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TECHNICAL EVALUATION OF THE ELECTRICAL, INSTRUMENTATION, AND CONTROL DESIGN ASPECTS OF THE OVERRIDE OF CONTAINMENT PURGE VALVE ISOLATION AND OTHER ENGINEERED SAFETY FEATURE SIGNALS FOR THE KEWAUNEE NUCLEAR POWER PLANT

(DOCKET No. 50-305)

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by

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ABSTRACT

This report documents the technical evaluation of the electrical, instrumentation, and control design aspects of the override of containment purge valve isolation and other engineered safety feature signals for the Kewaunee nuclear power plant. The review criteria are based on IEEE Std-279-1971 requirements for the safety signals to all purge and ventilation isolation valves.

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, Field Test Systems Division of the Electronics Engineering Department.

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1. INTRODUCTION

Several instances have been reported where automatic closure of the containment ventilation/purge valves would not have occurred because the safety actuation signals were either manually overridden or blocked during normal plant operations. These events resulted from procedural inadequacies, design deficiencies, and lack of proper management controls. These events also brought into question the mechanical operability of the containment isolation valves themselves. These events were determined by the U. S. Nuclear Regulatory Commission (NRC) to be an Abnormal Occurrence (#78-5) and were, accordingly, reported to the U. S. Congress.

As a follow-up on this Abnormal Occurrence, the NRC staff is reviewing the electrical override aspects and the mechanical operability aspects of containment purging for all operating power reactors. On November 28, 1978, the NRC issued a letter entitled "Containment Purging During Normal Plant Operation" [Ref. 1] to all boiling water reactor (BWR) and pressurized water reactor (PWR) licensees. In a letter [Ref. 2] dated January 3, 1979, the Wisconsin Public Service Corporation (WPSC), the licensee for the Kewaunee Nuclear Power Plant, replied to the NRC generic letter. A plant visit was made on June 6, 1979 by an NRC staff member accompanied by Lawrence Livermore Laboratory and EG&G, Inc. (San Ramon Operations) personnel. The applicable drawings were reviewed with the plant personnel, and the equipment was examined. Additional information was requested by the NRC in a letter [Ref. 3] dated September 14, 1979. WPSC replied in a letter [Ref. 4] dated October 18, 1979 and described design changes that they intend to make.

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

2. EVALUATION OF KEWAUNEE NUCLEAR POWER PLANT

2.1 REVIEW CRITERIA

The primary intent of this evaluation is to determine that the following requirements are met for the safety signals to all ESF equipment.

(1) Criterion no. 1--In keeping with the requirements of GDC 55 and 56 [Ref. 5], the overriding* of one type of safety actuation signal (e.g., radiation) should not cause the blocking of any other type of safety actuation signal (e.g., pressure) for those valves that have no function besides containment isolation.

(2) Criterion no. 2--Sufficient physical features (e.g., keylock switches) are to be provided to facilitate adequate administrative controls.

(3) Criterion no. 3--The system-level annunciation of the overriden status should be provided for every safety system impacted when any override is active (see R.G. 1.47).

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

(1) Criterion no. 4--Diverse signals should 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.

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*The following definition is given for clarity of use in this evaluation:
Override: The signal is still present, and it is blocked in order to perform a function contrary to the signal.

(2) Criterion no. 5--The instrumentation and control systems provided to initiate the ESF should be designed and qualified as safety-grade equipment.

(3) Criterion no. 6--The overriding or resetting* of the ESF actuation signal should not cause any valve or damper to change position.

Criterion 6 in this review applies primarily to related ESF systems because implementation of this criterion for containment isolation systems will be reviewed by the Lessons Learned Task Force, based on the recommendations in NUREG 0578, Section 2.1.4 [Ref. 6]. Automatic valve repositioning upon reset may be acceptable when containment isolation is not involved; consideration will be given on a case-by-case basis. Acceptability would be dependent upon system function, design intent, and suitable operating procedures.

