SAFETY EVALUATION REPORT

VERMONT YANKEE PLANT

OVERRIDE OF CONTAINMENT PURGE ISOLATION AND OTHER ENGINEERED SAFETY FEATURES ACTUATION SIGNALS

Introduction

Instances have been reported at nuclear power plants where the intended automatic closure of containment purge/ventilation valves during a postulated accident would not have occurred because the safety actuation signals were inadvertently overridden and/or blocked, due to design deficiencies. These instances were determined to constitute an Abnormal Occurrence (#78-5). As a followup action, NRR issued a generic letter requesting each licensee to take certain actions.

Evaluation

The enclosed report was prepared for us by Franklin Research Center, as part of our technical assistance contract program. The report provides their technical evaluation of the conformance of the plant design to the NRC criteria established for this review.

Regarding the containment purge/vent isolation system, the contractor's report concludes that four of the six criteria are satisfied. Criterion 3 requires that annunciation be provided when the system is in an overridden state. Criterion 4 requires diverse isolation signals, including containment high radiation. These two items are discussed below.

Regarding other ESF systems that have manual override design features, the contractor's report concludes that: (1) the 10 motor-operated valves associated with the containment spray function may not comply with criterion 1, which requires that the manual override features do not interfere with actuation signals that have not occurred; (2) the bypassing of the isolation signals to the oxygen analyzers sample lines would prevent these valves from responding to any isolation signal; and (3) the common inlet valves to the standby gas treatment system will change position directly upon "resetting" of an actuation signal, a violation of criterion 6. These three items are discussed below.

Regarding criterion 3 for the containment purge/vent system, we concur that a visual alarm only is not sufficient. For various reasons, including a reliability of electrical power to the alarm and shift turnover of plant status information, we have required all plants to provide a full annunciation.

Regarding criterion 4 for the containment purge/vent system, Appendix "A" to this SER provides our evaluation regarding the adequacy of the radiation monitoring as a diverse parameter for purge isolation. As discussed in Appendix "A", we have determined that the intent of this criterion is complied with.

The containment spray function in this plant design is an auxiliary function of the RHR system. Containment spray is not actuated automatically - only manually at the option of the reactor operator. Since the containment spray system would divert water that may be needed for core cooling, a safety interlock is provided so that containment spray may not be selected unless the core water level is above a pre-selected value. An emergency override of this interlock is provided in the design. The fact that the manual selector switch prevents the containment spray from being actuated automatically in response to high drywell pressure is an inherent part of this manual-option system and is acceptable. The emergency override feature satisfies the criteria for this review and is acceptable.

The adequacy of isolation of the oxygen sample lines was recently addressed and apparently found to be acceptable as part of license amendment #58, issued November 3, 1980.

The change of position of various values upon "reset" of the safety actuation signal is, in general, unacceptable. A comprehensive review of this matter is being handled separately regarding I&E Bulletin 80-06.

Conclusions

The electrical override aspects of ESF actuation signals at this plant have been reviewed against NRC criteria. Based upon our review of the contractor's report and our own review of these matters, we conclude:

1. The design of the containment purge/vent isolation system conforms to five of the six criteria. To comply with Criterion #3, the licensee should provide full annunciation whenever any actuation signal to the system is in an overridden state.

2. Based upon the audit of the design of other ESF systems that have manual override features, there is reasonable assurance that these systems conform to the NRC criteria, with only a single exception. The matter of valve motion upon "reset" of the safety signal is being addressed as part of I&E Bulletin 80-06.

APPENDIX "A"

The Contractor's report identifies that the radiation monitors which automatically actuate PCIS, monitor the fuel pool area and the reactor building. In discussing the details of this matter with the contractor, we were informed that the reactor building monitor is physically in the exhaust plenum for the reactor building vent and that flow through the containment purge and vent valves exhausts through the same plenum. Therefore, when the purge/vent valves are open, the reactor building monitor is capable of detecting high radiation from the drywell. The intent of the NRC Criterion #4 is to assure that, over the entire spectrum of break sizes, two diverse signals will be effective to detect a loss of coolant accident and will automatically isolate the purge and vent valves.

