UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

# SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

## RELATED TO AMENDMENT NO. 28 TO FACILITY OPERATING LICENSE NO. DPR-66

## DUQUESNE LIGHT COMPANY

## OHIO EDISON COMPANY

## PENNSYLVANIA POWER COMPANY

## BEAVER VALLEY POWER STATION, UNIT NO. 1

## DOCKET NO. 50-334

### Introduction

By letter dated November 17, 1977, the Duquesne Light Company (the licensee) initiated the required actions to satisfy the conditions and requirements of the Order for Modification of License which was issued by the NRC on September 30, 1977. This letter and subsequent correspondence referenced in Appendix 1 to this Safety Evaluation would change the Technical Specifications to reflect changes to assure the adequacy of the Net Positive Suction Head (NPSH) of the low head safety injection and recirculation spray pumps.

### Background

### NPSH and Containment Pressure and Temperature Analyses

During the course of the operating license review of the North Anna Station, that licensee reevaluated the net positive suction head (NPSH) available to the recirculation spray (RS) and low head safety injection (LHSI) pumps based on a more conservative containment analysis. NPSH is the head, or potential energy, available or required to force a given flow into the impeller of a pump. NPSH is affected by containment pressure, sump water vapor pressure, depth of sump water and suction piping resistance to flow. The revised analysis incorporated analytical techniques and assumptions that were selected to minimize the containment pressure and maximize the containment sump water temperature, thereby minimizing the calculated NPSH available to the pumps; the other factors, namely, depth of sump water and suction piping resistance to flow, have a lesser affect on the revised analysis. As a result of the analysis, certain design modifications were found to be necessary to assure the adequacy of the available NPSH for both the RS and LHSI pumps.

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The Beaver Valley Power Station, Unit 1 is an operating plant with a design similar to that of North Anna. It was determined that in the event of a major loss-of-coolant accident, the vapor pressure of the water in the Beaver Valley containment sump which is the source of water for the RS and LHSI pumps during the recirculation phase is higher than the original analyses had indicated. This situation can result in inadequate NPSH for the RS and LHSI pumps at specific times during the recirculation phase of long term core cooling and containment cooling.

By a letter dated September 8, 1977, the licensee proposed interim modifications of the RS and LHSI systems and requested that the Beaver Valley Power Station be permitted to operate with the proposed interim modifications until such time as permanent modifications are designed and installed. Based on our review of the information provided by the licensee, we found that the above proposed modifications were acceptable on an interim basis, and by Order dated September 30, 1977, we concluded that until permanent modifications are implemented, operation would not pose an undue threat to the health and safety of the public.

By a letter dated November 17, 1977, as supplemented by letters referenced in Attachment 1, the licensee submitted a report, which presented: (1) proposed permanent modifications of the RS and LHSI systems; (2) the containment pressure and temperature response analyses and associated NPSH available to the RS and LHSI pumps; and (3) proposed modifications to the Quench Spray systems and spray nozzles to support the NPSH modifications.

NPSH and related modifications made to Beaver Valley Unit 1 are:

1. Inside Recirculation Spray (IRS) System

   a. Remove and plug all type 1HH30100 nozzles in the spray headers.

   b. Replace with type 1713A nozzles as required and plug remaining holes.

   c. Install a 4-inch line from the QS line to the sump suction of the IRS and orifices to regulate 150 gpm QS discharge to each suction.

5. RWST Modifications

   a. Removal of mixing weir inside RWST.

   b. Installation of elbows on QS sump suction lines inside RWST.

   c. Upgrade of level instrumentation to provide input to control circuitry for automatic cut-back control by the QS system.

   d. Increase the total volume to 441,100 gallons.

6. Quench Spray System Modification

   a. Replace all 236 type 1HH30100 spray nozzles with 156 type 1713A nozzles and plug remaining holes.

   b. Add piping loop seal to QS flow paths inside containment to the IRS and ORS sump suctions.

   c. Install a larger impeller in each QS pump to handle additional flow.

   d. Install a motor-operated cut-back valve on each QS pump discharge. Install a flow restricting orifice in parallel with the cut-back valve to provide reduced flow for sub-atmospheric peak pressure control.

