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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 59

FACILITY OPERATING LICENSE NO. DPR-37

VIRGINIA ELECTRIC AND POWER COMPANY

SURRY POWER STATION, UNIT NO. 2

DOCKET NO. 50-281

Introduction

By letter dated June 30, 1980, the Virginia Electric and Power Company (the licensee) requested an amendment to the Surry Power Station, Unit No. 2, license which would change the Technical Specifications. These changes were required because of changes to the recirculation spray pumps, low head safety injection pumps and the containment spray system.

The licensee's letter of June 30, 1980 provides a list of correspondence related to this evaluation.

Background

NPSH and Containment Pressure and Temperature Analyses

During the course of the operating license review of the North Anna Station, the 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 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 were acceptable on a interim basis, and by Order dated August 24, 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 22, 1977, and June 30, 1980, the licensee submitted a report, which present: (1) proposed permanent modifications 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.

Containment Spray Modifications

In 1976, using the meteorological data from the Surry Power Station Units 3 and 4 (Surry 3/4) docket for the period March 3, 1974, to March 2, 1975, new accident relative concentration X/Q values were calculated by the staff for Surry 1/2. These X/Q values were higher than those used in the Surry 1/2 Safety Evaluation (SE) dated February 23, 1972. This prompted a request dated July 9, 1976, and February 1, 1977, to the licensee to supply the staff with additional information concerning the Surry 1/2 spray system and containment so that we could evaluate the containment spray system. The licensee responded to this request by letters dated August 31, 1976, and May 9, 1977, and June 30, 1980.

Modifications made to Surry Unit 2 are:

A. NPSH Modifications

1. Inside Recirculation Spray System

   a. Remove and plug all type 1HH30100 nozzles in the spray headers.
   b. Install and 2-1/2 in. bleed line from the discharge of the Recirculation Spray heat exchangers to the suction of the IRS pumps. Design flow is 350 gpm.

2. Outside Recirculation Spray System

   a. Remove and plug all type 1HH30100 nozzles in the containment recirculation spray headers.
   b. Install a restriction orifice on the ORS pump discharge to limit system flow to 3000 gpm.
   c. Install a 2-1/2 in. bleed line from each Containment Spray System supply header to the suction of the ORS pump in the containment sump. Design flow is 300 gpm.

3. Low Head Safety Injection System

   a. Install cavitating venturis in each of the cold leg injection lines to limit LHSI pump flow to 3250 gpm during the recirculation mode of operation.

4. Refueling Water Storage Tank (RWST)

   a. In conjunction with the RWST modifications for the Containment Spray (CS) Modification, elbows were installed inside the RWST on the CS pump suction lines.

B. Containment Spray System Modifications

1. Containment Spray Headers

   a. Install new containment spray header outside the crane wall.
   b. Replace nozzles in existing headers.

2. Caustic Addition Modifications

   a. Resize and reroute Chemical Addition Tank (CAT) outlet line directly to CS pump suction.

3. RWST Modifications

   a. Removal of mixing weir inside RWST
   b. Installation of elbows on CS pump suction lines inside RWST
   c. Upgrade of level instrumentation to provide input to control circuitry for automatic switchover of the LHSI system suction from the RWST to the containment sump.

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) provide increased caustic spray coverage, (2) reduce the delay time in caustic solution reaching the spray nozzles, (3) add caustic solution at a rate that will assure spray pH and sump pH is within bounds of the licensing requirements for all containment depressurization transients, (4) achieve maximum spray thermal effectiveness for the Containment and Recirculation Spray (RS) Systems, (5) reduce NPSH required for the LHSI and RS Systems by restricting maximum flow conditions, and (6) increase NPSH available for the RS Systems by providing subcooled water to pump suctions.

The above modification will be made to Surry Unit 1 during the outage for the steam generator repair and this evaluation will also apply to it when the same modifications are made.

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:

(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 2-1/2 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 2-1/3 inch line from the discharge of the RS cooler will be routed back to the suction of the respective inside RS pump. No active components will be used. This proposed modification will allow the RS pumps to perform with adequate NPSH and required RS flow rate.