In comparison with a PWR, the smaller free volume of the containment for a BWR (i.e., the drywell) and the smaller margin between the nominal drywell pressure and its setpoint for actuation of containment isolation (i.e., PCIS) both serve to provide a greater assurance that, if a SB LOCA inside containment were to occur when the purge/vent valves are closed, the drywell high pressure setpoint will be reached without significant delay. Vessel low water level will also actuate PCIS. If the purge/vent valves should be open at the time of the accident, PCIS will be actuated by high radiation, as sensed by the monitor in the reactor building exhaust plenum, as well as by vessel low water level. Therefore, signal diversity exists in the form of (1) reactor vessel low water level and (2) either drywell high pressure or exhaust radiation, depending upon the status of the purge/vent valves for breaks inside containment with the exception of the stuck open relief valve.

There are some scenarios that may be postulated where signal diversity may not exist. For breaks outside containment and small LOCAs caused by stuck open or partially stuck open relief valves (SORV) the high containment pressure signal may not be developed. When the purge/vent valves are closed (which is typically the case during power operation) the containment atmosphere is not being monitored for high radiation; therefore, the water level instrumentation must be depended upon to generate the containment isolation signal. If for analysis purposes, one presumes that the water level instrumentation does not actuate the PCIS, one must address the possibility that the operator may later decide to open the containment purge/vent valves. This is considered to be a remote possibility because several other instruments in the control room will alert the operator to the conditions. Vermont Yankee has a continuous air monitor (CAM) system that samples the drywell or torus atmosphere with indication/recording and alarming in the control room. There is also an area radiation monitor (ARM) in the drywell that is indicated/recorded/alarmed in the control room. Furthermore, normal operating and emergency procedures require sampling of the containment atmosphere prior to venting/purging. If level instrumentation is lost emergency procedures also require that the operator completely fill the vessel to preclude core uncovery and possible high radiation in

the containment. The operator also has other indications for a SORV. Suppression pool level and temperature as well as direct position indication on the safety/relief valve will alert him to the SORV and he can take corrective action to prevent core uncovery. For steam line breaks outside containment ample indication and protective features exist. High steam flow, high steam line radiation, high steam line tunnel temperature will initiate an MSIV closure and subsequent scram and alert the operator to take corrective action, if needed. Any radiation in the reactor building due to breaks outside containment will be monitored on the reactor building ventilation system area radiation monitor that will isolate the purge/vent lines.

While the radiation monitor in the reactor building exhaust plenum does not measure radiation levels inside the drywell under all conditions, this radiation monitor taken in combination with other signals and operational procedures does provide the intended diversity for containment isolation and is therefore an acceptable alternative to satisfy criterion #4 of this review.

1. INTRODUCTION

Several instances have been reported at nuclear power plants in which the containment ventilation/purge valves would not have automatically closed when required because the safety actuation signals were either overridden or blocked during normal plant operations due to procedural inadequacies, design deficiencies, and lack of proper management control. These instances also brought into question the mechanical operability of the containment isolation valves themselves. The U.S. Nuclear Regulatory Commission (NRC) determined these instances to be Abnormal Occurrences (#78-5) which were, accordingly, reported to the U.S. Congress.

As a follow-up to these Abnormal Occurrences, the NRC staff is reviewing the electrical override aspects and the mechanical operability aspects of containment purging for all operating power reactors. On November 29, 1978, the NRC issued a letter entitled "Containment Purging During Normal Plant Operation" [1]* to all boiling water reactor (BWR) and pressurized water reactor (PWR) licensees. In a letter dated January 9, 1979 [2], the Vermont Yankee Nuclear Power Corporation (VYC) replied to the NRC generic letter. On December 27, 1979 [3], VYC provided additional information pertaining to the NRC generic letter. On March 12, 1980 [4], the NRC requested that the Licensee provide additional information concerning electrical bypass and reset of engineered safety feature (ESF) signals for Vermont Yankee. On May 28, 1980 [5], the Licensee provided a partial response to this request. This information was supplemented by VYC on January 15, 1981 [6]; this submittal provided an evaluation of NRC criteria for ESF equipment and the necessary information (electrical schematics, system diagrams, and electrical data) to support their evaluation.

This document addresses only the electrical, instrumentation, and control (EI&C) design aspects of the containment ventilation isolation (CVI) system and other engineered safety features.

---

*Numbers in brackets refer to citations in the list of references, Section 4.