2.2 CONTAINMENT VENTILATION ISOLATION CIRCUITS DESIGN DESCRIPTION

Kewaunee Nuclear Power Plant has two ESF trains which can cause isolation of the containment ventilation system. The initating contacts for each train are combined as parallel inputs to form an "OR" circuit. These contacts are described below:

(1) Automatic Contacts

(a) Containment high radiation (two normally-open contacts in parallel from the radiation monitors).

(b) Safety injection actuation (a normally-open contact).

*The following definition is given for clarity of use in this evaluation:
Reset: The signal has come and gone, and circuit is being cleared in order to return it to the normal condition.

(2) Manual Contacts

(a) Containment isolation pushbuttons (two normally-open contacts in parallel).

(b) Containment spray pushbuttons (two normally-open contacts in series).

Each train includes separate automatic and manual input "OR" gates, a latching relay, and a slave relay with contacts in the control circuits of the pilot solenoid valves that control the CVI valves. A "reset" switch and a "reset" seal-in relay work in conjunction with the latching relays to provide the reset function. The "reset" switch and its seal-in relay are contacted downstream of all the automatic initiating contacts. The manual initiating contacts are connected to a point downstream of the "reset" switch. The "reset" switch for each train is an unprotected, simple, spring-loaded, pushbutton switch.

When a monitored plant condition (or manual input) calls for isolation, electric power is provided to operate the latching relay (type MG-6 relay) which, in turn, energizes its slave relay (e.g., V10X). Contacts of the slave relay open to remove electric power from the solenoid valves causing the isolation valves to close.

When the "reset" switch is operated, the "operate" coil of the latching relay is de-energized, the "reset" coil of the latching relay is energized, and the "reset" seal-in relay is energized. With the latching relay in the reset condition, the slave relay is de-energized making electric power available to the solenoid-valve circuits. The seal-in relay will stay energized by power obtained through the contacts of the initiating condition (e.g., high radiation, safety injection).

The circuit design does not include provisions to annunciate the "reset" or overridden status. Valve position lights (i.e., full-open/full-closed) and individual valve control switches are provided. The switches are three-position type with spring return to automatic from the open position and maintained contact in the closed position.

2.3 CONTAINMENT VENTILATION ISOLATION SYSTEM DESIGN EVALUATION

The CVI signal has a "reset" that is more properly termed a bypass or override, as defined in this review. This override, which contains a seal-in relay, constitutes a system-level override which prevents reactivation of CVI by other automatic input signals as long as an isolation signal continues uninterrupted. While in this override condition, none of the automatic safety signals can cause the containment ventilation/purge valves to close. When the last isolation signal is interrupted or cleared, the seal-in relay will drop out and allow a subsequent isolation input signal to generate a CVI actuation signal and reclose the valves. The manual CVI inputs are always active and available to the reactor operator, however. During this review, we determined that this override design does not satisfy NRC staff criterion no. 1. However, the licensee has recently committed to modify their system design.

The system modifications the licensee has committed to perform include moving the automatic safety injection (SI) signal over to the manual input "OR" gate. This leaves the high radiation automatic input(s) as the only signal that can be overridden. An automatic SI input will cause CVI, even with an existing high radiation override. We conclude that this modification will satisfy the NRC criterion no. 1. In addition, rather than overriding a high radiation alarm, the licensee intends to attempt to clear the alarm first by slightly upscaling the alarm setpoint. This would allow a subsequent high-radiation-initiated CVI in the event that the radiation level increases during the time that the containment is being purged. This higher alarm setpoint should be reviewed.

The existing CVI signal override ("reset") function uses simple, metal-ringed, spring-loaded pushbutton switches in each train which are located on the sloping part of the control panel. We conclude that this does not meet NRC staff criterion no. 2 regarding physical features that facilitate administrative controls. However, with the above described modifications to be performed by the licensee, an inadvertent system-level block of CVI will not likely occur. In addition, two "reset" buttons (one for each train) must be pressed in order to open the inboard and outboard valves. Finally, the purge and vent isolation valves will not reopen automatically following the "reset" or clearing of a CVI; a second intentional (manual) act of opening the valves must be initiated. Another safety feature would be the addition of plexiglass covers over the switches. We conclude that NRC staff criterion no. 2 will be satisfied with the incorporation of these modifications.

