent Change in Availability of the RHRS
RHRS Initiation	0
Short Term Cooling	25.5 increase
Long Term Cooling	39.8 increase

OVERPRESSURIZATION ANALYSIS

The effect of an overpressure transient at cold shutdown conditions will be altered by the removal of the RHRS ACI feature. An overpressurization analysis was conducted (Section 4.5), which used event trees to model the mitigating actions (both automatic and manual) following the occurrence of LTOP events. These mitigating actions affect the severity of the overpressurization events and reduce the possibility of damage to the plant. The analysis was conducted in two parts: 1) determination of the frequency of cold overpressurization events; and 2) the effect of mitigation on the transients. Nine initiating events that fell into two broad categories, heat input transients and mass input transients, were considered (Section 4.5.1).

For the heat input transients, which were considered, the pressure peak is either acceptably low with reference to the RHRS suction relief valves, or the transient proceeds so quickly that the RHRS ACI could not cause the slow acting RHRS suction/isolation valve to close in time to affect the transient. The analysis concludes that the removal of the RHRS ACI feature will have no effect on the heat input transients. (Refer to Section 4.5.2 and the WOG WCAP-11736 for discussion).

For the slower mass input transients event trees were utilized to model the mitigating actions that occur following the transients (Section 4.5.2). Operator actions and mitigating systems were included in the event trees. Success criteria for each event tree top event were developed and system/component failure probabilities were calculated.

The conclusion to be drawn from the overpressure analysis is that removal of the ACI has a positive impact on the consequences of LTOP events for Vogtle.

It should be understood that the ACI was not installed to mitigate overpressure transients. The RHRS suction valves are slow-acting and take approximately two minutes to close. The ACI will not protect the RHRS from a fast-acting overpressure transient such as the startup of a RCP.

The major impact with respect to overpressure concerns is that removal of the ACI will significantly reduce the number of letdown isolation transients.

8.0 REFERENCES

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2. "Safety Evaluation Report by the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, in the Matter of Westinghouse Electric Company Reference Safety Analysis Report RESAR-41, Docket No. STN 50-480," NUREG-75/103, December 31, 1975, pages 5-17 to 5-19, 7-15, 7-16, and Appendix C.

3. "Design Requirements of the Residual Heat Removal System," U.S. NRC Branch Technical Position RSB 5-1, Revision 2, July 1981.

4. Memorandum from B.W. Sheron, NRC to RSB members, "Auto Closure Interlocks for PWR Residual Heat Removal (RHR) Systems," January 28, 1985.

5. "Residual Heat Removal System Autoclosure Interlock Removal Report for the Westinghouse Owners," WCAP-11736, Volume I and II, February 1988.

6. Vogtle Precautions, Limits, and Setpoints Document, Revision 3, August 1988.

7. R. A. Bari, et. al., "Probabilistic Safety Analysis Procedures Guide," NUREG/CR-2815, Volume 1, Revision 1, August 1985.

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11. "Design Bases Inconsistencies of the RHR System Relief Valves Design Bases Inconsistencies," GP-14838, May 11, 1990.

12. "RHRS Relief Valve Performance for Cold Overpressure Protection," GP-14896, June 19, 1990.

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14. Military Handbook, "Reliability Prediction of Electrical Equipment," MIL-HDBK-2170, January 15, 1982.

APPENDIX A

VOGTLE
INTERFACING SYSTEM LOCA ANALYSIS

APPENDIX A

INTERFACING SYSTEM LOCA QUANTIFICATION

This appendix details the calculations performed to determine the change in the frequency of an interfacing system LOCA due to removal of the autoclosure interlock for Vogtle. An interfacing system LOCA is an important safety concern because a direct release of radionuclides to the atmosphere may occur. The frequency of an interfacing system LOCA via the RHRS suction path is calculated for two cases: 1) with the present interlock configuration; and, 2) with the proposed modification.

The methodology applied in the Westinghouse Owners Group generic program (WCAP-11736), Appendix B, is applied to the Vogtle plant. The data base from the WOG program was utilized in this analysis (Table 4-1).

The following boundary conditions and assumptions were applied in the analysis:

1. The calculation is based on an occurrence when the plant is at power (Modes 1, 2 or 3), not in the shutdown mode.

2. The valve closest to the RCS is at RCS pressure, and the valve closest to the RHRS is at RCS pressure only if the valve closest to the RCS fails open.

3. No common cause rupture of the valves is considered. This is based on the fact that no common cause ruptures of valves have actually occurred.

4. The frequency of valve rupture is that of catastrophic internal leakage. The failure rate is the same for either valve given that the valve is exposed to RCS pressure.

5. All electrical power to the control circuitry (i.e., 480 V AC bus) is assumed to be available with a probability of 1.0.

6. A refueling outage occurs approximately every 18 months (assumed to be the only time at which the plant will be in cold shutdown, on average).

The general expression from the WOG analysis used to calculate the frequency of an Event V (F(VSEQ)) for one RHRS suction line is:

$$F(VSEQ) = X\,[(g)_2\, Q(V_1) + (g)_1\, Q(V_2) + (g)_2\, Q(V_1R)]$$

where

- X = number of RHRS suction lines
- $(g)_2$ = failure rate of RHRS valve closest to the RCS (due to rupture)
- $(g)_1$ = failure rate of valve closest to RHRS (due to rupture)
- $Q(V_1)$ = probability that RHRS valve is open
- $Q(V_2)$ = probability that RCS valve is open
- $Q(V_1R)$ = probability of rupture of RHRS valve

In order to determine the probabilities of the motor-operated suction valves being "OPEN" ($Q(V_1)$ and $Q(V_2)$) in equation (1), detailed fault trees for the Vogtle control circuitry associated with these valves were developed.

Utilizing the present control circuitry diagram shown in Section 2.3 for suction valves MOV 8701A, 8701B, 8702A, and 8702B and the procedures for terminating the RHRS in preparation for startup, fault trees were developed that considered how a suction valve would be "OPEN" at power conditions. Component failures and human errors were included in the fault trees. The fault trees developed for the valves are shown in Figures A-1 and A-2. MOV 8701A and 8702B are identical and MOV 8701B and 8702A are also identical; therefore, only one fault tree for each set of valves was developed.

The scenarios examined in the fault trees for the case with the ACI are: 1) the operator fails to remove power to the valve by racking out the circuit breaker and subsequently the valve spuriously opens during power operation; or, 2) the operator fails to close the valve during startup (or the operator attempts to close the valve but due to some component failure, the valve does not close) and the ACI fails to perform its function and does not close the valve and an operator fails to detect that the valve is not closed during startup or power operation.

For the deletion of the ACI and the addition of an alarm, as shown in Section 3, detailed fault trees were also developed. The scenarios developed for this case are: 1) the operator fails to remove power to the valve by racking out the circuit breaker and subsequently the valve spuriously opens during power operation, or 2) the operator fails to close the valve during startup (or the operator attempts to close the valve but it does not close) and the operator fails to detect that the valve is not closed via the presence of an alarm (or the alarm fails to operate). The fault trees developed for this case are shown in Figures A-3 and A-4.

In each case (with the ACI and without the ACI), the first scenario is the same; only the second scenario differs due to the proposed modification.

For the Vogtle analysis, the following assumptions and boundary conditions were utilized:

1. The Shift Supervisor or Control Room Supervisor verifies the RHRS suction valves are closed before signing off checklist 2 of procedure 13011 "Residual Heat Removal System," and Instruction A4.3.11.c of procedure 12001-C, "Unit Heatup to Hot Shutdown."

2. The indicating lights associated with the RHRS suction valves do not have alarms associated with them.

3. A component failure would be detected in a 24 hour interval if it caused the suction isolation valve to spuriously open or fail to close.

In order to quantify the fault trees developed for these cases, each basic event probability was calculated and then input into the appropriate fault tree. For a component failure, the following formula was used:

$$Q(\text{component}) = \lambda \frac{T_{detect}}{2}$$

where

$Q(\text{component})$ = basic event probability

λ = failure rate for the component

T_{detect} = detection interval

Tables A-1 to A-4 show the basic event probabilities for each component utilizing a 24 hour detection interval.

The human error probabilities were calculated using "The Handbook for Human Reliability Analysis," Reference 10, and Vogtle's operating procedures for terminating the RHRS operation in preparation for startup. The calculations of the human error probabilities are shown in Table A-5.

RESULTS

The probabilities for $Q(V_1)$ and $Q(V_2)$, the probability that the isolation valve is open, for each case are shown below:

	With Autoclosure Interlock	Without Autoclosure Interlock
Q(8701A)	3.21E-04	9.32E-05
Q(8701B)	3.21E-04	9.32E-05
Q(8702A)	3.21E-04	9.32E-05
Q(8702B)	3.21E-04	9.32E-05

The major cutsets (failure combinations) and the probabilities of the cutsets for each case (with and without the ACI) are shown in Tables A-6 to A-9. For the case with the ACI (Tables A-6 and A-7), the dominant contributors are a component failure which causes the valve not to close along with the operator failing to detect that the valve did not close during startup and another operator failure to detect the wrong position during power operation.

For the ACI deletion case, the dominant contributors are the valve's limit switch failing along with the operator failing to detect that the valve is not closed during startup. The dominant contributors are listed in Tables A-8 and A-9.

Because Vogtle has two independent suction lines, the frequency of an interfacing system LOCA, is calculated using:

$$F(VSEQ) = 2\,\{(\lambda)_2\,Q(V_1) + (\lambda)_1\,Q(V_2) + (\lambda)_2\,Q(V_1R)\}$$

where

- 2 = the number of RHRS suction lines
- $(\lambda)_2$ = failure rate of RCS valve (due to rupture)
- $(\lambda)_1$ = failure rate of RHRS valve (due to rupture)
- $Q(V_1)$ = probability that RHRS valve is open
- $Q(V_2)$ = probability that RCS valve is open
- $Q(V_1R)$ = probability of rupture of RHRS valve

The failure rate due to rupture of a motor-operated valve is 1.0E-7 per hour ($(\lambda)_1$ and $(\lambda)_2$). The quantity $Q(V_1R)$ is determined by assuming that the total defined mission time is the time between refueling outages (i.e., every 18 months). The rupture of motor-operated valve is assumed to occur randomly in the time interval 0 - T_M where T_M is the total defined mission time. Therefore, the probability of the valve rupturing is:

$$Q(V_1R) = (\lambda)\ \frac{T_M}{2}$$

$$= \frac{1E\text{-}07}{hr}\ \left(\frac{8760\ hrs/year * 1.5\ years}{2}\right)$$

$$= 6.57E\text{-}04$$

Entering the failure probabilities leads to the following frequency for an interfacing system LOCA for the case with the ACI:

$$F(VSEQ) = 2\ \{(\lambda)_2\ Q(V_1) + (\lambda)_1\ Q(V_2) + (\lambda)_2\ Q(V_1R)\}$$

$$= 2\ [1E\text{-}07/hr * (3.21E\text{-}04) + 1E\text{-}07/hr * (3.21E\text{-}04) + 1E\text{-}07/hr * (6.57E\text{-}04)]$$

$$= 2\ [3.21E\text{-}11/hr + 3.21E\text{-}11/hr + 6.57E\text{-}11/hr]$$

$$= 2\ \{[1.30E\text{-}10/hr] * (8760\ hrs/yr)\}$$

$$= 2.28E\text{-}06/year$$

The same method was applied in the case without the ACI. The following summarizes the frequencies:

	With Autoclosure Interlock	Without Autoclosure Interlock
F(VSEQ)	2.28E-06/yr	1.48E-06/yr

The frequency of an Event V decreases by approximately 35 percent with removal of the ACI. The main contributor to the frequencies in each case is a double rupture of MOV 8701A(8702A) then 8701B(8702B)(frequency of 5.76E-07/year in both cases). The deletion of the ACI has no impact on this contributor. As can be seen, the frequency of a double rupture dominates the second case while the other contributor (the rupture of one valve while the other valve has failed open) does not contribute significantly. (The frequency for the rupture of one valve while the other is open decreases from 5.62E-7/year (6.42E-11/hr * 8760 hrs/year) for the case with the ACI to 1.63E-07/year (1.86E-11/hr * 8760 hrs/year) for the case with the ACI deleted.) This is a significant decrease in the occurrence of an Event V by this failure mode. Thus, the deletion of the ACI and the inclusion of an alarm is beneficial in reducing this contribution.

TABLE A-1

VALVE HV8701A WITH ACI BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1RHOE--CLOSE	OE	FAILURE TO OPEN (CLOSE) RHRS SUCTION VALVES	1.350E-02	0.000E+00	HE	0.000E+00	1.35E-02	0.00E+00
1RHSRTKS-LRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1RHCBABE151U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1RHTR8701A-F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	1.200E+01	4.20E-06	0.00E+00
1RHOL49A---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHOL49B---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHOL49C---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHCN42-CA-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCN42-CB-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCN42-CC-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCBABE152U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1RHMV8701A-K	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	1.200E+01	1.20E-04	0.00E+00
1RHLS8701A-F	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
1RHCN42-O--U	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-C--F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCO42-C--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHFU1-4A--F	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	1.200E+01	1.80E-06	0.00E+00
1RHCN49----U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHQS8701A-F	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	1.200E+01	2.40E-06	0.00E+00
1RHCSCS-R--F	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1RHOE---DET2	OE	SECOND OPERATOR FAILS TO DETECT OPEN MOV	9.800E-01	0.000E+00	HE	0.000E+00	9.80E-01	0.00E+00
1RHCOK155--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK155--F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHLPPQY438F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
1RHTSPS/438F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1RHTPPT-438F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.200E+01	2.08E-05	0.00E+00

TABLE A-1 (Cont.)

VALVE HV8701A WITH ACI BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1RHADP8438ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.200E+01	3.48E-05	0.00E+00
1RHTSP638ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1RHCOK735--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK735--F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHOE--DETAC	OE	SECOND OPERATOR FAILS TO DETECT OPEN MOV	9.800E-01	0.000E+00	HE	0.000E+00	9.80E-01	0.00E+00
1RHFTRACI-HE	OE	FAILURE TO RESTORE AUTOCLOSURE INTERLOCKS	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
1RHCOK734--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK734--V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHCOK154--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK154--V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.[illegible]-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHLS8812A-F	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
1RHCN42-0A-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-0B-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-0C-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-0--V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1R[illegible]CB-----OE	OE	OPERATOR FAILS TO REMOVE (SUPPLY) POWER FROM (TO) VLVS	1.590E-03	0.000E+00	HE	0.000E+00	1.59E-03	0.00E+00

TABLE A-2

VALVE HV8701B WITH ACI BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1RHOE--CLOSE	OE	FAILURE TO OPEN (CLOSE) RHRS SUCTION VALVES	1.350E-02	0.000E+00	HE	0.000E+00	1.35E-02	0.00E+00
1RHSRTRS-LRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1RHCBCD115-U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1RHTR8701B-F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	1.200E+01	4.20E-06	0.00E+00
1RHOL49A---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHOL49B---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHOL49C---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHCN42-CA-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCN42-CB-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCN42-CC-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCBCD115NU	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1RHMV8701B-K	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	1.200E+01	1.20E-04	0.00E+00
1RHLS8701B-F	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
1RHCN42-O--U	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-C--F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCO42-C--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHFU1-4A--F	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	1.200E+01	1.80E-06	0.00E+00
1RHCN49----U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHQS8701B-F	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	1.200E+01	2.40E-06	0.00E+00
1RHCSCS-R--F	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1RHOE---DET2	OE	SECOND OPERATOR FAILS TO DETECT OPEN MOV	9.800E-01	0.000E+00	HE	0.000E+00	9.80E-01	0.00E+00
1RHCOPY408BF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNPY408BF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHLPPQY408F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
1RHTJPS/408F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1RHTPPT-408F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.200E+01	2.08E-05	0.00E+00

TABLE A-2 (Cont.)

VALVE HV8701B WITH ACI BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1RHADPB40BABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.200E+01	3.48E-05	0.00E+00
1RHTSPS0BABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1RHCOK1302-F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK1302-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHOE--DETAC	OE	SECOND OPERATOR FAILS TO DETECT OPEN MOV	9.800E-01	0.000E+00	HE	0.000E+00	9.80E-01	0.00E+00
1RHFTRACI-HE	OE	FAILURE TO RESTORE AUTOCLOSURE INTERLOCKS	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
1RHCOK1301-F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK1301-V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHCOPY40BAF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCPNY40BAVV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHLSB812A-F	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
1RHCN42-0A-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-0B-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-0C-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-0--V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCB-----OE	OE	OPERATOR FAILS TO REMOVE (SUPPLY) POWER FROM (TO) VLVS	1.590E-03	0.000E+00	HE	0.000E+00	1.59E-03	0.00E+00

TABLE A-3

VALVE HV8701A WITHOUT ACI BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1RHOE--CLOSE	OE	FAILURE TO OPEN (CLOSE) RHRS SUCTION VALVES	1.350E-02	0.000E+00	HE	0.000E+00	1.35E-02	0.00E+00
1RHS?TRS-LRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1RHCBABE151U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1RHTR------F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	1.200E+01	4.20E-06	0.00E+00
1RHOL49A---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHOL49B---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHOL49C---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHCN42-CA-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCN42-CB-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCN42-CC-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCBABE152U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1RHMV8701A-K	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	1.200E+01	1.20E-04	0.00E+00
1RHLS8701A-F	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
1RHCN42-D--U	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-C--F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCO42-C--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHFU1.4A--F	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	1.200E+01	1.80E-06	0.00E+00
1RHCN49----U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHQS8701A-F	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	1.200E+01	2.40E-06	0.00E+00
1RHCSCS-R--F	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1RHOE---DET2	OE	SECOND OPERATOR FAILS TO DETECT OPEN MOV	9.800E-01	0.000E+00	HE	0.000E+00	9.80E-01	0.00E+00
1RHLP------F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
1RHCOK735--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK735--F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHAN------F	AN	ANNUCIATOR ALL MODES	4.250E-06	0.000E+00	IEEE	1.200E+01	5.10E-05	0.00E+00
1RHCOK155--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00

TABLE A-3 (Cont.)

VALVE HV8701A WITHOUT ACI BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1RHCNK155--F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHLPPQY438F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
1RHTSPS/438F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1RHTPPT-438F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.200E+01	2.08E-05	0.00E+00
1RHADPB38ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.200E+01	3.48E-05	0.00E+00
1RHTSPS38ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1RHOE--DETAN	OE	OPERATOR FAILS TO DETECT VIA ANNUNCIATOR	2.660E-04	0.000E+00	HE	0.000E+00	2.66E-04	0.00E+00
1RHCOK734--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK734--V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHCOK154--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK154--V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHLS8812A-F	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
1RHCN42-OA-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-OB-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-OC-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-O--V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCB---- OE	OE	OPERATOR FAILS TO REMOVE (SUPPLY) POWER FROM (TO) VLVS	1.590E-03	0.000E+00	HE	0.000E+00	1.59E-03	0.00E+00

TABLE A-4

VALVE HV8701B WITHOUT ACI BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1RHOE--CLOSE	OE	FAILURE TO OPEN (CLOSE) RHRS SUCTION VALVES	1.350E-02	0.000E+00	HE	0.000E+00	1.35E-02	0.00E+00
1RHSRTRS-LRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1RHCBCD115-U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1RHTR------F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	1.200E+01	4.20E-06	0.00E+00
1RHOL49A---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHOL49B---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHOL49C---F	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1RHCN42-CA-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCN42-CB-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCN42-CC-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCBCD115NU	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1RHMV8701B-K	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	1.200E+01	1.20E-04	0.00E+00
1RHLS8701B-F	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
1RHCN42-O--U	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-C--F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHCO42-C--F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHFU1.4A--F	FU	FUSE ALL MODES	1.500E-07	0.000E+0U	IEEE	1.200E+01	1.80E-06	0.00E+00
1RHCN49----U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHQS8701B-F	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	1.200E+01	2.40E-06	0.00E+00
1RHCSCS-R--F	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1RHOE---DET2	OE	SECOND OPERATOR FAILS TO DETECT OPEN MOV	9.800E-01	0.000E+00	HE	0.000E+00	9.80E-01	0.00E+00
1RHLP------F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
1RHCOK1302-F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK1302-F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHAN------F	AN	ANNUCIATOR ALL MODES	4.250E-06	0.000E+00	IEEE	1.200E+01	5.10E-05	0.00E+00
1RHCOPY408BF	CO	RELAY COIL FAILURF	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00

TABLE A-4 (Cont.)