2. EVALUATION

2.1 REVIEW CRITERIA

The primary intent of this evaluation is to determine if the following NRC staff criteria are met for the safety signals to all ESF equipment:

- o Criterion 1. In keeping with the requirements of General Design Criteria (GDC) 55 and 56, the overriding* of one type of safety actuation signal (e.g., radiation) shall not cause the blockage of any other type of safety actuation signal (e.g., pressure) for those valves that serve containment isolation function only.

- o Criterion 2. Sufficient physical features (e.g., keylock switches) shall be provided to facilitate adequate administrative controls.

- o Criterion 3. For every safety system, a system-level annunciation shall be provided when any override is active. (See NRC Regulatory Guide 1.47.)

Incidental to this review, the following additional NRC staff design criteria were used in the evaluation:

- o Criterion 4. Diverse signals shall be provided to initiate isolation of the containment ventilation system. Specifically, containment high radiation, safety injection actuation, and containment high pressure (where containment high pressure is not a portion of safety injection actuation) should automatically initiate CVI.

- o Criterion 5. The instrumentation and control systems provided to initiate the ESF shall be designed and qualified as safety-grade equipment.

- o Criterion 6. The overriding or resetting+ of the ESF actuation signal shall not cause any valve or damper to change position.

In this review, Criterion 6 applies primarily to other related ESF systems, because implementation of this criterion for containment isolation has been reviewed by the Lessons Learned Task Force, based on the recommendations in NUREG-0578, Section 2.1.4. Automatic valve repositioning

---

*Override: The signal is still present, but it is blocked in order that a function contrary to the signal may be performed.

+Reset: The signal has come and gone, and the circuit is being cleared in order to return it to the normal condition.

upon reset may be acceptable when containment isolation is not involved. The acceptability of repositioning upon reset will be determined on a case-by-case basis. Acceptability will be dependent upon system function, design intent, and suitable operating procedures.

2.2 CONTAINMENT VENTILATION SYSTEM DESIGN DESCRIPTION

2.2.1 Generalized System Design

The Licensee has indicated that the instrumentation and control systems were originally purchased and installed as safety grade equipment. A review of initiation logic and wiring diagrams has confirmed that no credible single malfunction will prevent proper protective action at the system level when required.

2.2.2 Logic Circuits for Reset, Seal-in, and Trip

At Vermont Yankee, containment ventilation is accomplished through the primary containment isolation system (PCIS). This system is composed of two control circuitry subsystems (operating an inboard and outboard group of valves) and two PCIS trip logic channels (A and B). The trip logic channels supply isolation signals to the control circuitry subsystem and will interrupt power to valve pilot solenoids, shutting ventilation isolation valves under the following conditions:

1. Automatic Isolation

   Outboard Group

   High drywell pressure or low reactor vessel water level (1-out-of-2 taken-twice)
   Reactor building ventilation exhaust high radiation (1 of 2)
   Reactor building (refueling floor zone) high radiation (1 of 2)
   Reactor building ventilation exhaust low radiation (2 of 2)
   Reactor building (refueling floor zone) low radiation (2 of 2)

   Inboard Group

   High drywell pressure or low reactor vessel water level (1 of 2 taken-twice)

Reactor building ventilation exhaust high radiation (1 of 2)
Reactor building (refueling floor zone) high radiation (1 of 2)
Reactor building (refueling floor zone) low radiation (2 of 2)
Reactor building ventilation exhaust low radiation (2 of 2)

2. Manual Isolation

No system level manual isolation is provided. Manual isolation is accomplished through individual valve control switches.

With the reactor protection system in the run mode, inboard and outboard valve group pilot solenoids receive power via a valve control logic network containing parameter isolation contacts, seal-in contacts (K23), and bypass switches (three-position, torus bypass-off-drywell bypass) as shown in Figure 1.

