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ComEd

September 23, 1996

United States Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Subject: LaSalle County Nuclear Power Station Units 1 and 2
PRA Report Concerning June 96 Service Water
Tunnel Foreign Material Intrusion Event
NRC Docket Nos. 50-373 and 50-374

Reference: Telephone Conversation between ComEd and NRR
Personnel, September 9, 1996

Attached for NRC review is the ComEd PRA Report Concerning the June, 1996 Service Water Tunnel Foreign Material Intrusion Event and the final report on behavior of the foam sealant which was prepared by the Iowa Institute for Hydraulic Research (IIHR), an independent research firm. This information was previously discussed in the above Reference. Additionally, two independent reviews of these documents performed by Tenera and Fauske & Associates, Inc. are attached.

The "Final Report on Foam Morphology and Transport Tests for the LaSalle Nuclear Plant", September 1996, prepared by the IIHR provides information on the structure, properties, and behavior of the foam sealant material which was injected into the LaSalle service water tunnel. This information formed the basis for developing "base estimate" probabilities that sufficient material could be ingested into safety-related service water systems to cause them to fail. It was concluded that the material was unlikely to be transported from the Unit 2 end of the tunnel to the Unit 1 end, such that the impact on Unit 1 was minimal. Using the latest LaSalle PRA model and base estimate failure probabilities developed from the IIHR report for Unit 2, this event is categorized, from a PRA perspective, as "low risk significance."

This perspective, however, does not diminish the seriousness with which ComEd and LaSalle County Station are treating this event.

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The basis for the estimated probabilities, the results of sensitivity studies, and comparisons with industry risk significance guidelines are discussed in the attached PRA report.

Fauske & Associates, Inc. were requested to independently analyze the behavior of positively and negatively bouyant samples and the likelihood that these could be ingested into the safety-related service water systems. This independent analysis was compared to the IIHR experiments and showed excellent correlation with the IIHR laboratory observations. Furthermore, two-dimensional fluid flow analyses demonstrated that the IIHR tests overestimate the flow velocities of the LaSalle service water tunnel. These analyses demonstrate that the PRA modeling overstates the likelihood that sufficient foam material could be ingested into the safety-related service water systems.

Tenera was asked to evaluate service water strainer clogging by foam material. Tenera has determined that those particles that could be close to neutrally bouyant for a significant interval, for whatever reason, would be diluted to a negligible concentration within minutes by non-essential service water. Therefore, Tenera has concluded that the ComEd PRA Report assumptions concerning service water strainer vulnerability are conservative.

As stated above, I consider this event to be very serious and LaSalle County Station is proceeding with extensive corrective actions and allocating resources to improve our performance. We will describe these actions in the upcoming enforcement conference on September 27, 1996.

If there are any questions or comments concerning this document, please refer them to JoEllen Burns at (815) 357-6761, extension 2383.

Respectfully,

W. T. Subalusky
Site Vice President
LaSalle County Station

Enclosure

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PROBABILISTIC RISK ASSESSMENT REPORT

of the

IMPACT OF FOAM SEALANT INJECTION

in the

LASALLE COUNTY NUCLEAR STATION SERVICE WATER TUNNEL

Introduction

An evaluation of the risk significance of the recent service water tunnel foreign material intrusion event was performed using the current LaSalle PRA model. The results of tests performed on the foam sealant material ("furmanite") by the Iowa Institute for Hydraulic Research (IIHR) discussed in the referenced report were used to estimate the probability that the sealant material would cause loss(es) of the emergency service water (Core Standby Coolant Supply, CSCS) subsystem(s).

Summary

The foam sealant injections began on May 20, 1996 and both units were shutdown on June 28, 1996, a time period of 40 days. A Core Damage Probability (CDP) was calculated for this period by adjusting initiating event frequencies and component failure probabilities due to the impact of the foam sealant, and converting an annual Core Damage Frequency (CDF) to a 40-day Core Damage Probability (CDP).

It was concluded that the foam sealant injection had essentially **no impact on Unit 1**. The analysis determined that the CDP due to the foam sealant injection was **4.93E-06 for Unit 2**. This result was reached by determining that (1) there was an increased risk due to a loss-of-service-water initiating event; and (2) the large "slab" of foam material found on the floor of the tunnel had an approximate probability of 0.01 (1.0×10^{-02}) of failing the Div. 2 CSCS equipment (most severe outcome) and that the remaining foam material had an estimated probability of 0.001 (1.0×10^{-03}) of failing the Div. 1 or Div. 3 CSCS equipment.

The calculated **change** in CDP was 3.86E-06. Comparing this value to the Nuclear Energy Institute thresholds for CDP changes for temporary conditions, the impact of the sealant injection would result in a classification slightly above "Non-Risk Significant".