VALVE HV8701B WITHOUT ACI BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1RHCNPY40BBF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1RHLPPQY40BF	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
1RHTSPS/40BF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1RHTPPT-40BF	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.200E+01	2.08E-05	0.00E+00
1RHADPB08ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.200E+01	3.48E-05	0.00E+00
1RHTSPS08ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1RHOE--DETAN	OE	OPERATOR FAILS TO DETECT VIA ANNUNCIATOR	2.660E-04	0.000E+00	HE	0.000E+00	2.66E-04	0.00E+00
1RHCOK1301-F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1RHCNK1301-V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHCOPY40BAF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	[illegible]50E-05	0.00E+00
1RHCNPY40BAV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1RHLS8812A-F	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
1RHCN42-0A-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-0B-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-0C-V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCN42-0--V	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.200E+01	3.60E-07	0.00E+00
1RHCB---- OE	OE	OPERATOR FAILS TO REMOVE (SUPPLY) POWER FROM (TO) VLVS	1.590E-03	0.000E+00	HE	0.000E+00	1.59E-03	0.00E+00

TABLE A-5

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: CLOSE HV8701A, HV8701B, HV8702A, and HV8702B. Verify valves are closed.

REFERENCE: Step 4.1.4 in Procedure 13011, "Residual Heat Removal System." Procedure 12001-C, "Unit Heatup to Hot Shutdown," Section A4.3, "Mode 4 Entry."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to close motor-operated suction valve

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator fails to close valve

Median HEP = 0.05	Table 20-12	Turn rotary control switch in
Mean HEP = 8.1E-02	(Reference 10)	wrong direction when design
Error Factor = 5		violates a strong populational
		stereotype and operating
		conditions are normal

3. Recovery error - Verifier fails to detect error by others

Median HEP = 0.1	Table 20-22	Checking routine tasks, checker
Mean HEP = 0.16	(Reference 10)	using written materials
Error Factor = 5		

$$P_{OE} = (1-3.75E-03)(8.1E-02)(0.16) + (3.75E-03)(0.16)$$
$$= 1.291E-02 + 6.0E-04$$
$$= 1.351E-02$$
$$= 1.35E-02$$

Fault Tree Identifiers: 1RHOE--CLOSE

TABLE A-5 (Cont.)

VOGTLE

HUMAN ERROR CALCULATIONS

TASK: Operator fails to detect wrong valve position

REFERENCE: None

BREAKDOWN OF TASK:

1. Omission error - Operator fails to detect wrong valve position

HEP = 0.98	Table 20-25 (Reference 10)	Legend light Other than annunciator light

P_{OE} = 0.98

Fault Tree Identifiers: 1RHOE--DET2 and 1RHOE--DETAC

TABLE A-5 (Cont.)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Restore ACI by reconnecting the leads.

REFERENCE: Step A4.3.2.f in "Unit Heatup to Hot Shutdown," procedure #12001-C. Section 6.3 of "RCS Draindown Modifications: RCS Sightglass, Tygon Tube and Defeat of RHRS Suction Valve Autoclosure Interlock," Procedure #54840.

BREAKDOWN OF TASK:

1. Omission error - Engineering group fails to restore ACI

Median HEP	= 0.003	Table 20-7	Long list > 10 items
Mean HEP	= 3.75E-03	(Reference 10)	When procedures with checkoff provisions are correctly used
Error Factor	= 3		

2. Commission error - Engineering group relands wrong conductor

Median HEP	= 0.003	Table 20-12	Improperly mate a conductor
Mean HEP	= 3.75E-03	(Reference 10)	
Error Factor	= 3		

3. Recovery error - Shift Supervisor fails to detect error by others

Median HEP	= 0.1	Table 20-22	Checking routine tasks, checker using written materials
Mean HEP	= 0.16	(Reference 10)	
Error Factor	= 5		

$$
\begin{aligned}
P_{OE} &= (1-3.75E-03)(3.75E-03)(0.16) + (3.75E-03)(0.16) \\
&= 5.978E-04 + 6.0E-04 \\
&= 1.198E-03 \\
&= 1.20E-03
\end{aligned}
$$

Fault Tree Identifiers: 1RHFTRACI-HE

TABLE A-5 (Cont.)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: HV8701A, HV8701B, (HV8701B and HV8702B) open and lock circuit breakers to valves.

REFERENCE: Steps 4.1.5.c and 4.1.5.d in procedure 13011, "Residual Heat Removal System." Procedure 12001-C, "Unit Heatup to Hot Shutdown, "Section A4.3.11.e, "Mode 4 Entry."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to open and lock open power supply breaker

Median HEP = 0.003 Mean HEP = 3.75E-03 Error Factor = 3	Table 20-7 (Reference 10)	Long list > 10 items When procedures with checkoff provisions are correctly used

2. Commission error - Operator selects wrong circuit breaker

Median HEP = 0.005 Mean HEP = 6.2E-03 Error Factor = 3	Table 20-12 (Reference 10)	Select wrong circuit breaker in a group of circuit breakers densely grouped and identified by labels only

3. Recovery error - Shift Supervisor fails to detect error by others

Median HEP = 0.1 Mean HEP = 0.16 Error Factor = 5	Table 20-22 (Reference 10)	Checking routine tasks, checker using written materials

P_{OE} = (1-3.75E-03)(6.2E-03)(0.16) + (3.75E-03)(0.16)
= 9.883E-04 + 6.0E-04
= 1.588E-03
= 1.59E-03

Fault Tree Identifiers: 1RHCB----OE

TABLE A-5 (Cont.)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Operator fails to detect wrong valve position via annunciator

REFERENCE: None

BREAKDOWN OF TASK:

1. Omission error - Operator fails to detect wrong valve position via annunciator and initiate some kind of corrective action

Median HEP	= 0.0001	Table 20-23	One annunciator
Mean HEP	= 2.66E-04	(Reference 10)	
Error Factor	= 10		

P_{OE} = 2.66E-04

Fault Tree Identifiers: 1RHOE--DETAN

TABLE A-6

DOMINANT CUTSETS FOR VALVE HV8701A WITH ACI

PAGE 1

TREE NAME: 8701A
CUTDES VER.1.7, 11-17-89
INPUT FILE: 8701A.CDS

CUT SETS FOR GATE G0001 WITH CUTOFF PROBABILITY OF 1.00E-10
GATE G0001 IS: VOGTLE MOTOR OPERATED VALVE 8701A IS OPEN W/ACI

NUMBER	CUTSET PROB.	BASIC EVENT NAME	EVENT PROB.	IDENTIFIER
1.	1.15E-04	MOV 8701A FAILS TO CLOSE	1.20E-04	1RHMV8701A-K
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE--DETAC
2.	8.32E-05	LIMIT SWITCH 8701A FAILS	8.66E-05	1RHLS8701A-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE--DETAC
3.	3.46E-05	LOCKIN 42-C COIL FAILS	3.60E-05	1RHCO42-C--F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE--DETAC
4.	1.59E-05	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		ENGINEERING FAILS TO RESTORE AUTOCLOSE INTERLOCK	1.20E-03	1RHFTRACI-HE
5.	1.15E-05	LOCKIN 42-C CONTACTS FAIL TO TRANSFER	1.20E-05	1RHCN42-C--F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE--DETAC
6.	1.15E-05	CLOSING COIL CONTACT PHASE C 42-C FAILS TO TRANSFER	1.20E-05	1RHCN42-CC-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE--DETAC
7.	1.15E-05	CLOSING COIL CONTACY PHASE B 42-C FAILS TO TRANSFER	1.20E-05	1RHCN42-CB-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE--DETAC
8.	1.15E-05	CLOSING COIL CONTACT PHASE A 42-C FAILS TO TRANSFER	1.20E-05	1RHCN42-CA-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE--DETAC
9.	9.34E-06	TRANSFER SWITCH TRS-LR FAILS	9.72E-06	1RHSRTRS-LRF
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE--DETAC
10.	4.03E-06	480V/120V TRANSFORMER FAILS	4.20E-06	1RHTR8701A-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE--DETAC

REDUCED SUM OF PROBABILITY OF FAILURE = 3.215E-04

TABLE A-7

DOMINANT CUTSETS FOR VALVE HV8701B WITH ACI

PAGE 1 TREE NAME: 8701B
CUTDES VER.1.7, 11-17-89
INPUT FILE: 8701B.CDS

CUT SETS FOR GATE G0001 WITH CUTOFF PROBABILITY OF 1.00E-10
GATE G0001 IS: VOGTLE MOTOR OPERATED VALVE 8701B IS OPEN W/ACI

NUMBER	CUTSET PROB.	BASIC EVENT NAME	EVENT PROB.	IDENTIFIER
1.	1.15E-04	MOV 8701B FAILS TO CLOSE	1.20E-04	1RHMV8701B-K
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE--DETAC
2.	8.32E-05	LIMIT SWITCH 8701B FAILS	8.66E-05	1RHLS8701B-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE--DETAC
3.	3.46E-05	LOCKIN 42-C COIL FAILS	3.60E-05	1RHCO42-C--F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE--DETAC
4.	1.59E-05	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		ENGINEERING FAILS TO RESTORE AUTOCLOSE INTERLOCK	1.20E-03	1RHFTRACI-HE
5.	1.15E-05	LOCKIN 42-C CONTACTS FAIL TO TRANSFER	1.20E-05	1RHCN42-C--F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE--DETAC
6.	1.15E-05	CLOSING COIL CONTACT PHASE C 42-C FAILS TO TRANSFER	1.20E-05	1RHCN42-CC-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE--DETAC
7.	1.15E-05	CLOSING COIL CONTACY PHASE B 42-C FAILS TO TRANSFER	1.20E-05	1RHCN42-CB-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE--DETAC
8.	1.15E-05	CLOSING COIL CONTACT PHASE A 42-C FAILS TO TRANSFER	1.20E-05	1RHCN42-CA-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE--DETAC
9.	9.34E-06	TRANSFER SWITCH TRS-LR FAILS	9.72E-06	1RHSRTRS-LRF
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE--DETAC
10.	4.03E-06	480V/120V TRANSFORMER FAILS	4.20E-06	1RHTR8701B-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE--DETAC

REDUCED SUM OF PROBABILITY OF FAILURE = 3.215E-04

TABLE A-8

DOMINANT CUTSETS FOR VALVE HV8701A WITHOUT ACI

PAGE 1 TREE NAME: AN8701A
CUTDES VER.1.7, 11-17-89
INPUT FILE: AN8701A.CDS

CUT SETS FOR GATE G0001 WITH CUTOFF PROBABILITY OF 1.00E-10
GATE G0001 IS: VOGTLE MOTOR OPERATED VALVE 8701A IS OPEN W/O ACI

NUMBER	CUTSET PROB.	BASIC EVENT NAME	EVENT PROB.	IDENTIFIER
1.	8.49E-05	LIMIT SWITCH 8701A FAILS	8.66E-05	1RHLS8701A-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
2.	3.52E-06	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701A VIA THE ALARM	2.66E-04	1RHOE--DETAN
3.	9.21E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		ALARM POWER SUPPLY FAILS	6.96E-05	1RHLP------F
4.	9.21E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		LOOP POWER SUPPLY PQY-438 FAILS	6.96E-05	1RHLPPQY438F
5.	6.75E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		ALARM FAILS	5.10E-05	1RHAN------F
6.	4.76E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		SSPS INPUT RELAY K155 COIL FAILS	3.60E-05	1RHCOK155--F
7.	4.76E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		SSPS RELAY K735 COILS FAILS	3.60E-05	1RHCOK735--F
8.	4.60E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		DUAL COMPARATOR PB-438A/B FAILS	3.48E-05	1RHADPB38ABF
9.	2.75E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		PRESSURE TRANSMITTER PT-438 FAILS	2.08E-05	1RHTPPT-438F
10.	1.59E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		SSPS INPUT RELAY K155 CONTACTS FAIL TO TRANSFER	1.20E-05	1RHCNK155--F
11.	1.59E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701A	9.80E-01	1RHOE---DET2
		SSPS RELAY K735 CONTACTS 1 & 2 FAIL TO TRANSFER	1.20E-05	1RHCNK735--F

REDUCED SUM OF PROBABILITY OF FAILURE = 9.327E-05

TABLE A-9

DOMINANT CUTSETS FOR VALVE HV8701B WITHOUT ACI

PAGE 1 TREE NAME: AN8701B
CUTDES VER.1.7, 11-17-89
INPUT FILE: AN8701B.CDS

CUT SETS FOR GATE G0001 WITH CUTOFF PROBABILITY OF 1.00E-10
GATE G0001 IS: VOGTLE MOTOR OPERATED VALVE 8701B IS OPEN W/O ACI

NUMBER	CUTSET PROB.	BASIC EVENT NAME	EVENT PROB.	IDENTIFIER
1.	8.49E-05	LIMIT SWITCH 8701B FAILS	8.66E-05	1RHLS8701B-F
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
2.	3.52E-06	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		OPERATOR FAILS TO DETECT OPEN MOV 8701B VIA THE ALARM	2.66E-04	1RHOE--DETAN
3.	9.21E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		ALARM POWER SUPPLY FAILS	6.96E-05	1RHLP------F
4.	9.21E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		LOOP POWER SUPPLY PQY-408 FAILS	6.96E-05	1RHLPPQY408F
5.	6.75E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		ALARM FAILS	5.10E-05	1RHAN------F
6.	4.76E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		AUXILIARY RELAY PY/408B COIL FAILS	3.60E-05	1RHCOPY408BF
7.	4.76E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		SSPS RELAY K1302 COILS FAILS	3.60E-05	1RHCOK1302-F
8.	4.60E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		DUAL COMPARATOR PB-408A/B FAILS	3.48E-05	1RHADPB08ABF
9.	2.75E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		PRESSURE TRANSMITTER PT-408 FAILS	2.08E-05	1RHTPPT-408F
10.	1.59E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		AUXILIARY RELAY PY/408B CONTACTS FAIL TO TRANSFER	1.20E-05	1RHCNPY408BF
11.	1.59E-07	OPERATOR FAILS TO CLOSE VALVE DURING STARTUP PER 2.1.e	1.35E-02	1RHOE--CLOSE
		SECOND OPERATOR FAILS TO DETECT OPEN MOV 8701B	9.80E-01	1RHOE---DET2
		SSPS RELAY K1302 CONTACTS 1 & 2 FAIL TO TRANSFER	1.20E-05	1RHCNK1302-F

REDUCED SUM OF PROBABILITY OF FAILURE = 9.327E-05

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APPENDIX B

VOGTLE
RHRS UNAVAILABILITY ANALYSIS

APPENDIX B
RHRS UNAVAILABILITY ANALYSIS

The Residual Heat Removal System (RHRS) was analyzed to determine the unavailability of the system to remove decay heat and the impact of removal of the ACI on this unavailability due to spurious closure of the suction valves. Fault trees were developed to determine the unavailability for startup of the RHRS System, for short term cooling (72 hours) and for long term cooling (six weeks). This appendix describes the calculations and fault tree quantifications used to determine the system unavailabilities.

The following boundary conditions and assumptions were utilized during the analysis.

1. Two trains of RHRS are assumed required for 72 hours injecting into 2 of 4 cold legs following initiation of the RHRS (short term cooling phase).

2. One train of RHRS is assumed required for 6 weeks (representative of the time of a refueling outage) injecting into 2 of 4 cold legs for the long term RHRS cooldown phase.

3. No testing or maintenance operations are assumed to occur during the initial phase of cooldown using the RHRS (first 72 hours).

4. During the warm-up period of the RHRS, both RHRS pumps are started and must run for approximately two hours before injection into the RCS cold legs.

5. All electric power (AC and DC) is assumed to be available with a probability of 1.0.

6. For long term cooling, it is assumed that the Train A pump is operating and the Train B pump is in standby and thus must start and run should the Train A pump fail. No switching of trains during long term cooling is assumed.

Three fault trees were developed to model the RHRS unavailability for Vogtle. These fault trees were developed from the system flow diagrams and control wiring diagrams shown and described in Section 2.0. Each fault tree is discussed below. The RHRS suction valves 8701A, 8701B, 8702A and 8702B were modeled in detail down to the control circuitry level to explicitly show the change in unavailability due to removal of the ACI.

Failure during RHRS Initiation

The fault tree developed for this phase of cooldown (Figure B-1) details the failure during initiation of the RHRS. The fault tree was developed based on the RHRS Operating Procedure 13011, Section 4.2, "Placing the RHRS in Service for RCS Cooldown." The steps for RHRS initiation are summarized below (Train B components are listed in parentheses):

1. Close RHRS to RCS hot leg crossover valve HV-8716A(B).

2. Close RHRS heat exchanger outlet valve HV-0606(0607).

3. Close RHRS heat exchanger bypass valve FV-0618(FV-0619).

4. Close RWST to RHRS pump suction valve HV-8812A(B).

5. Open RHRS suction valves HV-8701A, HV-8701B (HV-8702A, HV-8702B).

6. Remove power from the RHRS to Charging and SI Pump Isolation valves HV-8804A (HV-8804B).

7. Start RHRS Pump A(B).

8. Open RHRS heat exchanger bypass valve FV-0618 (FV-0619).

9. Place RHRS heat exchanger bypass valve FV-0618(FV-0619) in "AUTO" position.

10. Open RHRS heat exchanger outlet valve HV-0606(0607).

Each of these steps was modeled in the fault tree to involve an operator error or a component failure. For example, the first step requires the closing of the RHRS to RCS hot leg crossover valve. Failure of this step could involve: 1) the operator failing to close the valve or 2) the valve failing to close.

This phase of cooldown is not dependent on the ACI but on the prevent-open interlock. Thus only one fault tree was developed to determine the unavailability due to RHRS initiation.

Loss of Short Term Cooling

The fault trees developed for this phase of cooldown assumes that both trains of RHRS are required for operation. Injection into two of four cold legs for 72 hours is required for success in this phase. The RHRS suction valves were modeled in detail to show how the valves could spuriously close. Finally, fault trees were developed without the ACI and with the proposed modification to the suction valves. The fault trees developed for these cases are shown in Figures B-2 and B-3.

Loss of Long Term Cooling

The fault tree developed for this phase of plant cooldown assumes only one RHRS train (pump and heat exchanger) is required to be operating. Injection into two of four cold legs for six weeks is the success criteria. The fault trees developed for this mode of cooling are shown in Figures B-4 and B-5. The models were developed to show the suction valves with and without the ACI.

The fault trees were quantified for the case with and without the ACI. The basic event probabilities (component unavailabilities and human error probabilities) are shown in Table B-2. The equation used to calculate the component unavailability is:

$$Q = (\lambda)\ T_M$$

where

Q = component failure probability

(λ) = failure rate for component

T_M = total defined mission time in which the component must operate.

The human error probability calculations for Vogtle are shown in Table B-3.

The unavailability of the Train B pump due to test modeled in the long term cooling phase is based on the Technical Specification 3.4.1.4-1 which states: "One residual heat removal loop may be inoperable for up to 2 hours for surveillance testing provided the other RHRS loop is OPERABLE and in operation." Because pump testing occurs on a quarterly basis (every 2160 hours), the unavailability due to test is calculated by:

$$Q_{test} = (Y)/T_T$$

where Y = average duration of test (hours)

T_T = interval between tests (hours)

$$Q_{test} = (Y)/T_T$$
$$= (2 \text{ hours}) / (2160 \text{ hours})$$
$$= 9.26E-04$$

The unavailability due to maintenance, which is modeled to occur during long term cooling, was extracted from Reference 9, "Individual Plant Evaluation Methodology for Pressurized Water Reactors," April 1987, Section 2.4, Table 2.4-2 Generic Maintenance Durations for a standby pump tested monthly or quarterly and a component inoperability time limit of 72 hours. Therefore the unavailability due to maintenance is:

$$Q_{main} = (f_r)\ (Y)_R$$
$$= (8.42E-05 \text{ events/hour})\ (18.7 \text{ hours/ event})$$
$$= 1.57E-03$$

where f_r = frequency of maintenance (events/hour)

$(Y)_R$ = mean component repair time (hours/event)

Results

The results of the RHRS unavailability are shown in Table B-1. The dominant cutsets for each phase are shown in Tables B-4 to B-8.

