Attachment 1

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TECHNICAL EVALUATION OF THE ELECTRICAL, INSTRUMENTATION, AND CONTROL DESIGN ASPECTS OF THE LOW TEMPERATURE OVERPRESSURE PROTECTION SYSTEM FOR THE KEWAUNEE NUCLEAR POWER PLANT

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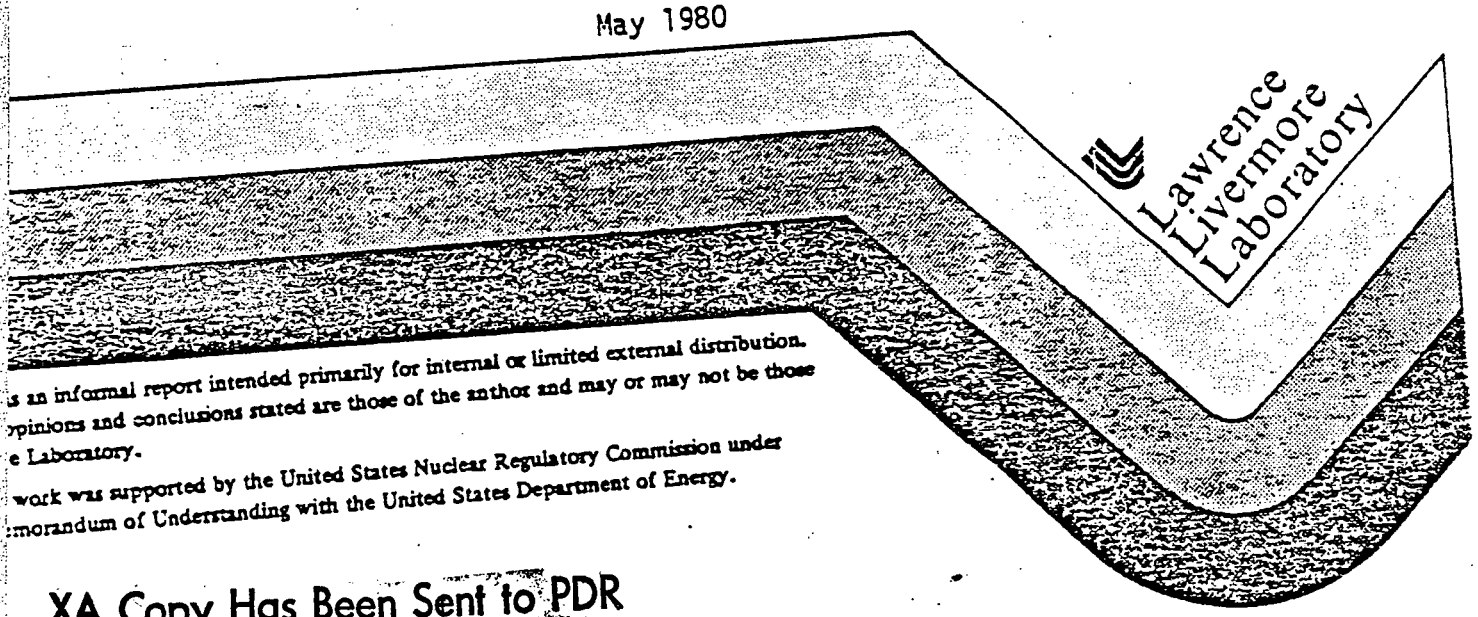

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ABSTRACT

This report documents the technical evaluation of the electrical, instrumentation, and control design aspects for the low temperature overpressure protection system of the Kewaunee Nuclear Power Plant. Design basis criteria used to evaluate the acceptability of the system included operator action, system testability, single failure criterion, and seismic Category I and IEEE Std-279-1971 criteria.

FOREWORD

This report is supplied as part of the Selected Electrical, Instrumentation, and Control Systems Issues (SEICSI) Program being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Operating Reactors, by Lawrence Livermore Laboratory, Engineering Research Division of the Electronics Engineering Department.