Based on the actual amount of foam injected, the expected performance of the foam as identified in the IIHR tests, the results of equipment tests and inspections, the time the condition existed, and the results of the PRA **base estimate** calculations, it is concluded that the injection of the foam sealant into the service water tunnel was, from a PRA perspective, of **low risk significance**.

Analysis

Loss of Service Water as an Initiating Event

Since loss of Service Water (SW) is not a modeled initiating event (IE) in the LaSalle PRA, it can be approximated as a T1 (Turbine Trip w/byp.) IE with a coincident loss of Turbine Building Closed Cooling Water (TBCCW) and Reactor Building Closed Cooling Water (RBCCW) (modeled systems which fail due to a loss of SW).

The sealant injections resulted in two SW transients. The SW system was significantly degraded in the first event, but the operators were better prepared for the second event. Based on the judgment of personnel responding to the events, the combined probability (likelihood) that either event could have caused a total loss of service water and subsequent dual unit scram is approximated to be 0.5. To accommodate this initiating event probability in the model, the T1 probability was set to 0.5, and TBCCW and RBCCW were considered failed.

Loss of Diesel Fire Pumps

The "A" and "B" diesel fire pump suctions are widely separated, one on the north end and one on the south end of the tunnel. Actual experience had the "B" pump trip on high temperature due to fouling from the sealant material. However, the IIHR study done on the sealant material transport indicates that migration of material to the south end of the tunnel was unlikely, and in fact, no problems with the "A" pump were experienced. Therefore, the failure probability of "B" pump was set to 1 and "A" pump remained unchanged from the base PRA failure probability.

Loss of CSCS Subsystems

Sufficient material was injected into the service water tunnel to cause suction pipe, pump suction, or strainer blockage in the Residual Heat Removal Service Water (RHRSW) and Diesel Generator Cooling Water (DGCW) systems. The IIHR study evaluated the potential for the material which was actually injected to reach and/or cause failures in these systems.

First, the report concluded that widespread transport throughout the tunnel was very unlikely. This conclusion is supported by the actual material location in the tunnel, which was concentrated in the Unit 2 (North) end of the tunnel, where the

majority of the material injection took place. Therefore, it is concluded that the actual impact from the material on Unit 1 systems (other than SW) was minimal, and further discussions will apply specifically to Unit 2.

Second, the potential for the material to be entrained and actually cause blockage was evaluated. The first way to impact the CSCS would be to totally block CSCS suction lines or strainers with the large slab of furmanite found in the floor of the tunnel. The IIHR study concludes that this was unlikely since the slab (board) actually found in the tunnel was too large to rotate in the tunnel and forces due to currents in the tunnel were too low to deform or break the slab into a piece which could cover the outlet pipe. However, the slab had been formed over a number of days and there may have been a point in that time when the slab was large enough to cover the pipe, yet small enough to rotate in the tunnel. It is estimated that this time may be 10% of the time that the injections took place prior to unit shutdown. The IIHR report also estimated the probability of a large (≥8 in. dia.) piece being entrained in a CSCS suction line to be about 10%. This value was derived from tests where buoyant pieces were floating up or negatively buoyant pieces were sinking down, past an outlet pipe. This condition actually exists for only a short time during curing of the furmanite following injection, and this estimate is therefore conservative for this analysis which covers about 40 days of operation. Therefore, the resultant probability that the large slab would cover a suction line is bounded by a value of 1%, the product of the two numbers.

Further, the IIHR report indicated that, should the slab become entrained and pulled into the suction pipe, it would not remain intact. The force on the slab due to hydraulic pressure would exceed the ultimate strength of the slab and cause it to fail into several "pie-shaped" pieces, thereby preventing it from blocking flow at that point. Since the slab could physically cover only one suction line, the Division 2 line was conservatively chosen for analysis since both RHRSW and DGCW pumps take suction from this line. For the purpose of this evaluation, it is conservatively assumed that either the resultant pieces are large enough to plug the inlets to all pumps taking suction from the line (2 RHRSW Pumps, 1 DGCW Pump) or sufficient material is available after passing through the pumps to completely plug both strainers (1 RHRSW, 1 DGCW). Therefore, the resultant probability is 0.01 that 2 RHRSW pumps and 1 DGCW pump will fail due to blockage. This value was added to the fault trees modeling the failure of the pumps in Division 2 CSCS ("2C" RHRSW Pump, "2D" RHRSW Pump, "2A" DGCW Pump).