The presence of an override ("reset") of the CVI signal is not annunciated which does not satisfy NRC staff criterion no. 3. However, the licensee's proposed modifications eliminate the possibility of a system-level override of the CVI. Furthermore, the modifications will include an alarm that annunciates when a high-radiation-initiated CVI is overridden. We conclude that NRC staff criterion no. 3 will be satisfied with the incorporation of these modifications.

The CVI signal is generated in each train by a safety injection signal as well as by either of two containment high-radiation signals. The safety injection signal is a result of several diverse input signals, including containment high-pressure. Hence, the CVI system design includes diverse actuation signals, and we conclude that NRC staff criterion no. 4 is satisfied. Based on information from the licensee [Ref. 7], the containment high-radiation signal is provided by safety-grade equipment. Thus, we conclude that NRC staff criterion no. 5 is satisfied.

Resetting the safety injection signal cannot cause the CVI system to reset, nor will it cause the automatic reopening of the containment ventilation/purge valves. Clearing the CVI isolation signal requires manual operation of the "reset" pushbutton switch in each train. Reopening of the valves further requires the manual operation of the individual ventilation/purge valve switches. NRC staff criterion no. 6 is satisfied; however, that evaluation will be performed by the Lessons Learned Task Force as discussed in Section 2.1.

2.4 OTHER ENGINEERED SAFETY FEATURE SYSTEM CIRCUITS

It was determined during this review that the containment spray and containment isolation (for fluid systems) have a "reset" override circuit similar to that of the CVI.

The containment isolation and containment spray systems each has a single automatic actuation input signal. Hence, we conclude that NRC staff criterion no. 1 is satisfied.

The "reset" switches for both trains of the containment spray and containment isolation are simple, metal-ringed, spring-loaded push-button switches on the sloping part of the control panel. The design and location of these switches are judged to minimize inadvertent "reset." Another safety feature would be the addition of plexiglass covers over the switches. With that modification, we conclude that NRC staff criterion no. 2 is satisfied.

The presence of an override ("reset") of the containment spray or containment isolation is not annunciated. We conclude that NRC staff criterion no. 3 is not satisfied. We recommend the installation of the appropriate system-level annunciation of the overridden system for every safety system impacted.

Based on information from the licensee, the ESF equipment (including radiation monitors) is safety grade equipment which meets the intent of IEEE 279-1968. Thus, we conclude that NRC staff criterion no. 5 is satisfied.

Initiation of SI will cause the closing of the CVI and CI valves. After 90 seconds, the circuit design allows the SI actuation signal to be overridden ("reset"). Thus, the SI actuation input signal to these systems can be removed. While none of the CVI or CI valves will automatically reopen, these systems could be reset and the valves manually reinitiated to an open position. This design meets the NRC staff criteria used in this evaluation. Any further evaluation of this situation will be conducted by the NRC staff outside of this evaluation.

When the CVI or CI circuits are "reset", none of the valves will automatically reopen. We conclude that NRC criterion no. 6 is satisfied for these systems.

3. CONCLUSIONS

The EI&C design aspects of containment purge valve isolation and other ESF signals for the Kewaunee Nuclear Power Plant were evaluated using those design criteria stated in Section 2.1 of this report.

We conclude that, with the CVI system design modifications the licensee has committed to perform, and with the addition of plexiglass covers over the reset switches, the CVI system design meets the NRC staff criteria. The evaluation of the CVI system with regard to criterion no. 6 will be performed by the Lessons Learned Task Force. The NRC should review the new radiation monitor alarm setpoint discussed in Section 2.3.

We conclude that, with the addition of plexiglass covers over the reset switches, the other ESF circuit designs discussed (containment spray and containment isolation) satisfy the NRC criteria, with one exception. The single exception is that there is no system-level annunciation of the overridden condition, as discussed in Section 2.4. We recommend that safety-level annunciation be provided.

REFERENCES

1. NRC/DOR letter (A. Schwencer) to WPSC (E. James), "Containment Purging During Normal Plant Operation," dated November 28, 1978.

2. WPSC letter (E. James) to NRC (A. Schwencer) "Docket 50-305, Containment Purging During Normal Plant Operations," dated January 3, 1979.

