EVALUATION OF THE FLOODING OF THE INCORE INSTRUMENTATION ROOM

SURRY POWER STATION
UNIT 1

POWER ENGINEERING SERVICES

TECHNICAL REPORT
PE-0005, REVISION 1

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QA CATEGORY SAFETY RELATED

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INTRODUCTION

Engineering has evaluated the effect of flooding the Incore Instrument Room due to leakage past the reactor vessel cavity seal during refueling operations. This occurred during the 1988 Unit 1 refueling outage when the Incore Instrument Room was flooded following deflation of the inflatable seal. The water level of the refueling cavity was observed to have decreased by approximately 36 inches. This corresponds to approximately 25,800 gallons of borated water and is conservatively estimated to have produced a maximum water level of six feet in the Incore Instrument Room. The water drained down to a level approximately three feet above the floor where it remained for approximately 30 days. Retraction of the incore detector guide thimbles, resulting in high area radiation levels, precluded access to facilitate draining of the area. This leakage is of concern because of the known corrosiveness of boric acid and its solutions to carbon and low alloy steels and the potential effect of retained water on the performance of electrical circuits.

DISCUSSION

Initial leakage past the J seal would have collected in the drip pans and would have been carried away by the drain piping. Once the leakage exceeded the capacity of the drip pan drainage piping the flow path would have been primarily down the exterior of the reflective insulation, over the neutron shield tank and into the Incore Instrument Room. A small amount of the leakage could have flowed onto the reactor vessel nozzle reflective insulation and flowed and/or splashed along the reactor coolant piping into the loop rooms. Any components wetted by this leakage/splash would be in the immediate vicinity of the penetration through the primary shield wall.

The small amount of water that could have entered the loop room either inside or outside the reactor coolant pipings' reflective insulation would quickly drain to the floor through joints in the insulation. There is no equipment in the loop room that would have been adversely affected by this small amount of borated water. This equipment, by design, in the loop room located below -23'11" is fully qualified for chemical spray and submergence as a result of a LOCA. Equipment above -21'11", by design, is qualified for chemical spray. The wetted conditions that resulted from the leakage past the J seal from the refueling cavity would in no way prevent any equipment in the loop rooms from performing their design functions.

The following critical components that could be affected by the leakage in the Incore Instrument Room were identified by review of controlled station drawings and verified on the Videodisc Information System:

1. Reactor Vessel
2. Neutron Shield Tank
3. Reactor Vessel Sliding Supports
4. Incore Instrumentation Guide Tubes and Supports
5. Reflective Insulation
6. Reactor Vessel Level (RVLIS) Strap-on RTDs
7. Conduit for Excore Neutron Detectors
8. Supply and Return Lines for the Neutron Shield Tank Coolers
9. The Containment Mat Liner Plate
10. Reactor Coolant Piping

Of these components the reflective insulation, the Reactor Coolant Piping, and incore instrumentation guide tubes can be eliminated from consideration because they are fabricated of austenitic stainless steel which will not be adversely affected by wetting with borated water solution.

The Reactor Vessel Level (RVLIS) Strap-on RTDs (TE-1317, 1327) are mounted onto the guide tubes below the reactor vessel at elevations -21.5' and -20.0'. The RTD's provide inputs to the RVLIS system for temperature compensation. The sensing element of the RTD assembly is mounted in a solid copper block. All internal parts including this element, lead wires, and mineral insulation are hermetically sealed in a solid stainless steel (Type 347) sheath. Exposure of the RTD assembly to water from the refueling cavity will not impact their ability to perform their design functions. The RTDs are located approximately 8 feet above the floor plate (elevation -29'7"). Based on a flooding level of 6 feet above the floor, these RTDs may have received spray, but were not submerged.

The Gamma Metrics Excore Neutron Detector signal cables are made up of a solid copper conductor coaxial cable insulated with Kapton tape encased in a flexible stainless steel hose and covered by woven glass fiber. The detector junction box is made of 3/8" thick carbon steel and is pressure sealed with a silicon rubber O-ring. The conduit for the Excore Neutron Detectors is mounted approximately 7 feet above the floor on the primary shield wall. This location precludes submergence and wetting by spray. In either case, exposure of the detector cable, and the detector junction box to water from the refueling cavity will have no impact on the ability of these devices to perform their design functions.