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1. INTRODUCTION

By letter to the Wisconsin Public Service Company (WPSC) dated August 11, 1976 [Ref. 1], the U.S. Nuclear Regulatory Commission (NRC) requested an evaluation of system designs to determine susceptibility to overpressurization events and an analysis of these possible events, and proposed interim and permanent modifications to the systems and procedures to reduce the likelihood and consequences of such events. By letter dated October 15, 1976 [Ref. 2] and subsequent letters (Refs. 3 through 22), the Wisconsin Public Service Company submitted the additional information requested by the NRC staff, including the administrative operating procedures and the proposed low temperature overpressure mitigating system. The system hardware includes sensors, actuating mechanisms, alarms, and valves to prevent a reactor coolant system (RCS) transient from exceeding the pressure and temperature limits of the Technical Specifications for Kewaunee as required by the Code of Federal Regulations, Title 10, Part 50 (10 CFR 50), Appendix G.

The purpose of this report is to evaluate the electrical, instrumentation, and control (EI&C) aspects of the licensee's equipment and procedures based on the information provided (Refs. 3 through 22), and to define how well they meet the criteria established by NRC as necessary to prevent unacceptable overpressurization events.

2. EVALUATION OF THE KEWAUNEE NUCLEAR POWER PLANT

2.1 INTRODUCTION

A review of the Kewaunee low temperature overpressure protection system design by WPSC was begun in 1976 at NRC's request. The proposed overall approach to eliminating overpressure events incorporates administrative, procedural, and hardware controls, with reliance upon the plant operator for the principal line of defense. Preventive administrative/procedural measures include:

(1) Procedural precautions.

(2) Deenergization (power removed) of essential components which are not required to be operable during the cold shutdown mode of operation.

(3) Maintenance of a non-water-solid reactor coolant system condition whenever possible.

(4) Incorporation of an additional 4-inch relief valve (RV) suction header in the residual heat removal (RHR) system which would be set to open at 500 psig and with a relief capacity of 1400 gpm at 525 psig. Also WPSC proposed to lower the setpoint of the 2-inch RV to 480 psig with a 230 gpm capacity at 500 psig. The licensee has also proposed adjusting the residual heat removal system autoclosure setpoint to 700 psig.

The design basis criteria that were applied in evaluating the acceptability of the electrical, instrumentation, and control aspects of the low temperature overpressure protection system (OPS) are as follows:

(1) Operator Action. No credit for operator action is taken until 10 minutes after the operator is aware, through an action alarm, that an overpressure transient is in progress.

(2) Single Failure Criterion. The OPS shall be designed to protect the reactor vessel given a single failure which is in addition to the failure that initiated the pressure transient.

(3) Testability. The OPS must be testable on a periodic basis prior to dependence on the OPS to perform its function.

(4) Seismic Category I and IEEE Std-279-1971 Criteria. The OPS should satisfy both the seismic Category I and IEEE Std-279-1971 criteria. The basic objective is that the OPS should not be vulnerable to a failure mode that would both initiate a pressure transient and disable the low temperature overpressure protection system. Events such as loss of instrument air and loss of offsite power must be considered.

2.2 WPSC OVERPRESSURE PROTECTION SYSTEM DESIGN

The WPSC overpressure protection system design information detailed in this section was derived from References 10 and 12. The overpressure protection system for low temperature operation (in accordance with 10 CFR 50 Appendix G) relies on an installed relief valve on the RHR system suction. Two parallel paths are available from the reactor coolant system to the relief valve. The controls associated with the isolation valves in each flow path from the reactor coolant system are designed to prevent a single event from disabling the relief valve. Annunciation within the control room is provided to indicate a misalignment of any isolation valve to the operators. This annunciation system provides continuous monitoring of the proper alignment of the overpressure relief system.

In the event that the relief valve is inoperable for any reason, comparable protection will be provided in the form of an administratively-controlled vent of at least equal cross sectional flow area to the relief valve. Normal administrative control in the form of tagging the vent and associated valves, if included in the vent path, will ensure the existence of overpressure protection.

