EGG-EA-5194

June 1980

ELECTRICAL, INSTRUMENTATION AND CONTROL ASPECTS OF THE LOW TEMPERATURE OVERPRESSURE MITIGATING SYSTEM, ARKANSAS NUCLEAR ONE - UNIT 1, DOCKET NO. 50-313, TAC NO. 6806

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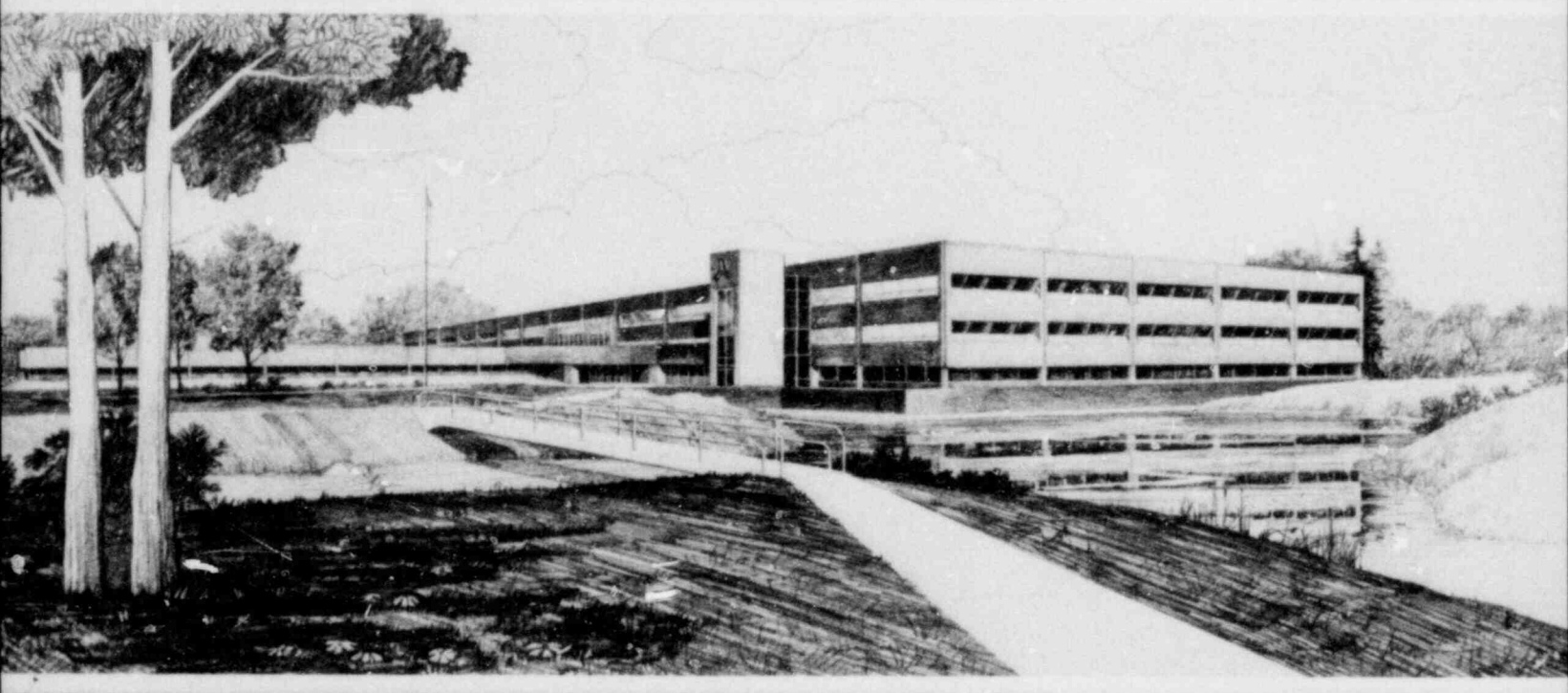

Prepared for the
U.S. Nuclear Regulatory Commission
Under DOE Contract No. DE-AC07-76ID01570
FIN No. A6256

EG&G Idaho

EG&G Idaho, Inc.

