UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30323

Report Nos.: 50-280/88-27 and 50-281/88-27

Licensee: Virginia Electric and Power Company
Richmond, VA 23261

Docket Nos.: 50-280 and 50-281 License Nos.: DPR-32 and DPR-37

Facility Name: Surry 1 and 2

Inspection Conducted: July 5-8, 1988

Inspector: R. H. Bernhard — 8/12/88 Date Signed

Approved by: F. Jape, Chief — 8/12/88 Date Signed
Test Programs Section
Engineering Branch
Division of Reactor Safety

SUMMARY

Scope: This routine, unannounced inspection was conducted in the area of design review of the Reactor Building Recirculation Spray Heat Exchangers (RSHX). The inspection included a review of FSAR design requirements, interviews with the responsible engineering staff and walkdowns of the accessible service water piping to the RSHXs, the RSHX in containment and the intake structures for the circ/service water.

Results: In the areas inspected, violations or deviations were not identified.

One Unresolved Item (URI) is identified in Section 6.0. It involves the adequacy of the engineering evaluation with respect to the impact of the new RSHXs on the design basis of service water and recirculation spray. With the resolution of this URI, the heat exchangers new design and the new plant procedures for insuring the heat exchangers stay dry should resolve the past problems with the RSHXs.

REPORT DETAILS

1. Persons Contacted

   Licensee Employees

   *J. A. Bailey, Superintendent of Operations
   *D. L. Benson, Station Manager
   *C. T. Duonh, ISI Engineer
   *E. S. Grecheck, Assistant Station Manager
   *R. V. Green, Senior Staff Engineer
   M. W. Henig, Project Engineer, Power Engineering Services (PES)
   *H. L. Miller, Assistant Station Manager
   R. L. Rasnic, Supervisor, Mechanical Engineering, Nuclear, PES
   *D. W. Wong, Senior Engineer

   Other licensee employees contacted during this inspection included craftsmen, engineers, operators, technicians, and administrative personnel.

   NRC Resident Inspector

   *L. E. Nicholson

   *Attended exit interview

2. Details

   The Reactor Building Recirculation Spray System (RS) at Surry consists of four subsystems, each containing a pump, piping, a heat exchanger and spray nozzles. The system provides containment heat removal by using the Reactor Building Sump as a suction source, pumping the water through the Recirculation Spray Heat Exchangers (RSHX) whose cooling water is supplied by service water, and spraying the cooled water through spray nozzles inside containment. The RSHX are designed to be in a dry, isolated condition during normal plant operations, on both the RS (shell) and service water (tube) sides of the heat exchanger. The original RSHX were found to have fouling and corrosion caused by inleakage of service water. The Unit 1 RSHX have been replaced by newly designed titanium tubed heat exchangers. Replacement on Unit 2 is to occur at the next refueling outage, currently scheduled for September 1988.

   This inspection effort reviewed the new heat exchanger replacement effort. Engineers from the Power Engineering Services group were interviewed, and questions on design of the new heat exchangers were discussed. The service water system providing cooling water to the RSHX was walked down, as well as the RSHX, themselves. The FSAR was reviewed, and calculations were made to verify design assumptions. Answers to questions asked by the inspector while at the site were sent to the inspector in the week following the onsite portion of the inspection. An in office review of the material was conducted. The results of the inspection follow.

3. Design Review

In order for the new heat exchangers to remove the design heat loads, adequate flow through both the shell and tube side of the exchanger must be available. The efficiency and heat transfer coefficients of the new exchanger must also be high enough to insure the heat passes from one load to the other. These were the items concentrated on by the inspector.

Discussions with two Virginia Power Engineering Services engineers were conducted onsite at the Surry Station. One engineer was the Project Engineer for the Surry facility and the other a supervisor in the Mechanical Engineering group who was responsible for the engineering evaluation for the heat exchanger replacement.

It was established in the discussions that the new RSHX were essentially a newly designed heat exchanger using current Tubular Exchanger Manufacturers Association (TEMA) codes, but maintaining the bolt up arrangement, seismic considerations and flow paths of the old heat exchangers.