Figure 1 presents a section of the residual heat removal system (RHR) flow diagram which identifies the location of the proposed overpressurization relief valve in relationship to the reactor coolant system and the remainder of the RHR system. As noted in Figure 1, the relief valve would be located within containment on the common-normal suction header to the RHR pumps downstream of the isolation valves from the RCS. The existing RHR relief valve will be retained at a setting lower than the planned overpressurization relief valve to provide relief from small flowrate transients, thereby avoiding operation of the large overpressurization relief at low flowrates. The overpressurization relief valve will discharge to the containment sump, since at the maximum possible anticipated flowrates the discharged water would rupture the PRT rupture disk and ultimately would collect in the sump in any case.

The overpressurization relief valve can be isolated from the reactor coolant system by RHR suction isolation valves RHR 1A (8702A), RHR 1B (8702B), RHR 2A (8701A), and RHR 2B (8701B). The present design of the Kewaunee Nuclear Power Plant includes redundant automatic closure and opening protection of the suction isolation valves by two pressure channels that monitor RCS pressure. The automatic closure feature will be modified to prevent a single active failure from disabling the mitigating system. Figure 2 presents the control logic diagram for the RHR valves which can isolate the overpressurization relief valve. The proposed control system design will provide redundant opening interlocks, automatic isolation of each suction line from the RCS, and indication of improper valve alignment by means of an annunciator.

2.3 EVALUATION OF THE KEWAUNEE NUCLEAR POWER PLANT USING DESIGN BASIS CRITERIA

The Kewaunee Nuclear Power Plant was evaluated under the guidance of the four design basis criteria stated in Section 2.1 of this evaluation. Specific attention was given to various pertinent NRC staff positions resulting from these criteria. Sections 2.3.1 through 2.3.4 are concerned with the four design criteria.