FORM EG&G 398
(Rev. 11-79)

INTERIM REPORT

Accession No. _____

Report No. EGG-EA-5194

Contract Program or Project Title:

Electrical, Instrumentation and Control System Support

Subject of this Document:

Electrical, Instrumentation and Control Aspects of the Low Temperature Overpressure Mitigating System, Arkansas Nuclear One - Unit 1, Docket No. 50-313, TAC No. 6806

Type of Document:

Informal Report

Author(s):

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Date of Document:

June 1980

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Prepared for the
U.S. Nuclear Regulatory Commission
Washington, D.C.
Under DOE Contract No. DE-AC07-76ID01570
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INTERIM REPORT

TECHNICAL EVALUATION
ELECTRICAL, INSTRUMENTATION, AND CONTROL ASPECTS OF THE LOW TEMPERATURE OVERPRESSURE MITIGATING SYSTEM

ARKANSAS NUCLEAR ONE--UNIT 1
(Docket No. 50-313)
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ARKANSAS NUCLEAR ONE--UNIT 1
(Docket No. 50-313)

1. INTRODUCTION

By letter dated August 11, 1976[1], the NRC requested Arkansas Power and Light Company (AP&L) to evaluate the Arkansas Nuclear One--Unit 1 "overpressure protection system designs to determine their susceptibility to overpressurization events," and their ability to mitigate the consequences of these events. It was also requested that operating procedures be examined and administrative controls be implemented to guard against initiating overpressure events at temperatures below the Nil Ductility Transition Temperature (NDTT).

By letter dated December 3, 1976[3], AP&L submitted to the NRC a plant specific analysis. The NRC questioned portions of this analysis in a letter dated December 13, 1976[4]. In responding, AP&L, in a letter dated March 24, 1977[5], revised their analysis and answered the NRC questions. In a letter dated November 7, 1977[6], the NRC expressed some additional concerns as a result of a preliminary review of the overpressure protection system. AP&L responded to these concerns on May 16, 1978[7] and proposed some design changes.

The electrical, instrumentation, and control system aspects of the existing AP&L low temperature overpressure mitigating system (OMS) and the proposed design changes have been reviewed in this report. Section 2 describes the one event which AP&L's analysis indicates would result in an overpressure transient. Section 3 describes the Arkansas Unit 1 overpressure protection and AP&L's proposed design change. Section 4 provides an evaluation of the existing OMS and the proposed design change as they apply to the staff requirements. Section 5 lists recommendations as they apply to Technical Specifications, the existing OMS, and the proposed design change. Section 6 is a summary of this report.

2. DESIGN BASIS EVENTS (DBE)

AP&L has analyzed seven low temperature overpressure events to determine whether they are applicable to Arkansas Unit 1[5].

Based on the AP&L analysis, erroneous actuation of the high pressure injection (HPI) system, has been identified as the limiting mass addition overpressure transient. Operation of an HPI pump, which is capable of delivering flow against full system operating pressure, is required whenever a reactor coolant pump is in operation (provides RCS pump seal water). Since the discharge of an HPI pump is isolated from the reactor coolant system by a single injection valve, a single error or equipment failure could open the injection valve and overpressurize the reactor coolant system (RCS). If failure of the single low setpoint power-operated relief valve (PORV) is then assumed as the single failure following the event, AP&L's analysis shows that operator action would be required within five minutes to maintain the RCS pressure below Appendix G limits.

3. OVERPRESSURE PROTECTION

3.1 Description

For the Arkansas Unit 1, overpressure protection consists of operator action and the Overpressure Mitigating System (OMS). The Decay Heat Removal (DHR) system does not provide additional relief protection from overpressure transients as it is automatically isolated from the Reactor Coolant System (RCS).