The replacements have titanium tubes to preclude future corrosion problems if in leakage of service water into the exchangers occurs. The new exchangers were designed for the same total heat removal in btu/hour at rated conditions. With the new tube material, the tube wall thickness is less than the original tubes. In addition, the new heat exchanger design has more tubes (1650 vs 1615 tubes).

With the new heat exchanger design, the pressure drops across the heat exchanger at rated conditions also change. The inspector requested the evaluation that considered these changes to determine their effect on system performance.

Another factor effecting heat removal is service water flow through the heat exchangers. The service water is gravity fed through the heat exchangers. It originates in the high level intake canal maintained by the circulating water and emergency service water pumps. The water gravity flows through the circulating water inlet tunnel, branches off this tunnel, goes through two isolation valves, then into containment, through the RSHX, exits containment, through a single outlet isolation valve, and then joins the circulating water discharge tunnel. The circulating water discharge tunnel's level is not a continuous slope down to the level of the discharge canal, but slopes upward then down. A vacuum priming system is designed to keep the high point from being air bound. Without air blocking the discharge tunnel, the water is siphoned to the level of the discharge canal. The service water total available head (in feet of water) varies from a maximum of the upper canal level less the lower canal level to a minimum of the upper canal level less eight feet (the height of the floor of the circulation water discharge canal if vacuum priming is not available). The nominal level of the discharge canal is roughly sea level. The service water flow rates through the system can be up to 30% greater if vacuum priming is maintaining the circulating water discharge canal free of air. The inspector asked the engineers for an impact of the priming system operation on system operability.

Fouling of the system piping could cause the system resistance to flow to increase. In addition, accumulation of shell debris in stagnant supply lines can cause blockage of heat exchanger tubes when the system is placed in service decreasing heat transfer. The licensee was asked to provide information on programs in place to preclude inoperability of the system due to fouling in the stagnant supply lines.

Fouling of water caused by accumulation has been found in the old heat exchangers. The inspector questioned the licensee as to the steps taken to insure the new heat exchangers stay in a dry layup condition.

The licensee's answers to the preceding questions and requests for information were addressed in a memorandum dated July 12, 1988, report and are discussed in Section 6 of this report.

4. System Walkdown

The inspector performed a system walkdown of the accessible piping of the service water flowpath. The intake structure and moving screens at the high level intake canal were looked at to obtain perspectives on the plant physical layout and areas of potential biofouling. The canal side and the traveling screen wash areas were full of crabs and fish of various sizes indicating presence of marine life in the canal. Plant construction drawings were examined to show the placement of the underground piping forming the circulation water intake tunnel. Inside the plant, accessible piping and valves were examined. Layout drawings were used to estimate position of buried piping in the turbine building and yard and the amount of piping that would be subject to flooding in the event of inleakage past the 103 valves. The location of the 104 and 105 valves in the safeguards building was examined. A containment entry was made to walkdown the service water piping to and from the RSHX. The new RHSXs were examined.

The walkdown showed the inspector that most of the service water piping to the RSHX was inaccessible during normal operations. With the exception of the 103 valve pits in the turbine building and the limited piping in the safeguards building around the 104 and 105 valves, the piping outside containment, if inspection was necessary, would be limited to inspecting the inside of the piping by draining and crawling through the pipe.

A walkdown of control room instrumentation and controls for the RSHX service water piping was conducted. Flow indicators for heat exchanger outlet flows were available in the control room, as well as control and indication for the major valves.

The walkdown did not reveal any problems that could effect operability of the new RSHXs.

5. Documentation Review

The FSAR, Technical Specifications and plant drawings for the effected portions of the service water system and RS system were reviewed.

Technical Specification sections reviewed were 3.4, 4.5, and 3.14. The inspector's onsite review of these sections indicated the new heat exchangers would not impact technical specifications.

A review was performed of the following documents:

RSHX Fouling Analysis, Project NP-1020, memorandun dated March 24, 1984, to Kansler from Rasnic

RSHX Fouling Reanalysis, Project NP-511, memorandum dated July 30, 1984, to Kansler from Rasnic

Surry 2 Recirculation Spray Heat Exchanger Integrity Evaluation, Final Report, December 1987

Heat Transfer Capability of Surry Unit 2 Recirculation Spray Heat Exchangers, June 10, 1988 (Technical Report No. ME-0166)

These documents were used to provide a history of the RSHX problems experienced in the past at Surry.