The basis for implementing the above modifications was to: (1) ensure adequate iodine removal for the most restrictive LOCA for all Engineered Safety Feature pump combinations; (2) provide adequate spray to ensure containment depressurization for all pump combinations; and (3) ensure adequate NPSH available for all LOCA transients. This has been accomplished by modifications to: (1) assure caustic solution reaching the spray nozzles, (2) add caustic solution at a rate that will assure spray pH is within bounds of the licensing requirements for all containment depressurization transients, (3) achieve maximum spray thermal effectiveness for the Quench and Recirculation Spray (RS) Systems, (4) reduce NPSH required for the LHSI by restricting maximum flow conditions, and (5) increase NPSH available for the RS Systems by providing subcooled water to pump suctions.

The above modifications are being made to Beaver Valley Unit 1 during the current outage.

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## Evaluation

### NPSH and Containment Analysis

The calculated pressure in the containment and temperature of the water that accummulates in the containment sumps are important parameters, in regard to available NPSH, in determining the RS and LHSI pump operability following a LOCA. These terms, in combination with the pump static head and associated line friction losses, establish the available NPSH during the transient.

The required NPSH may be reduced by a reduction in the pump flow rate. Alternately, the NPSH available at a given flow rate may be increased by the injection of cold water into the pump suction. The injection of cold water lowers the water temperature at the pump suction and, therefore, lowers the vapor pressure of the water entering the pump. The licensee proposed to utilize both of the above methods to resolve this problem.

### Recirculation Spray Pumps

In order to assure an adequate amount of NPSH for the RS pumps, the licensee proposed to divert cold quench spray (QS) water from the QS headers to the RS pump suctions. One hundred and fifty gallons per minute (gpm) will be diverted to each of the inside RS pumps, and 300 gpm will be diverted to each of the outside pumps. The cold QS water injection will lower the water temperature at the pump suction and, thereby lower the vapor pressure of the water entering the pump. Therefore, a 4-inch line leading from each quench spray header will be routed to the suction side of each of the RS pump on the same safety train as the QS pump supplying the water. A flow restricting orifice will be installed in each line to ensure the correct flow. No active components will be used. This proposed modification will allow the pumps to perform as originally specified. No reduction in flow rate to increase the available NPSH is necessary.

### Low Head Safety Injection Pumps

The change in the low safety injection flow was needed in order to meet the NPSH requirements of the LHSI pumps. The flow was limited by means of a cavitating venturi and flow restrictor. This change resulted in a slighly lower safety injection flow. However, the licensee has demonstrated that this flow is still higher than the value assumed in the LOCA analysis.

### Containment Analysis for Evaluation of NPSH

The new containment response analysis submitted by the licensee to determine the containment pressure and sump water temperature response was based on the following.

The analytical technique used to determine the distribution of mass and energy in the liquid and vapor regions of the containment following a LOCA can influence the containment pressure/temperature response. The pressure flash method and temperature flash method are the two currently used techniques. For the NPSH analysis, the licensee used the pressure flash method which assumes that liquid being expelled from the break flashes at the saturation temperature corresponding to the containment total pressure. This maximizes the temperature of the water entering the sump, and is, therefore, conservative. Previously, the containment analytical model for NPSH analysis assumed that the liquid flashes at the dew point temperature of the containment atmosphere (temperature flash method). The temperature flash method is typically used for peak containment pressure calculations.

The pipe break effluent was assumed to be uniformly mixed with the ECCS injection water spilling from the break. This is an important consideration for postulated cold leg breaks and essentially increases the energy transferred to the sump. This assumption does not affect NPSH calculations for postulated hot leg breaks since the break effluent is already uniformly mixed. Previously, for the NPSH analysis of postulated cold leg breaks, ECCS water was assumed to spill directly to the sump without mixing, which resulted in lower calculated sump water temperatures.

The licensee conducted a number of sensitivity studies to identify the other assumptions that should be used to minimize the calculated available NPSH. We have reviewed the results of these sensitivity studies and conclude that the following conservative assumptions will minimize the calculated available NPSH.

(1) A spray thermal effectivenes of 100% was assumed.