The parameter isolation contacts shown in Figure 1 are driven by slave relays in series with the detector (not shown). An "out of normal operating band signal" will cause the detector contacts to open, thus deenergizing the slave relays and opening the associated contacts in the valve control logic network. Power will then be removed from the slave/seal-in relays (K23) and subsequently from the valve pilot solenoids. When the monitored parameter returns to the normal operating band (signal cleared), the isolation logic is reestablished. However, as a result of an open seal-in relay contact, power will not yet be restored to the seal-in relay or the valve group pilot solenoids. Power is restored to the seal-in relay through contacts K23A, which are closed when all local valve control switches (in series with the pilot solenoids) are positioned to deenergize the pilot solenoids (i.e., to close the valves). This will cause the "reset permissive string" local switch contacts to shut, energizing K23A. Once the K23A contacts are closed, the reset switch K11 is placed in the reset position, causing the reset contacts (K11) to close. This will return power to the reset/seal-in relay (K23) and make power available to the valve pilot solenoids.

Either reactor building ventilation exhaust or refueling floor zone high radiation isolation signals can be bypassed by switches (Figure 1), one for each electrical train, which close contacts paralleling the appropriate logic network parameter isolation contacts. Activating any of these bypass switches

is indicated by a single red light for each of the electrical trains. Since the contacts providing this bypass feature are incorporated in the trip logic network, the actuation of these switches cannot in itself restore power to the pilot solenoids. Restoration of power to the valve solenoids, allowing valve operation, is accomplished by the use of the bypass switch followed by the system reset as previously described.

2.2.3 Individual Valve Control Circuits

Major isolation valves--nitrogen purge supply inlet, air purge supply inlet, drywell and torus vent to reactor building exhaust (outboard group), and drywell and torus purge and vent valves (inboard group)--are normally not supplied with power when in the run mode (K41 open, controlled by a relay and switch in series). Power can be supplied to the pilot solenoids for these valves, allowing them to be opened by local switches and the use of permissive switches (16AS50) for the outboard and inboard groups.

With the reactor protection system mode switch in any position other than "Run," the 2-in vent relief valves from the drywell or torus and the vent to the emergency gas treatment system may be opened regardless of the condition of the valve control logic network. This bypass is accomplished by selection of "Torus" or "Drywell," as appropriate, on a spring return-to-normal keylocked bypass switch. This switch will operate contacts K42/K43 as appropriate and the use of this bypass is annunicated via the PCIS annunciation system.

Since the permissive circuit used to allow system reset requires that all local valve control switches be in the electrically open position (i.e., valves closed) in order to allow reset, the valves cannot change position upon reset and will remain closed until individually reopened.

2.3 CONTAINMENT VENTILATION SYSTEM DESIGN EVALUATION

No instances were found in which the overriding of one type of safety actuation signal (e.g., reactor building ventilation exhaust high radiation) caused the blockage of any other type of safety actuation signal (e.g., high

drywell pressure) for those valves that serve containment isolation function only. Therefore, it was concluded that NRC staff Criterion 1 has been satisfied in the PCIS at Vermont Yankee.

Override switches provided are keylock-type switches and will support adequate administrative controls. Therefore, it was concluded that NRC staff Criterion 2 has been satisfied in the PCIS at Vermont Yankee.

Each override switch provides one contact which energizes a red light in the control room to display the bypass condition to the operator for each individual trip parameter when the switch is placed in the override position. However, no audible alarm is provided, and consequently Criterion 3 is not satisfied.

The six isolation parameters listed in Section 2.2 will automatically initiate primary containment isolation. However, reactor building ventilation exhaust radiation (high and low) monitors indicate containment atmosphere during a venting operation only and do not sample the containment atmosphere when the containment vent and purge system is isolated. Because this is not in complete compliance with Criterion 4, this situation has been identified for NRC staff evaluation with respect to acceptability.

The Licensee has indicated that the instrumentation and control systems provided to initiate the PCIS were purchased and installed as safety grade equipment. The detailed determination of the adequacy of the environmental qualification of all safety-related systems is being accomplished separately by the Equipment Qualification Branch of the NRC. For the purposes of this review, NRC staff Criterion 5 is satisfied in the PCIS at Vermont Yankee.

The overriding or resetting of any actuation signal will not cause any valve or damper to change position. This is accomplished by the use of permissive switches at the equipment level and also by the provision of reset and override controls at the accident parameter level. Therefore, it was concluded that NRC staff Criterion 6 has been satisfied in the PCIS at Vermont Yankee.

2.4 OTHER ENGINEERED SAFETY FEATURE (ESF) SYSTEM CIRCUITS

To provide a complete evaluation of the ESF system circuits, a general audit of all ESF system circuits and an in-depth review of the circuit for the residual heat removal (RHR) system was conducted.

