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

OCONEE UNITS 1, 2, AND 3
(Docket Nos. 50-269, 50-270, and 50-287)
TAC 6887

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1. INTRODUCTION

By letter dated August 11, 1976[1], the NRC requested Duke Power Company (DPC) to evaluate the Oconee Units 1, 2, and 3 "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 October 14, 1976[2], DPC submitted to the NRC a plant specific analysis. The NRC questioned portions of this analysis in a letter dated December 13, 1976[3]. In responding, the DPC, in a letter dated April 1, 1977[4], revised their analysis and answered the NRC questions. This prompted design changes documented in Reference 5, 6, 7, and 8.

The electrical, instrumentation, and control system aspects of the existing DPC low temperature overpressure mitigating system (OMS) and the proposed design changes have been reviewed in this report. Section 2 describes the one event which DPC's analysis indicates would result in an overpressure transient. Section 3 describes the Oconee Units 1, 2, and 3 overpressure protection and DPC'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)

DPC has analyzed seven low temperature overpressure events to determine whether they are applicable to Oconee Units 1, 2, and 3[4].

Based on the DPC 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, DPC'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 each of the Oconee Units 1, 2, and 3, overpressure protection consists of operator action and the Overpressure Mitigating System (OMS). The Decay Heat Removal (DHR) system can also provide some additional relief protection from overpressure transients as it is not 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. DPC 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 275°F, respectively.

DPC has stated in their letter of April 1, 1977[4], 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."[4]

DPC 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 initialling to indicate satisfactory completion of each step (Reference 4, Attachment 1). 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 250°F.[4] 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 275 psig, the analysis has determined the time required for a pressure transient to reach 550 psig (required relief setting) after initiation varies between 4.4 and 46.6 minutes, depending on the transient source. Only a pressure transient caused by the actuation of a HPI train will reach the vessel overpressure point of 550 psig in less than ten minutes. Therefore, DPC proposes an overpressure protection system design concept which provides redundant means to prevent an overpressurization incident caused by HPI system actuation.[8]

This concept includes an alerting statalarm which activates upon reaching an RCS temperature, during normal cooldown, above the minimum pressurization temperature. This alarms alerts the operator to activate the overpressure protection system. The alarm monitors RCS temperature from an indicator located in the control room. The overpressure protection system is activated by valving into service an additional pressure switch located on the HPI system, sensing RCS pressure, and operating an electrical keylock switch in the control room. Once the system is activated and the RCS pressure exceeds the limiting value of approximately 500 psig, the pressure switch closes to energize a lock-out relay, which in turn, trips the breakers to the HPI pumps. When a heatup from cold shutdown commences, the overpressure protection system remains in operation until a deactivate alarm is energized. During normal operation (as directed by station procedures for heatup), the operator will deactivate the overpressure protection system by valving out of service the pressure switch and repositioning the keylock switch.

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 meet this requirement if installed.

The only event which would require operator action in less than ten minutes is an HPI transient. The proposed OMS design would automatically mitigate an HPI transient in less than ten minutes by tripping the HPI pumps. Operator action would not 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 Oconee OMS does not comply with the IEEE 279 or Seismic criteria. DPC has not provided information to evaluate this requirement for their proposed OMS.

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 Oconee 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. DPC has not described the testability of the proposed OMS design.

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 Oconee Units 1, 2, and 3 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 275^{o}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 HPI motor-operated valves must be closed and the supplying circuit breakers open, locked out, and tagged when the temperature is below 275^{o}F and the reactor coolant is not vented to the atmosphere.

4. The low temperature overpressure protection system and alarm (dual setpoing 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 set-point 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.

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.

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 10, 1977[5], and February 2, 1978[7]

3. Identify, in the Technical Specifications, the enabling temperature and PORV setpoint[5]

4. Propose Technical Specifications related to system testing[5]

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.[5]

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 seismic qualified.

6. SUMMARY

The NRC letter of August 11, 1976, regarding reactor vessel overpressurization, requested the Duke Power Company to evaluate their low temperature overpressure mitigating systems for Oconee Units 1, 2, and 3 to determine their susceptibility to overpressure events.

The evaluation that DPC 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 10, 1978, DPC provided details of a proposed HPI overpressure protection system in addition to an existing PORV dual setpoint system that would trip the HPI pumps in case of an overpressurization event without operator action.

The existing and proposed system satisfactorily meets the staff requirements regarding operator action for an HPI transient, but the existing OMS does not meet the staff requirements with regard to the seismic and single failure requirements. DPC has not provided information regarding seismic, IEEE 279 criteria, and testability of the proposed system.

Although the Oconee Units 1, 2, and 3 do 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 operates 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 DPC, Re: "Reactor Vessel Overpressurization in Pressurized Water Reactor Facilities," August 11, 1976.

2. W. O. Parker, "Evaluation of Potential Vessel Overpressurization," October 14, 1976.

3. R. W. Reid, NRC letter to DPC, Re: "Additional Information to Evaluate Overpressure Mitigating System," December 13, 1976.

4. W. O. Parker, "Evaluation of Potential Vessel Overpressurization," April 1, 1977.

5. R. W. Reid, NRC letter to DPC, Re: "RCS Overpressurization," November 10, 1977.

6. W. O. Parker, "Proposed Overpressure Protection System Modification," January 4, 1978.

7. R. W. Reid, NRC letter to DPC, Re: "Request for Additional Information Concerning Design of an Overpressure Protection System Modification," February 2, 1978.

8. W. O. Parker, "Description of a Preliminary Design Concept and Preliminary Drawings of the Overpressure System Modification," March 10, 1978.