(2) A low initial containment pressure and high initial containment temperature were assumed.

Sensitivity studies were also done to identify the single failure, break size and pipe break location that will give the lowest calculated available NPSH for the RS and LHSI pumps. The results of these studies indicated that for the RS pumps, a postulated hot leg double-ended rupture will result in the lowest available NPSH, and for the LHSI pumps a postulated pump suction double-ended pipe rupture will result in the lowest available NPSH. The available NPSH for the inside recirculation pumps was calculated to be 12.7 feet, the available NPSH for the outside recirculation pumps was calculated to be 12.0 feet and the available NPSH for the LHSI pumps was calculated to be 12.1 feet. The minimum NPSH required are 9.3 feet for the RS pumps and 10.6 feet for the LHSI pumps.

We have performed confirmatory analyses for the pipe break locations that the licensee has identified as giving the lowest available NPSH for the pumps. For our confirmatory analyses, we used CONTEMPT (MOD26) computer code. The code has been modified to permit the analyses to be based on the pressure flash method. The results of our analysis; i.e., the containment pressure and sump water temperature versus time, are in good agreement with the licensee's results. We, therefore, conclude that the licensee's NPSH analysis is acceptable.

Effects on Containment Depressurization

In view of the system modifications that were found necessary to satisfy the NPSH requirements of the RS and LHSI pumps, the licensee also performed a sensitivity study to determine the impact on the depressurization time used in performing the analysis of the radiological consequences following a postulated loss-of-coolant accident. The results indicate that the containment will be depressurized to below atmospheric presure within an hour following a LOCA.

We have reviewed the input parameters used by the licensee to perform the depressurization analysis and concluded that the analysis would result in a reasonably conservative calculation of the containment depressurization time. The limiting case for containment depressurization is a pump suction double-ended rupture with minimum engineered safety feature operation.

A depressurization time of 3550 seconds was calculated, which is less than the one hour used in performing the analysis of the radiological consequenses following a LOCA. We have performed a confirmatory analysis for the limiting case for containment depressurization. The results of our analysis, i.e., containment pressure and depressurization time are in good agreement with the licensee's results. Therefore, we conclude that the licensee's containment depressurization analysis is acceptable.

Quench Spray System

Based on our requests for information on the containment spray systems and on our discussions on this system, the licensee modified several quench spray components. These modifications will provide additional assurance that the potential consequences of the postulated LOCA remain below the guidelines of 10 CFR Part 100. By controlling the volume flow rate of the caustic solution, the pH of containment spray and the recirculation water in the sump can be kept within acceptable limits. The original design of the Beaver Valley Unit No. 1 included a gravity feed system which fed the caustic solution to the bottom of the RWST. A weir arrangement in the RWST would assure the caustic solution mixed properly with the borated water. The proposed system will feed the caustic solution directly to the quench spray pumps suction at a metered rate provided by positive displacement, chemical injection pumps (CIPs).

The licensee added four positive displacement pumps to the chemical addition lines of the quench spray system: two each, in parallel, to each of the two quench spray trains. These will ensure that the quench spray will have a pH of at least 8.5 while the chemical addition tank (CAT) is emptying. The earliest the CAT can empty is 55 minutes. After this, the quench spray is borated water from the refueling water storage tank. The licensee plans to shut off the quench spray during a LOCA after about 100 minutes. However, the recirculation spray system starts after 5 minutes, and when the CAT is emptying at the maximum rate, the recirculation spray pH is up to 8 after about 24-30 minutes. In the case of a chemical addition valve failing closed, the CAT takes about 110 minutes to empty; and the quench spray pH is kept to 8 or above until well after the recirculation spray pH increases to 8.

The proposed Technical Specification changes include increased CAT pH, which will ensure that the final containment sump pH will be at least 8.0.

The licensee's changes will improve the overall iodine scrubbing reliability of the containment spray additive systems, and will ensure that at least one spray of pH 11 to 8 will be used at all times during an accident. This is consistent with the iodine scrubbing effectiveness of the containment spray system assumed in the original Safety Evaluation Report. Therefore, the calculated doses from a design basis accident will not increase due to the proposed changes.

