UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING CHANGES TO THE SAFETY ANALYSIS REPORT AND

AMENDMENT NO. 22 TO

AMENDED FACILITY OPERATING LICENSE NO. R-66

THE UNIVERSITY OF VIRGINIA

DOCKET NO. 50-62

1.0 INTRODUCTION

By letter dated October 10, 1995, as supplemented on October 19 and 26, 1995, the University of Virginia (UVA or licensee) submitted a request for amendment of the Safety Analysis Report (SAR) for the UVA Pool Research Reactor (UVAR). The requested change was for the installation of mechanical expanding plugs in secondary-side heat exchanger tubes to repair leaking tubes. The safety analysis included an analysis of leaking tubes in the UVAR heat exchanger. In response to questions from the staff, the licensee proposed an addition to the UVAR technical specifications (TS) to add a surveillance requirement for measurement of activity in the secondary cooling system water to help monitor the condition of heat exchanger plugs and tubes.

2.0 EVALUATION

2.1 Background

The UVAR is a material testing reactor (MTR) type reactor using low enriched uranium fuel. The reactor is licensed to operate at a maximum steady-state thermal power of 2 MW. Reactor heat is transferred between the primary and secondary coolants in an aluminum shell and tube heat exchanger, and dissipated to the atmosphere by a cooling tower.

During the month of August 1995, the UVAR staff performed a cleaning procedure on the secondary side of the reactor heat exchanger. During the maintenance procedure, accumulated scale was removed from several tubes. Following the heat exchanger cleaning and reassembly, the UVAR was briefly operated until a small heat exchanger leak was identified. On August 22, 1995, a secondary water sample was taken. The secondary water sample analysis indicated low levels of sodium-24 (Na-24) of approximately 8.8×10^{-7} Ci/ml. The regulations in 10 CFR Part 20, Appendix B, Table 3, limit monthly average Na-24 releases to the sanitary sewer to 5×10^{-4} Ci/ml; therefore, the secondary concentration measured at UVAR was a factor of approximately 600 below the 10 CFR Part 20 release limit without considering any additional dilution.

During reactor operation Na-24 is the predominant radioactive isotope and is normally found in the reactor pool water from activation of aluminum dissolved in the primary water. Na-24 is not found in the secondary water; therefore, there was evidence of a primary-to-secondary leak. The fact that Na-24 was found in the secondary coolant was unexpected since under most operating conditions the differential pressures are such that leakage would be from the secondary to the primary side of the heat exchanger.

On August 23, the licensee isolated and drained the secondary system and inspected the secondary side of the heat exchanger. Two leaking tubes were initially identified, and on closer inspection, two additional tubes with smaller leak rates were found.

The UVAR staff isolated the heat exchanger and has resumed operation at power levels up to 200 kW(t) in natural convection mode only (as permitted by UVAR Technical Specifications).

2.2 Heat Exchanger Repairs

The licensee has submitted a proposed design for a heat exchanger tube plug to be used to seal the heat exchanger secondary tubes that are found to be leaking. The plug specifications are shown in Figure 1. Due to the fact that the proposed plugs will form part of the primary system boundary, the NRC staff has reviewed the plug design, the UVAR staff analysis for installing the plugs, the potential for and consequences of plug failure, and the UVAR heat exchanger primary to secondary leak analysis.

We have reviewed the proposed secondary tube plug design as proposed by the licensee. From a material compatibility standpoint, the proposed plug material should be compatible with the secondary tube material and more importantly, with the tube-sheet support material, which will be an aluminum to aluminum contact point. The expandable/compressible material being made of norprene or equivalent rubber has been tested under environmental conditions similar or more extreme than those to be present at the UVAR; therefore, no significant degradation is expected. Further, the plug is designed so that a double seal will be accomplished with the installation of a single plug.

The analysis of the design and use of the proposed secondary tube plugs and the analysis to be performed following installation has been reviewed. The monitoring of the secondary heat exchanger inlet and outlet pressures following plug insertion, and periodically thereafter, will provide assurances of the integrity of the secondary interface components of the heat exchanger, including any installed plugs. Any reduction in cooling capability of the heat exchanger will be detected and controlled in accordance with the current "maximum pool water temperature" technical specification.

From our assessment of the potential for and consequences of plug failure, we conclude that plug failure is an unlikely event; however, if one plug should fail, there does not appear to be a mechanism for that plug to cause others to fail. We reviewed all of the failure modes defined in Section 9.19.2 of the proposed revisions to the UVAR SAR and have found it to be a complete and thorough listing and analysis of the possible failure mechanisms. In addition, given the operating pressure gradient between the primary and secondary systems (15 psi) and the plug test pressure (150 psi), the margin should be adequate to insure that the plugs will maintain the integrity of the primary-secondary interface in the heat exchanger.