The following drawings were reviewed:

11448-FM-071A, Rev. 24, Flow Diagram Circulating and Service Water System
11448-FM-071B, Rev. 25, Flow Diagram Circulating and Service Water System
11448-FM-071C, Rev. 26, Flow Diagram Circulating and Service Water System
11448-FM-21C, Rev. 7, Flow Diagram Circulating and Service Water System
11448-ESK-613R, Rev. 11, Elementary Diagram, Motor Operated Valves
11448-ESK-613N2, Rev. 9, Elementary Diagram, Motor Operated Valves
11448-FC-2A, Rev. 4, Foundation Key Plans, Turbine and Service Buildings
11448-FC-2C, Rev. 6, Foundation Details, Turbine Building
11448-FC-5E, Rev. 2, Service Water Lines Encasement
11448-FC-5F, Rev. 1, Service Water Lines Encasement
11448-FP-4A, Rev. 12, Service Water Lines
11448-FP-4B, Rev. 9, Service Water Lines
11448-FP-4C, Rev. 7, Service Water Lines
11448-FP-4D, Rev. 11, Service Water Lines

6. In Office Review of Licensee Responses

During the inspection period, the inspector raised the following questions. Responses were not available until after the inspection and were, therefore, reviewed in office.

QUESTION: The flow rate of service water through the RSHX's would be adversely affected by a loss of vacuum priming in the Circulating Water discharge tunnel. Has this adverse effect on the service water flow rate been considered in the accident analyses?

RESPONSE: The service water flow rate with the vacuum priming system in operation on the discharge tunnel is about 8000 gpm per RSHX. If the vacuum priming system is not in operation and the discharge tunnel is not primed, the service water flow rate is about 6000 gpm per RSHX. The 6000 gpm value is used for all design basis accident analyses.

QUESTION: The new RSHXs which were just installed on Unit 1 and are scheduled for installation in Unit 2 during the September 1988 refueling outage have slightly different pressure losses at design flow rates when compared with the original RSHX's. What is the effect of this change on system operation and on system heat transfer.

RESPONSE: The new Unit 1 and Unit 2 RSHX's have a lower pressure drop than the old heat exchangers. The shell side pressure drop reduced from 6.34 psi to 5.38 psi while the tube side drop went from 1.82 psi to 1.1 psi. these reductions in head loss are small when compared with the system head loss and result in small increases in flow rate (shell side less than 1/2%; tube side less than 3%). These small increases in flow would improve the heat transfer characteristics slightly, but as a conservative measure, they will not be factored into any accident analysis. By the same logic, no redefinition of the system head and flow characteristics is required given the minor but conservative nature of the new values. The U_oA for the original RSHX's is 3.797×10^6 BTU/hr.°F. The U_oA utilized for accident analyses for the new RSHX's is also 3.797×10^6 BTU/hr.°F. The actual TEMA data sheet U_oA for the new RSHX's is 3.989×10^6 BTU/hr.°F. All U_oA values provided here are calculated using an inside fouling factor of 0.0005 hr. ft.°F/BTU.

QUESTION: Discuss the effect of marine growth in stagnant areas of the service water system on the design flow rate.

RESPONSE: A review of service water piping diagrams has been performed to identify areas of stagnant flow conditions upstream of the 103/203 inlet isolation valves and downstream of the 105/205 outlet isolation valves. The 103/203 A, B, C & D valves have stagnant piping sections upstream with the following respective lengths: 22 ft. 6 in., 17 ft, 6 ft and 6 ft. The two return headers downstream of the 105/205 valves each have a wetted stagnant length of about 20 ft.