2.4.1 Description of RHR System Design

Initiation signals, Phase A and Phase B, are provided for all RHR engineered safety feature equipment on each of two separate electrical trains, A and B. Each train consists of automatic and manual inputs processed through a relay logic circuitry to actuate a relay logic component actuation system. The initiation signals for each electrical train are arranged to provide automatic initiation upon either of the following signals:

1. high drywell pressure (1 of 2 taken twice)
2. reactor low water level (1 of 2 taken twice) AND low reactor pressure (1 of 2).

The RHR logic circuit is activated when an isolation signal is received, thus energizing slave relay K73 (Figure 2). The K73 contacts in the auto initiation circuit are then closed, causing the seal-in (K77) relay and contacts to pick up. Switch S9 in the RHR logic circuit is provided to allow testing of the high drywell pressure signal; it is a keylocked, two-position (Auto-Test) switch.

Individual pump and valve control circuits have both manual and automatic control schemes for start-stop or open-close as well as an indication for run status or position.

2.4.2 Evaluation of Other ESF Systems Design

2.4.2.1 RHR System

No instances were found in which the overriding of one type of safety actuation signal caused the blockage of any other type of safety actuation signal for those valves that serve containment isolation function only. However, ten ESF actuated valves (MO-39 A & B, MO-31 A & B, MO-26 A & B, MO-34 A & B, and MO-38 A & B), which have functions in addition to containment

isolation, are provided with control circuitry that allows the bypassing of automatic ESF actuation (Figure 3). However, operation of these valves may be required to provide containment spray for pressure control of the containment atmosphere in an accident environment.

It should be noted that manual initiation of containment spray with an isolation signal present requires (1) activation of the containment spray valve control circuit (positioning of S17, high drywell pressure signal present, and positioning of S18 [Rx low shroud level emergency override] or K1C [RHR auto initiation activated] and reactor water level above the shroud - Figure 3), (2) manual operation of a control switch (access restricted) in each individual valve control circuit, and (3) a containment high pressure signal. In addition, system-level annunciation of this condition is provided. Consequently, Criteria 2 and 3 are satisfied for these ten valves.

Other than for the ten valves identified above, Criteria 2 and 3 do not apply.

Either high drywell pressure OR reactor low level AND low pressure will cause automatic initiation of the RHR system. Therefore, it was concluded that NRC staff Criterion 4 has been satisfied in the RHR system at Vermont Yankee.

The Licensee has indicated that the instrumentation and control systems provided to initiate the RHR system were originally purchased and installed as safety grade equipment. A review of these circuits by FRC has revealed no credible single malfunction that would prevent proper protective action at the system level when required. Therefore, for the purposes of this review, NRC staff Criterion 5 is satisfied in the RHR system at Vermont Yankee.

The overriding or resetting of any RHR actuation signal will not cause any valve or damper to change position. Therefore, it was concluded that NRC staff Criterion 6 has been satisfied in the RHR system at Vermont Yankee.

2.4.2.2 Other ESF Systems

An audit conducted of other ESF valve control circuits indicate that equipment level bypasses are provided for several equipment items at

Vermont Yankee which, if actuated following one safety actuation signal, will block a second safety actuation signal (or will block an initiating signal if actuated prior to receipt of the signal), thus preventing the equipment from performing its protective action. This equipment, however, serves functions other than containment isolation. These valves are identified as follows:

Sample System Oxygen Analyzer Valves

Inboard Isolation	FSO - 109-75-A1
	FSO - 109-75-B1
	FSO - 109-75-C1
	FSO - 109-75-D1
	VG-26
Outboard Isolation	FSO - 109-75-A2
	FSO - 109-75-B2
	FSO - 109-75-C2
	FSO - 109-75-D2
	VG-23

An acceptable alternative to Criteria 2 and 3 is provided, in that:

a. Two or more sequential switch actions are required.

b. Bypass/override actions are administratively controlled by operating procedures, technical specifications, and/or plant directives (including access restriction).

c. Open/closed valve position indication is provided for each valve.

Criterion 4 does not apply to ESF valves other than PCIS valves.

The Licensee has indicated that the instrumentation and control systems were originally purchased and installed as safety grade equipment. A review of these circuits by FRC has revealed no credible single malfunction that would prevent proper protective action at the system level when required. Therefore, Criterion 5 is satisfied.

