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U.S. Nuclear Regulatory Commission
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Subject: Amendment to the Safety Analysis Report (SAR) for the University of Virginia Reactor (UVAR), Docket No. 50-62, License R-66, pertaining to its Heat Exchanger.

Gentlemen:

In August 1995, the University of Virginia Reactor staff performed maintenance on the non-radioactive secondary side of the UVAR heat exchanger. Secondary water carries heat from the reactor to the environment by way of an outdoor cooling tower. Due to secondary coolant contact with the environment, maintenance involving cleaning of biological fouling in the tubes is done from time to time. While performing this cleaning, accumulated scale was noted on the ends of some tubes at the tube sheet. This scale was removed and samples sent for analysis by the commercial provider of secondary water corrosion inhibiting chemicals.

Following the cleaning of the heat exchanger, the UVAR was operated for a brief time until a small heat exchanger leak was discovered. It was noted that, depending on the on/off status of the primary and secondary pumps, the leak would go from the secondary to the primary side and vice-versa. Throughout this period, poolwater quality was monitored and maintained within technical specification limits, and secondary water radioisotope concentrations levels were determined to have been low and not to have exceeded off-site release limits. Currently, the heat exchanger has been valved off and the UVAR only is available for low-power operation in natural circulation mode.

This submittal contains a request for an amendment to the UVAR license, to permit the staff to install mechanical expanding plugs in secondary-side heat exchanger tubes which leak (at present, four out of 712). Please find in attachment a safety analysis performed by the University of Virginia (U.Va.) with reference to the repair, and eventual replacement, of the UVAR heat exchanger. We propose that the UVAR LEU Safety Analysis Report be amended by the addition or replacement of the following:

- Table of Contents for UVAR LEU SAR (revised)
- Figure 4.1, pg 4-4: Cooling System Flow Diagram (updated)
- Section 4.6.1., pg 4-7-A: Replacement of Heat Exchanger System Components (new)
- Sections 4.7 and 4.8, pg 4-7-B (reformatted)
- Table 4.1, pg 4-8: Current Heat Exchanger Specifications (updated)
- Table 4.1.A., pg 4-8-A: Heat Exchanger Secondary Tube Plug Specification (new)
- Section 9.19, pg 9-73..: Heat Exchanger Secondary Tube Plugging Analysis (new)
- Section 9.20, pg 9-77..: Heat Exchanger Primary-to-Secondary Leak Analysis (new)
- Section 9.21, pg 9-87..: Heat Exchanger Secondary-to-Primary Leak Analysis (new)

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(UVAR SAR Amendment, page 2, cont.)

Also included in this submittal is a report describing the events surrounding the discovery and the proposed repair of the small heat exchanger leak.

The analysis of "unreviewed safety questions" is required by 10CFR50.59, as a precondition to obtaining authorization from the U.Va. Reactor Safety Committee, and from the Nuclear Regulator Commission, for the plugging of several tubes in the heat exchanger and a return to full-power operation. On October 9, 1995 the U.Va. Reactor Safety Committee reviewed and approved this safety analysis as well as new or revised procedures for annual heat exchanger inspections, increased secondary water monitoring frequency, actions to be taken in the event of heat exchanger leaks, and heat exchanger repair. Historically, the impact of heat exchanger leaks has not been analyzed for research reactors. As determined in our safety analysis, realistic short-term leaks of reactor pool water through the heat exchanger to the environment are of negligible impact. Moreover, these leaks are, of course, bounded by the analyzed survivable design-basis accident scenario involving loss of all poolwater.

Mindful of the needs of its faculty and reactor users, and in view of the benign results of the analysis and the simple heat exchanger repair, U.Va. is requesting an expedited review and approval of the SAR amendment from the NRC, as well as an early authorization to repair the heat exchanger and return the UVAR to full power operation.

The return of the reactor to forced-circulation operating mode will help prevent potentially corrosive effects of stagnant water in the primary and secondary systems. Following the repair of the UVAR heat exchanger, the surveillance regime over primary system water quality and radioisotope concentration levels in the secondary system water will be increased to assure that the repair has been successful, and to identify future leaks at an early stage, were they to occur. The enhanced surveillance regime will provide reasonable assurance that there will be no effluent releases above regulatory limits, and that the health and safety of the public will not be endangered.