For the failure of initiation fault tree, the dominant failure modes are the operator error in which the operator fails to open the suction valves and the RHRS pumps failing to start. The deletion of the ACI has no impact on the failure probability for RHRS initiation.

The failure probabilities for the short term cooling phase for Vogtle are reduced by approximately 26 percent with the deletion of the ACI. The dominant failure mode for each case is the failure of either pump to run for 72 hours (both pumps are required for success in this phase). For the case with the ACI, failure of components associated with the ACI contribute approximately 5E-03 to the failure probability.

In the long term cooling phase for Vogtle, for both cases the failure of both pumps to run for six weeks is the dominant contributor to the system unavailability. For the deletion of the ACI case, the failure probability is reduced by 43 percent. For the case with the ACI present, the failure of a component associated with the ACI such as the power supplies, signal comparators, comparator trip switches or pressure transmitters in combination with failure of one of the pumps to run contributes approximately 7.2E-03 to the system unavailability.

The results of the quantification of the Vogtle RHRS unavailability fault trees show that deletion of the ACI reduces the number of spurious closure of the suction valves and thus increases the availability of the RHRS.

TABLE B-1

RESULTS OF RHRS UNAVAILABILITY
FOR VOGTLE

FAULT TREE PHASE	WITH AUTOCLOSURE	WITHOUT AUTOCLOSURE	PERCENT CHANGE
INITIATION	1.05E-01	1.05E-01	--
SHORT TERM COOLING	1.96E-02	1.46E-02	25.5
LONG TERM COOLING	1.96E-02	1.18E-02	39.8

TABLE B-2

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1ACB152U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	2.000E+00	2.00E-08	0.00E+00
1AMV01AD	MV	FAILURE TO OPEN	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
1AQS01AU	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	2.000E+00	4.00E-07	0.00E+00
1ACN42CU	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	2.000E+00	6.00E-08	0.00E+00
1ACO42OF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
1AFU1.4F	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	2.000E+00	3.00E-07	0.00E+00
1AOLCN49U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	2.000E+00	4.00E-08	0.00E+00
1ALS01AF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
1ACNK734F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1ACOK734F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
1ACNK154F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1ACOK154F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
1ALP438F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+0U	TOPS	2.000E+00	1.16E-05	0.00E+00
1APS438F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	2.000E+00	1.16E-06	0.00E+00
1ATP4EBF	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	2.000E+00	3.46E-06	0.00E+00
1APB438ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	2.000E+00	5.80E-0[illegible]	0.00E+00
1ATS438ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	2.000E+00	1.16E-06	0.00E+00
1AMVCBOE	OE	OPERATOR FAILS TO CLOSE CB	1.600E-03	0.000E+00	HE	0.000E+00	1.60E-03	0.00E+00
1BMVOEOPEN	OE	FAILURE TO OPEN (CLOSE) RHRS SUCTION VALVES	1.350E-02	0.000E+00	HE	0.000E+00	1.35E-02	0.00E+00
1BSR01BF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	2.000E+00	1.62E-06	0.00E+00
1BCN42OF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1BLS11AF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
1BLS12AF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
1BLS04AF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
1BCSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	2.000E+00	1.62E-06	0.00E+00
1ACB115U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEZ	2.000E+00	2.00E-08	0.00E+00
1BCT4812F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	2.000E+00	7.00E-07	0.00E+00
1BOL49AF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
1BOL49BF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00

TABLE B-2 (Cont'd)

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
AV06060EK	OE	OPERATOR FAILS TO CLOSE VALVE	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
AV0606K	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
AV06070EK	OE	OPERATOR FAILS TO CLOSE VALVE	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
AV0607K	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
AV06180EK	OE	OPERATOR FAILS TO PLACE IN MANUAL AND CLOSE VALVE	1.800E-03	0.000E+00	HE	0.000E+00	1.80E-03	0.00E+00
AV0618K	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
AV06190EK	OE	OPERATOR FAILS TO PLACE IN MANUAL AND CLOSE VALVE	1.800E-03	0.000E+00	HE	0.000E+00	1.80E-03	0.00E+00
AV0619K	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
MV8812AOEK	OE	OPERATOR FAILS TO CLOSE VALVE	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
MV8812AK	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
MV8812BOEK	OE	OPERATOR FAILS TO CLOSE VALVE	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
MV8812BK	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
1AMVOEOPEN	OE	FAILURE TO OPEN (CLOSE) RHRS SUCTION VALVES	1.350E-02	0.000E+00	HE	0.000E+00	1.35E-02	0.00E+00
1ASR01AF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	2.000E+00	1.62E-06	0.00E+00
1ACN420F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1ALS11AF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
1ALS12AF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
1ALS04AF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
1ACSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	2.000E+00	1.62E-06	0.00E+00
1ACB151U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	2.000E+00	2.00E-08	0.00E+00
1ACT4812F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	2.000E+00	7.00E-07	0.00E+00
1AOL49AF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
1AOL49BF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
1AOL49CF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
1ACN420AF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1ACN420BF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1ACN420CF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00

TABLE B-2 (Cont'd)

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1BOL49CF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
1BCN420AF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1BCN420BF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1BCN420CF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1ACB15MU	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	2.000E+00	2.00E-08	0.00E+00
1BMV01BD	MV	FAILURE TO OPEN	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
1BQS01BU	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	2.000E+00	4.00E-07	0.00E+00
1BCN42CU	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	2.000E+00	6.00E-08	0.00E+00
1BCO420F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
1BFU1.4F	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	2.000E+00	3.00E-07	0.00E+00
1BOLCN49U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	2.000E+00	4.00E-08	0.00E+00
1BLS01BF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
1BCNK1301F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1BCOK1301F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
1BCNPY408F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
1BCPY408AF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
1BLP118F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	2.000E+00	1.16E-05	0.00E+00
1BLP408F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	2.000E+00	1.16E-05	0.00E+00
1BTS408F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	2.000E+00	1.16E-06	0.00E+00
1BTP408F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	2.000E+00	3.46E-06	0.00E+00
1BPB408ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	2.000E+00	5.80E-06	0.00E+00
1BTS408ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	2.000E+00	1.16E-06	0.00E+00
1BMVCBOE	OE	OPERATOR FAILS TO CLOSE CB	1.600E-03	0.000E+00	HE	0.000E+00	1.60E-03	0.00E+00
2AMVOEOPEN	OE	FAILURE TO OPEN (CLOSE) RHRS SUCTION VALVES	1.350E-02	0.000E+00	HE	0.000E+00	1.35E-02	0.00E+00
2ASR01BF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	2.000E+00	1.62E-06	0.00E+00
2ACN420F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2ALS11BF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
2ALS12BF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00

TABLE B-2 (Cont'd)

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
2ALSC'BF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
2ACSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	2.000E+00	1.62E-06	0.00E+00
2ACB116U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	2.000E+00	2.00E-08	0.00E+00
2ACT4812F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	2.000E+00	7.00E-07	0.00E+00
2AOL49AF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
2AOL49BF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
2AOL49CF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
2ACN420AF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2ACN420BF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2ACN420CF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2ACB16MU	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	2.000E+00	2.00E-08	0.00E+00
2AMV02AD	MV	FAILURE TO OPEN	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
2AQS02AU	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	2.000E+00	4.00E-07	0.00E+00
2ACN42CU	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	2.000E+00	6.00E-08	0.00E+00
2ACO420F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
2AFU1.4F	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	2.000E+00	3.00E-07	0.00E+00
2AOLCN49U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	2.000E+00	4.00E-08	0.00E+00
2ALS02AF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
2ACNK1301F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2ACOK1301F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
2ACNPY418F	CN	RELAY CONTACTS FAIL TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2ACPY418AF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
2ALPY118F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	2.000E+00	1.16E-05	0.00E+00
2ALP418F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	2.000E+00	1.16E-05	0.00E+00
2ATS418F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	2.000E+00	1.16E-06	0.00E+00
2ATP418F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	2.000E+00	3.46E-06	0.00E+00
2APB418ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	2.000E+00	5.80E-06	0.00E+00
2ATS418ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	2.000E+00	1.16E-06	0.00E+00

TABLE B-2 (Cont'd)

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
2AMVCBOE	OE	OPERATOR FAILS TO CLOSE CB	1.600E-03	0.000E+00	HE	0.000E+00	1.60E-03	0.00E+00
2BMVOEOPEN	OE	FAILURE TO OPEN (CLOSE) RHRS SUCTION VALVES	1.350E-02	0.000E+00	HE	0.000E+00	1.35E-02	0.00E+00
2BSR02BF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	2.000E+00	1.62E-06	0.00E+00
2BCN42OF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2BLS11BF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
2BLS12BF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
2BLS04BF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
2BCSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	2.000E+00	1.62E-06	0.00E+00
2BCB131U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	2.000E+00	2.00E-08	0.00E+00
2BCT4812F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	2.000E+00	7.00E-07	0.00E+00
2BOL49AF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
2BOL49BF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
2BOL49CF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	2.000E+00	3.00E-07	0.00E+00
2BCN42OAF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2BCN42OBF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2BCN42OCF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2BCB132U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	2.000E+00	2.00E-08	0.00E+00
2BMV02BO	MV	FAILURE TO OPEN	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
2BQS02BU	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	2.000E+00	4.00E-07	0.00E+00
2BCN42CU	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	2.000E+00	6.00E-08	0.00E+00
2BCO42OF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
2BFU1.4F	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	2.000E+00	3.00E-07	0.00E+00
2BOLCN49U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	2.000E+00	4.00E-08	0.00E+00
2BLS02BF	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	2.000E+00	1.44E-05	0.00E+00
2BCNK734F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00
2BCOK734F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
2BCNK254F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	2.000E+00	2.00E-06	0.00E+00

TABLE B-2 (Cont'd)

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
2BCOK254F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	2.000E+00	6.00E-06	0.00E+00
2BLP42BF	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	2.000E+00	1.16E-05	0.00E+00
2BPS42BF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	2.000E+00	1.16E-06	0.00E+00
2BTP42BF	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	2.000E+00	3.46E-06	0.00E+00
2BPB42BABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	2.000E+00	5.80E-06	0.00E+00
2BTS42BABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	2.000E+00	1.16E-06	0.00E+00
2BMVCBOE	OE	OPERATOR FAILS TO CLOSE CB	1.600E-03	0.000E+00	HE	0.000E+00	1.60E-03	0.00E+00
MV716AOEK	OE	OPERATOR FAILS TO CLOSE VALVE	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
MV716AK	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
MV716BOEK	OE	OPERATOR FAILS TO CLOSE VALVE	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
MV716BK	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
4ACBOEF	OE	OPERATOR FAILS TO REMOVE POWER FROM CB	1.600E-03	0.000E+00	HE	0.000E+00	1.60E-03	0.00E+00
4BCBOEF	OE	OPERATOR FAILS TO REMOVE POWER FROM CB	1.600E-03	0.000E+00	HE	0.000E+00	1.60E-03	0.00E+00
PMAS	PM	FAILURE TO START	1.000E-05	0.000E+00	2815	1.080E+03	1.08E-02	0.00E+00
PMAR	PM	FAIL TO RUN,GIVEN START	1.000E-04	0.000E+00	2815	2.000E+00	2.00E-04	0.00E+00
PMBS	PM	FAILURE TO START	1.000E-05	0.000E+00	2815	1.080E+03	1.08E-02	0.00E+00
PMBR	PM	FAIL TO RUN,GIVEN START	1.000E-04	0.000E+00	2815	2.000E+00	2.00E-04	0.00E+00
AV0606OED	OE	OPERATOR FAILS TO OPEN AOV	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
AV[illegible]	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
AV0607OED	OE	OPERATOR FAILS TO OPEN AOV	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
AV0607D	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
MV0610V	MV	FAILURE TO REMAIN OPEN	2.000E-07	0.000E+00	2815	2.000E+00	4.00E-07	0.00E+00
MV0611V	MV	FAILURE TO REMAIN OPEN	2.000E-07	0.000E+00	2815	2.000E+00	4.00E-07	0.00E+00
AV0618OED	OE	OPERATOR FAILS TO OPEN AOV	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
AV0618D	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00
AV0619OED	OE	OPERATOR FAILS TO OPEN AOV	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
AV0619D	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	2.000E+00	2.00E-05	0.00E+00

TABLE B-2 (Cont'd)

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
FC0618AOE	OE	OPERATOR FAILS TO SWITCH VALVE TO AUTO	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
FC0619AOE	OE	OPERATOR FAILS TO SWITCH VALVE TO AUTO	1.200E-03	0.000E+00	HE	0.000E+00	1.20E-03	0.00E+00
CV009D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	2.000E+00	4.00E-07	0.00E+00
CV010D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	2.000E+00	4.00E-07	0.00E+00
RHRS SHORT TERM COOLING								
CV083D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	7.200E+01	1.44E-05	0.00E+00
CV147D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	7.200E+01	1.44E-05	0.00E+00
MV8809AV	MV	FAILURE TO REMAIN OPEN	2.000E-07	0.000E+00	2815	7.200E+01	1.44E-05	0.00E+00
PM5X	PM	FAIL TO RUN,GIVEN START	1.000E-04	0.000E+00	2815	7.200E+01	7.20E-03	0.00E+00
1ACN42CAV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
1ACN42CBV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
1ACN42CCV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
1ACSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	7.200E+01	5.83E-05	0.00E+00
1ACN42CV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
1ACNK155V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
1ACOK155F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	7.200E+01	2.16E-04	0.00E+00
1ACNK735V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
1ACOK735F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	7.200E+01	2.16E-04	0.00E+00
1ATP438F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	7.200E+01	1.25E-04	0.00E+00
1ATS438F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	7.200E+01	4.18E-05	0.00E+00
1ALP438F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	7.200E+01	4.18E-04	0.00E+00
1AAD438ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	7.200E+01	2.09E-04	0.00E+00
1ATS438ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	7.200E+01	4.18E-05	0.00E+00
1BCN42CAV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
1BCN42CBV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
1BCN42CCV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
1BCSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	7.200E+01	5.83E-05	0.00E+00

TABLE B-2 (Cont'd)

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1BCN42CV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
1BCN408BV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
1BCO408BF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	7.200E+01	2.16E-04	0.00E+00
1BCNK1302V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
1BCOK1302F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	7.200E+01	2.16E-04	0.00E+00
1BTP408F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	7.200E+01	1.25E-04	0.00E+00
1BTS408F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	7.200E+01	4.18E-05	0.00E+00
1BLP408F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	7.200E+01	4.18E-04	0.00E+00
1BAD408ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	7.200E+01	2.09E-04	0.00E+00
1BTS408ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	7.200E+01	4.18E-05	0.00E+00
CV084D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	7.200E+01	1.44E-05	0.00E+00
CV148D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	7.200E+01	1.44E-05	0.00E+00
CV085D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	7.200E+01	1.44E-05	0.00E+00
CV149D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	7.200E+01	1.44E-05	0.00E+00
MV8809BV	MV	FAILURE TO REMAIN OPEN	2.000E-07	0.000E+00	2815	7.200E+01	1.44E-05	0.00E+00
PMBX	PM	FAIL TO RUN,GIVEN START	1.000E-04	0.000E+00	2815	7.200E+01	7.20E-03	0.00E+00
2ACN42CAV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
2ACN42CBV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
2ACN42CCV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
2ACSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	7.200E+01	5.83E-05	0.00E+00
2ACN42CV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
2ACN418BV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
2ACO418BF	CO	RELAY COIL FAILURE	3 [illegible]E-06	0.000E+00	2815	7.200E+01	2.16E-04	0.00E+00
2ACNK1302V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
2ACOK1302F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	7.200E+01	2.16E-04	0.00E+00
2ATP418F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	7.200E+01	1.25E-04	0.00E+00
2ATS418F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	7.200E+01	4.18E-05	0.00E+00
2ALP418F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	7.200E+01	4.18E-04	0.00E+00
2AAD418ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	7.200E+01	2.09E-04	0.00E+00

TABLE B-2 (Cont'd)

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
2ATS418ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	7.200E+01	4.18E-05	0.00E+00
2BCN42CAV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
2BCN42CBV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
2BCN42CCV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	7.200E+01	2.16E-06	0.00E+00
2BCSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	7.200E+01	5.83E-05	0.00E+00
2BCN42CV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
2BCNK255V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
2BCOK255F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	7.200E+01	2.16E-04	0.00E+00
2BCNK735V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	7.200E+01	1.44E-06	0.00E+00
2BCOK735F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	7.200E+01	2.16E-04	0.00E+00
2BTP428F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	7.200E+01	1.25E-04	0.00E+00
2BTS428F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	7.200E+01	4.18E-05	0.00E+00
2BLP428F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	7.200E+01	4.18E-04	0.00E+00
2BAD428ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	7.200E+01	2.09E-04	0.00E+00
2BTS428ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	7.200E+01	4.18E-05	0.00E+00
CV0860	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	7.200E+01	1.44E-05	0.00E+00
CV1500	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	7.200E+01	1.44E-05	0.00E+00
RHRS LONG TERM COOLING								
MV8809AV	MV	FAILURE TO REMAIN OPEN	2.000E-07	0.000E+00	2815	1.008E+03	2.02E-04	0.00E+00
PMAX	PM	FAIL TO RUN,GIVEN START	1.000E-04	0.000E+00	2815	1.008E+03	1.01E-01	0.00E+00
1ACN42CAV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
1ACN42CBV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
1ACN42CCV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
1ACSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.008E+03	8.16E-04	0.00E+00
1ACN42CV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
1ACNK155V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
1ACOK155F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.008E+03	3.02E-03	0.00E+00

TABLE B-2 (Cont'd)

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1ACNK735V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
1ACOK735F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.008E+03	3.02E-03	0.00E+00
1ATP438F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.008E+03	1.74E-03	0.00E+00
1ATS438F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.008E+03	5.85E-04	0.00E+00
1ALP438F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.008E+03	5.85E-03	0.00E+00
1AAD438ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.008E+03	2.92E-03	0.00E+00
1ATS438ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.008E+03	5.85E-04	0.00E+00
1BCN42CAV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
1BCN42CBV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
1BCN42CCV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
1BCSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.008E+03	8.16E-04	0.00E+00
1BCN42CV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
1BCN408BV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
1BCO408BF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.008E+03	3.02E-03	0.00E+00
1BCNK1302V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
1BCOK1302F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.008E+03	3.02E-03	0.00E+00
1BTP408F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.008E+03	1.74E-03	0.00E+00
1BTS408F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.008E+03	5.85E-04	0.00E+00
1BLP408F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.008E+03	5.85E-03	0.00E+00
1BAD408ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.008E+03	2.92E-03	0.00E+00
1BTS408ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.008E+03	5.85E-04	0.00E+00
CV085D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	1.008E+03	2.02E-04	0.00E+00
CV149D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	1.008E+03	2.02E-04	0.00E+00
MV8809BV	MV	FAILURE TO REMAIN OPEN	2.000E-07	0.000E+00	2815	1.008E+03	2.02E-04	0.00E+00
CV010D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	1.008E+03	2.02E-04	0.00E+00
PMBX	PM	FAIL TO RUN,GIVEN START	1.000E-04	0.000E+00	2815	1.008E+03	1.01E-01	0.00E+00
PMBA	PM	FAILURE TO START	1.000E-05	0.000E+00	2815	1.080E+03	1.08E-02	0.00E+00
PMBMAINT	MA	PUMP MAINTENANCE UNAVAILABILITY	1.570E-03	0.000E+00	MAIN	0.000E+00	1.57E-03	0.00E+00
PMBTEST	TE	PUMP TEST UNAVAILABILITY	9.260E-04	0.000E+00	TEST	0.000E+00	9.26E-04	0.00E+00

TABLE B-2 (Cont'd)

VOGTLE BASIC EVENT PROBABILITIES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
2ACN42CAV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
2ACN42CBV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
2ACN42CCV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
2ACSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.008E+03	8.16E-04	0.00E+00
2ACN42CV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
2ACN418BV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
2ACO418BF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.008E+03	3.02E-03	0.00E+00
2ACNK1302V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
2ACOK1302F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.008E+03	3.02E-03	0.00E+00
2ATP418F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.008E+03	1.74E-03	0.00E+00
2ATS418F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.008E+03	5.85E-04	0.00E+00
2ALP418F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.008E+03	5.85E-03	0.00E+00
2AAD418ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.008E+03	2.92E-03	0.00E+00
2ATS418ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.008E+03	5.85E-04	0.00E+00
2BCN42CAV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
2BCN42CBV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
2BCN42CCV	CN	MOTOR STARTER SPURIOUS OPERATION	3.000E-08	0.000E+00	IEEE	1.008E+03	3.02E-05	0.00E+00
2BCSCSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.008E+03	8.16E-04	0.00E+00
2BCN42CV	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
2BCNK255V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
2BCOK255F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.008E+03	3.02E-03	0.00E+00
2BCNK735V	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.008E+03	2.02E-05	0.00E+00
2BCOK735F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.008E+03	3.02E-03	0.00E+00
2BTP428F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.008E+03	1.74E-03	0.00E+00
2BTS428F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.008E+03	5.85E-04	0.00E+00
2BLP428F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.008E+03	5.85E-03	0.00E+00
2BAD428ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.008E+03	2.92E-03	0.00E+00
2BTS428ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.008E+03	5.85E-04	0.00E+00
CV086D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	1.008E+03	2.02E-04	0.00E+00
CV150D	CV	FAILURE TO OPEN	2.000E-07	0.000E+00	2815	1.008E+03	2.02E-04	0.00E+00

TABLE B-3

VOGTLE

HUMAN ERROR CALCULATIONS

TASK: Close RHRS Heat exchanger A(B) outlet flow control valves HV-0606 (HV-0607).