The audit of about five other ESF valve control circuits showed that at least two valves (SB-1A and SB-1B, standby gas treatment system common inlet valves) will change position upon resetting of an ESF actuation signal. Therefore, Criteria 6 is not satisfied and further review is indicated.

3. CONCLUSIONS

The EI&C design aspects of ESF systems for Vermont Yankee were evaluated using staff design criteria.

It is concluded that the PCIS circuit design satisfies the NRC staff criteria for containment ventilation and purging operation with the exception of Criteria 3 and 4. Satisfaction of Criterion 3 will require the installation of an audible alarm associated with the bypass switches for reactor building ventilation exhaust and refueling floor zone high radiation. Satisfaction of Criterion 4 will require that a radiation detector which monitors containment (i.e., drywell or torus) activity be provided and used to automatically initiate primary containment isolation.

Other ESF System Circuits

1. RHR System

   The RHR circuit design at Vermont Yankee satisfies the NRC staff criteria with the exception of Criterion 1 for ten valves associated with the containment spray function of the RHR system. This matter is identified for NRC staff consideration.

2. Sample System Oxygen Analyzer Valves

   For these ten valves, bypasses exist which, if actuated prior to or following a safety actuation signal, will block the initiating signal or a second safety actuation signal, respectively. However, FRC has determined that the administrative controls and indication provided are an acceptable alternative to the NRC staff criteria. FRC recommends that a complete review be conducted by the Licensee to ensure that no violations of Criterion 1 for other ESF system valve control circuits exist and that, for the ten valves identified above, administrative controls should be established to prevent inadvertent blocking of ESF signals to these valves.

3. Standby Gas Treatment System Common Inlet Valves

   Satisfaction of Criterion 6 will require the modification of the two valve control circuits identified. In addition, it is recommended that Vermont Yankee perform an in-depth review of all other ESF valve control circuits to determine their compliance with Criterion 6, and modify those circuits which do not comply with the criterion.

4. REFERENCES

1. NRC, Letter to all BWR and PWR licensees, Subject: "Containment Purging During Normal Plant Operation," November 29, 1978.

2. D. E. Vandenburgh (VYC)
   Letter to T. Ippolito (NRC), Subject:
   Containment Purging During Normal Plant Operation
   Vermont Yankee Corporation, January 9, 1979.

3. W. P. Johnson (VYC)
   Letter to T. Ippolito (NRC), Subject:
   Purge and Vent Valves Operability, December 27, 1978.

4. T. Ippolito (NRC)
   Letter to R. L. Smith (VYC), Subject:
   Request for Additional Information - Containment Purge System
   Vermont Yankee, March 12, 1980.

5. R. L. Smith (VYC)
   Letter to T. Ippolito (NRC), Subject: Additional Information Concerning the Electrical Design of Containment Purge Valves
   Vermont Yankee, May 28, 1980.

6. R. L. Smith (VYC)
   Letter to T. Ippolito (NRC), Subject:
   Bypass and Reset of Engineered Safety Features for
   Vermont Yankee, January 15, 1981.

7. IEEE Std 279-1971, Criteria for Protection Systems for Nuclear Power Generating Stations, Institute of Electrical and Electronics Engineers, Inc., New York, New York.

NOTES:

1) K5A, B, C, D — HIGH DRYWELL PRESSURE OR REACTOR VESSEL LOW LEVEL
2) CLOSED WHEN ALL VALVE SOLENOIDS ARE DE-ENERGIZED
3) TORUS BYPASS PERMISSIVE
4) DRYWELL BYPASS PERMISSIVE