3.1.1 Operator Action

With a steam or nitrogen bubble in the pressurizer, the operator has about 4.4 minutes in which he can respond to an erroneous HPI. The operator action necessary to prevent overpressurization is to determine the cause of the transient and to deenergize or control the responsible equipment before the RCS pressure reaches the PORV setpoint.

3.1.2 Overpressure Mitigating System (OMS)

The OMS consists of a single, dual setpoint, power-operated relief valve (PORV). The valve has a high overpressure setpoint of 2255 psig for reactor operation and a low temperature overpressure setpoint of 550 psig for reactor cooldown and heatup. A manually operated switch under administrative control is provided to change the PORV setpoint. AP&L does not provide an enabling alarm to alert the operator to switch to the lower setpoint when the RCS temperature and pressure are below 500 psig and 280°F, respectively.

AP&L has stated in their letter of March 24, 1977[5], that the PORV has a steam (or nitrogen) relief capacity greater than the injection rate of two HPI trains, and a liquid relief capacity equal to or greater than the injection rate of one HPI train.

3.1.3 Transient Indications and Alarms

Alarms and indications which give direct indication that a transient is in progress include, three wide-range pressure transmitters (0-2500 psig) used for actuation of the engineered safeguards systems; a pressure transmitter (0-600 psig) on the pressurizer sample line that controls the power-operated relief valve; two pressurizer level instruments and associated high and high-high level alarms; a letdown storage tank low level alarm; makeup system flowrate indication; and makeup valve position indication.

AP&L provides three acoustic monitors, downstream of the PORV and each of the two pressurizer safety valves, to provide direct indication of the positions of each valve. A single alarm is actuated if any of the three monitors detects flow. The operator then checks the indicators for each valve to determine which has lifted.

3.1.4 Procedural Precautions

The staff position with regard to the inadvertent operation of components capable of causing a low temperature overpressurization requires the

deenergization and either lockout or alarming of unused equipment capable of causing the overpressurization.

Procedural steps requiring the removal of equipment from operation, e.g., the racking-out of pump and valve circuit breakers, require "hold cards" to be placed on the breaker which are opened, and "sign offs" to indicate satisfactory completion of each step.[5] Critical steps performed under administrative control are included.

To prevent the erroneous action of an HPI train, circuit breakers for the two normally-closed HPI motor-operated valves are racked-out with the valves closed during plant cooldown and prior to start-up of the DHR system. This is accomplished by opening, racking out, and tagging the valve circuit breakers at the motor control center. These circuit breakers are not racked-in again until startup when RCS temperature is above 280°F.[5] The operator has indication that power has been removed as the status lights in the control room will be off.

3.2 Proposed HPI OMS Addition

With the initial RCS conditions at NDTT and a pressure of 250 psig, the analysis has determined the time required for a pressure transient to each 550 psig (required relief setting) after initiation varies between 4.4 and 53 minutes, depending on the transient source. Only a pressure transient caused by the actuation of an HPI train will reach the vessel overpressure point of 550 psig in less than ten minutes. Therefore, AP&L has proposed to install additional alarms which will assure proper alignment of the overpressure protection system and the status of the four HPI valve circuit breakers.[7]

Specifically, a circuit will be provided to actuate an alarm if either of two conditions are not satisfied. When the reactor coolant temperature falls below a predetermined setpoint (280°F), a signal monitor will close a contact to set up part of the alarm circuitry. With this condition established, the alarm will be actuated if the isolation valve CV-1000 to

the electomatic relief valve PSV-1000 is closed or if the key-operated switch for the lower setpoint on the electomatic relief valve is not enabled. In addition to the above-requested alarms, AP&L plans to add an alarm on the circuit breaker for the four HPI valves, CV-1219, -1220, -1227, and -1228. A circuit will be provided to actuate an alarm if any of the four HPI valve circuit breakers is not deenergized (locked out) and the reactor coolant temperature has fallen below a predetermined setpoint.

4. EVALUATION OF THE EXISTING AND PROPOSED OMS

The OMS, present and proposed, as it is designed to respond to transients, is evaluated relative to the staff requirements as follows:

1. Requirement

   Operator Action - No credit can be taken for operator action until ten minutes after the operator is aware, through an alarm, that a pressure transient is in progress.

