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MEMORANDUM FOR: A. Schwencer, Chief, Operating Reactors Branch #1, Division of Operating Reactors

FROM: G. Lainas, Chief, Plant Systems Branch, Division of Operating Reactors

SUBJECT: DRAFT SAFETY EVALUATION: NET POSITIVE SUCTION HEAD AVAILABLE TO CONTAINMENT RECIRCULATION SPRAY AND LOW HEAD SAFETY INJECTION PUMPS

REFERENCES:
1. Letter from Dr. F. G. Hammitt to B. Buckley, dated January 24, 1979.
2. Memorandum for R. J. Mattson from V. Stello, Jr., Request for Review Assistance (TAC 7170) dated December 16, 1978.

Plant Name: Surry Nuclear Power Station Units 1 and 2
Docket Nos.: 50-280/281
Responsible Branch: ORB#1
Project Manager: D. Neighbors
Reviewing Branch: Plant Systems Branch
Status: Complete

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Enclosed is a draft Safety Evaluation Report for the Surry Nuclear Power Station, Units 1 and 2, addressing the licensee's revised analysis of the available net positive suction head (NPSH) for the containment recirculation spray (RS) system pumps and the low head safety injection (LHSI) pumps. The impact of the proposed permanent system modifications and revised analytical methods on the previously accepted containment depressurization analysis are also addressed.

The licensee has redone the NPSH analysis to minimize the calculated available NPSH to the recirculation spray pumps and the low head safety injection pumps, and determined that certain system design changes would be necessary to assure that the NPSH available to the pumps would be adequate.

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Our consultant (Ref. 1) and we have completed our evaluation of the licensee's analysis which is based on the proposed permanent system modifications and conclude that the NPSH analysis is adequate. In addition, our consultant recommends further investigation of the adequacy of the LHSI cavitation venturis. RSB (Berlinger) is seeing this aspect of the report.

During the course of the review, the Analysis Branch was also requested (Ref. 2) to review the licensee's mass and energy release model and data for the containment analysis. The Analysis Branch found that the mass and energy released data calculated by Westinghouse with the NRC approved model are acceptable. In addition, the Reactor Safety Branch (DOR) will provide input for the impact of the LHSI system modification on the ECCS performance.

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SAFETY EVALUATION FOR NET POSITIVE SUCTION HEAD AVAILABLE TO CONTAINMENT RECIRCULATION SPRAY AND LOW HEAD SAFETY INJECTION PUMPS

SURRY NUCLEAR POWER STATION, UNITS 1 AND 2

DOCKET NOS.: 50-280/281

1.0 INTRODUCTION

During the course of the operating license review of the North Anna Station, the applicant 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.

The Surry Station, Units 1 and 2 are operating plants 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 Surry 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 August 24, 1977, the licensee proposed interim modifications of the RS and LHSI systems and requested that the Surry 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 are acceptable on an interim basis.

By a letter dated November 22, 1977, the lciensee submitted a report, which presented: (1) proposed permanent modification of the RS and LHSI systems; and (2) the containment pressure and temperature response analyses and associated NPSH available to the RS and LHSI pumps. We have completed our review of the information presented by the licensee. Our evaluation follows.

2.0 EVALUATION

2.1 SYSTEM MODIFICATION

The calculated pressure in the containment and the 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.

2.1.1 RECIRCULATION SPRAY PUMPS

In order to assure an adequate amount of NPSH for the RS pumps, the licensee proposed:

(1) Diverting a portion (300 gpm) of the cold quench spray (QS) water from each of the QS headers to each of the outside RS pump suction piping; and

(2) Routing a bleed flow (350 gpm) from the discharge of the RS cooler back to the suction of the respective inside RS pump.

The cold QS water and the cool bleed flow injection will lower the water temperature at the pump suction and, thereby lower the vapor pressure of the water entering the pump.

A 4-inch line from each QS header inside the containment will be routed to the suction of each of the outside RS pumps on the same safety train as the QS pumps supplying the water. Also, a 4-inch line from the discharge of the RS cooler will be routed back to the suction of the respective inside RS pump. 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 RS pumps to perform with adequate NPSH and required RS flow rate.

2.1.2 LOW HEAD SAFETY INJECTION PUMPS

(Description of the LHSI system modification and the evaluation of the inpact of the system modification on the ECCS performance to be provided by Reactor Safety Branch, DOR).

2.2 CONTAINMENT ANALYSIS FOR THE EVALUATION OF AVAILABLE 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.

2.2.1 THERMODYNAMIC STATE OF LIQUID AND VAPOR PHASES IN CONTAINMENT

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.

2.2.2 PIPE BREAK EFFLUENT

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 breask since the break effluent is already uniformly mixed. Previously, for the NPSH analysis of postulating cold leg breaks, ECCS water was assumed to spill directly to the sump without mixing, which resulted in lower calculated sump water temperatures.

2.2.3 OTHER CONSERVATIVE ASSUMPTIONS

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 effectiveness of 100% was assumed.

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

(3) A low service water temperature entering the recirculation spray system heat exchangers was 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 hog 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 13.9 feet, the available NPSH for the outside recirculation pumps was calculated to be 11.8 feet and the available NPSH for the LHSI pumps was calculated to be 18.0 feet. The minimum NPSH required are 8.2 feet for the outside RS pumps; 10.1 feet for the inside RS pumps; and 16.2 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.

2.2.4 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 pressure within an hour following a LOCA.

We have reviewed the input parameterss 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 2662 seconds was calculated, which is less than the one hour used in performing the analysis of the radiological consequences 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.