The Supply and Return Lines for the Neutron Shield Tank Coolers are carbon steel. As described in NUS-188, carbon steel piping inside containment was painted with a DBA qualified coating which provides protection against borated water.

The carbon steel Containment Mat Liner Plate as described in SNC-1019 and NUS-188, is also painted with a DBA qualified coating providing corrosion protection against borated water.

The carbon steel Neutron Shield Tank is also coated with a DBA qualified paint which is not affected by the boric acid.

The incore instrumentation guide tube supports are carbon steel and are painted with a DBA qualified coating as described in NUS-188. This coating provides protection against borated water.

Even where the coating on these carbon steel components might not provide complete protection, the concentration of the boric acid is such that only very little wall loss would occur from corrosion. Any residual boric acid crystals that might be left on the surface by evaporation of the water could result in further corrosion, but only until the boric acid was consumed by the chemical reaction. The maximum total wall loss that the submerged components could eventually experience is estimated to be less than .006 inches. The function of these components would not be impaired by such a small reduction in thickness in those few areas not completely protected by the coating.

The outside of the Reactor Vessel, because it is fabricated of low alloy steel, would be subject to degradation by continuous exposure to concentrated solutions of boric acid. The walls of the vessel below the flange were protected from exposure to the borated water by the reflective insulation which is installed so that the bottom edge of each row overlaps the top edge of the next lower row, thus shedding water much as the shingles on a roof. Because the leak occurred at the OD of the vessel flange and because that location is outboard of the vessel insulation the leakage would have impinged on and flowed down the insulation without contacting the vessel wall. The bottom of the vessel is at elevation (-)14'10" which is significantly above the flood level. Finally, while it is likely that some of the refueling water did wet the OD surface of the vessel flange, this brief wetting would have resulted in only minimal corrosion of the flange, estimated to be less than .001 inches of material loss, and would not adversely affect the integrity of the reactor.

The Reactor Vessel sliding supports are located under the vessel nozzles and bear on mating parts on the neutron shield tank. Because of the geometrical configuration of the nozzle and its integral support pad there would be a tendency for water flow to be directed away from the actual bearing parts of the sliding supports. Additional protection is provided by a fitted cover that shields all of the bearing, moving, parts of the support. Finally, the mating parts of the support have been coated with a lubricant material that should eliminate any tendency for capillary action to draw water into the mating surfaces even if it did manage to come in contact with those parts. Given the brief exposure of the supports to the borated water and the features which tend to keep that water away from the supports, there is no reason to be concerned that the function of the sliding supports may have been harmed by the leak.

CONCLUSION

As a result of these investigations described above, the flooding of the Incore Instrument Room with borated water will have no adverse effect on continued safe operation of the plant.

REFERENCES

Drawings

11448-FM-40A	Reactor Cavity Water Seal Arrangement and Details
11448-FM-40B	Reactor Cavity Water Seal Arrangement and Details
11448-FM-41A	Arrangement Neutron Shield and Incore Instrumentation
11448-FE-46A	Conduit Plan Reactor Containment Elevation 18'4"
11448-FE-46B	Conduit Plan Reactor Containment Elevation 18'4"
11448-FV-7B	Reactor Neutron Shield Tank
2654C65	W Clamp on RTD
1465F19	W RVLIS Installation Schematic

Documents

1. SNC-1019 Specification for Shop Fabrication and Field Erection of the Reactor Containment Steel Plate Liner and Dome

2. NUS-96 Specification for Fabrication of Neutron Shield Tank

3. RVLIS Installation and Technical Manual

4. NUS-188 Specification for Painting for Surry Power Station 1972 Extension

5. Human Performance Evaluation Report (HPES) #88-012, Dated June 7, 1988

6. Qualification Document Review Packages S-8.5 and S-8.16

Calculation

ME-0182 "Corrosion of Reactor Vessel Shell by Borated Water"

ME-0183 "Incore Room Flood Level"