Sincerely,

Robert U. Mulder

Robert U. Mulder, Director
U.Va. Reactor Facility &
Assoc. Prof. of Nuclear Eng.

City/County of Albemarle
Commonwealth of Virginia

I hereby certify that the attached document is a true and exact copy of a letter (type of document), presented before me this 10th day of Oct, 1995, by Robert Mulder (name of person seeking acknowledgement).

Vickie S. Thomas
Notary Public

My commission expires 2/28, 1998.

cc: Mr. Craig Basset, NRC Region II, Atlanta, GA
Mr. Alexander Adams, Jr., NRC Headquarters, Rockville, MD

A Report of the
Heat Exchanger Leak Discovery on August 22, 1995

The following chronology outlines events leading to the generation and discovery of a heat exchanger leak.

1. March 1995: Analysis by the Nalco Chemical Company and visual inspection of aluminum test coupons taken from the secondary cooling system in January 1995 show, for the first time, slight scaling and a slightly elevated corrosion rate compared to past examinations.

2. Aug. 7, 1995: The secondary side of the heat exchanger had last been opened in October 1987. In view of the test coupon analysis and this long period since the previous inspection the heat exchanger was opened in August 1995 to examine the tubes and to clean them, as necessary. Scaling was noted on the tube sheets, primarily on the intake sides on both ends and just inside the beginning of many of the tubes near to the point where they are swaged to the tube sheet. Only minor scaling was observed in the tubes past the point where they are held by the tube sheet. No fouling by biological scum was noted.

3. Aug. 7-14, 1995: The insides of heat exchanger tubes were flushed out with clean water and scale was removed to the extent possible. The local service representative from Nalco Chemical Company and her supervisor visit the building (on August 9) to examine the condition of the heat exchanger and begin the process of trying to determine why the corrosion and scale inhibiting chemicals used in the secondary water did not prevent the scaling observed.

4. Aug. 15, 1995: Prior to closing the secondary side of the heat exchanger, the slight stream of water seen coming out was sampled for radionuclide analysis. The large amount of water which had been used in the cleaning process was believed to be the source of this water. At this time there was full static pressure on the primary side, about 24 feet of water, and atmospheric pressure on the secondary side which had been drained. Analysis results obtained on August 16 showed tritium to be present in the leaking water at about the same concentration that it exists in the pool.

   The heat exchanger was closed on August 15, the secondary side refilled and the secondary pump was turned on in the expectation that a positive pressure differential from secondary to primary would stop or reverse the leak. Pool water began to be checked for evidence (change in water quality or other indication) of a secondary to primary leak.

5. Aug. 16, 1995: The first indirect indication of a possible secondary to primary leak is derived from the observation that the pool water level, monitored every normal workday, did not slightly drop overnight as is expected from evaporation and demineralizer pump shaft seal losses.

6. Aug. 17, 1995: Reactor was operated at powers up to 2MW for about seven hours. Pool water samples were taken for analysis. These were analyzed over the next day by gamma spectroscopy and molybdenum-99 from the activation of a molybdenum compound used as a corrosion inhibitor in the secondary water was seen. This verified that a small secondary to primary leak truly existed. An increase in the pool water conductivity at a faster than normal rate supported this conclusion. The water quality was better than the minimum Technical Specification limits (conductivity < 5 μmho/cm). Since the leak was observed to be into the pool extra samples of the secondary system water were not taken until the normal sampling on August 22.

7. Aug. 18, 1995: Reactor was operated at powers up to 2MW for about 7.5 hours. Changes in reactor pool water quality (conductivity goes from 1.4 to 2.2 μmho/cm) indicate a continuing secondary to primary leak.

8. Aug. 22, 1995: Reactor was operated at powers up to 2MW for about seven hours. Near the end of the operation the monthly water sample from the cooling tower was taken.