The proposed system modifications to the quench spray system for positive injection of caustic solution required electrical, instrumentation, and control changes which have been reviewed by our contractor, EG&G Idaho, Inc. The discussion of the modifications and results of their review have been included as Attachment II. Our subsequent review of the remaining items from EG&G's review are as follows.

Thermal Overload Protection - QS System

Our review has determined that the only new valves added to the chemical addition system for which R.G. 1.106, "Thermal Overload Protection for Electric Motors on MOVs," is applicable are the flow cutback valves which were added to the discharge of the Quench Spray Pumps. These valves are normally open but receive a containment isolation - Phase B signal to open and close on a low-low level in the RWST. The motor operated thermal overload will be bypassed for both of these signals. The licensee has committed to installing the bypass scheme prior to plant startup.

Testing - QS System

The licensee has committed to developing and implementing by plant startup procedures which will institute the following administrative controls to be used for testing the chemical addition system.

(1) Procedures will require notifying personnel performing the test of a containment isolation - Phase B signal so they can restore the system to its normal emergency configuration.

(2) After completion of the test, procedures will require an independent verification of the valve lineup to ensure correct system configuration.

These administrative controls provide assurance that the system will be operable during and after testing.

Automatic QS Flow Reduction - Actuation Instrumentation

The proposed revision to the logic for the actuation of the automatic Quench Spray flow reduction reduces the total number of channels, the channels to trip and the minimum channels operable to one per train.

The application of the single failure criterion in which the failure of one of the quench spray cutback valves to function is bounded by the single failure of a diesel generator or a quench spray pump. Therefore, the results of the containment depressurization analysis are not invalidated by assuming that the single active failure which occurs is a failure of the cutback valve to activate at the required time.

Technical Specifications

We have evaluated the proposed Technical Specifications and conclude that they adequately incorporate the requirements for NPSH as evaluated herein. In the performance of the depressurization study, the licensee also proposed to modify Technical Specification Figures 3.6-1 and 3.6-2 and the Limited Condition for Operation statement 3.6.1.5. The staff has not completed the review of these proposed changes and since they are not required for resolution of the NPSH problem, these proposed changes will be addressed by a separate and subsequent review.

Environmental Consideration

We have determined that the amendment does not authorize a change in effluent types or total amounts nor an increase in power level and will not result in any significant environmental impact. Having made this determination, we have further concluded that the amendment involves an action which is insignificant from the standpoint of environmental impact and, pursuant to 10 CFR §51.5(d)(4), that an environmental impact statement or negative declaration and environmental impact appraisal need not be prepared in connection with the issuance of this amendment.

Conclusion

We have concluded, based on the considerations discussed above, that: (1) because the amendment does not involve a significant increase in the probability or consequences of accidents previously considered and does not involve a significant decrease in a safety margin, the amendment does not involve a significant hazards consideration, (2) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and (3) such activities will be conducted in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public.

Date: August 27, 1980

Attachment I

References


1. R. W. Reid to C. N. Dunn letter dated September 30, 1977 transmitted "Order for Modification of License."

2. C. N. Dunn to R. W. Reid letter dated November 17, 1977 proposed permanent modifications to correct NPSH inadequacies, includes Technical Specifications.

3. A. Schwencer to C. N. Dunn letter dated April 5, 1978 request for additional information.

4. C. N. Dunn to A. Schwencer letter dated May 15, 1978 with partial response.

5. C. N. Dunn to A. Schwencer letter dated August 3, 1978 completed request for additional information.

6. C. N. Dunn to A. Schwencer letter dated September 11, 1978 corrected analysis for NPSH adequacy.

7. C. N. Dunn to A. Schwencer letter dated October 24, 1978 transmitted mass and energy release data and revised Technical Specifications.

8. C. N. Dunn to A. Schwencer letter dated September 28, 1979 transmitted revisions to NPSH modifications and revised Technical Specifications.

9. C. N. Dunn to A. Schwencer letter dated October 18, 1979 included revised Technical Specifications.

10. E. J. Woolever to A. Schwencer letter dated February 27, 1980 transmitted revisions to NPSH modifications and revised Technical Specifications.