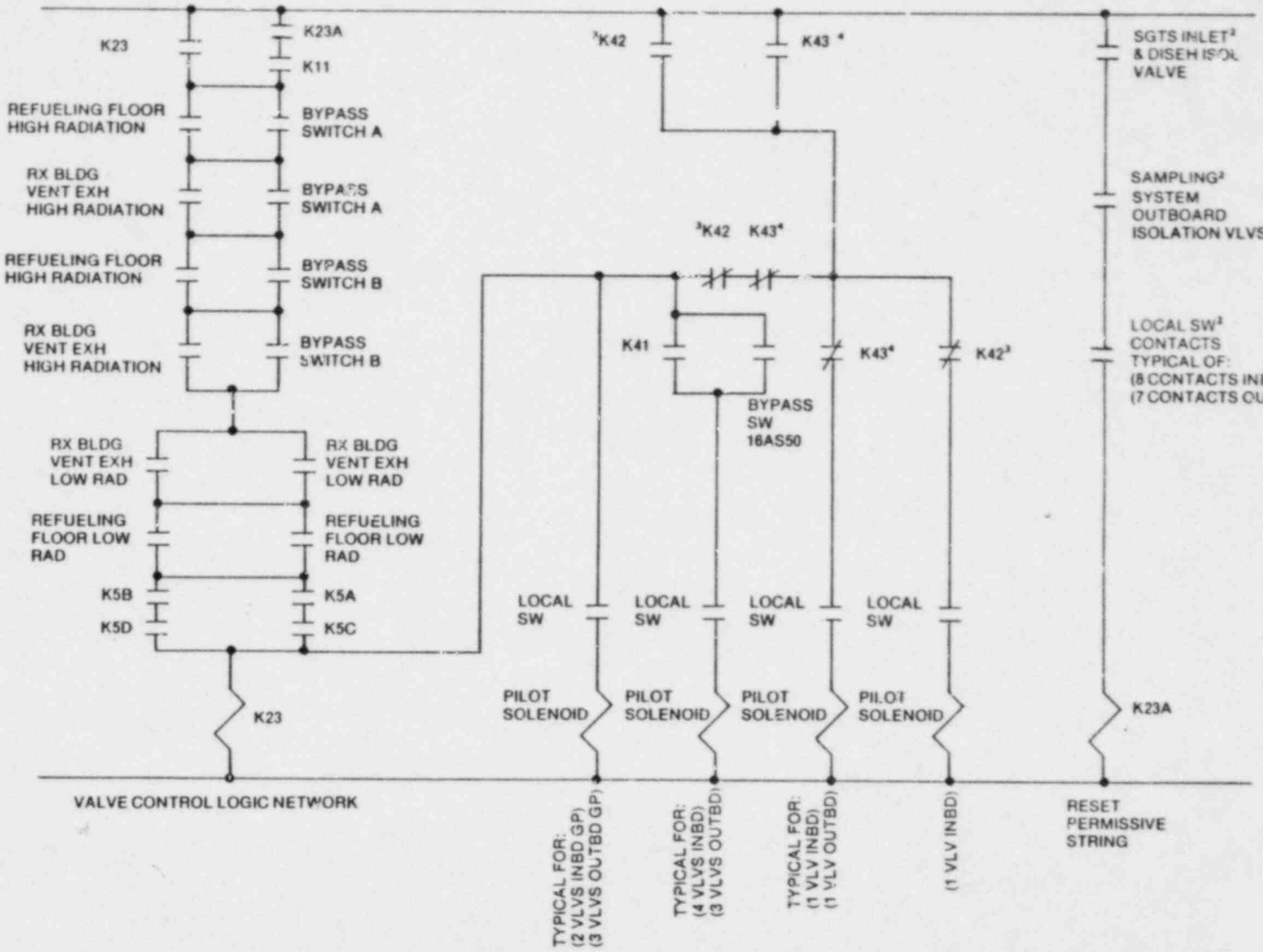

Figure 1. PCIS Control Scheme

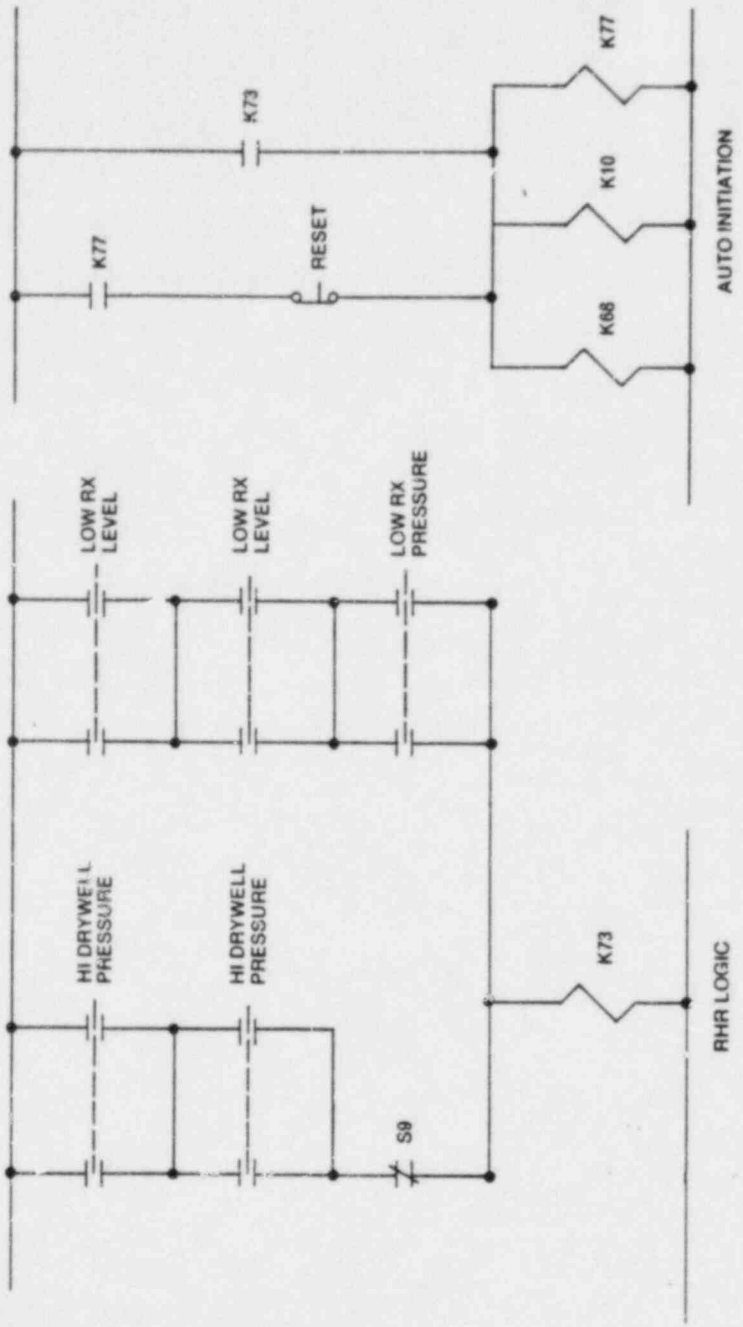