REFERENCE: Step 2.b of Section 4.2, "Placing the RHRS in Service for RCS Cooldown," in procedure 13011, "Residual Heat Removal System."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to close air-operated heat exchanger bypass flow control valve

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator fails to close valve by selecting wrong control

Median HEP = 0.003	Table 20-12	Select wrong control on a panel
Mean HEP = 3.75E-03	(Reference 10)	from an array of similar-
Error Factor = 3		appearing controls identified
		by labels only

3. Recovery error - Shift supervisor fails to detect error by others

Median HEP = 0.1	Table 20-22	Checking routine tasks, checker
Mean HEP = 0.16	(Reference 10)	using written materials
Error Factor = 5		

$$
\begin{aligned}
P_{OE} &= (1-3.75E-03)(0.00375)(0.16) + 0.00375(0.16) \\
&= 5.9775E-04 + 6.0E-04 \\
&= 1.198E-03 \\
&= 1.2E-03
\end{aligned}
$$

Fault Tree Identifiers: AV06060EK and AV06070EK

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Place in manual and close RHRS Heat exchanger A(B) bypass flow control valves FV-0618 (FV-0619).

REFERENCE: Step 2.c of Section 4.2, "Placing the RHRS in Service for RCS Cooldown," in procedure 13011, "Residual Heat Removal System."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to close air-operated heat exchanger bypass flow control valves

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator fails to place valve in manual by selecting wrong control

Median HEP = 0.003	Table 20-12	Select wrong control on a panel
Mean HEP = 3.75E-03	(Reference 10)	from an array of similar-
Error Factor = 3		appearing controls identified
		by labels only

3. Commission error - Operator fails to close valve by selecting wrong control

Median HEP = 0.003	Table 20-12	Select wrong control on a panel
Mean HEP = 3.75E-03	(Reference 10)	from an array of similar-
Error Factor = 3		appearing controls identified
		by labels only

4. Recovery error - Shift supervisor fails to detect error by others

Median HEP = 0.1	Table 20-22	Checking routine tasks, checker
Mean HEP = 0.16	(Reference 10)	using written materials
Error Factor = 5		

$$P_{OE} = 3.75E\text{-}03(0.16) + (1-3.75E\text{-}03)(3.75E\text{-}03)(0.16) + (1-3.75E\text{-}03)^2 (3.75E\text{-}03)(0.16)$$
$$= 6.0E\text{-}04 + 5.98E\text{-}04 + 5.96E\text{-}04$$
$$= 1.794E\text{-}03$$
$$= 1.8E\text{-}03$$

Fault Tree Identifiers: AV0618OEK and AV0619OEK

TABLE B-3 (Cont'd)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Close RWST to RHRS pump A(B), valve HV-8812A (HV-8812B).

REFERENCE: Step 2.d of Section 4.2, "Placing the RHRS in Service for RCS Cooldown," in procedure 13011, "Residual Heat Removal System."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to close motor-operated valve from RWST

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator fails to close valve by selecting wrong control

Median HEP = 0.003	Table 20-12	Select wrong control on a panel
Mean HEP = 3.75E-03	(Reference 10)	from an array of similar-
Error Factor = 3		appearing controls identified
		by labels only

3. Recovery error - Shift supervisor fails to detect error by others

Median HEP = 0.1	Table 20-2[illegible]	Checking routine tasks, checker
Mean HEP = 0.16	(Reference 10)	using written materials
Error Factor = 5		

P_{OE} = (1-3.75E-3)(3.75E-3)(0.16) + 3.75E-3(0.16)
= 5.9775E-04 + 6.0E-04
= 1.198E-03
= 1.2E-03

Fault Tree Identifiers: MV8812AOEK and MV8812BOEK

TABLE B-3 (Cont'd)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Open RHRS pump suctions from RCS loops HV-8701A, HV-8701B (HV-8702A, HV-8702B).

REFERENCE: Steps 2.f and 2.g of Section 4.2, "Placing the RHRS in Service for RCS Cooldown," in procedure 13011, "Residual Heat Removal System."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to open motor-operated suction valve using rotary switch

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator fails to turn control to open valve

Median HEP = 0.05	Table 20-12	Turn rotary switch in wrong
Mean HEP = 8.1E-02	(Reference 10)	direction when design violates
Error Factor = 5		a strong populational stereotype and operation conditions are normal by labels only

3. Recovery error - Verifier fails to detect error by others

Median HEP = 0.1	Table 20-22	Checking routine tasks, checker
Mean HEP = 0.16	(Reference 10)	using written materials
Error Factor = 5		

P_{OE} = (1-3.75E-03)(8.1E-02)(0.16) + 0.00375(0.16)
= 1.291E-02 + 6.0E-04
= 1.351E-02
= 1.35E-02

Fault Tree Identifiers: 1AMVOEOPEN and 1BMVOEOPEN
2BMVOEOPEN and 2AMVOEOPEN

TABLE B-3 (Cont'd)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Unlock and close the supply breakers and the K2 links to HV-8701A (HV-8702A) and HV-8701B (HV-8702B).

REFERENCE: Steps 1.b and 1.c of Section 4.2, "Placing the RHRS in Service for RCS Cooldown," in procedure 13011, "Residual Heat Removal System."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to unlock and close power supply breaker and close the K2 links

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator selects wrong circuit breaker

Median HEP = 0.005	Table 20-12	Select wrong circuit breaker in
Mean HEP = 6.25E-03	(Reference 10)	a group of circuit breakers
Error Factor = 3		densely grouped and identified by labels only

3. Commission error - Operator selects wrong K2 link

Median HEP = 0.005	Table 20-12	Select wrong circuit breaker in
Mean HEP = 6.25E-03	(Reference 10)	a group of circuit breakers
Error Factor = 3		densely grouped and identified by labels only

4. Recovery error - Foreman fails to detect error by others

Median HEP = 0.1	Table 20-22	Checking routine tasks, checker
Mean HEP = 0.16	(Reference 10)	using written materials
Error Factor = 5		

$$P_{OE} = (1-3.75E-3)(0.00625)(0.16) + 0.00375(0.16) + (1-3.75E-03)(1-6.25E-03)(6.25E-03)(0.16)$$
$$= 9.96E-04 + 6.0E-04 + 9.90E-04$$
$$= 2.586E-03$$
$$= 2.60E-03$$

Fault Tree Identifiers: 1BMVCBOE, 2BMVCBOE
1AMVCBOE, 2AMVCBOE

TABLE B-3 (Cont'd)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Close RHRS to RCS hot legs cross-connect HV-8716A (HV-8716B).

REFERENCE: Steps 2.a of Section 4.2, "Placing the RHRS in Service for RCS Cooldown," in procedure 13011, "Residual Heat Removal System."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to close motor-operated valve to hot leg cross-connect

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator fails to close valve by selecting wrong control

Median HEP = 0.003	Table 20-12	Select wrong control on a panel
Mean HEP = 3.75E-03	(Reference 10)	from an array of similar-
Error Factor = 3		appearing controls identified
		by labels only

3. Recovery error - Shift supervisor fails to detect error by others

Median HEP = 0.1	Table 20-22	Checking routine tasks, checker
Mean HEP = 0.16	(Reference 10)	using written materials
Error Factor = 5		

$$
\begin{aligned}
P_{OE} &= (1-3.75E-3)(3.75E-3)(0.16) + 0.00375(0.16) \\
&= 5.9775E-04 + 6.0E-04 \\
&= 1.198E-03 \\
&= 1.2E-03
\end{aligned}
$$

Fault Tree Identifiers: MV716AOEK and MV716BOEK

TABLE B-3 (Cont'd)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Open and lock the supply breaker and open the K2 links to HV-8804A (HV-8804B).

REFERENCE: Step 3 of Section 4.2, "Placing the RHRS in Service for RCS Cooldown," in procedure 13011, "Residual Heat Removal System."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to open and lock power supply breaker and open K2 links

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator selects wrong circuit breaker

Median HEP = 0.005	Table 20-12	Select wrong circuit breaker in
Mean HEP = 6.25E-03	(Reference 10)	a group of circuit breakers
Error Factor = 3		densely grouped and identified
		by labels only

3. Commission error - Operator selects wrong K2 link

Median HEP = 0.005	Table 20-12	Select wrong circuit breaker in
Mean HEP = 6.25E-03	(Reference 10)	a group of circuit breakers
Error Factor = 3		densely grouped and identified
		by labels only

4. Recovery error - Foreman fails to detect error by others

Median HEP = 0.1	Table 20-22	Checking routine tasks, checker
Mean HEP = 0.16	(Reference 10)	using written materials
Error Factor = 5		

$$
\begin{aligned}
P_{OE} &= (1-3.75E-3)(0.00625)(0.16) + 0.00375(0.16) + (1-3.75E-03)\\
&\quad (1-6.25E-03)(0.16)(6.25E-03)\\
&= 9.96E-04 + 6.0E-04 + 9.90E-04\\
&= 2.586E-03\\
&= 2.60E-03
\end{aligned}
$$

Fault Tree Identifiers: 4ACBOEF, 4BCBOEF

TABLE B-3 (Cont'd)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Open RHRS HX discharge HV-0606 (HV-0607).

REFERENCE: Step 6.e of Section 4.2, "Placing the RHRS in Service for RCS Cooldown," in procedure 13011, "Residual Heat Removal System."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to open air-operated HX discharge valve

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator fails to open valve by selecting wrong control

Median HEP = 0.005	Table 20-12	Select wrong control on a panel
Mean HEP = 3.75E-03	(Reference 10)	from an array of similar-
Error Factor = 3		appearing controls identified
		by labels only

3. Recovery error - Shift supervisor fails to detect error by others

Median HEP = 0.1	Table 20-22	Checking routine tasks,
Mean HEP = 0.16	(Reference 10)	checker using written materials
Error Factor = 5		

P_{OE} = (1-3.75E-3)(3.75E-03)(0.16) + 0.00375(0.16)
= 5.9775E-04 + 6.0E-04
= 1.198E-03
= 1.2E-03

Fault Tree Identifiers: AV0606OED and AV0607OED

TABLE B-3 (Cont'd)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Open RHRS HX bypass valve FV-0618 (FV-0619).

REFERENCE: Step 6.a of Section 4.2, "Placing RHRS in Service for RCS Cooldown," in procedure 13011, "Residual Heat Removal System."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to open air-operated valve to cold legs

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator fails to open valve by selecting wrong control

Median HEP = 0.003	Table 20-12	Select wrong control on a panel
Mean HEP = 3.75E-03	(Reference 10)	from an array of similar-
Error Factor = 3		appearing controls identified
		by labels only

3. Recovery error - Shift supervisor fails to detect error by others

Median HEP = 0.1	Table 20-22	Checking routine tasks, checker
Mean HEP = 0.16	(Reference 10)	using written materials
Error Factor = 5		

$$P_{OE} = (1-3.75E-03)(0.00375)(0.16) + 0.00375(0.16)$$
$$= 5.9775E-04 + 6.0E-04$$
$$= 1.198E-03$$
$$= 1.2E-03$$

Fault Tree Identifiers: AV0618OED and AV0619OED

TABLE B-3 (Cont'd)

VOGTLE
HUMAN ERROR CALCULATIONS

TASK: Place RHRS HX bypass valve FV-0618 (FV-0619) in "AUTO" position.

REFERENCE: Step 6.c of Section 4.2, "Placing the RHRS in Service for RCS Cooldown," in procedure 13011, "Residual Heat Removal System."

BREAKDOWN OF TASK:

1. Omission error - Operator fails to place air-operated HX bypass valve in "AUTO" position.

Median HEP = 0.003	Table 20-7	Long list > 10 items
Mean HEP = 3.75E-03	(Reference 10)	When procedures with checkoff
Error Factor = 3		provisions are correctly used

2. Commission error - Operator fails to place valve in "AUTO" by selecting wrong control

Median HEP = 0.003	Table 20-12	Select wrong control on a panel
Mean HEP = 3.75E-03	(Reference 10)	from an array of similar-
Error Factor = 3		appearing controls identified by labels only

3. Recovery error - Shift supervisor fails to detect error by others

Median HEP = 0.1	Table 20-22	Checking routine tasks, checker
Mean HEP = 0.16	(Reference 10)	using written materials
Error Factor = 5		

$$
\begin{aligned}
P_{OE} &= (1-3.75E-03)(0.00375)(0.16) + 0.00375(0.16) \\
&= 5.9775E-04 + 6.0E-04 \\
&= 1.198E-03 \\
&= 1.2E-03
\end{aligned}
$$

Fault Tree Identifiers: FC0618AOE and FC0619OE

TABLE B-4

VOGTLE
DOMINANT CONTRIBUTORS
RHRS INITIATION

NUMBER	CUTSET PROB.	BASIC EVENT NAME	EVENT PROB.	IDENTIFIER
1.	1.35E-02	OPERATOR FAILS TO OPEN 8702B SUCTION VALVE	1.35E-02	2BMVOEOPEN
2.	1.35E-02	OPERATOR FAILS TO OPEN 8702A SUCTION VALVE	1.35E-02	2AMVOEOPEN
3.	1.35E-02	OPERATOR FAILS TO OPEN 8701B SUCTION VALVE	1.35E-02	1BMVOEOPEN
4.	1.35E-02	OPERATOR FAILS TO OPEN 8701A SUCTION VALVE	1.35E-02	1AMVOEOPEN
5.	1.08E-02	TRAIN B RHRS PUMP FAILS TO START	1.08E-02	PMBS
6.	1.08E-02	TRAIN A RHRS PUMP FAILS TO START	1.08E-02	PMAS
7.	2.60E-03	FAIL TO REMOVE POWER & K2 LEADS TO VALVE HV-8804B	2.60E-03	4BCBOEF
8.	2.60E-03	FAIL TO REMOVE POWER & K2 LEADS TO VALVE HV-8804A	2.60E-03	4ACBOEF
9.	2.60E-03	OPERATOR FAILS TO RACK IN CIRCUIT BREAKER FOR 8702B	2.60E-03	2BMVCBOE
10.	2.60E-03	OPERATOR FAILS TO RACK IN CIRCUIT BREAKER FOR 8702A	2.60E-03	2AMVCBOE
11.	2.60E-03	OPERATOR FAILS TO RACK IN CIRCUIT BREAKER FOR 8701B	2.60E-03	1BMVCBOE
12.	2.60E-03	OPERATOR FAILS TO RACK IN CIRCUIT BREAKER FOR 8701A	2.60E-03	1AMVCBOE
13.	1.80E-03	RHRS HX BYPASS VALVE FV0619 FAILS TO CLOSE OPERATOR ERROR	1.80E-03	AV0619OEK
14.	1.80E-03	RHRS HX BYPASS VALVE FV0618 FAILS TO CLOSE OPERATOR ERROR	1.80E-03	AV0618OEK
15.	1.20E-03	HX BYPASS FLOW CONTROL FIC0619A NOT PUT IN AUTO; OPERATOR ERROR	1.20E-03	FC0619AOE
16.	1.20E-03	HX BYPASS FLOW CONTROL FIC0618A NOT PUT IN AUTO; OPERATOR ERROR	1.20E-03	FC0618AOE
17.	1.20E-03	RHRS HX BYPASS VALVE FV0619 FAILS TO OPEN; OPERATOR ERROR	1.20E-03	AV0619OED
18.	1.20E-03	RHRS HX BYPASS VALVE FV0618 FAILS TO OPEN; OPERATOR ERROR	1.20E-03	AV0618OED
19.	1.20E-03	RHRS HX OUTLET VALVE HV0607 FAILS TO OPEN OPERATOR ERROR	1.20E-03	AV0607OED
20.	1.20E-03	RHRS HX OUTLET VALVE HV0606 FAILS TO OPEN OPERATOR ERROR	1.20E-03	AV0606OED
21.	1.20E-03	H. LEG CROSSOVER VALVE HV-8716B FAILS TO CLOSE OPERATOR ERROR	1.20E-03	MV716BOEK
22.	1.20E-03	H. LEG CROSSOVER VALVE HV-8716A FAILS TO CLOSE OPERATOR ERROR	1.20E-03	MV716AOEK
23.	1.20E-03	RHRS SUCTION RWST VALVE 8812B FAILS TO CLOSE OPERATOR ERROR	1.20E-03	MV8812BOEK
24.	1.20E-03	RHRS SUCTION RWST VALVE 8812A FAILS TO CLOSE OPERATOR ERROR	1.20E-03	MV8812AOEK
25.	1.20E-03	RHRS HX OUTLET VALVE HV0607 FAILS TO CLOSE OPERATOR ERROR	1.20E-03	AV0607OEK
26.	1.20E-03	RHRS HX OUTLET VALVE HV0606 FAILS TO CLOSE OPERATOR ERROR	1.20E-03	AV0606OEK
27.	2.00E-04	TRAIN B RHRS PUMP FAILS TO RUN FOR 2 HOUR	2.00E-04	PMBR
28.	2.00E-04	TRAIN A RHRS PUMP FAILS TO RUN FOR 2 HOUR	2.00E-04	PMAR

REDUCED SUM OF PROBABILITY OF FAILURE = 1.050E-01

TABLE B-5

VOGTLE
DOMINANT CONTRIBUTORS
LOSS OF SHORT TERM COOLING
WITH AUTOCLOSURE INTERLOCK

NUMBER	CUTSET PROB.	BASIC EVENT NAME	EVENT PROB.	IDENTIFIER
1.	7.20E-03	RHRS PUMP B FAILS TO RUN FOR 72 HOURS	7.20E-03	PMBX
2.	7.20E-03	RHRS PUMP A FAILS TO RUN FOR 72 HOURS	7.20E-03	PMAX
3.	4.18E-04	LOOP POWER SUPPLY PQY-428 FAILS	4.18E-04	2BLP428F
4.	4.18E-04	LOOP POWER SUPPLY PQY-418 FAILS	4.18E-04	2ALP418F
5.	4.18E-04	LOOP POWER SUPPLY PQY-408 FAILS	4.18E-04	1BLP408F
6.	4.18E-04	LOOP POWER SUPPLY PQY-438 FAILS	4.18E-04	1ALP438F
7.	2.16E-04	SSPS RELAY K735 COIL FAILS	2.16E-04	2BCOK735F
8.	2.16E-04	SSPS RELAY K255 COIL FAILS	2.16E-04	2BCOK255F
9.	2.16E-04	SSPS RELAY K1302 COIL FAILS	2.16E-04	2ACOK1302F
10.	2.16E-04	AUXILIARY RELAY PY/418B COIL FAILS	2.16E-04	2ACO418BF
11.	2.16E-04	SSPS RELAY K1302 COIL FAILS	2.16E-04	1BCOK1302F
12.	2.16E-04	AUXILIARY RELAY PY/408B COIL FAILS	2.16E-04	1BCO408BF
13.	2.16E-04	SSPS RELAY K735 COIL FAILS	2.16E-04	1ACOK735F
14.	2.16E-04	SSPS RELAY K155 COIL FAILS	2.16E-04	1ACOK155F
15.	2.09E-04	DUAL COMPARATOR PB-428A/B FAILS	2.09E-04	2BAD428ABF
16.	2.09E-04	DUAL COMPARATOR PB-418A/B FAILS	2.09E-04	2AAD418ABF
17.	2.09E-04	DUAL COMPARATOR PB-408A/B FAILS	2.09E-04	1BAD408ABF
18.	2.09E-04	DUAL COMPARATOR PB-438A/B FAILS	2.09E-04	1AAD438ABF
19.	1.25E-04	PRESSURE TRANSMITTER PT-428 FAILS	1.25E-04	2BTP428F
20.	1.25E-04	PRESSURE TRANSMITTER PT-418 FAILS	1.25E-04	2ATP418F
21.	1.25E-04	PRESSURE TRANSMITTER PT-408 FAILS	1.25E-04	1BTP408F
22.	1.25E-04	PRESSURE TRANSMITTER PT-438 FAILS	1.25E-04	1ATP438F