   Sample analysis showed low levels of sodium-24 (~8.8×10^{-7} μCi/ml). During reactor operation sodium-24 is normally the most abundant isotope seen in the reactor pool (typically in the range of 10^{-3} to 10^{-5} μCi/ml) but it is not seen in the cooling tower water. Its presence was evidence of a primary to secondary leak. This was surprising since it was assumed that there was always sufficient differential pressure between the primary and secondary sides of the heat exchanger to force leaks from the secondary to the primary side. It was subsequently observed that with the reactor primary pump on, the secondary pump on, and the secondary-side discharge throttle valves to the cooling tower in their current positions, the primary side pressure was somewhat larger than the secondary pressure, making a primary to secondary leak possible. Under other conditions, any leakage is from secondary to primary.

   The primary coolant isolation valves were closed approximately 45 minutes after the leak was identified, and UVAR operation restricted to natural convection cooling mode until reviews, approvals and fixes were implemented. The measured concentrations of identified radionuclides in the cooling tower water remained below the effluent concentration limits in 10CFR20.

9. Aug. 23, 1995: Secondary system isolation valve (isolating water in the lower basin of the cooling tower from the heat exchanger) was closed and the secondary water in the heat exchanger and on the downstream side of the isolation valve was drained to the liquid radioactive water tanks. The heat exchanger secondary side was re-opened. Upon close inspection two leaking tubes were identified. Two additional leaking tubes, with a much smaller leak rate, were found later. Scale was again observed located where it had been cleaned off just two weeks earlier.

10. Aug. 23 - to date: The situation and possible licensee options were discussed with NRC and NIST personnel. NIST provided suggestions for a type of plug design ideally suited to the UVAR's aluminum heat exchanger. In preparation for the future, and to assess feasibility, rubber tubing, stainless steel bolts and nuts were ordered. Plugs were then made and pressure tested in a tube similar to those in the heat exchanger. Reactor operation continues, but restricted to 200 kW in natural convection mode only. This is permitted by Technical Specifications and Standard Operating Procedures (SOP).

Maintenance and Upgrade Actions Being Instituted

Plug Leaking Tubes

1. Currently four heat exchanger tubes (out of 712) have been identified as leakers. These tubes can be plugged at both ends. Then, leakage through the tubes is impossible. Pressure fittings plugs of a simple design can be used. The system will not "challenge" the plugs in terms of pressure, vibration or radiation levels. The plug design has been used successfully in a more challenging environment at the National Institutes cf Standards and Technology's NBS Reactor. The plugs can be removed in the future, if desired. The installation does not affect nearby tubes in any manner.

2. A Method has been written to provide direction for the assembly, testing and installation of plugs in secondary side heat exchanger tubes that have been identified as leaking. This method is titled "Assembly, Testing and Installation of Plugs in Secondary Side Heat Exchanger Tubes".

Procedural Changes

1. A new Standard Operating Procedure (SOP) titled "Actions to be Taken in the Event of a Suspected Heat Exchanger Tube Leak" has been approved by the U.Va. Reactor Safety Committee (ReSC) and will be added as procedure 11.W. to the UVAR SOP Chapter 11 which deals with abnormal conditions. This procedure outlines the symptoms of a possible tube leak, methods to verify whether or not a leak actually exits and remedial actions to take in order to limit the effects of any leak.

2. The current SOP 10.4.G. has been modified (and approved by the ReSC) to increase the frequency of secondary water sampling and analysis by gamma-ray spectroscopy from monthly to weekly.

3. A new maintenance procedure has been approved by the ReSC for addition to the SOP as Section 7.15: "Heat Exchanger", to provide for the annual inspection of secondary side of the heat exchanger to check for corrosion, scale buildup, fouling and plug integrity. Previously, there was no established frequency for this maintenance item (nor have there been any plugs to check in the past).

Additional Methods

The current method, "Cleaning Cooling Tower and Heat Exchanger", has been modified to preclude the removal of scale found inside the secondary tubes. The removal of this scale can induce leaks so it is considered prudent to leave any scale in place, although this might lead to somewhat enhanced corrosion near the site of the scale. Several other improvements to this method have been instituted.