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 venturi flow restrictor. This change resulted in a slightly lower safety injection flow. However, the licensee has demonstrated that this flow is still higher than the value assumed in the LOCA analysis and was evaluated in our Safety Evaluation on ECCS performance dated May 16, 1980.

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.

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 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.

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.

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 15.0 feet, the available NPSH for the outside recirculation pumps was calculated to be 11.9 feet and the available NPSH for the LHSI pumps was calculated to be 17.2 feet. The minimum NPSH required are 8.4 feet for the outside RS pumps; 10.1 feet for the inside RS pumps; and 15.2 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.

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 a atmospheric pressure within an hour following a LOCA.

The limiting case for containment depressurization is a pump suction double-ended rupture with minimum engineered safety feature operation. A depressurization time of 45.3 minutes was calculated, which is less than the one hour used in performing the analysis of the radiological consequences 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. Therefore, we conclude that the licensee's containment depressurization analysis is acceptable.

CONTAINMENT SPRAY MODIFICATIONS

Based on our requests for information on the containment spray systems and on our discussions on this system, the licensee modified several containment spray components. These modifications will provide additional assurance that the potential consequences of the postulated LOCA are below the guidelines of 10 CFR Part 100. This included adding restricting flow orifices to the lines that carry NaOh solution from the chemical addition tank (CAT) to each of the two containment spray (CS) trains. By controlling the volume flow rate of the gravity-fed caustic solution, the pH of containment spray and the recirculation water in the sump can be kept within acceptable limits. A drawdown test of the new system was used to test the components and determine the head loss coefficients for the CAT and refueling water storage tank (RWST) lines. The results of this test were used by the licensee to predict CS pH under a variety of limiting operating conditions. The licensee's proposed Technical Specification changes ensure that CS pH will be within current Standard Review Plan (SRP) 6.5.2 limits.

The licensee's drawdown test and application of hydraulic and chemical models predict that the containment spray (but not the recirculation spray) will have a pH within 8.5 to 11, as recommended in SRP 6.5.2. To keep the pH within these limits, under a variety of operating conditions, Technical Specifications were proposed to require narrower limits on volumes and concentrations in the RWST and CAT. These constraints, and the demonstration of the predictable nature of the gravity feed flow from the CAT, provide reasonable assurance that the pH can be kept within those limits.

However, for the case of the CAT drawing down at the maximum rate, the CAT will be effectively empty at about 42 minutes after the initiation of spray, and from then on the containment spray will be less effective in removing iodine. Since the Technical Specifications require the capability for reduction of containment pressure to subatmospheric within 60 minutes following a LOCA, there could be a period between 42 and 60 minutes when the containment would be at a positive pressure and there would not be a highly effective containment spray. Our analysis (see Tables 1, 2 and 3) indicates that the 0-2 hr. exclusion area boundary (EAB) dose for a LOCA and containment ECCS leakage exceeds 10 CFR Part 100 limits when no credit is taken for recirculation spray. The recirculation spray starts after about five minutes, with an initial pH of 7.0, which slowly rises as containment spray water mixes with ECCS water. However, after 42 minutes, the sump water is predicted to have only reached a pH of 8.0 (lower than the pH 8.5 recommended in SRP 6.5.2). Elemental iodine removal coefficients were conservatively estimated to be 10 hr^{-1} for pH>8.0, and 5 hr^{-1} for 7.0<pH<8.0, for the volume covered by recirculation spray. Using these removal coefficients, our analysis (see Tables 1, 2 and 3) indicated that therewwould be adequate iodine removal to keep the doses resulting from the worst case design basis accident within 10 CFR Part 100 guidelines. The relative concentration X/Q values used in the analyses were calculated by us for Surry 1 and 2 in 1979. These values were higher than the values in the SE dated February 23, 1972, but lower than the values calculated by us in 1976.