REDUCED SUM OF PROBABILITY OF FAILURE = 1.961E-02

TABLE B-6

VOGTLE
DOMINANT CONTRIBUTORS
LOSS OF SHORT TERM COOLING
WITHOUT AUTOCLOSURE INTERLOCK

NUMBER	CUTSET PROB.	BASIC EVENT NAME	EVENT PROB.	IDENTIFIER
1.	7.20E-03	RHRS PUMP B FAILS TO RUN FOR 72 HOURS	7.20E-03	PMBX
2.	7.20E-03	RHRS PUMP A FAILS TO RUN FOR 72 HOURS	7.20E-03	PMAX
3.	5.83E-05	CONTROL SWITCH CS-R FAILS MOV 8702B	5.83E-05	2BCSCSRF
4.	5.83E-05	CONTROL SWITCH CS-R FAILS MOV 8702A	5.83E-05	2ACSCSRF
5.	5.83E-05	CONTROL SWITCH CS-R FAILS MOV 8701B	5.83E-05	1BCSCSRF
6.	5.83E-05	CONTROL SWITCH CS-R FAILS MOV 8701A	5.83E-0[illegible]	[illegible]CSCSRF
7.	1.44E-05	MOTOR OPERATED VALVE HV8809B SPURIOUSLY CLOSES	1.44E-05	MV8809BV
8.	1.44E-05	MOTOR OPERATED VALVE 8809A SPURIOUSLY CLOSES	1.44E-05	MV8809AV
9.	1.44E-06	LOCKIN CONTACT 42-C SHORTS MOV 8702B	1.44E-06	2BCN42CV
10.	1.44E-06	LOCKIN CONTACT 42-C SHORTS MOV 8702A	1.44E-06	2ACN42CV
11.	1.44E-06	LOCKIN CONTACT 42-C SHORTS MOV 8701B	1.44E-06	1BCN42CV
12.	1.44E-06	LOCKIN CONTACT 42-C SHORTS MOV 8701A	1.44E-06	1ACN42CV

REDUCED SUM OF PROBABILITY OF FAILURE = 1.461E-02

TABLE B-7

VOGTLE
DOMINANT CONTRIBUTORS
LOSS OF LONG TERM COOLING
WITH AUTOCLOSURE INTERLOCK

NUMBER	CUTSET PROB.	BASIC EVENT NAME	EVENT PROB.	IDENTIFIER
1.	1.02E-02	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
2.	1.09E-03	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		RHRS PUMP B FAILS TO START	1.08E-02	PMBA
3.	5.91E-04	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		LOOP POWER SUPPLY PQY-428 FAILS	5.85E-03	2BLP428F
4.	5.91E-04	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		LOOP POWER SUPPLY PQY-418 FAILS	5.85E-03	2ALP418F
5.	5.91E-04	LOOP POWER SUPPLY PQY-408 FAILS	5.85E-03	1BLP408F
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
6.	5.91E-04	LOOP POWER SUPPLY PQY-438 FAILS	5.85E-03	1ALP438F
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
7.	3.05E-04	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		SSPS RELAY K735 COIL FAILS	3.02E-03	2BCOK735F
8.	3.05E-04	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		SSPS RELAY K255 COIL FAILS	3.02E-03	2BCOK255F
9.	3.05E-04	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		SSPS RELAY K1302 COIL FAILS	3.02E-03	2ACOK1302F
10.	3.05E-04	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		AUXILIARY RELAY PY/418B COIL FAILS	3.02E-03	2ACO418BF
11.	3.05E-04	SSPS RELAY K1302 COIL FAILS	3.02E-03	1BCOK1302F
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
12.	3.05E-04	AUXILIARY RELAY PY/408B COIL FAILS	3.02E-03	1BCO408BF
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
13.	3.05E-04	SSPS RELAY K735 COIL FAILS	3.02E-03	1ACOK735F
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
14.	3.05E-04	SSPS RELAY K155 COIL FAILS	3.02E-03	1ACOK155F
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
15.	2.95E-04	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		DUAL COMPARATOR PB-428A/B FAILS	2.92E-03	2BAD428ABF
16.	2.95E-04	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		DUAL COMPARATOR PB-418A/B FAILS	2.92E-03	2AAD418ABF
17.	2.95E-04	DUAL COMPARATOR PB-408A/B FAILS	2.92E-03	1BAD408ABF
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
18.	2.95E-04	DUAL COMPARATOR PB-438A/B FAILS	2.92E-03	1AAD438ABF
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX

REDUCED SUM OF PROBABILITY OF FAILURE = 2.086E-02

TABLE B-8

VOGTLE
DOMINANT CONTRIBUTORS
LOSS OF LONG TERM COOLING
WITHOUT AUTOCLOSURE INTERLOCK

NUMBER	CUTSET PROB.	BASIC EVENT NAME	EVENT PROB.	IDENTIFIER
1.	1.02E-02	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
2.	1.09E-03	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		RHRS PUMP B FAILS TO START	1.08E-02	PMBA
3.	1.59E-04	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		RHRS PUMP B UNAVAILABLE DUE TO MAINTENANCE	1.57E-03	PMBMAINT
4.	9.35E-05	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		RHRS PUMP B UNAVAILABLE DUE TO TEST	9.26E-04	PMBTEST
5.	8.24E-05	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		CONTROL SWITCH CS-R FAILS MOV 8702B	8.16E-04	2BCSCSRF
6.	8.24E-05	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		CONTROL SWITCH CS-R FAILS MOV 8702A	8.16E-04	2ACSCSRF
7.	8.24E-05	CONTROL SWITCH CS-R FAILS MOV 8701B	8.16E-04	1BCSCSRF
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
8.	8.24E-05	CONTROL SWITCH CS-R FAILS MOV 8701A	8.16E-04	1ACSCSRF
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
9.	2.04E-05	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		CHECK VALVE 010 FAILS TO OPEN	2.02E-04	CV010D
10.	2.04E-05	RHR PUMP A FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMAX
		MOTOR OPERATED VALVE HV8809B SPURIOUSLY CLOSES	2.02E-04	MV8809BV
11.	2.04E-05	MOTOR OPERATED VALVE 8809A SPURIOUSLY CLOSES	2.02E-04	MV8809AV
		RHRS PUMP B FAILS TO RUN FOR 1008 HOURS	1.01E-01	PMBX
12.	8.81E-06	CONTROL SWITCH CS-R FAILS MOV 8701B	8.16E-04	1BCSCSRF
		RHRS PUMP B FAILS TO START	1.08E-02	PMBA
13.	8.81E-06	CONTROL SWITCH CS-R FAILS MOV 8701A	8.16E-04	1ACSCSRF
		RHRS PUMP B FAILS TO START	1.08E-02	PMBA
14.	2.18E-06	MOTOR OPERATED VALVE 8809A SPURIOUSLY CLOSES	2.02E-04	MV8809AV
		RHRS PUMP B FAILS TO START	1.08E-02	PMBA

REDUCED SUM OF PROBABILITY OF FAILURE = 1.195E-02

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APPENDIX C

VOGTLE
LOW TEMPERATURE OVERPRESSURIZATION ANALYSIS

APPENDIX C
LOW TEMPERATURE OVERPRESSURIZATION ANALYSIS

This appendix details the calculations performed to determine the change in the frequency of the consequences of low temperature overpressure transients due to removal of the ACI for Vogtle. The frequencies are calculated for two cases: 1) with the present interlock configuration and 2) with the proposed modification.

The methodology applied in the Westinghouse Owners Group generic program (WCAP-11736), Appendix D, is applied to the Vogtle plant.

The effect of the mass input overpressure transients identified in the WOG analysis was evaluated utilizing event trees (charging/safety injection pump actuation and letdown isolation). Each mitigating system and operator action was modeled as a top node on the event tree for the given transient. The following describe the event tree structure, the success criteria defined for each transient, and the nodal probabilities utilized in the quantification and the results.

The safety functions, i.e., the event tree top events or nodes, for the Vogtle event trees are defined below:

1. Initiating Event (IE): The mass input initiator that could lead to overpressurization and/or possible RHRS damage, either charging pump actuation or letdown isolation (both with the RHRS operable and with the RHRS isolated). Operation of the safety injection pumps is not included with the charging pumps as part of the initiating event since they are racked out, however, the positive displacement pump is included.

2. RHRS Isolated (RI): The RHRS will be isolated during certain periods of shutdown. This dictates whether or not the RHRS relief valves are available to mitigate the transient and if the possibility exists for damage to the RHRS. For Vogtle, the event tree allows for both trains of RHRS to be isolated, one train or no trains.

3. RHRS Suction Relief Valve Lifts (RV): If the RHRS is not isolated, the spring loaded relief valves will open at the setpoint pressure. If one train of RHRS is isolated, only one RHRS relief valve is available and if both trains are isolated, there are no RHRS relief valves available to mitigate the transient.

4. COPS Operates (COP): The cold overpressure protection system (COPS) consists of two redundant and independent systems utilizing the pressurizer's PORVs. When the system is energized and reactor coolant temperature is below 350°F, a high pressure signal (above the COPS setpoint) will trip the system automatically and open a PORV until the pressure drops below the reset value. For Vogtle, the COPS has a variable setpoint. An auctioneered system temperature is continuously converted to an allowable pressure and then compared to the actual RCS pressure. The system logic will first annunciate a main control board alarm whenever the measured pressure approaches within a predetermined amount of the allowable pressure. On a further increase in measured pressure, an actuation signal is transmitted to the power-operated relief valve. For this analysis, it was assumed that the COPS would actuate at its lowest setpoint (505 psig).

5a. RHRS Suction/Isolation Valves Automatically Close (RSV): When the pressure increases to the autoclosure setpoint (750 psig), the ACI receives a pressure signal that actuates the circuitry and closes the motor-operated valve. This node is addressed in the case with the ACI only.

5b. Operator Detects Overpressure Alarm and Isolates the RHRS (OD): For the modification case, an alarm would sound when the pressure reached approximately 750 psig. Through a revision in operating procedures, it is assumed that the operator will detect the overpressure and isolate the RHRS before the pressure reaches 150% of the RHRS design pressure.

6. Operator Secures Running Pump (OA1): Given an alarm, caused when the RHRS relief valves open to the pressurizer relief tank (PRT) and actuate one of its alarms, or from the operation of at least one train of COPS, or from the high pressure alarm on the RHRS suction valves (in the modification case only), the operator will stop the extra running pump. If the operator stops the running pump, the overpressure event is halted.

7. Operator Opens a PORV (OA2): Given an alarm, if no or one relief valve operates successfully and the pressure still continues to rise, the operator may open a PORV in order to reduce the pressure. The operator may also open a PORV if he fails to stop the running pump in order to increase the time available to mitigate the transient.

8. Pressurizer PORV Reseats (POR): Given that a PORV has opened and the transient has been stopped, the PORV must close in order to avert a loss of coolant condition.

9. RHRS Relief Valve Reseats (RVR): Given that a RHRS relief valve successfully operates and the transient is terminated, the relief valve must reseat or coolant would be lost to the PRT. If the transient is not stopped, the relief valve will cycle open and closed and is assumed to eventually fail open.

For each of these nodes, failure probabilities were calculated. These nodal probability calculations for Vogtle are shown in Table C-1 .

The success criteria for the event tree top events were determined based on conservative estimates of the flow rates and relieving capacities of the relief valves. For the charging pump actuation case, it is assumed that two PORVs, or two RHRS relief valves, or one PORV and one RHRS relief valve are required to mitigate the transient, since the maximum flow rate to the RHRS from the two charging pumps and the positive displacement pump is 1208 gpm (conservative assumption that all three pumps operate at their maximum flow rates; 555, 555, and 98 gpm). The Vogtle LTOP analysis, documented in Westinghouse letters FSE/SS-GAE-6397 (3/15/90) and FSD/SS-GAE-3731 (8/27/85), calculated the maximum flow rate for the charging pumps actuation case to be 673 gpm at 495 psig. However, the 1208 gpm number is being conservatively used to maintain consistency with the WOG-11736 methodology. The following assumptions were also utilized in the analysis of the charging mass input transient.

1. No credit is taken for venting via the Reactor Vessel Head Vent System.

2. A failure detection time was assumed to be 24 hours for the suction valve components while six weeks (1008 hours) was assumed for the PORVs and block valves (assumed to be representative of a refueling outage). These times were conservatively determined from the monitoring frequencies of the valves.

The event trees for these cases are in Figures C-6 through C-9. Figures C-1 through C-5 are the fault trees required to quantify the event tree top events.

The results from the quantification of the event trees for Vogtle are shown in Tables C-3 to C-5. The results show that the frequencies of most of the overpressure consequence categories remain unchanged with the deletion of the ACI. Refer to Table 4-5 for a description of the consequence categories.

For the charging case, the frequencies of consequence categories MSFO and MSCO increased, while the category HOPV decreased. The two increases were 3.76E-12 and 2.35E-12/shutdown year, respectively. These are very insignificant increases in the frequency of these events.

For the letdown isolation - RHRS operable case, the frequency of the consequence category MOPI, decreased slightly, while the category HOPV increased by 4.30E-17/shutdown year.

In the letdown isolation - RHRS isolated case, the frequencies of all the impacted consequence categories decreased due to the reduction in the initiating event frequency (i.e., the reduction in the loss of letdown due to spurious closure of the RHRS suction valves).

The conclusion to be drawn from the overpressure analysis is that removal of the ACI and the inclusion of an alarm has a positive impact on the consequences of low temperature overpressure events for Vogtle.

TABLE C-1

VOGTLE NODAL PROBABILITY CALCULATIONS

1. RHRS Isolated (RI)

Description: This node divides into three branches. The upper branch indicates that the RHRS is isolated from the RCS, the middle branch indicates that one RHRS train is isolated from the RCS, and the bottom branch indicates that both trains of the RHRS are open to the RCS. For this node, it was assumed that the RHRS may be isolated for a period of time during cold shutdown. The nodal probabilities for the charging actuation case are based on assumptions that both trains of the RHRS would be isolated only 5 percent of the time and that one RHRS train would be isolated only 10 percent of the time. Thus, both trains of the RHRS would be open 85 percent of the time. For the letdown isolation case with the RHRS operable, the nodal probability is 1.0 while for the case with the RHRS isolated, the nodal probability is 0.0.

Failure probabilities: The probabilities for this node for each case are shown below:

Charging pump actuation

Both trains isolated	0.05
One train isolated	0.10
No trains isolated	0.85

Letdown Isolation

RHRS operable	1.0
RHRS isolated	0.0

2. RHRS Relief Valve Operates (RV)

Description: This node divides into three branches when both trains of the RHRS are open to the RCS. Two RHRS relief valves can operate (indicated by the top branch), one RHRS relief valve can operate (indicated by the middle branch), or both relief valves can fail to open (indicated by the bottom branch). When only one train of RHRS is open to the RCS, the one operable RHRS relief valve can open (the top branch) or can fail to open (the bottom branch).

The RHRS relief valves are spring-loaded relief valves set to actuate at 450 psig. Each relief valve can relieve 950 gpm at 450 psig.

Failure probabilities: The failure of a relief valve to open is 3E-04 per demand (Refer to Table 4-1). Thus the probability for this node are:

Two (of 2) RHRS relief valves fail to open = (3E-04)(3E-04)=9E-08
One (of 2) RHRS relief valve fails to open = 3E-04 +3E-04=6E-04
One (of 1) RHRS relief valve fails to open = 3E-04

TABLE C-1 (Cont)

VOGTLE NODAL PROBABILITY CALCULATIONS

3. PORV COPS system operates at 435 psig (COP)

Description: The event tree divides into three branches at the COP node. The top branch symbolizes that both trains of COPS operate, the middle branch shows only one train of COPS operates while the bottom branch signifies both trains of COPS have failed to operate.

The COPS utilizes two pressurizer's PORVs. The operator must energize the system prior to reaching the RCS temperature of 350°F. An alarm is actuated thereby alerting the operator to arm the COPS. The COPS has a variable pressure setpoint determined by the measured RTD temperature. For this analysis, the setpoint was assumed to be constant at 505 psig (the lowest setpoint allowed).

Failure probabilities: The failure probabilities associated with this node were calculated utilizing fault trees. Figure C-3 shows the fault tree developed for two trains of COPS failing to operate while the failure of one train is shown in Figure C-4. The operator error in failing to enable the COPS is calculated below:

Task: Operator fails to arm the COPS following alarm.

Median HEP	= 0.0001	Table 20-23	Failure to initiate some kind
Error Factor	= 10	(Reference 9)	of intended corrective action
Mean HEP	= 2.66E-04		as required

The basic event probabilities utilized in the fault trees are shown in Table C-2. The failure probabilities quantified from the fault trees are:

Two trains of COPS Fail = 3.01E-04
One train of COPS Fails = 1.18E-02

4a. RHRS Suction Valves Close at P=750 psig with ACI (RSV)

Description: The node determines whether or not the RHRS suction valve ACI closes the valves when the RCS pressure reaches 750 psig. It was assumed that only one valve of the two isolation valves on each train must close for success. Failure was considered to be the RHRS open to the RCS (i.e. the ACI failed to close one of two valves on each train).

Failure probabilities: The failure probability associated with this node was calculated using the fault tree shown in Figure C-1. The basic event probabilities used to quantify the fault tree are shown in Table C-2. The failure probabilities for this node are:

Both trains of RHRS fail to isolate = 5.00E-07
One train of RHRS fails to isolate = 2.50E-07

4b. Operator Isolates RHRS System Given Overpressure Alarm (OD)

Description: The proposed modification deletes the ACI and adds an alarm to alert the operator when the pressure exceeds 750 psig and an isolation valve is in the open position. Given an overpressure transient and this alarm the operator will close at least one RHRS suction valve on each suction line to isolate the RHRS.

Failure Probabilities: The failure probability associated with this node was calculated utilizing the fault tree shown in Figure C-2. The human error probability with a time frame of 20 minutes was chosen since it is a low probability that both the relief valves and the PORVs will fail to open. These mitigating events increase the operator's response time. The operator error probabilities shown in the fault tree are calculated below:

TASK: Operator closes isolation valve given high pressure alarm.

1. Diagnosis within time T by control room personnel of abnormal event annunciated

Median HEP = 0.01	Table 20-3	within 20 minutes
Error factor = 10	(Reference 9)	
Mean HEP = 2.66E-02		

2. Operator failure in operating manual controls

Median HEP = 0.001	Table 20-12	Select wrong control from an array of similar-appearing controls arranged in well-delineated functional groups
Error factor = 3	(Reference 9)	
Mean HEP = 1.25E-03		

3. Recovery factor - special short term one-of-a-kind checking

Median HEP = 0.05	Table 20-22	
Error factor = 5	(Reference 9)	
Mean HEP = 8.07E-02		

P(Fail in 20 minutes) = 2.66E-02(8.07E-02) + (1-2.66E-02)(1.25E-03)(8.07E-02)
= 2.15E-03 + 9.82E-05
= 2.25E-03

The basic event probabilities are shown in Table C-2. The result of the quantification of the fault tree is shown below:

Fail to Isolate two Trains = 1.32E-05
Fail to Isolate one Train = 6.60E-06

5. Operator Secures Running Pump (OA1)

Description: For any operator action to occur, an alarm must be actuated. This alarm can occur by actuation of a relief valve, or from the operation of one train of COPS, or in the modification case, the high pressure alarm on the RHRS suction valves.