The licensee has committed in the proposed SAR revision to a program for the surveillance of installed secondary tube plugs to follow aging of the plugs and provide assurance that the torque applied to the plugs for installation is sufficient to seal off any corroded tubes. The UVAR staff commitment specifically provides for: "...visually inspect all plugs annually without removing any of them. (Plugs that leak will be observed to wet the tube sheet at the affected end(s)). In addition, torque on all plugs shall be checked during the annual inspection; and, where necessary, they shall be retorqued to design specifications."

Based on our review of the proposed licensee plug design, the proposed procedures for installing the plugs, monitoring heat exchanger pressures, and the commitments by the UVAR staff for performing annual plug inspections, we conclude that the use of the UVAR secondary tube plugs to be acceptable.

2.3 Analysis of Potential Primary-to-Secondary Leaks

The licensee analyzed two primary to secondary leak scenarios. The first is a slowly developing tube leak that continues until discovered by radionuclide analysis of secondary system water. The second scenario is the sudden complete failure of a heat exchanger tube. This is considered to be a bounding analysis.

The licensee analyzed three cases involving primary to secondary system heat exchanger leaks. The first case assumed that all of the primary water that leaks into the secondary system becomes airborne in the cooling tower exhaust. The second case assumes that all of the primary water is discharged to the on-site holding pond. This pond is used to hold liquid effluents from the facility before discharge from the site. The third case assumes that all of the primary water that leaks into the secondary system is discharged into the sewer. The licensee defined the "worst-credible primary-to-secondary heat exchanger tube leak rate" that could develop before discovery to be about 1 ml/sec (~1 gph). The assumption is that the leak starts very small and grows with time. This leak rate would not violate 10 CFR Part 20 limits for annual average effluent concentrations for release to air or water, or the monthly average concentration for release to sewers.

In response to a request for additional information from the NRC staff, the licensee determined that even a continuous leak rate of 3 ml/sec (~3 gph) without discovery by the licensee from the primary system would not violate 10 CFR Part 20 limits for annual average effluent concentrations for release to air or water and the monthly average concentration for release to sewers. In this analysis the controlling release path is the water release to the on-site pond. However, the normal release path for water in the cooling tower is by blowdown to the sewer. Under normal conditions the pond would only be the release path if the cooling tower basin overflows which can release 1000 gallons (3800 l) of water to the pond when the secondary pump is turned off.

The UVAR staff has committed in their October 19, 1995, submittal (Answer to Question 7): "...during working days of the first two weeks following the heat exchanger repair, primary water quality (conductivity) shall be monitored at least daily and cooling tower samples shall be collected for radioisotopic analysis by the end of any day that the reactor has been operated." The licensee has also requested that a surveillance requirement be added to the TS that requires the secondary system water to be sampled and analyzed for radionuclides at least weekly. This ensures that a small leak that could not be quickly detected by abnormal changes in the water level of the reactor pool would continue for no longer than 10 days (maximum interval for a weekly surveillance).

The licensee submitted a postulated bounding case given in proposed SAR Section 9.20.8, "Double-Ended-Heat-Exchanger-Tube-Break Leak Analysis." This event assumes the complete failure of a heat exchanger tube while the primary system is operating. Because the primary system is turned off when the facility is unoccupied, this event could only happen when UVAR staff is present. Primary coolant flows into the secondary system at a rate of 10 gpm (40 lpm) and continues until the low reactor pool level alarm is activated at about 1.2 hours after the break. About 700 gallons (2700 l) of primary coolant is released into the secondary cooling system. This is an event that, given the pressures, temperatures, and flow-rates of the UVAR heat exchanger, is very conservative and results in an impact that is more conservative than any slowly developing heat exchanger leak. Again, three cases, air release, sewer release, and pond release were analyzed by the licensee.

For the airborne release, assuming all of the activity is released into the air from the cooling tower, the concentration during the 1.2 hour release is about 5 times greater than the annual average allowed concentration. This concentration is at the cooling tower and assumes no dilution from the cooling tower to the site boundary. However, because the 10 CFR Part 20 limit is an annual average, if the reactor and cooling tower are shut down for about 7 hours and no airborne release occurs, the concentration for that 8 hour period is less than the annual 10 CFR Part 20 limit for airborne release. This airborne release if averaged over a year would be a very small fraction of the 10 CFR Part 20 limit.

The licensee has assumed in the case of a release to the on-site pond that the entire volume of the secondary system (2000 gallons or 7600 l) is released to the pond. The volume of the effluent hold-up-pond is about 750,000 gallons (2,900,000 l). The pond is normally used for controlled release of liquid effluents from the reactor facility to the environment. Water is released from the pond periodically, subject to analysis for radionuclides to confirm that the release is within the regulations. For a 2000 gallon addition to the pond, the pond provides a dilution factor of 375. The concentration of radioisotopes in the pond is well below 10 CFR Part 20 annual average for release to the environment; therefore, the off-site consequences when the pond water is released would be minimal.