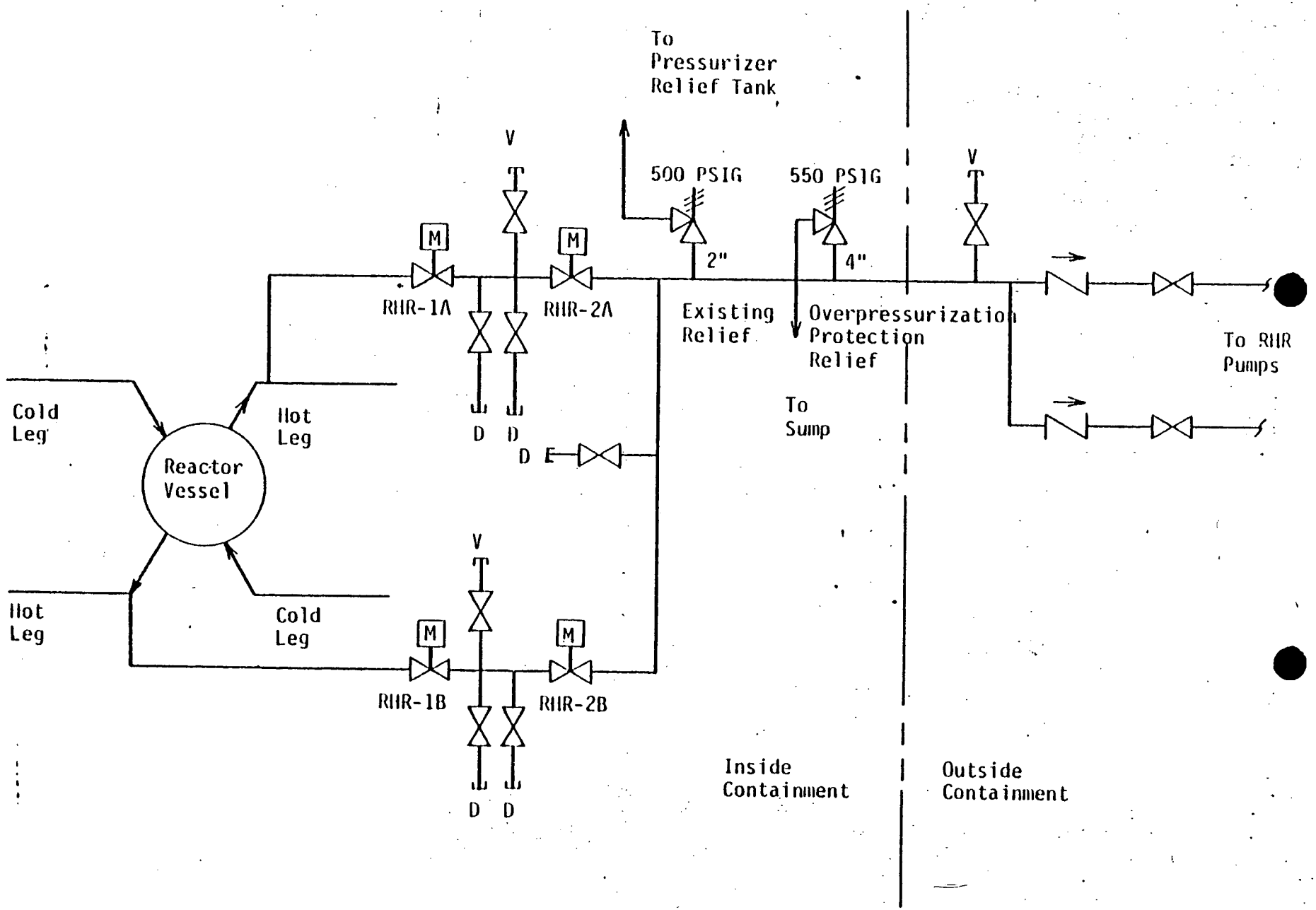

Figure 1. Flow diagram of residual heat removal system.

2.3.1 Operator Action

In each design basis transient analyzed, no credit for operator action was taken until 10 minutes after the initiation of the RCS overpressure transient and after the operator was made aware of the overpressure transient by the low temperature overpressure transient alarm. The criterion for operator action is consistent with that suggested at recent meetings between pressurized water reactor (PWR) owners and the NRC (i.e., when a plant is operated in accordance with established operating procedures, the protection afforded by normal operating procedures is a vital part of the overall plan for protection against overpressurization).

In the analysis of postulated overpressure events defined in Appendix G of 10 CFR 50, operator actions to mitigate the consequences of the event are conservatively assumed not to occur for 10 minutes after the event. The analysis assumes that the operator is alerted to a possible overpressure event by the RHR relief valve open alarms and/or high pressure alarm on the master control board. In this analysis, it is seen that adherence to normal operating procedures is the only requirement placed upon the operator to guarantee overpressure protection.

The redundant instrument and control channels provide an alarm to the operator when the RHR is not correctly aligned. Although we recommend the installation of an RHR relief valve open alarm, which may also be used as a high pressure alarm (see Sections 2.4.1 and 2.4.5), to alert the operator to a high pressure transient, the set-point analysis provided by the Reactor Safety Branch (RSB), along with the comparison of pump rates with the relief capabilities of the RHR relief and overpressure relief valves, lead us to conclude that the Kewaunee Nuclear Power Plant satisfies the NRC criterion on operator action.

2.3.2 Single Failure Criterion

The NRC staff position requires that the OPS shall be designed to protect the reactor vessel given a single failure which is in addition to

the failure that initiated the pressure transient. The NRC staff position also requires that the power supplies and power sources for the pressurizer PORVs be completely separate and distinct from those of the RHR-RVs, and that they should be vital sources. Since the Kewaunee design relies solely on the RHR spring-loaded relief valves, this requirement does not apply in this case. However, all four of the RHR isolation valves, which are motor-operated valves, are currently powered from nonvital buses. This configuration not only violates the single failure criterion, but the staff position as well.

The NRC staff has informed WPSC personnel of this problem and numerous discussions have been held between the two parties. WPSC has been informed by the NRC to proceed with the modifications to the isolation valves which would result in the Kewaunee OPS satisfying the single failure criterion and the related staff position. These modifications include wiring the RHR isolation valves to two separate Class 1E buses.

One interpretation of the single failure criterion would indicate that the control circuitry shown in Figure 2 fails to satisfy the criterion because one failure would deny use of the OPS to the plant. This situation exists because if either of the pressure transducers (PT 419 or PT 420) or the associated circuitry fails, neither leg of the RHR system would open, since each of these channels controls two MOV isolation valves (one in each leg, as shown in Figure 1). It is concluded, however, that the OPS control circuitry does satisfy the single failure criterion, based on the following:

(1) At plant temperatures at which the OPS would normally be activated, the Appendix G limits will not be exceeded.