Failure Probability: The human error probability with a time frame of 20 minutes was chosen since it is a low probability that both the relief valves and the PORVs will fail to open. These mitigating events increase the operator's response time. The human error probability is calculated below:

1. Failure to diagnose transient in time T

Median HEP = 0.1	Table 20-1	within 20 minutes
Error factor = 10	(Reference 9)	
Mean HEP = 0.266		

2. Select wrong control

Median HEP = 0.001	Table 20-12	Select wrong control
Error factor = 3	(Reference 9)	on a panel from an array of
Mean HEP = 1.25E-03		similar-appearing controls arranged in well-delineated functional groups

P(Fail in 20 minutes) = 0.266 + (1-0.266)(1.25E-03)
= 0.267

6. Operator Opens PORV (OA2)

Description: If no relief valve operates or the ACI isolates the relief valve, the operator can open a PORV to reduce the pressure, given an alarm has actuated. If the operator fails to secure the pump, he can open a PORV in order to increase the time he has available in which to act.

Failure Probabilities: This action was modeled as dependent on the operator's success or failure to stop the running pump. The failure probabilities are:

Given failure of previous task

OA2 = 0.36	Table 20-18 (Reference 9)	Medium dependence

Given success of previous task

OA2 = 0.21	Table 20-19 (Reference 9)	Medium dependence

TABLE C-1 (Cont)

VOGTLE NODAL PROBABILITY CALCULATIONS

7. RHRS Relief Valve Reseats (RVR)

Description: Given that the transient is successfully mitigated, the RHRS relief valves must reseat (close) in order to prevent a loss of coolant.

Failure Probability: The probability that the relief valve will not reseat is 3E-2 per demand (Refer to Table 4-1). If both RHRS relief valves actuated, both relief valves must close. If only one RHRS relief valve actuates, it must close. Thus the failure probabilities are:

Both relief valves fail to close = 3E-02 +3E-02 = 6E-02
One relief valve fails to close = 3E-02

8. PORVs Reseat (POR)

Description: Given that the transient is successfully mitigated, the PORV must close in order to prevent a loss of coolant. If the PORV fails to close, the operator can isolate the open PORV using the associated block valve.

Failure Probability: The failure probabilities for the PORVs to reseat was calculated utilizing the fault tree shown in Figure C-5. The basic event probabilities are shown in Table C-2. The human error calculation for the operator failing to close the block valve is shown below:

TASK: Operator closes block valve

1. Operator fails to detect leaking PORV

Median HEP = 0.001 Error factor = 3 Mean HEP = 1.25E-03	Table 20-11 (Reference 9)	Error of commission in check reading display (digital indicators)

2. Operator selects wrong control

Median HEP = 0.001 Error Factor = 3 Mean HEP = 1.25E-03	Table 20-12 (Reference 9)	Select wrong control from an array of similar-appearing controls arranged in well-delineated functional groups

3. Recovery factor - special short term one-of-a-kind checking

Median HEP = 0.05 Error factor = 5 Mean HEP = 8.07E-02	Table 20-22 (Reference 9)

P(Fail to close block valve) = 1.25E-03(8.07E-02) + (1-1.25E-03)(1.25E-03)(8.07E-02)
= 1.01E-04 + 1.01E-04
= 2.02E-04

Thus, the failure probabilities for this node are:

Two PORVs fail to close = 5.28E-05
One PORV fails to close = 2.64E-05

TABLE C-2

VOGTLE BASIC EVENT PROBABILITIES FOR FAULT TREES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
VOGTLE OVERPRESSURE WITH ACI								
1ALSU	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
1ACOK155F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1ACNK155F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1ALPPQY438F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
1ATSPS/438F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1ATPPT438F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.200E+01	2.08E-05	0.00E+00
1ADPB438ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.200E+01	3.48E-05	0.00E+00
1ATSPS38ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1ASRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1ACNK735F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1ACOK735F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1ACB521U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1ACT480120F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	1.200E+01	4.20E-06	0.00E+00
1AOL49AF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1AOL49RF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1AOL49CF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1ARECN42CAF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1ARECN42CBF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1ARECN42CCF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1ACB522U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1AMVK	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	1.200E+01	1.20E-04	0.00E+00
1ACN420U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1ARECO42CF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1AFU1	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	1.200E+01	1.80E-06	0.00E+00
1AOLCN49U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1AQS8701AF	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	1.200E+01	2.40E-06	0.00E+00

TABLE C-2 (Cont)

VOGTLE BASIC EVENT PROBABILITIES FOR FAULT TREES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1ACN42CF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1ACSF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1BLSU	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
1BCOK408F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1BCN408BF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1BALP408F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
1BLP408F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
1BTS408F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1BTP408F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.200E+01	2.08E-05	0.00E+00
1BD408ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.200E+01	3.48E-05	0.00E+00
1BTS408ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
1BSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
1BCNX1302F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1BCOK1302F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1BCB115U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1BCT480120F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	1.200E+01	4.20E-06	0.00E+00
1BOL49AF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1BOL49BF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1BOL49CF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
1BRECN42CAF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1BRECN42CBF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1BRECN42CCF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1BCB115NU	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
1BMVK	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	1.200E+01	1.20E-04	0.00E+00
1BCN420U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1BRECO42CF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
1BFU1	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	1.200E+01	1.80E-06	0.00E+00

TABLE C-2 (Cont)

VOGTLE BASIC EVENT PROBABILITIES FOR FAULT TREES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
1BOLCN49U	CN	RELAY CONTACTORS SPURIOUS OPERATION	[illegible].000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
1BQS8701BF	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	1.200E+01	2.40E-06	0.00E+00
1BCN42CF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
1BCSF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
2ALSU	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
2ACOK418F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
2ACN418BF	CN	RELAY CON[illegible] FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2AALP418F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
2ALP418F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
2ATS418F	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
2ATP418F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.200E+01	2.08E-05	0.00E+00
2AD418ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.200E+01	3.48E-05	0.00E+00
2ATS418ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
2ASRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
2ACNK1302F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.[illegible]0E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2ACOK1302F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
2ACB116U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
2ACT480120F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	1.200E+01	4.20E-06	0.00E+00
2AOL49AF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
2AOL49BF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
2AOL49CF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
2ARECN42CAF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2ARECN42CBF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2ARECN42CCF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2ACB116NU	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
2AMVK	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	1.200E+01	1.20E-04	0.00E+00
2ACN420U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00

TABLE C-2 (Cont)

VOGTLE BASIC EVENT PROBABILITIES FOR FAULT TREES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
2ARECO42CF	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
2AFU1	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	1.200E+01	1.80E-06	0.00E+00
2AOLCN49U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
2AQSB702AF	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	1.200E+01	2.40E-06	0.00E+00
2ACN42CF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2ACSF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
2BLSU	LS	LIMIT SWITCH ALL MODES	7.220E-06	0.000E+00	IEEE	1.200E+01	8.66E-05	0.00E+00
2BCOK255F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
2BCKK255F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2BLP428F	PS	LOOP POWER SUPPLY ALL MODES	5.800E-06	0.000E+00	TOPS	1.200E+01	6.96E-05	0.00E+00
2BTS428F	CN	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
2BTP428F	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	1.200E+01	2.08E-05	0.00E+00
2BDP428ABF	CM	COMPARATOR ALL MODES	2.900E-06	0.000E+00	TOPS	1.200E+01	3.48E-05	0.00E+00
2BTS428ABF	CM	COMPARATOR TRIP SWITCH	5.800E-07	0.000E+00	IEEE	1.200E+01	6.96E-06	0.00E+00
2BSRF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
2BCNK735F	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2BCOK735F	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
2BCB521U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
2BCT480120F	CT	CURRENT TRANSFORMER ALL MODES	3.500E-07	0.000E+00	IEEE	1.200E+01	4.20E-06	0.00E+00
2BOL49AF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
2BOL49BF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
2BOL49CF	OL	THERMAL OVERLOAD PREMATURE OPEN	1.500E-07	0.000E+00	RATE	1.200E+01	1.80E-06	0.00E+00
2BRECN42CAF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2BRECN42CBF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2BRECN42CCF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2BCB522U	CB	CIRCUIT BREAKER OPEN W/O COMMAND	1.000E-08	0.000E+00	IEEE	1.200E+01	1.20E-07	0.00E+00
2BMVK	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	1.200E+01	1.20E-04	0.00E+00

TABLE C-2 (Cont)

VOGTLE BASIC EVENT PROBABILITIES FOR FAULT TREES

FT IDENT	COMP	FAILURE MODE	FAIL RATE	VARIANCE	SOURCE	TIME	PROBABILITY	VARIANCE
2BCN42OU	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
2BRECO42C	CO	RELAY COIL FAILURE	3.000E-06	0.000E+00	2815	1.200E+01	3.60E-05	0.00E+00
2BFU1	FU	FUSE ALL MODES	1.500E-07	0.000E+00	IEEE	1.200E+01	1.80E-06	0.00E+00
2BOLCN49U	CN	RELAY CONTACTORS SPURIOUS OPERATION	2.000E-08	0.000E+00	IEEE	1.200E+01	2.40E-07	0.00E+00
2BQS8702BF	QS	TORQUE SWITCH FAIL TO OPERATE	2.000E-07	0.000E+00	2815	1.200E+01	2.40E-06	0.00E+00
2BCN42CF	CN	RELAY CONTACTS FAIL TO TRANSFER	1.000E-06	0.000E+00	2815	1.200E+01	1.20E-05	0.00E+00
2BCSF	SR	ROTARY SWITCH ALL MODES	8.100E-07	0.000E+00	IEEE	1.200E+01	9.72E-06	0.00E+00
VOGTLE OVERPRESSURE WITHOUT ACI WITH ALARM								
MV8701AOE	OE	20 MINUTE OPERATOR CLOSE SUCTION VALVES	2.250E-03	0.000E+00	HE	0.000E+00	2.25E-03	0.00E+00
MV8701BOE	OE	20 MINUTE OPERATOR CLOSE SUCTION VALVES	2.250E-03	0.000E+00	HE	0.000E+00	2.25E-03	0.00E+00
MV8702AOE	OE	20 MINUTE OPERATOR CLOSE SUCTION VALVES	2.250E-03	0.000E+00	HE	0.000E+00	2.25E-03	0.00E+00
MV8702BOE	OE	20 MINUTE OPERATOR CLOSE SUCTION VALVES	2.250E-03	0.000E+00	HE	0.000E+00	2.25E-03	0.00E+00
VOGTLE ONE OR TWO TRAINS OF COPS FAIL TO OPERATE								
OPARMCOPS	OE	OPERATOR FAILS TO ARMS COPS	2.660E-04	0.000E+00	HE	0.000E+00	2.66E-04	0.00E+00
PORV1	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	5.040E+02	5.04E-03	0.00E+00
PORV1SIG	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	5.040E+02	8.72E-04	0.00E+00
PORV2	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	5.040E+02	5.04E-03	0.00E+00
PORV2SIG	TP	P TRANSMITTER ALL MODES	1.730E-06	0.000E+00	IEEE	5.040E+02	8.72E-04	0.00E+00
VOGTLE PORVS FAIL TO RESEAT								
PORV1CLOSE	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	5.040E+02	5.04E-03	0.00E+00
PORV1BLOCK	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	5.040E+02	5.04E-03	0.00E+00
PORV1OPERA	OE	OPERATOR FAIL BLOCK VALVE	2.020E-04	0.000E+00	HE	0.000E+00	2.02E-04	0.00E+00
PORV2CLOSE	AO	FAILURE TO OPERATE	1.000E-05	0.000E+00	2815	5.040E+02	5.04E-03	0.00E+00
PORV2BLOCK	MV	FAILURE TO CLOSE	1.000E-05	0.000E+00	2815	5.040E+02	5.04E-03	0.00E+00
PORV2OPERA	OE	OPERATOR FAIL BLOCK VALVE	2.020E-04	0.000E+00	HE	0.000E+00	2.02E-04	0.00E+00

TABLE C-3

VOGTLE
CHARGING ACTUATION
RESULTS

CONSEQUENCE CATEGORY	FREQUENCY WITH ACI	FREQUENCY WITHOUT ACI	FREQUENCY CHANGE
SUCCESS	8.667E-02	8.667E-02	0
LSFO	2.761E-04	2.761E-04	0
LSCI	0.00	0.00	0
LSCO	0.00	0.00	0
LLFO	4.671E-03	4.671E-03	0
LLCO	3.171E-02	3.171E-02	0
LLCI	1.661E-03	1.661E-03	0
LSFI	0.00	0.00	0
LLFI	2.412E-07	2.412E-07	0
MSFO	1.479E-13	3.906E-12	+3.758E-12
MLFO	0.00	0.00	0
MSFI	1.355E-05	1.355E-05	0
MLFI	0.00	0.00	0
MSCO	9.238E-14	2.439E-12	+2.347E-12
MSCI	7.739E-06	7.739E-06	0
MLCO	0.00	0.00	0
MLCI	0.00	0.00	0
MOPI	5.821E-07	5.821E-07	0
HOPI	2.245E-06	2.245E-06	0
HOPV	2.836E-16	7.488E-15	+7.204E-15
TOTAL	1.25E-01	1.25E-01	

TABLE C-4

VOGTLE
LETDOWN ISOLATION RHRS OPERABLE
RESULTS

CONSEQUENCE CATEGORY	FREQUENCY WITH ACI	FREQUENCY WITHOUT ACI	FREQUENCY CHANGE
SUCCESS	8.613E-02	8.613E-02	0
LSFO	1.649E-06	1.649E-06	0
LSCI	5.786E-13	5.786E-13	0
LSCO	2.003E-05	2.003E-05	0
LLFO	5.494E-03	5.494E-03	0
LLCO	3.336E-02	3.336E-02	0
LLCI	0.00	0.00	0
LSFI	5.177E-17	5.177E-17	0
LLFI	0.00	0.00	0
MSFO	0.00	0.00	0
MLFO	0.00	0.00	0
MSFI	0.00	0.00	0
MLFI	0.00	0.00	0
MSCO	0.00	0.00	0
MSCI	0.00	0.00	0
MLCO	0.00	0.00	0
MLCI	0.00	0.00	0
MOPI	5.213E-13	5.212E-13	-1.00E-16
HOPI	3.255E-13	3.255E-13	0
HOPV	1.693E-18	4.470E-17	+4.30E-17
TOTAL	1.25E-01	1.25E-01	

TABLE C-5

VOGTLE
LETDOWN ISOLATION RHRS ISOLATED
RESULTS

CONSEQUENCE CATEGORY	FREQUENCY WITH ACI	FREQUENCY WITHOUT ACI	FREQUENCY CHANGE
SUCCESS	3.261E-01	1.627E-01	-1 634E-01
LSFO	0.00	0.00	0
LSCI	1.402E-03	6.994E-04	-7.026E-04
LSCO	0.00	0.00	0
LLFO	0.00	0.00	0
LLCO	0.00	0.00	0
LLCI	1.174E-01	5.856E-02	-5.884E-02
LSFI	1.016E-07	5.069E-08	-5.091E-08
LLFI	1.701E-05	8.488E-06	-8.522E-06
MSFO	0.00	0.00	0
MLFO	0.00	0.00	0
MSFI	0.00	0.00	0
MLFI	0.00	0.00	0
MSCO	0.00	0.00	0
MSCI	0.00	0.00	0
MLCO	0.00	0.00	0
MLCI	0.00	0.00	0
MOPI	0.00	0.00	0
HOPI	1.339E-04	6.682E-05	-6.708E-05
HOPV	0.00	0.00	0
TOTAL	4.45E-01	2.22E-01	