The stagnant regions upstream of the inlet isolation valves are regularly dewatered to perform valve maintenance during refueling outages. Inspection of these areas has revealed no evidence of any type of marine growth other than that commonly found in the full flowing portions of the service water system, circulating water system and bearing cooling water system (service water side). Further conclusive evidence exists that there is no marine growth which could obstruct flow in these stagnant areas of the service water system. During the regular periodic testing of the 103/203 valves, these valves are cycled admitting the stagnant water to the piping section between the 103/203 and 104/204 valves. This water is then drained from this piping section using 2 inch drain valves. No evidence of any flow blockage has been encountered during this draining operation.

Some marine growth exists on areas of the pipe wall on portions of the service water system upstream of the 103/203 valves and downstream of the valves. This is an expected condition of operation for those sections of pipe and is considered in the design of the system. According to the LeQuie Center for Corrosion Technology, the marine growth attached to the walls could detach but would dissolve quickly into a fine sediment which would not represent a flow blocking concern. The history at Surry for the specific types of marine growth and corrosion products which exist throughout the wetted portions of the circulating water and service water systems shows that these are not flow blocking products. This conclusion is base on regular inspections of the bearing cooling, component cooling and condenser tube sheets. The piping upstream of the (1)(2) 03 MOVs will be inspected during the 1989-1990 refueling outage.

QUESTION: Procedures are now in effect to periodically check the inlet piping between the 103 and 104 valves for leakage and to drain leakage that is present. Will the station institute a procedure (i.e., a formal written station procedure) to drain the RSHXs during refueling outages? this would identify any back-leakage from the 105 valves.

RESPONSE: A procedure for draining the service water side of the RSHXs has been developed. A copy of the approved Unit 2 procedure is attached. This procedure is to be performed at anytime water potentially may have entered the RSHXs through the 104 valves; i.e., following the quarterly stroking of the 103s or if excessive leakage of the 103s is detected. We agree to drain the RSHXs at least once per cycle.

QUESTION: There have been several evaluations performed which considered reduced flow, increased fouling, etc. and the resulting effect on containment depressurization time. While the containment was still depressurized within a one hour period, did the actual radioactive release to the public increase above values stated in the FSAR?

RESPONSE: Consistent with TID-14844, the offsite dose calculations assume a constant containment leak rate for the full hour. During the one hour time interval, the leak rate from the containment is assumed constant at a rate of 0.1% of the containment volume per day. Therefore the calculated dose to the public will not be increased as a result of the longer depressurization time. In summary, the FSAR calculation yields a significantly greater release to the public than would result from using the depressurization characteristics of either the original RSHX analyses or the revised RSHX analyses with greater fouling and lower flow rates.

QUESTION: Since no nitrogen purge system or "dry air" system is employed on the shell or tube side of the RSHXs, discuss the fouling factors appropriate for the new RSHXs.

RESPONSE: The RSHXs currently installed in Surry Unit 1 and scheduled to be installed in Unit 2 in September 1988 have Titanium tubes. During the manufacturing process and prior to actual installation at Surry, an oxide layer was formed on these tubes. No mechanism has been present since manufacture and installation which would disturb this original oxide layer. The tube and shell side lay-up conditions will not alter the condition of the oxide layer on the tube side or shell side, even though there are no specific measures being taken to reduce the humidity of the air in contact with the tubes.

The design specification has included adequate conservatisms in the calculation of the overall heat transfer coefficient (including the 0.0005 hr. ft^2°F/BTU assumed inside fouling factor) to correctly account for the oxide layer on both the inside and outside surfaces of the Titanium tubes. The Titanium tubes are not subject to biological fouling, corrosion or scaling in the dry lay-up mode with no humidity control. The station leakage monitoring program on the service water system will ensure that the conservative heat transfer assumptions remain valid for Units 1 and 2.

QUESTION: Recently the original RSHXs were removed from Surry Unit 1. Have plans been made to evaluate the "as-found" condition of the old heat exchanger tubes? The shell side and tube side conditions should be noted. A copy of any report on the "as-found" tube conditions is requested.

RESPONSE: Plans are underway to pull several tubes and submit them to an independent laboratory for evaluation. the RSHXs are now being decontaminated and negotiations are proceeding to contract an organization for this "as-found" tube evaluation. When this evaluation has been completed, a copy of the results can be provided for your information.