(2) The plant Technical Specifications permit the plant to operate at hot standby for an indefinite period.

(3) Operational procedures should allow plant personnel to either correct the malfunction or enable the system by other means.

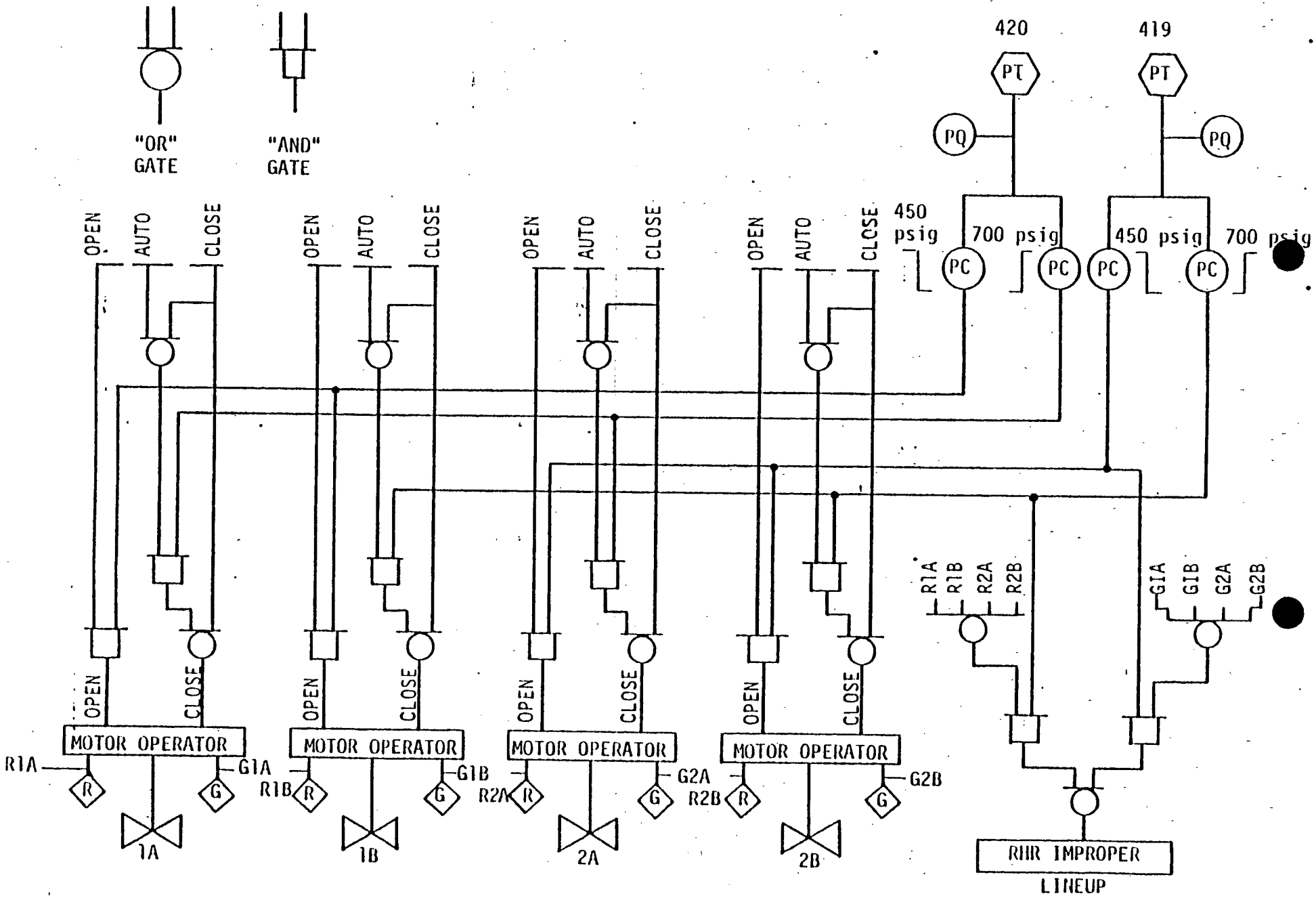

Figure 2. Kewaunee control circuitry.