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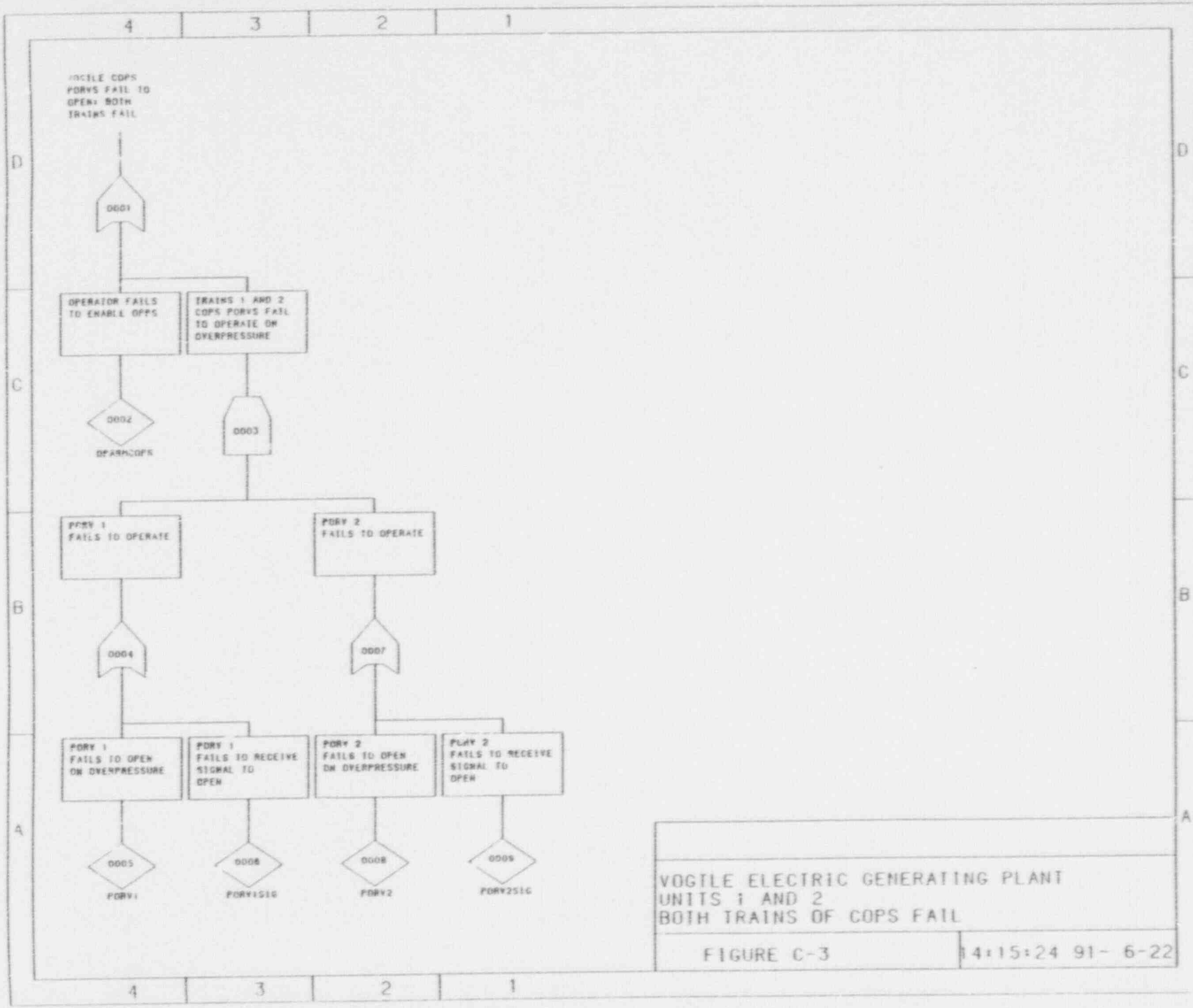
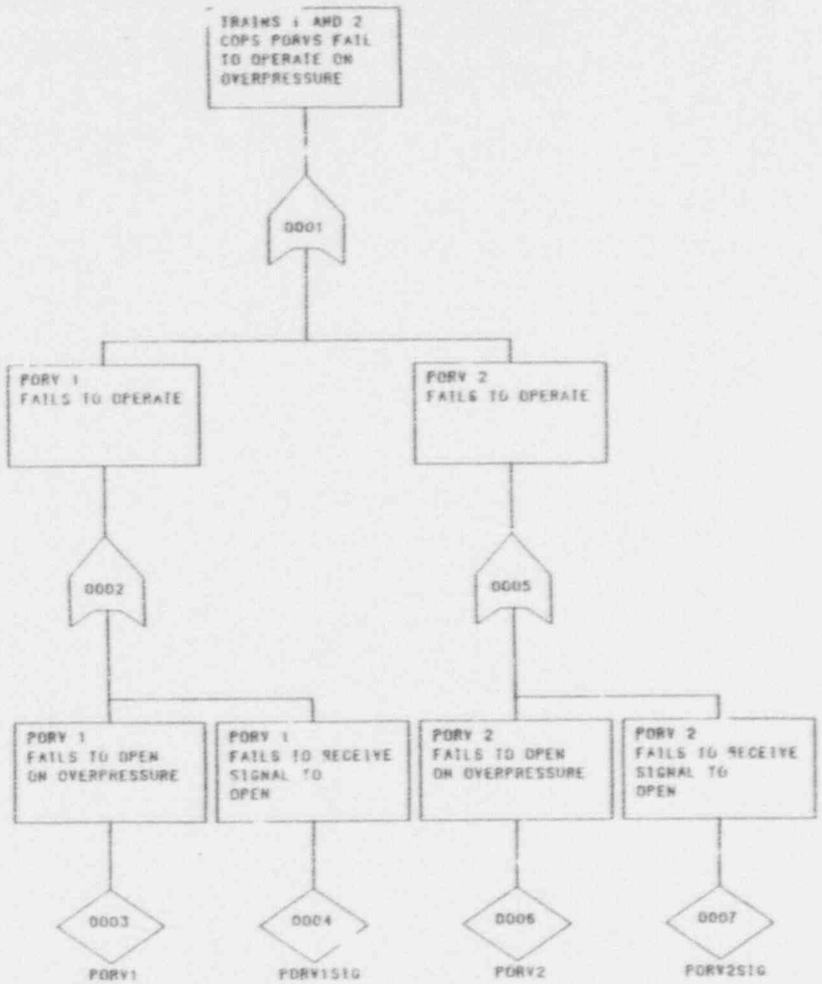
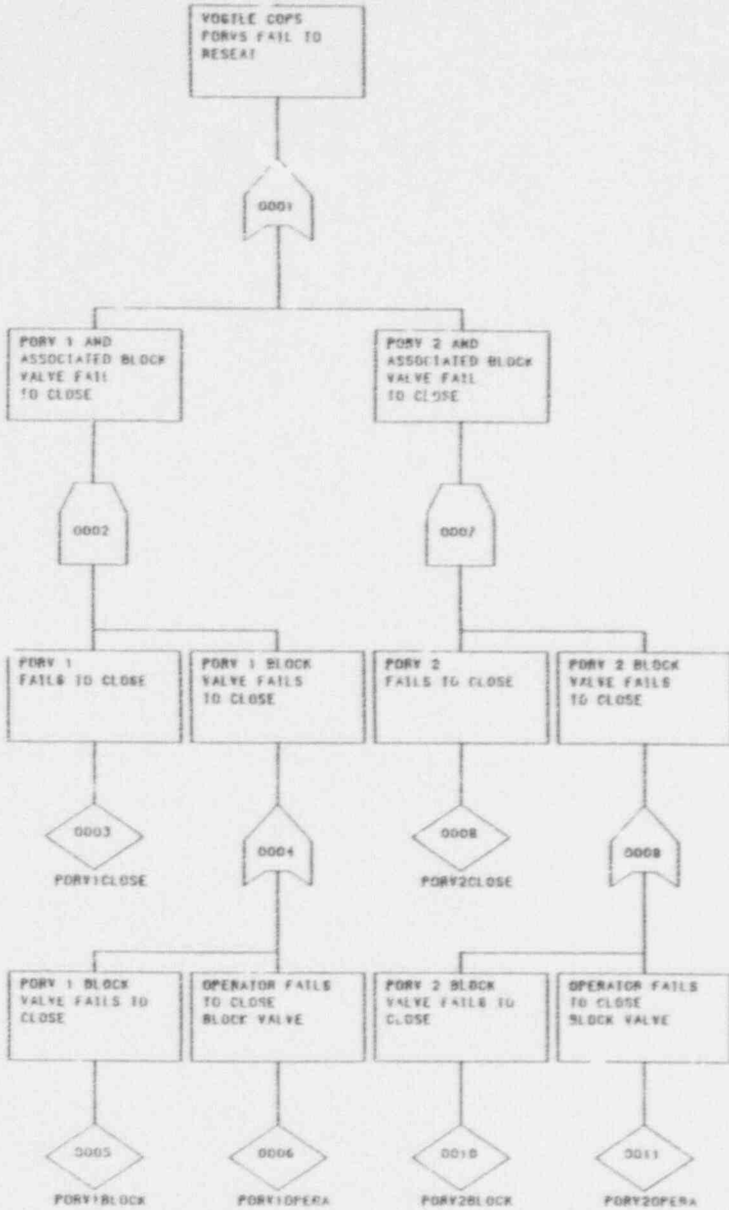


VOGTLE COPS PORVS FAIL TO OPEN: BOTH TRAINS FAIL
0001
OPERATOR FAILS TO ENABLE OPPS
TRAINS 1 AND 2 COPS PORVS FAIL TO OPERATE ON OVERPRESSURE
0002
OPARMCOPS
0003
PORV 1 FAILS TO OPERATE
PORV 2 FAILS TO OPERATE
0004
0007
PORV 1 FAILS TO OPEN ON OVERPRESSURE
PORV 1 FAILS TO RECEIVE SIGNAL TO OPEN
PORV 2 FAILS TO OPEN ON OVERPRESSURE
PORV 2 FAILS TO RECEIVE SIGNAL TO OPEN
0005
PORV1
0006
PORV1SIG
0008
PORV2
0009
PORV2SIG
VOGTLE ELECTRIC GENERATING PLANT
UNITS 1 AND 2
BOTH TRAINS OF COPS FAIL
FIGURE C-3
14:15:24 91- 6-22



VOGTLE ELECTRIC GENERATING PLANT
UNITS 1 AND 2
ONE OF TWO COPS TRAINS FAIL TO OPERATE

FIGURE C-4 | 14:17:37 91- 6-22



VOGTLE ELECTRIC GENERATING PLANT
UNITS 1 AND 2
PORVS FAIL TO RESEAT

FIGURE C-5

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FIGURE C-6. VOGTLE CHARGING WITH ACI EVENT TREE

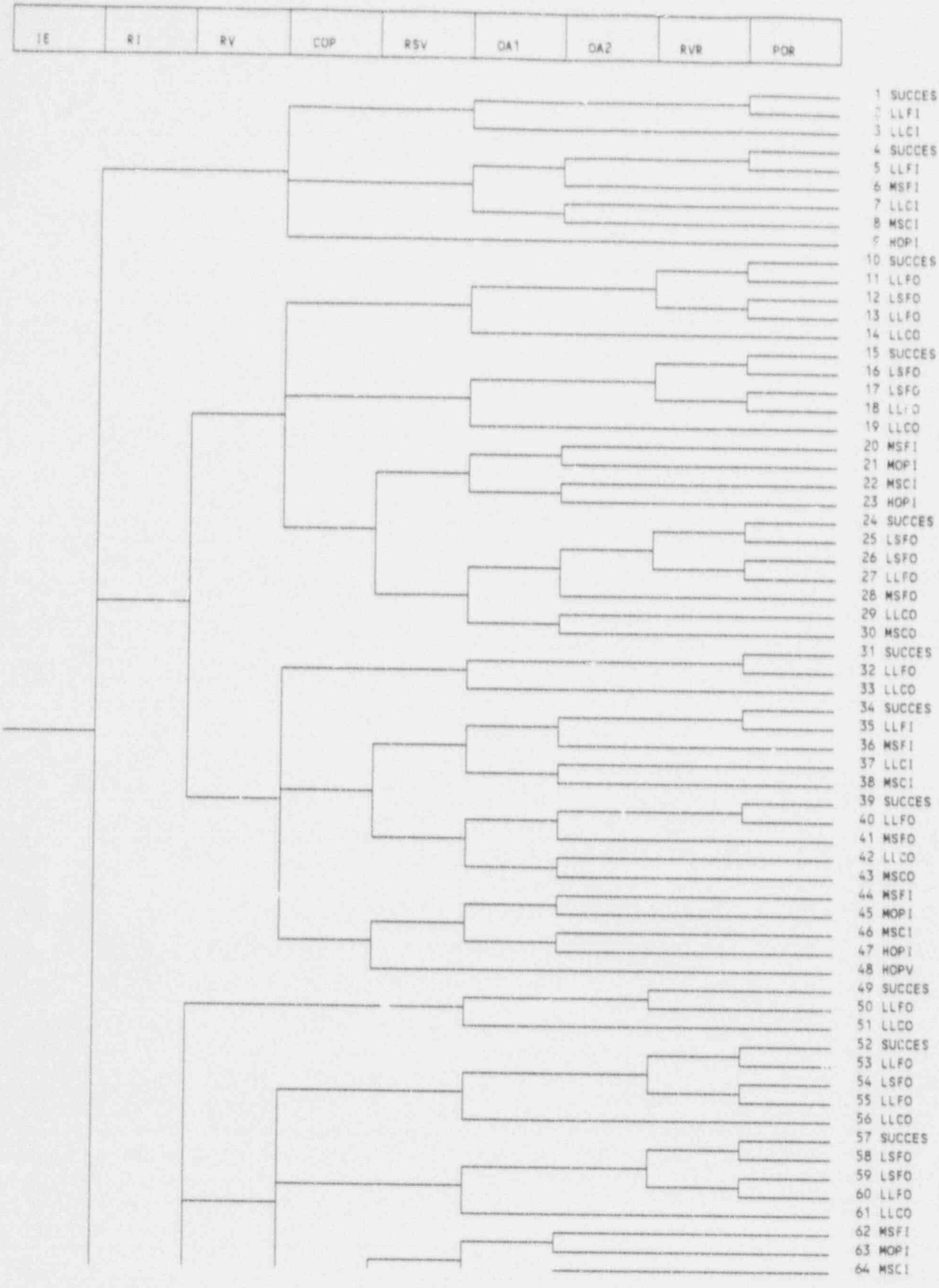
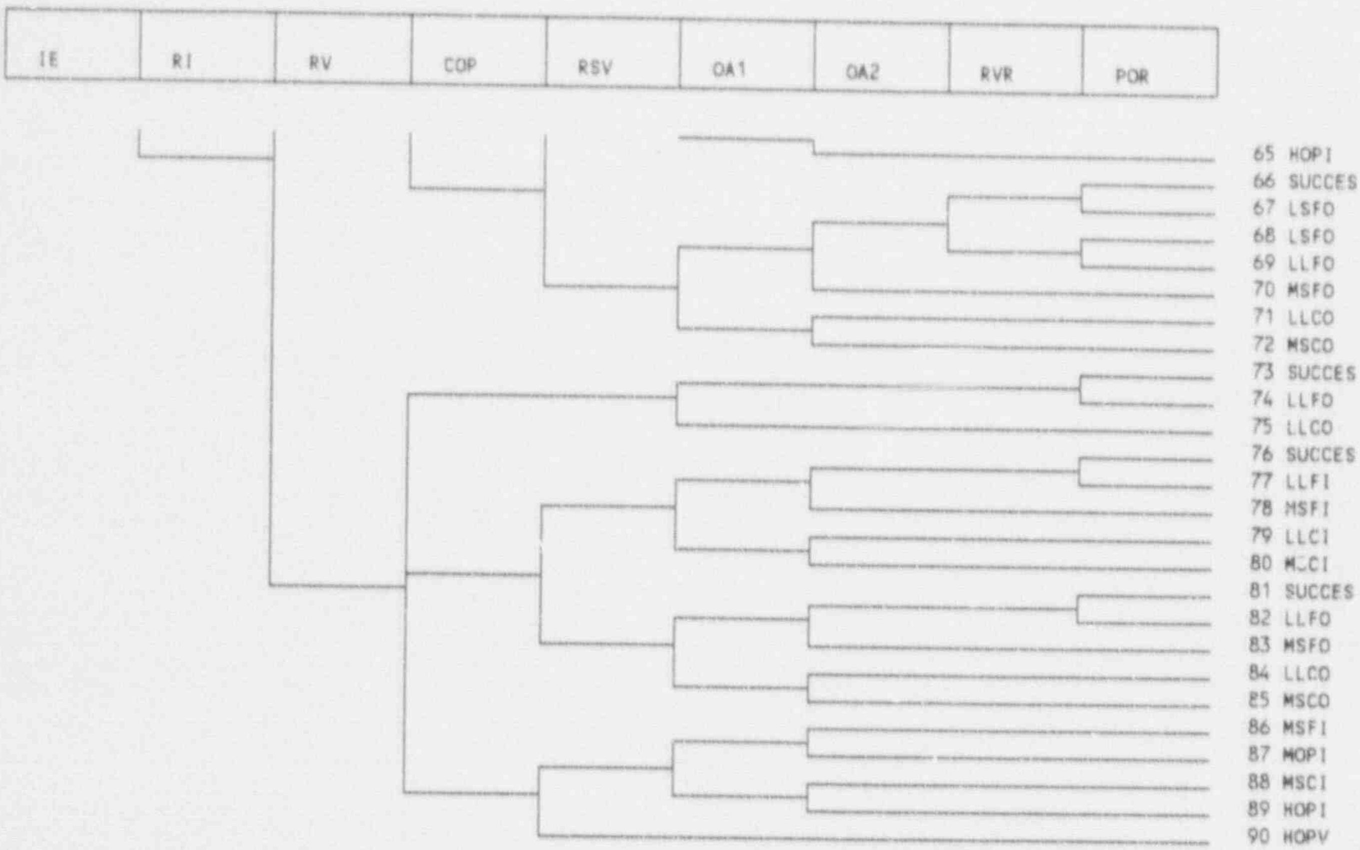


FIGURE C-6. VOGTLE CHARGING WITH ACI EVENT TREE (Cont'd)



EVENT	EVENT NAME
IE	CHARGING/SI INJECTION
RI	RHRS ISOLATED
RV	RHR RELIEF VALVES LIFT
COP	OPS PORVS OPEN
RSV	RHR SUCTION VALVES CLOSE
OA1	OPERATOR STOPS PUMP
OA2	OPERATOR OPENS PORV
RVR	RHR RELIEF RESEATS
POR	PORVS RESEAT

CATEGORY	DESCRIPTION
SUCCES	SUCCESS
LLFI	LOW SMALL FINITE ISOLATED
LLCI	LOW LARGE CONTINUOUS ISOLATED
MSFI	MEDIUM SMALL FINITE ISOLATED
MSCI	MEDIUM SMALL CONTINUOUS ISOLATED
HOPI	HIGH OVERPRESSURE ISOLATED
LLFO	LOW LARGE FINITE OPEN
LSFO	LOW SMALL FINITE OPEN
LLCO	LOW LARGE CONTINUOUS OPEN
MOPI	MEDIUM OVERPRESSURE ISOLATED
MSFO	MEDIUM SMALL FINITE OPEN
MSCO	MEDIUM SMALL CONTINUOUS OPEN
HOPV	HIGH OVERPRESSURE VSEQUENCE

FIGURE C-7. VOGTLE CHARGING WITHOUT ACI EVENT TREE

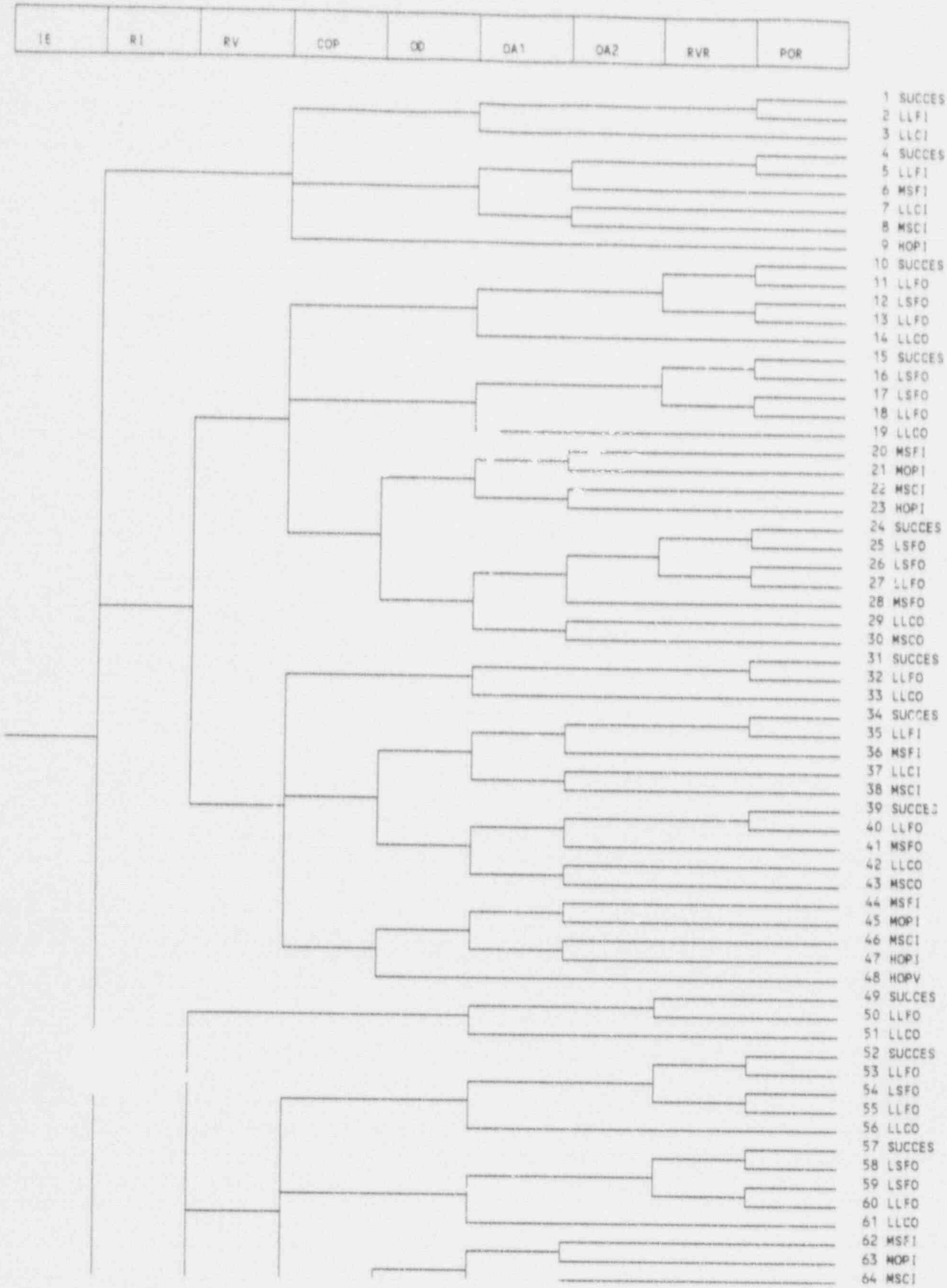
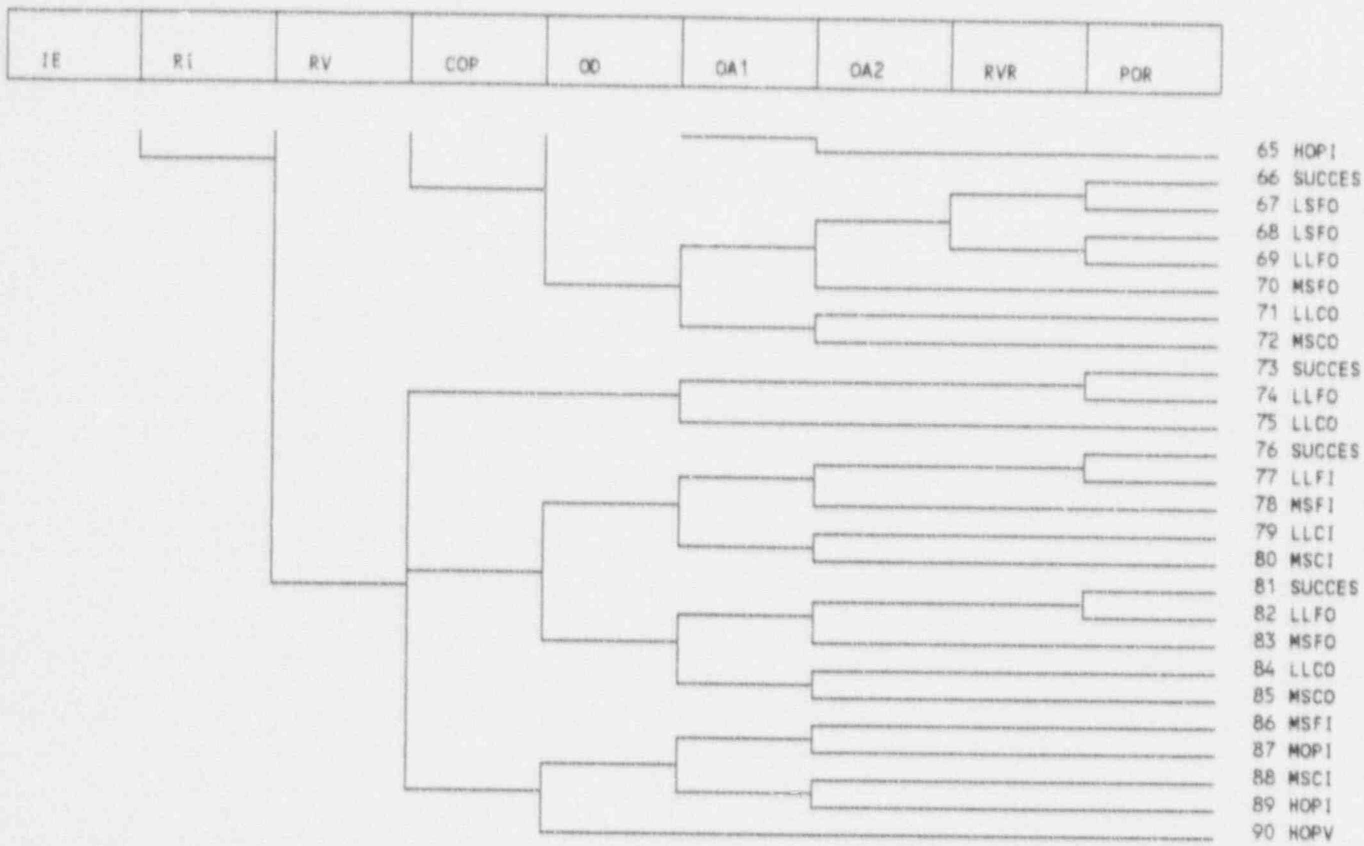