3. NRC/DOR letter (A. Schwencer) to WPSC (E. Mathews), no title, dated September 14, 1979.

4. WPSC letter (E. Mathews) to NRC (A. Schwencer) "Docket 50-305, Operating License DPR-43, Containment Purge and Vent System," dated October 18, 1979.

5. 10 CFR 50, Appendix A, General Design Criterion.

6. U.S. NRC, "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations", NUREG-0578, published July, 1979.

7. WPSC letter (Charles A. Schrock) to NRC (Bob Licciardo), no title, dated March 27, 1980.

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LIMITING CONDITION FOR OPERATION

3.6.1.7 The containment purge supply and exhaust isolation valves may be open for safety-related reasons [or shall be locked closed]. The containment vent line isolation valves may be open for safety-related reasons [or shall be locked closed].

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTION:
(For plants with valves closed by technical specification)

With one containment purge supply and/or one exhaust isolation valve open, close the open valve(s) within one hour or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

(For plants with valves that may be opened by technical specifications)

1. With one containment purge supply and/or one exhaust isolation or vent valve inoperable, close the associated OPERABLE valve and either restore the inoperable valve to OPERABLE status within 72 hours or lock the OPERABLE valve closed.

2. Operation may then continue until performance of the next required valve test provided that the OPERABLE valve is verified to be locked closed at least once per 31 days.

3. Otherwise, be in at least HOT STANDBY within the next six hours and in COLD SHUTDOWN within the following 30 hours.

4. The provisions of Specification 3.0.4 are not applicable.

SURVEILLANCE REQUIREMENTS

4.6.1.7.1 The __ -inch containment purge supply and exhaust isolation valves and the __ -inch vent line isolation valves shall be determined locked closed at least once per 31 days.

4.6.1.7.2 The valve seals of the purge supply and exhaust isolation valves and the vent line isolation valves shall be replaced at least one per __ years.

3/4 4.6.3 CONTAINMENT ISOLATION VALVES

LIMITING CONDITION FOR OPERATION

3.6.3 The containment isolation valves specified in Table 3.6-1 shall be OPERABLE with isolation times as shown in Table 3.6-1.

APPLICABILITY: MODES 1, 2, 3 and 4.

ACTION:

With one or more of the isolation valves(s) specified in Table 3.6-1 inoperable, maintain at least one isolation valve OPERABLE in each affected penetration that is open and either:

a. Restore the inoperable valve(s) to OPERABLE status within 4 hours or

b. Isolate each affected penetration within 4 hours by use of at least one deactivated automatic valve secured in the isolation position, or

c. Isolate each affected penetration within 4 hours by use of at least one closed manual valve or blind flange; or

d. Be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

SURVEILLANCE REQUIREMENTS

4.6.3.1 The isolation valves specified in Table 3.6-1 shall be demonstrated OPERABLE prior to returning the valve to service after maintenance, repair or replacement work is performed on the valve or its associated actuator, control or power circuit by performance of a cycling test, and verification of isolation time.

SURVEILLANCE REQUIREMENTS (Continued)

4.6.3.2 Each isolation valve specified in Table 3.6-1 shall be demonstrated OPERABLE during the COLD SHUTDOWN or REFUELING MODE at least once per 18 months by:

a. Verifying that on a Phase A containment isolation test signal, each Phase A isolation valve actuates to its isolation position.

b. Verifying that on a Phase B containment isolation test signal, each Phase B isolation valve actuates to its isolation position.

4.6.3.3 The isolation time of each power operated or automatic valve of Table 3.6-1 shall be determined to be within its limit when tested pursuant to Specification 4.0.5.

4.6.3.4 The containment purge and vent isolation valves shall be demonstated OPERABLE at intervals not to exceed ___ months. Valve OPERABILITY shall be determined by verifying that when the measured leakage rate is added to the leakage rates determined pursuant to Specification 4.6.1.2.d for all other Type B and C penetration, the combined leakage rate is less than or equal to 0.60La. However, the leakage rate for the containment purge and vent isolation valves shall be compared to the previously measured leakage rate to detect excessive valve degradation.