The second way for the furmanite to impact CSCS is by the ingestion of numerous smaller pieces of furmanite into a CSCS suction. Approximately 275 gallons (5 - 55 gallon drums) of material (other than the large slab) was recovered from the tunnel and would have been available for ingestion. These pieces were not large enough to plug a pump suction and would have passed through the pump to the strainer. Again, the IIHR report indicates that the pieces

could be entrained if they were buoyant and somehow detached from the floor or were negatively buoyant and somehow sank from the surface. The most likely time for this to occur, as evidenced from the IIHR report was during the curing process while the foam structure was being formed on the floor of the tunnel. This time period was very short, certainly less than 10% of the total 40 day period in question. In addition, the report indicates only a 10% probability that pieces in transit from the floor to the surface (or vice versa) will be entrained. Therefore, probabilistically, only 2.75 gallons of material would be available to plug a strainer. This is not sufficient material to cause the 90% fouling required to reduce the system flow to less than design in either the Div. 1 RHRSW (35 gallons required) or the Div. 3 DGCW (8.75 gallons required) strainer. Therefore, it is concluded that plugging by this mechanism is not a significant contributor. This conclusion is consistent with the inspection findings and test results following system operation (the CSCS systems were run for approximately 2 hours at full flow prior to cleaning of the tunnel). One can conclude that the chance of fouling strainers sufficiently to make a system inoperable is very small. Rather than accepting a "0%" probability to account for any possible impact from the loose material, assumed failure probabilities of 0.001 were added to the PRA fault trees for Div. 1 RHRSW ("2A" and "2B" RHRSW Pumps) and Div. 3 DGCW (HPCS DGCW Pump). Since the Div.1 DGCW Pump ("0" DGCW Pump) takes suction from the Unit 1 CSCS piping, it is unaffected by the sealant material.

Results

To assess the Core Damage impact of the sealant injection, two calculations are performed. The first determines the effect of the increased risk due to the new initiator, loss of service water, by using the PRA model with the estimated initiating event frequency (identified earlier) and any consequential failures and revised failure probabilities to calculate a core damage probability (CDP_1). The second calculation determines the effect, on all existing PRA initiators, of equipment degradation due to the furmanite. It uses the baseline PRA model with revised failure probabilities to calculate a revised CDF, which is then multiplied by the fraction of a year represented by 40 days, to obtain a core damage probability (CDP_2) due to degraded equipment. The two probabilities are then combined to obtain a total core damage probability (TCDP). Note that the majority of the furmanite risk is due to the increased probability of a loss of service water causing a plant trip. Finally, a ΔCDP is obtained by subtracting the baseline PRA CDP for the time period in question (1.07E-06) from the previous results. This ΔCDP is then used to evaluate the impact of the event relative to the Nuclear Energy Institute (NEI) guidelines for temporary changes. The results of these calculations, including the sensitivity studies done on the revised failure probabilities, are shown in Table 1 below. The NEI guidelines are shown in Table 2.

Table 1

Results of CDP Calculations

Calculation Basis	CDP_1	CDP_2	TCDP	ΔCDP
Base Estimate Input Probabilities	3.66E-06	1.27E-06	4.93E-06	3.86E-06
Input Probabilities x 10	1.42E-05	3.93E-06	1.81E-05	1.70E-05
Input Probabilities x 0.1	2.86E-06	1.08E-06	3.94E-06	2.87E-06

Table 2

NEI Guidelines for Temporary Changes

Condition	ΔCDP
Non-Risk-Significant	$\Delta CDP \leq 1E\text{-}06$
Assess Non-Quantifiable Factors	$1E\text{-}06 < \Delta CDP \leq 1E\text{-}05$
Potentially Risk Significant	$\Delta CDP > 1E\text{-}05$

Comparing the ΔCDP's to the NEI guidelines, the "base estimate" and the factor-of-0.1 probability calculations result in increases in CDP which fall into the "Assess Non-Quantifiable Factors" range, slightly **above** the "Non-Risk-Significant" range. The calculation using 10-factor increased probabilities resulted in a CDP increase which is in the "Potentially Risk Significant" range, slightly above the lower threshold. Considering the conservatisms identified in the base estimate probabilities, this condition is considered to be an extreme bounding case, and should be used only for information relative to the sensitivity of the assumptions. Since this event went undetected for approximately 40 days, and normal on-line maintenance continued during this time, no compensatory measures were available which can be credited in the evaluation of non-quantifiable factors. Therefore, based on the "base estimate" ΔCDP results, and with no actions available with which to reduce the classification to "Non-Risk-Significant", this event is best classified as having **low risk significance.**

Reference: Iowa Institute for Hydraulic Research, "Final Report on Foam Morphology and Transport Tests for the LaSalle Nuclear Plant", September 1996.