FIGURE C-7. VOGTLE CHARGING WITHOUT ACI EVENT TREE (Cont'd)



EVENT	EVENT NAME
IE	CHARGING/SI INJECTION
RI	RHRS ISOLATED
RV	RHR RELIEF VALVES LIFT
COP	OPS PORVS OPEN
OD	OPERATOR CLOSE SUCTION VALVES
OA1	OPERATOR STOPS PUMP
OA2	OPERATOR OPENS PORV
RVR	RHR RELIEF RESEATS
POR	PORVS RESEAT

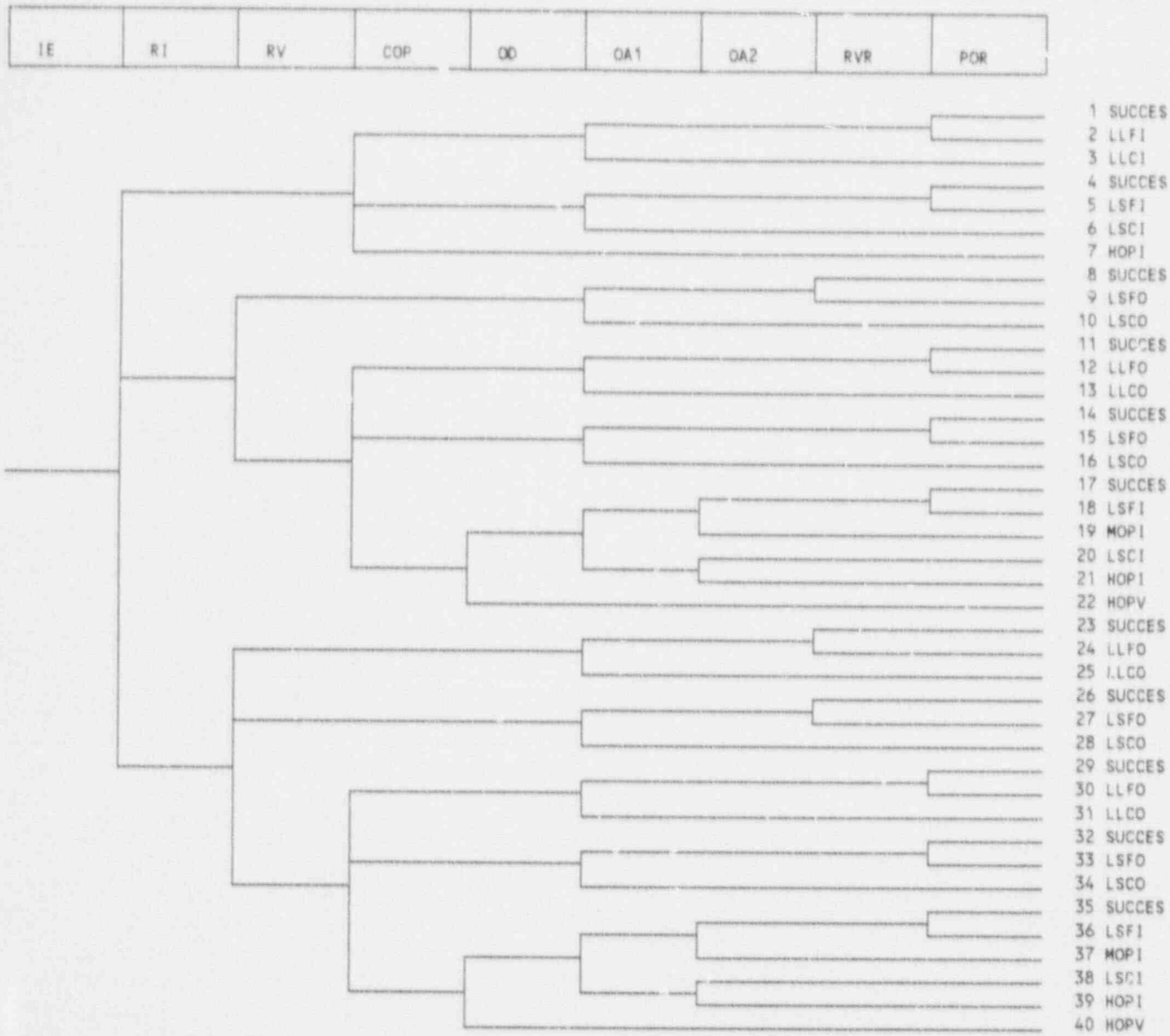
CATEGORY	DESCRIPTION
SUCCES	SUCCESS
LLFI	LOW SMALL FINITE ISOLATED
LLCI	LOW LARGE CONTINUOUS ISOLATED
MSFI	MEDIUM SMALL FINITE ISOLATED
MSCI	MEDIUM SMALL CONTINUOUS ISOLATED
HOPI	HIGH OVERPRESSURE ISOLATED
LLFO	LOW LARGE FINITE OPEN
LSFO	LOW SMALL FINITE OPEN
LLCO	LOW LARGE CONTINUOUS OPEN
MOPI	MEDIUM OVERPRESSURE ISOLATED
MSFO	MEDIUM SMALL FINITE OPEN
MSCO	MEDIUM SMALL CONTINUOUS OPEN
HOPV	HIGH OVERPRESSURE VSEQUENCE

FIGURE C-8. VOGTLE LETDOWN ISOLATION - RHRS OPERABLE WITH ACI EVENT TREE

EVENT	EVENT NAME
IE	LETDOWN ISOLATION
RI	RHRS ISOLATED
RV	RHR RELIEF VALVES LIFT
COP	OPS PORVS OPEN
RSV	RHR SUCTION VALVES CLOSE
OA1	OPERATOR STOPS PUMP
OA2	OPERATOR OPENS PORV
RVR	RHR RELIEF RESEATS
POR	PORVS RESEAT

CATEGORY	DESCRIPTION
SUCCES	SUCCESS
LLFI	LOW LARGE FINITE ISOLATED
LLCI	LOW LARGE CONTINUOUS ISOLATED
LSFI	LOW SMALL FINITE ISOLATED
LSCI	LOW SMALL CONTINUOUS ISOLATED
HOPI	HIGH OVERPRESSURE ISOLATED
LSFO	LOW SMALL FINITE OPEN
LSCO	LOW SMALL CONTINUOUS OPEN
LLFO	LOW LARGE FINITE OPEN
LLCO	LOW LARGE CONTINUOUS OPEN
MOPI	MEDIUM OVERPRESSURE ISOLATED
HOPV	HIGH OVERPRESSURE VSEQUENCE

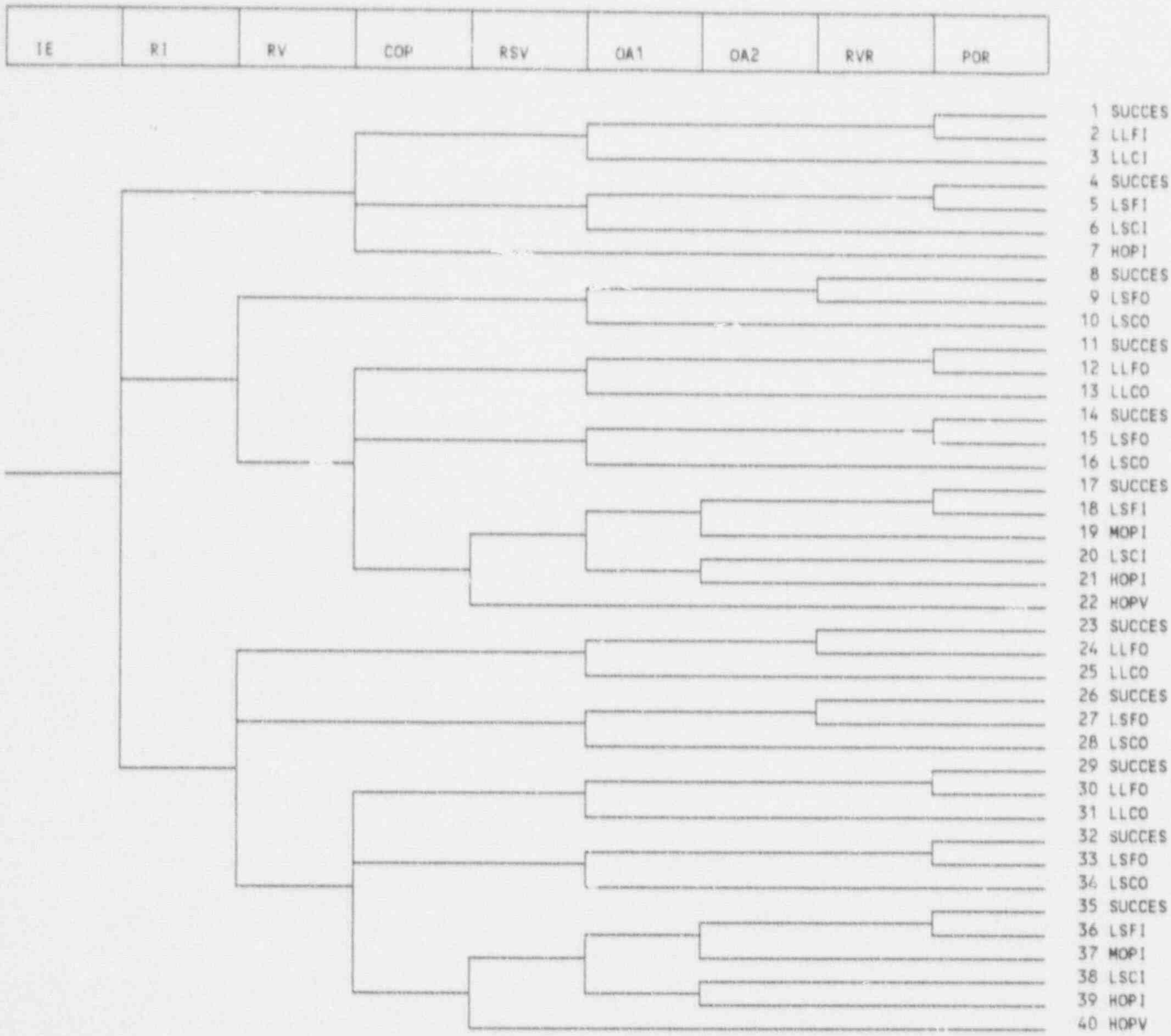
FIGURE C-9. VOGTLE LETDOWN ISOLATION - RHRS OPERABLE WITHOUT ACI EVENT TREE



EVENT	EVENT NAME
IE	LETDOWN ISOLATION
RI	RHRS ISOLATED
RV	RHR RELIEF VALVES LIFT
COP	OPS PORVS OPEN
OD	OPERATOR CLOSES SUCTION VALVES
OA1	OPERATOR STOPS PUMP
OA2	OPERATOR OPENS PORV
RVR	RHR RELIEF RESEATS
POR	PORVS RESEAT

CATEGORY	DESCRIPTION
SUCCES	SUCCESS
LLFI	LOW LARGE FINITE ISOLATED
LLCI	LOW LARGE CONTINUOUS ISOLATED
LSFI	LOW SMALL FINITE ISOLATED
LSCI	LOW SMALL CONTINUOUS ISOLATED
HOPI	HIGH OVERPRESSURE ISOLATED
LSFO	LOW SMALL FINITE OPEN
LSCO	LOW SMALL CONTINUOUS OPEN
LLFO	LOW LARGE FINITE OPEN
LLCO	LOW LARGE CONTINUOUS OPEN
MOPI	MEDIUM OVERPRESSURE ISOLATED
HOPV	HIGH OVERPRESSURE VSEQUENCE

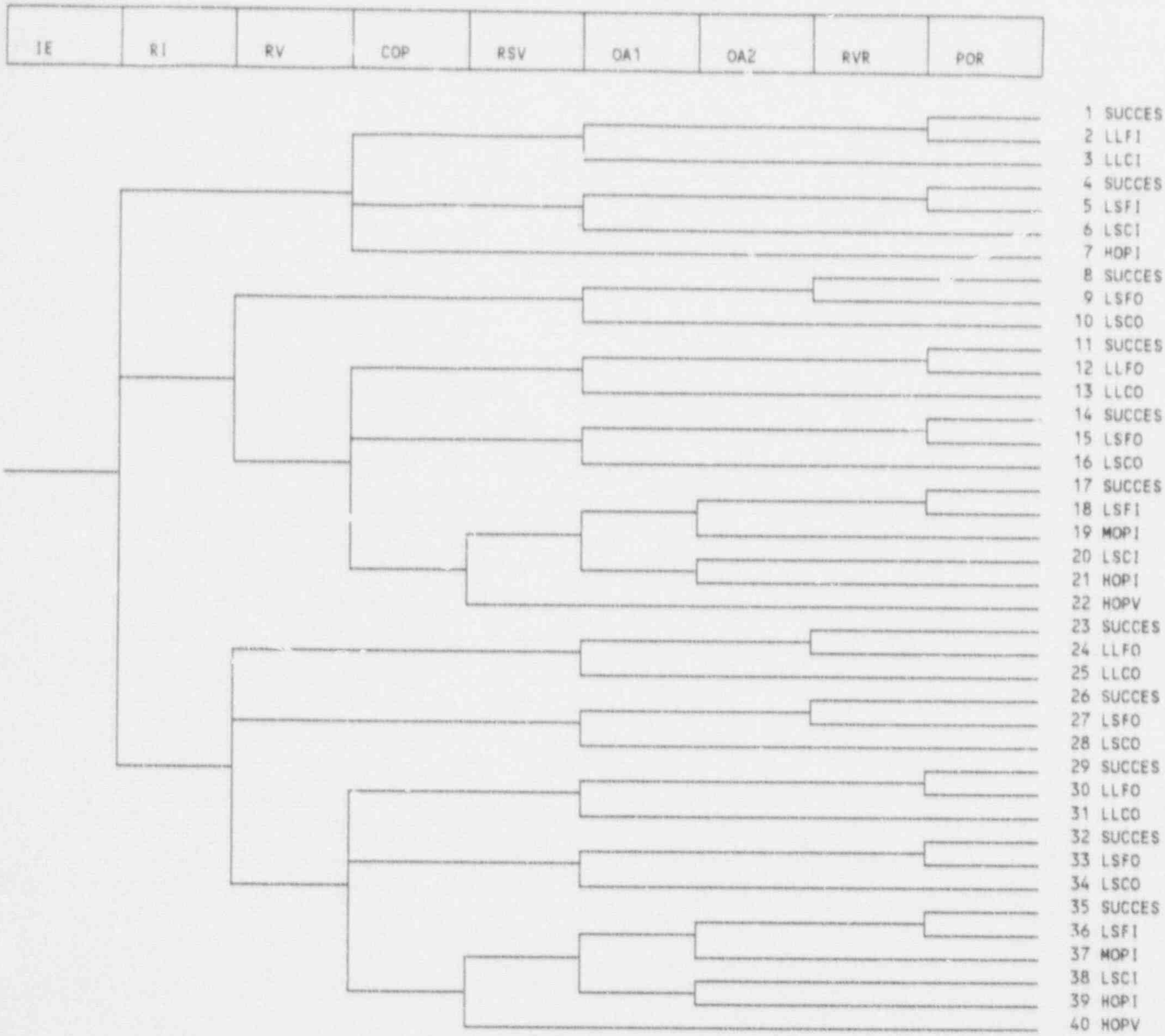
FIGURE C-10. VOGTLE LETDOWN ISOLATION - RHRS ISOLATED WITH ACI EVENT TREE



EVENT	EVENT NAME
IE	LETDOWN ISOLATION
RI	RHRS ISOLATED
RV	RHR RELIEF VALVES LIFT
COP	OPS PORVS OPEN
RSV	RHR SUCTION VALVES CLOSE
OA1	OPERATOR STOPS PUMP
OA2	OPERATOR OPENS PORV
RVR	RHR RELIEF RESEATS
POR	PORVS RESEAT

CATEGORY	DESCRIPTION
SUCCES	SUCCESS
LLFI	LOW LARGE FINITE ISOLATED
LLCI	LOW LARGE CONTINUOUS ISOLATED
LSFI	LOW SMALL FINITE ISOLATED
LSCI	LOW SMALL CONTINUOUS ISOLATED
HOPI	HIGH OVERPRESSURE ISOLATED
LSFO	LOW SMALL FINITE OPEN
LSCO	LOW SMALL CONTINUOUS OPEN
LLFO	LOW LARGE FINITE OPEN
LLCO	LOW LARGE CONTINUOUS OPEN
MOPI	MEDIUM OVERPRESSURE ISOLATED
HOPV	HIGH OVERPRESSURE VSEQUENCE

FIGURE C-11. VOGTLE LETDOWN ISOLATION - RHRS ISOLATED WITHOUT ACI EVENT TREE



EVENT	EVENT NAME
IE	LETDOWN ISOLATION
RI	RHRS ISOLATED
RV	RHR RELIEF VALVES LIFT
COP	OPS PORVS OPEN
RSV	RHR SUCTION VALVES CLOSE
OA1	OPERATOR STOPS PUMP
OA2	OPERATOR OPENS PORV
RVR	RHR RELIEF RESEATS
POR	PORVS RESEAT

CATEGORY	DESCRIPTION
SUCCES	SUCCESS
LLFI	LOW LARGE FINITE ISOLATED
LLCI	LOW LARGE CONTINUOUS ISOLATED
LSFI	LOW SMALL FINITE ISOLATED
LSCI	LOW SMALL CONTINUOUS ISOLATED
HOPI	HIGH OVERPRESSURE ISOLATED
LSFO	LOW SMALL FINITE OPEN
LSCO	LOW SMALL CONTINUOUS OPEN
LLFO	LOW LARGE FINITE OPEN
LLCO	LOW LARGE CONTINUOUS OPEN
MOPI	MEDIUM OVERPRESSURE ISOLATED
HOPV	HIGH OVERPRESSURE VSEQUENCE