Calculations performed by the inspector, based upon the supplied material, did not agree with the assumptions made in all the responses. In addition the 10 CFR 50.59 evaluation attached did not consider all the implications of the RSHX changeout.

The licensee was contacted on July 14 to provide additional information. Questions 1 and 2 of the attachment dealt with service water flows through the heat exchangers. The increased flows through the RSHXs were examined only from the point of heat exchanger capabilities. FSAR Section 9.9.1.2, Emergency Service Water Pumps (ESW) deals with the design basis of the pumps. The FSAR assumes at minimum level in the high level canal, the maximum water flow required to the RSHXs is 12,000 gpm. The pumps are sized at 15,000 gpm to maintain water level. With a LOCA and concurrent loss of offsite power the requirement is stated to be 21,000 gpm (12,000 for RSHXs plus 9,000 to cool the other units component cooling water (CCW) heat exchanger). In addition, the station Technical Specification 3.14 basis states only 15,000 gpm is required for long term cooling for or LOCA with a loss of offsite power.

The inspector's calculations show that prior to breaking vacuum on the circulating water discharge tunnel, the new heat exchangers, due to their lower resistance to flow, would pass over 8700 gpm each. Without operator action, the outflow from the four RSHXs would be about 35,000 gpm. Without any additional loads (CCW for instance), if two ESW pumps were operating (the FSAR assumes one out for maintenance, one fails, and one available), their capacity to supply water would be exceeded by the losses through the components.

When vacuum is lost in the circulating water discharge canal, flow will drop to about 6,500 gpm per heat exchanger. This is about a nine percent increase over the flow through the original heat exchangers. The 10 CFR 50.59 review supplied to the inspector did not consider the effect of the new heat exchangers increased flows on the plants ability to maintain cooling water available via the emergency service water pumps.

An Unresolved Item, URI 88-27-01, Potential Inadequate 10 CFR 50.59 Review for RSHX Replacement, is opened for both units. Resolution of the URI will involve review of the completed engineering package for replacement of the RSHX to determine adequacy of the engineering evaluation, a review of the proposed FSAR changes, and a review of the evaluation of the impact of the RSHX on service water and recirculation spray design basis.

Interim review of the question by the licensee, provided via telephone to the inspector the week of July 18, indicated the 6000 gpm required flow through the heat exchangers could be maintained at canal level of 16.1 feet. It was also indicated that this level would not be reached for at least four hours after a loss of offsite power, if tunnel vacuum had also not been maintained. The plant is not currently maintaining tunnel vacuum. This would allow operator action to avoid a further decline in inventory through isolation of two of the RSHXs. The licensee indicated operations was taking administrative action to ensure instruction is provided to the operators on actions to be taken to maintain the canal water level.

On July 21, 1988, a memorandum was issued to ES Grecheck from R. W. Calder correcting the question 2 response of the July 12 memo. It discuss the effect of the higher flow rates on heat transfer but does not address the canal level question.

The July 12, 1988 letter contained a copy of temporary operating procedure 2-TOP-2024. This procedure is to be used as the basis for permanent procedures to drain the RSHXs periodically to preclude future fouling. A daily surveillance is currently being performed for the Unit 2 RSHXs, until the exchangers are replaced. The licensee indicated to the inspector after the heat exchanger replacement, whenever the 103 valve is cycled for periodic surveillance and once per refueling cycle, the RSHXs would be drained to check for presence of water. The procedure currently has a weakness in that no attempt is made to measure or document the amount of drainage, if any. The amount of water present in the heat exchangers could impact fouling analysis, if required. The current limit of 0.0005 fouling factor was set assuming dry layup conditions.

7. Exit Interview

The inspection scope and results were summarized on July 8, 1988, with those persons indicated in paragraph 1. The inspector described the areas inspected and discussed in detail the inspection results.

In addition the information concerning the unresolved item was discussed with licensee representatives on July 22, 1988. The unresolved item is:

> URI 88-27-01, "Potential Inadequate 10 CFR 50.59 Review for RSHX Replacement" - (Reference: Paragraph 6.0)

Dissenting comments were not received from the licensee.