Figure 2. RHR Control Scheme

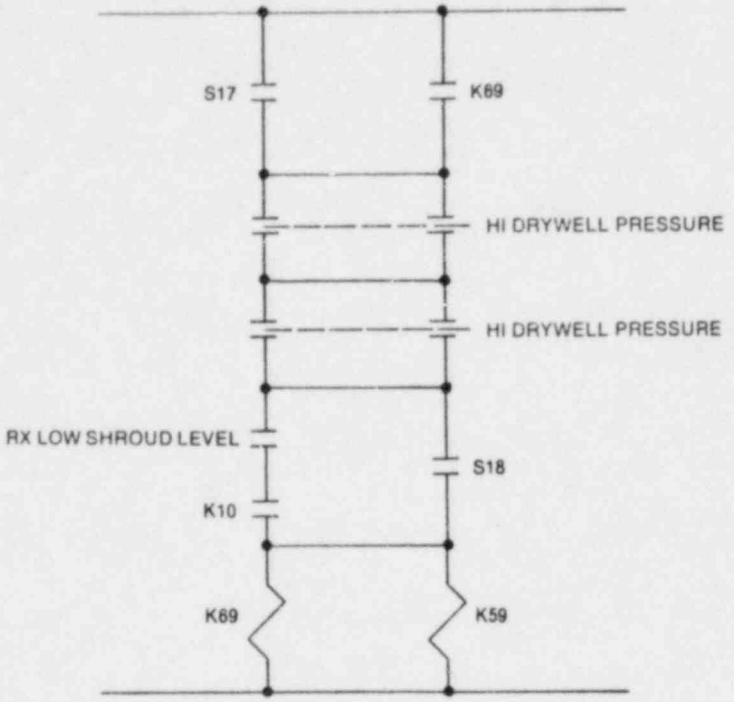

Figure 3. Containment Spray Valve Control Circuit