2.3.3 System Testability

The NRC staff position requires that the OPS control circuitry from the pressure sensor to the valve solenoid should be tested prior to each heatup or cooldown. The RHR RVs should be tested during each refueling. Deviations from this criteria should be justified.

There are two aspects associated with the testability of the Kewaunee OPS. The first aspect concerns the RHR-RVs testing program for low pressure protection system operability. WPSC has stated that testability will be provided. Verification of operability is possible prior to solid system, low temperature operation by the use of the remotely-operated isolation valve, the enable/disable switch, and normal electronics surveillance procedure methodology. Testing requirements could be incorporated into the operating procedures to insure performance prior to the existence of plant conditions which would require operability of the protection system.

The second aspect of the testing program involves plant tests during cold shutdown which could result in an RCS overpressurization above the minimum operating limit curves, as overpressurization transients may result from testing high-head SIS pumps, charging pumps, or letdown valves.

The high-head SIS pumps and containment isolation valves are the only items routinely tested during cold shutdown conditions. These pumps are tested yearly either when the reactor vessel head is removed or when the pressurizer is drained. The purpose of the yearly test is to verify the performance of the diesel generators with a full loading of each safety train. The pump is operated for about 10 minutes for this test.

The containment isolation valves associated with the letdown line are tested yearly when the head is removed during refueling periods. Performance of the letdown valve testing does not present a potential for overpressurization transients.

Based upon the responses from WPSC, we conclude that the Kewaunee Nuclear Power Plant satisfies the NRC staff position on system testability.

2.3.4 Seismic Design and IEEE Std-279-1971 Criteria

2.3.4.1 Seismic Design Criteria. Seismic design of the electronic equipment now installed in the Kewaunee Nuclear Power Plant will be retained. Additional electronic equipment will be installed to avoid compromising the present seismic qualifications of existing safety systems.

2.3.4.2 IEEE Std-279-1971 Criteria. Based on the December 9, 1976 submittal by WPSC [Ref. 5], Kewaunee will utilize electrical equipment for their OPS that will have the same control/protection grading as the present systems. The OPS now in use is a two-channel, redundant configuration, which utilizes two keylock switches to enable/disable the system. The Licensee has also stated that they use separate, vital buses for the power supply to each channel. The motor-operated RHR isolation valves, however, are all powered from the same nonvital bus at present. WPSC has been informed of this deficiency and has promised to rewire the motor-operated valves (MOVs) to two (2) separate Class 1E vital buses. We conclude, therefore, that the Kewaunee OPS at Kewaunee Nuclear Power Plant will satisfy the IEEE-Std-279-1971 criteria.

2.4 ALARM SYSTEMS DESIGN AND OPERATION

Specific details concerning the design and operation of acceptable alarm systems for the Kewaunee OPS are described below.

2.4.1 High-Pressure Alarm

The NRC staff position requires that a high-pressure, audio/visual alarm shall be used during low RCS temperature operations as an effective means to provide unambiguous information to the operator that a pressure transient is in progress.

At the present time, the Kewaunee Nuclear Power Plant does not have a high pressure alarm. Since it is a staff requirement, we recommend the installation of an audio/visual high pressure alarm.

2.4.2 RHR-RV-Isolation Valve(s) Alarm

The NRC staff position requires that

(1) The upstream isolation valves to the RHR-RVs shall be wired into the overpressure protection alarm in such a way that the alarm will not clear unless the system is enabled and the isolation valves are open. Means shall be provided to ensure proper alignment of the isolation valves during OPS operation.

(2) The alarms shall be of the audio/visual type and provide unambiguous information to the operator.

The OPS for the Kewaunee Nuclear Power Plant was described in Section 2.2. From the system description and diagrams in that section, we conclude that Kewaunee satisfies the NRC staff position on isolation valve(s) alarm(s).

2.4.3 Enable Alarm

The NRC staff position requires that

(1) An alarm shall be activated as part of the plant cooldown process to ensure that the OPS is activated before the RCS temperature is less than 350°F. Prior to cooling the RCS below 350°F, operating procedures require the activation of the OPS by setting both keylock permissive switches to the "enable" position.

(2) The alarm shall be of the audio/visual type and provide unambiguous information to the operator.