   Evaluation

   The existing dual setpoint PORV OMS, when in service, will relieve all low temperature pressure transients. However, it is not single failure free. The proposed OMS would not meet this requirement if installed.

   The only event which would require operator action in less than ten minutes is an HPI transient. The addition of the proposed alarms would not automatically mitigate an HPI transient in less than ten minutes. Operator action would still be required for this event.

2. Requirement

Seismic and IEEE 279 Criteria - Ideally, the system should meet Seismic Category I and IEEE 279 criteria. The basic objective is that the system should not be vulnerable to a common failure that would both initiate a pressure transient and disable the overpressure mitigation system.

The original intent of the NRC staff was that at least two independent automatic low pressure protection channels should make up the OMS. Each channel should include separate sensors, alarms, power trains, and relief valves. Each channel should have complete electrical and physical independence from each other to prevent common mode failures. The OMS should be operable upon loss of offsite power. In addition, each OMS channel should not be susceptable to seismic events that could cause a transient and fail the channel at the same time.

Evaluation

The existing and proposed Arkansas Unit 1 OMS does not comply with the IEEE 279 or Seismic criteria. Regarding the IEEE 279 criteria, the existing and proposed OMS does not provide for a second independent automatic low-pressure protection channel. The addition of the enabling alarm will assure proper alignment of the overpressure protection system. The addition of an alarm to the four HPI valve circuit breakers will assure that the circuit breakers are deenergized when the reactor coolant temperature has fallen below a predetermined setpoint. Regarding Seismic criteria, AP&L states that detailed stress analyses have been performed for the pilot-actuated relief valve in accordance with

ASME Section III, Class 1 requirements and have been found adequate for Class 1 applications. However, testing with simulated seismic loadings has not been performed as this was not a requirement at the time the plant was designed and constructed.[5]

3. Requirement

Single Failure - The system must be designed to relieve the pressure transient given a single failure in addition to the failure that initiated the pressure transient.

Evaluation

The Arkansas Unit 1 OMS does not comply with the single failure criteria in that there is only one RCS low temperature overpressure protection channel, i.e., there is no channel redundancy.

4. Requirement

Testability - The system shall include provisions for testing on a schedule consistent with the frequency that the system is relied upon for pressure protection.

Evaluation

The single existing PORV system is designed to allow testing of the system prior to its use. AP&L is preparing Technical Specifications regarding HPI and PORV testing and maintenance.[7]

5. RECOMMENDATIONS

5.1 Technical Specifications

It is the staff position that administrative controls shall appear in the Technical Specifications as Limiting Conditions for Operation when administrative controls are used to limit overpressurization scenarios. Therefore, it is recommended that the licensee be required to submit Technical Specification changes for Arkansas Unit 1 consistent with the following:

1. Any operation or failure of the PORV to operate to relieve pressure transients must be reported to the NRC.

2. The existing OMS and alarms must be operable (in operation) when the RCS temperature is below 280°F. If the OMS design is installed and in operation, then the system and its related alarms must be operable when the RCS temperature is below the minimum pressurization temperature. If these conditions are not met, the primary system must be depressurized and vented to the atmosphere within eight hours.

3. The two motor-operated valves normally aligned to provide high-pressure injection[7] must be closed and the supplying circuit breakers open, locked out, and tagged when the temperature is below 280°F and the reactor coolant is not vented to the atmosphere.