11. C. N. Dunn to S. Varga letter dated May 22, 1980 transmitted drawings to EG&G.

12. C. N. Dunn to S. Varga letter dated July 3, 1980 transmitted revisions to Technical Specifications.

13. C. N. Dunn to S. Varga letter dated August 6, 1980 provided additional information on NPSH modifications.

14. E. J. Woolever to S. Varga letter dated August 11, 1980 transmitted revision to Technical Specifications.

ATTACHMENT II

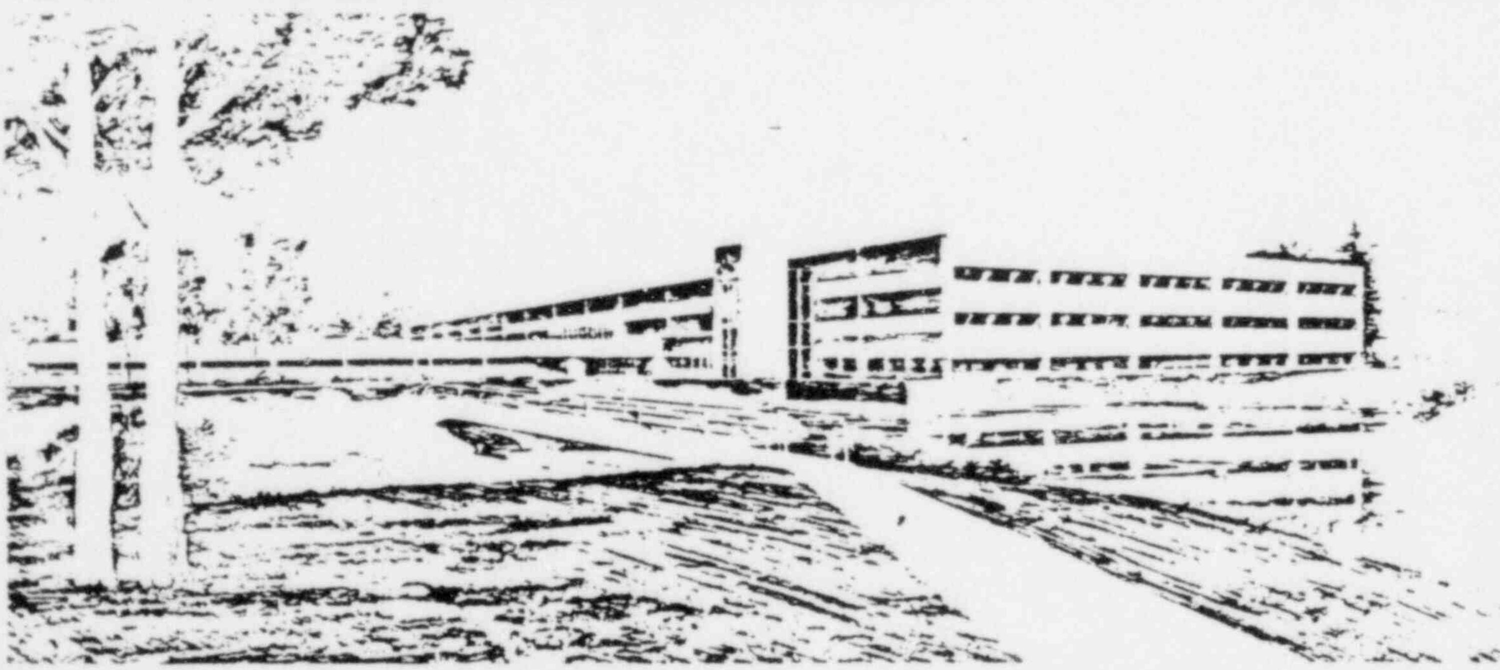
EGG-EA-5174

June 1980

# ELECTRICAL, INSTRUMENTATION AND CONTROL FEATURES OF QUENCH SPRAY SYSTEM MODIFICATIONS - BEAVER VALLEY NUCLEAR STATION, UNIT 1

S. E. Mays

U.S. Department of Energy
Idaho Operations Office • Idaho National Engineering Laboratory



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