The OPS system for Kewaunee Nuclear Power Plant was described in Section 2.2. As mentioned previously, when the pressure falls below 450 psig, the system should be enabled by use of the two keylock permissive switches. If the RHR system is not properly aligned, an alarm will be

annunciated in the control room. A signal is sent automatically from PT 419 when the pressure is $\leq$450 psig. This signal, in conjunction with a signal from any one of the four "closed" indicators, will activate the RHR Improper Alignment alarm. Therefore, it is concluded that this alarm will also serve the enable function.

2.4.4 Disable Alarm

The NRC staff position requires that

(1) An alarm shall be activated as part of the plant heatup process to ensure that the RHR isolation valves are closed when the RCS temperature is greater than 350°F.

(2) The alarm shall be of the audio/visual type and provide unambiguous information to the operator.

The Kewaunee Nuclear Power Plant does have provision for a signal to be generated from the PT 419 circuitry when the pressure is $\geq$700 psig (increasing). This signal, when combined with any one of the four MOV isolation valve "open" signals, will activate the RHR Improper Alignment annunciator. This alarm informs the operator that further action is required to isolate the RHR system from the RCS, an action which essentially results in disabling the OPS. Since this RHR Improper Alignment annunciator also is associated with a visual display, we conclude that the OPS at Kewaunee Nuclear Power Plant satisfies the staff position on Disable alarms.

2.4.5 Power-operated Relief Valve (PORV) Open

The PSB staff position requires that

(1) An alarm shall be activated to alert the operator that a power-operated relief valve is in the "open" position.

(2) An alarm shall be of the audio/visual type and provide unambiguous information to the operator.

As described earlier in this report, the Kewaunee Nuclear Power Plant does not use the PORVs in the OPS system. The valves used are the RHR spring-loaded relief valves. Because the staff positon on OPS systems applies to PORVs, and since there are other NRC requirements on SLRVs [Ref. 19], we conclude that the alarm requirement in this section is not applicable to the Kewaunee OPS.

2.5 PRESSURE TRANSIENT REPORTING AND RECORDING REQUIREMENTS

The NRC staff position is that a pressure transient which causes the OPS to function, thereby indicating the occurrence of a serious pressure transient, is a 30-day reportable event. In addition, pressure-recording and temperature-recording instrumentation are required to provide a permanent record of the pressure transient. The response time of the pressure/temperature recorders shall be compatible with pressure transients that increase at a rate of approximately 100 psig/s.

The Kewaunee Plant has installed wide-range temperature and pressure monitoring equipment. As indicated in the WPSC letter of October 15, 1976 [Ref. 2], this installed monitoring equipment provides a continuous record of the temperature and pressure condition of the plant [Ref. 3].

It is concluded that this installation satisfies the NRC staff position for pressure transient reporting and recording equipment.

2.6 DISABLING OF ESSENTIAL COMPONENTS NOT REQUIRED DURING COLD SHUTDOWN

The NRC staff position requires the deenergizing of safety injection system (SIS) pumps and the closure of safety injection (SI) header/discharge valves during cold shutdown operations.

As stated in WPSC's letter of October 15, 1976 [Ref. 2], solid system operation is limited to the minimum time consistent with conformance to limiting conditions of operating, as presented in the Technical Specifications, and to efficient plant operation.

During low pressure operation, the safety injection pump (high-head pumps) controls are placed in a "pull-out" condition with power available to the breaker. The alignment is assured by established operating procedures.

A precautionary statement has been added to the reactor coolant pump operating procedure to caution the operator of the danger of starting a pump without a steam bubble.

An additional interim requirement has been added to the operational limits of the reactor coolant pumps. This requirement prohibits starting the first pump without a steam bubble when the reactor coolant temperatures are above 180°F and there is a nonuniform temperature distribution, and when the system is filled and vented and both pumps have been shut down for in excess of 15 minutes.

We conclude that this implementation satisfies the NRC staff position.

3. TECHNICAL SPECIFICATIONS

The Technical Specifications information detailed in this section was derived from the February 5, 1979 NRC memorandum "Review of Kewaunee Overpressure Protection System" (see Ref. 17). To ensure operation of the Kewaunee overpressure protection system (OPS), the licensee has submitted technical specifications for staff review that are to be incorporated into the license. These specifications are summarized below.