4. The low temperature overpressure protection system and alarm (dual setpoint PORV), and the HPI OMS and alarms must be tested on a periodic basis consistent with the need for its use. A system functional test and a setpoint verification test shall be performed prior to enabling the overpressure protection system during cooldown and startup. The system shall be calibrated,

and the PORV and HPI OMS operation tested at refueling intervals. The HPI valve will be allowed to be cycled only if (a) all HPI pumps are out of service, or vessel temperature is above the minimum value for which the vessel can be fully pressurized, or (b) the reactor vessel head is removed.[7]

5. When the reactor vessel temperature is below the minimum value for which the vessel can be fully pressurized, the PORV may be removed from service for a maximum of two hours only if (a) charging pumps are out of service and all HPI injection valves are closed and power removed, or (b) the vessel head is removed.[7]

5.2 Existing OMS

With regard to recommendations concerning the existing OMS, the licensee should:

1. Submit Technical Specifications to comply with the requirements listed in Section 5.1

2. Provide an OMS enabling alarm to comply with the staff position stated in the NRC letters of November 7, 1977[6]

3. Identify, in the Technical Specifications, the enabling temperature and PORV setpoint[6]

4. Propose Technical Specifications related to system testing[6]

5. Provide a method to continuously record RCS pressure and temperature to ensure that a permanent record is available for all low temperature-pressure events

6. Install pressure alarms to give the operator direct indication that a low temperature-pressure transient is in progress and that the RCS pressure has exceeded 550 psig

7. Examine the maintenance and testing restrictions to assure compatibility with present/proposed Technical Specifications regarding the operability and periodic testing of ECC and emergency boration system.[6]

5.3 Proposed OMS

It is recommended that the following be required of the licensee:

1. All alarms, instrumentation, control circuits, and power required by the operator to detect and mitigate HPI overpressure transients should be electrically and physically separated from the PORV system (i.e., meet IEEE 279 criteria)

2. Assure that the new equipment is siesmic qualified and testable.

6. SUMMARY

The NRC letter of August 11, 1976, regarding reactor vessel overpressurization, requested the Arkansas Power and Light Company to evaluate their low temperature overpressure mitigating system for Arkansas Unit 1 to determine their susceptibility to overpressure events.

The evaluation that AP&L provided indicated that there was one event, a transient caused by the inadvertent operation of the high pressure injection system, that would require operator action in less than the ten minutes allowed by the staff requirement to prevent overpressurization. On March 16, 1978, AP&L stated that they would install a circuit which would activate an alarm if any of the four HPI-valve circuit breakers are not

deenergized and the reactor coolant temperature is below a predetermined setpoint.

The existing and proposed system does not meet the staff requirements regarding operator action for an HPI transient, and the seismic and single failure requirements.

Although the Arkansas Unit 1 does not comply with the original staff requirements, there are other factors which should be considered. The staff requirements for an OMS was originated for plants that are operated with the RCS in a water-solid condition during cooldown and startup. With a water-solid condition, a transient can cause an overpressurization of the vessel within seconds of initiation. This step transient makes it impossible for an operator to detect a transient and act in time to prevent overpressurization. The B&W-designed plant never operate with a water-solid condition. A steam or nitrogen bubble is maintained in the reactor pressurizer at all times, which does not allow step transients to occur. Instead, transients occur as a ramp function with the HPI transient reaching the overpressurization point 4.4 minutes or more after initiation and all others requiring over ten minutes. This delay allows the operator time to detect the transient and take action to prevent the RCS pressure from reaching the PORV relief point. There has been only one low temperature overpressurization at the B&W-designed plants.

7. REFERENCES

1. R. W. Reid, NRC letter to AP&L, Re: "Reactor Vessel Overpressurization in Pressurized Water Reactor Facilities," August 11, 1976.

2. D. A. Rueter, "Reactor Vessel Overpressurization," November 15, 1976.

3. J. D. Phillips, "Reactor Vessel Overpressurization--B&W Generic Analysis," December 3, 1976.

4. R. W. Reid, NRC letter to AP&L, Re: "Additional Information to Evaluate Overpressure Mitigating System," December 13, 1976.

5. D. A. Rueter, "Evaluation of Potential Vessel Overpressurization," March 24, 1977.

6. R. W. Reid, NRC letter to AP&L, Re: "RCS Overpressurization," November 7, 1977.

7. D. H. Williams, "Reactor Vessel Overpressurization--Response to NRC Positions," May 16, 1978.