In order to provide additional assurance that these evaluations are valid, the licensee will submit Technical Specifications for engineered safety system ventilation filters by October 1, 1980. Based on the above, we conclude that the potential radiological dose consequences of the postulated LOCA at Surry 2 are below the 10 CFR Part 100 guidelines and are therefore acceptable.

Technical Specifications

We have evaluated the proposed Technical Specifications and conclude that they adequately incorporate the requirements evaluated herein, and when the modifications are made on Unit 1 as on Unit 2, this evaluation will also apply.

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 1, 1980

TABLE 1

ASSUMPTIONS USED IN THE LOCA DOSE REEVALUATION

Power Level	2490 MWt
Fraction of Core Inventory Available for Leakage	
Iodines	25 Percent
Noble Gases	100 Percent
Initial Iodine Composition in Containment	
Elemental	91 Percent
Organic	4 Percent
Particulate	5 Percent
Containment Free Volume	1.753×10^6 ft^3
Containment Volume:	
Sprayed Fraction, Containment (quench) spray	0.72
Sprayed Fraction, Recirculation Spray	0.14
Unsprayed Fraction	0.14
Containment Mixing Rate Between Sprayed and Unsprayed Volumes	2.0 Unsprayed Volumes per hour
Spray Removal Coefficients for Containment Spray (Quench Spray)	
Elemental Iodine	10 per hour
Particulate Iodine	0.45 per hour
Organic Iodine	0
Spray Initiation Delay Time	0 seconds
Duration	42 minutes

TABLE 1 (cont'd)

ASSUMPTIONS USED IN THE LOCA DOSE REEVALUATION (cont'd)

Spray Removal Coefficients for recirculation Spray	
Elemental Iodine, 5-42 minutes $(7.0 < pH < 8.0)$	5 per hour
42-60 minutes $(8.0 < pH < 8.5)$	10 per hour
Particulate Iodine	.45 per hour
Organic Iodine	0 per hour
Spray Initiation Delay Time	5 minutes
Duration	5 minutes to indef.
0.5% Sector Probability Direction-Dependent χ/Q Values	
Exclusion Area Boundary (NE @ 520m)	
0 - 1 Hour	1.6×10^{-3} sec/m^3
Low Population Zone (NE @ 4828m)	
0 - 1 Hour	1.6×10^{-4} sec/m^3
Containment Leak Rate	
0 - 60 minutes	0.1 Percent per day
> 60 minutes	0.0 Percent per day

TABLE 2

ASSUMPTIONS USED IN THE ECCS LEAKAGE ANALYSIS

Power Level	2490 MWt
Fraction of Core Iodine Inventory in Containment Sump	50 Percent
Volume of Containment Sump Water	56117.0 ft^3
Volume of Sump Water not recirculated (10%)	5611.7 ft^3
Iodine Decontamination Factor	10
Filter Efficiency for Iodine	90 Percent

ECCS Leak Rates Outside Containment

Time	Leak Rate*
0 - 5 minutes	0
5 - 20 minutes	5.7×10^{-4} ft^3/min
20 min - 30 days	2.825×10^{-3} ft^3/min

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* Twice the proposed technical specification leak rates were used for calculations.

TABLE 3

RESULTS OF LOCA DOSE ANALYSIS AT SURRY 2

Using 0.5% Sector Probability X/Q Values

I. Allowing Surry 2 Credit for Iodine Removal By Recirculation Sprays

	Containment Leakage		ECCS Leakage	
Exclusion Area Boundary	Thyroid Dose (Rem)	Whole Body Dose (Rem)	Thyroid Dose (Rem)	Whole Body Dose (Rem)
0 - 2 Hour	248	5	5	1
Low Population Zone				
0 - 30 Days	25	0.5	3	1

II. Allowing Surry 2 No Credit for Recirculation Spray Iodine Removal

	Containment Leakege		ECCS Leakage*	
Exclustion Area Boundary	Thyroid Dose (Rem)	Whole Body Dose (Rem)	Thyroid Dose (Rem)	Whole Body Dose (Rem)
0 - 2 Hours	307	6	5	1
Low Population Zone				
0 - 30 Days	31	0.6	3	1