(1) The OPS must be enabled when the RCS average temperature is below 342°F and the vessel head is installed. The OPS is defined as being enabled when all four RHR isolation valves are open or if the RCS is vented with a flow cross sectional area $\geq$6.4 in^2.

(2) The RHR 4-inch safety valve (RHR 33-1) will have an open setpoint at $\leq$505 psig.

(3) If any of the four RHR MOVs are closed when the OPS is required to be enabled, the two series MOVs in the opposite RHR leg will be locked open and de-energized (power supply breaker locked open).

(4) The setpoint of the 4-inch RHR safety valve will be verified at alternate refueling outages (not to exceed 30 months).

The staff has reviewed these proposed technical specifications [Ref. 20], and finds them acceptable.

4. CONCLUSIONS

The electrical, instrumentation, and control design aspects of the low temperature overpressure protection system (OPS) for Kewaunee were evaluated using those design basis criteria originally prescribed by the NRC staff and later expanded during subsequent discussions with the licensee.

We conclude that the OPS at WPSC's Kewaunee Nuclear Power Plant, as described, does not satisfy all of the NRC criteria, requirements, or staff positions concerning the electrical, instrumentation, and control systems' aspects of their design. WPSC has been informed of these deficiencies and of the following recommendations to correct them, and has agreed to make the necessary modifications [Ref. 23].

(1) All OPS electrical equipment should conform to IEEE-279-1971 criteria. This includes all electrical equipment that interfaces with the rest of the reactor safety system.

(2) It is recommended that all alarms be of the audio/visual type.

(3) It is recommended that WPSC install a high pressure alarm.

(4) It is recommended that each parallel set of RHR isolation MOVs be powered by a separate, vital power supply bus.

Except as noted above, we conclude that the WPSC's use of the RHR system relief valves and associated electrical instrumentation and control subsystems satisfies the NRC criteria and staff positions for the low temperature overpressurization protection of the Kewaunee Nuclear Power Plant.

REFERENCES

1. NRC letter (Schwencer) to Wisconsin Public Service Corporation (WPSC) dated August 11, 1976.
2. WPSC letter (James) to NRC (Schwencer), dated October 15, 1976.
3. WPSC letter (James) to NRC (Schwencer), dated September 2, 1976.
4. WPSC letter (James) to NRC (Rusche), dated October 26, 1976.
5. WPSC letter (James) to NRC (Schwencer), dated December 9, 1976.
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8. NRC letter (Schwencer) to WPSC (James), dated April 1, 1977.
9. WPSC letter (James) to NRC (Schwencer), dated April 14, 1977.
10. WPSC letter (James) to NRC (Schwencer), dated June 24, 1977.
11. NRC letter (Schwencer) to WPSC (James), dated October 19, 1977.
12. WPSC letter (James) to NRC (Schwencer), dated January 30, 1978.
13. "Staff Discussion of Fifteen Technical Issues listed in Attachment G, November 3, 1965 Memorandum from Director NRR to NRR Staff" NUREG-0138, November 1976.
14. "Pressure Mitigating System Transient Analysis Results" prepared by Westinghouse for the Westinghouse user's group on reactor coolant system overpressurization, dated July 1977.
15. WPSC letter (James) to NRC (Schwencer), dated June 23, 1978.
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17. U.S. NRC memorandum (P.S. Check to A. Schwencer), "Review of Kewaunee Overpressure Protection System", (TACS #6886) dated February 5, 1979.
18. WPSC letter (Mathews) to NRC (Schwencer), dated June 15, 1979.
19. U.S. NRC, "TMI Short-term Implementation Action", NUREG-0578.
20. NRC memorandum (P.S. Check to A. Schwencer) "Review of Kewaunee Overpressure Protection System Technical Specification", (TACS #10865) dated June 20, 1979.

21. NRC letter (Schwencer) to WPSC (Mathews), dated October 19, 1979.

22. WPSC letter (Mathews) to NRC (Schwencer), dated December 12, 1979.

23. Telephone conversation (V. R. Latorre) with NRC (P. Shemanski), April 22, 1980.

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