The concentration of radionuclides in the secondary system water is about 8 times greater than the monthly average limit for release to the sewer. The licensee can retain water in the secondary system to allow for decay of the 15 hour half-life Na-24 which is the predominant radionuclide. Even if the entire inventory of secondary water were released to the sewer during the event, dilution with cooling tower blowdown water (300 gph) with no measurable radioactivity would allow the release to the sewer when averaged over a month be much less than the 10 CFR Part 20 limit.

In addition, the UVAR staff has committed in their letter of October 19, 1995, to NRC: "Were a heat exchanger leak to be determined by radioisotopic analysis or unaccounted-for pool level changes, staff would drain heat exchanger and establish whether the source of leakage was a failing plug or an additional number of corroded and/or thinned tubes."

Based on our review and assessment of the above postulated leakage scenarios and the licensee's calculations of releases, we agree that the release to the environment in the event of a tube failure in the heat exchanger would be a very small percentage of 10 CFR Part 20 limits for all release paths.

2.4 Change to Technical Specifications

In response to requests for additional information from the NRC staff, the licensee proposed an addition to the TSs (TS 4.9). The proposed specification is as follows:

> <u>Specification</u>: Cooling tower (secondary system) water shall be sampled and analyzed for radionuclides, <u>at least weekly</u>.

The licensee proposed applicability, objective and bases statements for the TS. This TS ensures that a small leak that could not be quickly detected by abnormal changes in the water level of the reactor pool would continue for no longer than 10 days (maximum interval for a weekly surveillance). The licensee also submitted a new TS table of contents page to reflect the addition to the TS. The staff finds the proposed TS acceptable because it will provide a surveillance that is timely in determining heat exchanger primary to secondary leaks long before applicable 10 CFR Part 20 time-averaged liquid or airborne off-site concentration limits are approached.

3.0 ENVIRONMENTAL CONSIDERATION

This license amendment involves changes in the installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 or changes in inspection and surveillance requirements. The staff has determined that this license amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released off site, and no significant increase in individual or cumulative occupational radiation exposure. Accordingly, this license amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of this license amendment.

4.0 CONCLUSION

The staff has concluded, based on the considerations discussed above, that: (1) because the license amendment does not involve a significant increase in the probability or consequences of accidents previously evaluated, or create the possibility of a new or different kind of accident from any accident previously evaluated, and does not involve a significant reduction in a margin of safety, the license 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 the proposed activities, and (3) such activities will be conducted in compliance with the Commission's regulations and the issuance of this license amendment will not be inimical to the common defense and security or the health and safety of the public.

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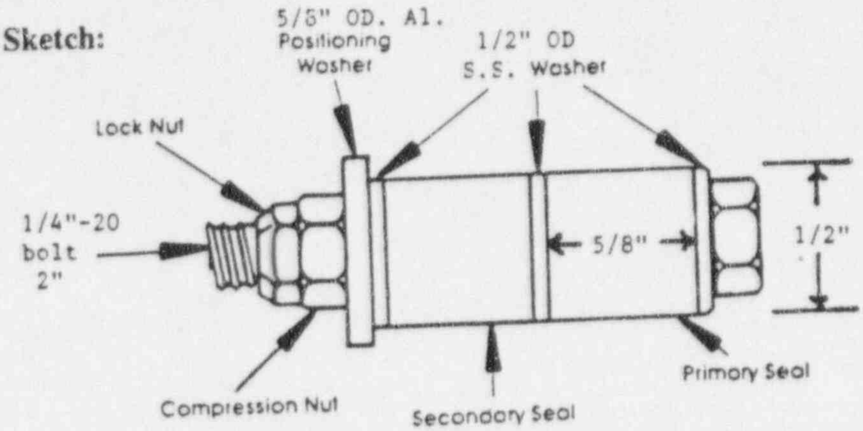
Date: November 9, 1995

Attachment:
Figure 1

TABLE 4.1.A Heat Exchanger Secondary Tube Plug Specification

Plug Sketch:



Screw, nuts, and interior washers may be stainless steel or aluminum.

Retaining washer must be aluminum. No dissimilar metal shall be in contact with the heat exchanger tubes.

Expandable/Compressible Tubing Material: Norprene or equivalent rubber.

Shaft (Screw): 1 pcs., 1/4"-20 by 2".

Nuts: 2 pcs., 1/4"-20, 1 locking, 1 normal.

Washer 1: 3 pcs., 1/2 O.D., stainless steel between seals.

Washer 2: 1 pcs., 5/8" O.D., aluminum only, plug positioning washer

Installation: against tube sheet support only.

Maximum Number to be Installed: To be determined, based upon allowable heat exchanger secondary-side working pressure, and secondary pump flow.

Testing and final installation torque: 12 inch-pounds.
Test Pressure: 150 psi (checked in a bench-rig).

Surveillance interval: annual, with removal and inspection of one plug from longest-installed group of plugs.

FIGURE 1