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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. 12 TO

FACILITY OPERATING LICENSE NO. R-76

WASHINGTON STATE UNIVERSITY

DOCKET NO. 50-27

1.0 INTRODUCTION

In a letter dated September 6, 1989, as supplemented on November 21, 1989, Washington State University (WSU) requested that the pulsing limit be reduced and restated in terms of peak fuel temperature. In addition, during a telephone conversation on December 12, 1989 between the WSU Radiation Center Associate Director and the NRC WSU Project Manager, WSU agreed to amendment of paragraph 2.C.(1) of Facility Operating License No. R-76 to include reference to the pulse mode of operation.

2.0 BACKGROUND

In September 1975 while moving fuel in the reactor core to increase excess reactivity, the staff of the Texas A&M Nuclear Science Center (Texas A&M) discovered three deformed Fuel Lifetime Improvement Program (FLIP) fuel elements adjacent to the transient rod. These elements had spent their entire operating history adjacent to the transient rod. The core had been operated for 287 megawatt-days in the steady state mode and was pulsed 725 times for a total reactivity insertion of 1413.43$. While bulged and bowed, none of the fuel elements failed and no fission products were released. This behavior had not been seen in TRIGA reactor fuel prior to this incident.

After a lengthy study (GA-A16613, 1981) conducted by Texas A&M, General Atomics (the fuel vendor), and the Argonne National Laboratory, the fuel damage mechanism was determined to involve long-term, high fuel temperature, steady state operation which caused redistribution of the hydrogen in the fuel by migration from hot to cooler regions. During steady state operation peak fuel temperature is at the fuel element center with decreasing temperature towards the outside of the fuel element. This hydrogen redistribution can cause phase changes in the zirconium-hydride fuel matrix. Large pulses (2.70$) after hydrogen redistribution resulted in sufficiently high pressures in the hydrogen-rich areas to cause swelling, porosity, and rapid release of hydrogen, which can deform the cladding. This occurs because peak temperature in the fuel during a pulse occurs in the outer region of the fuel. In addition, the unhydrided axial zirconium rod in the center of the fuel element can act as a stress raiser by swelling as it hydrides in situ during high power pulses and presses against the surrounding fuel meat.

3.0 EVALUATION

There is a direct correlation between the peak temperature in the fuel during a pulse and the onset of fuel damage. The equilibrium hydrogen pressure of the fuel during a pulse is related to the temperature. By limiting temperature, pressure is limited and fuel damage is prevented. The temperature, if exceeded, at which fuel damage may be observed was determined to be 874°C. This results in a equilibrium hydrogen pressure of about 70 psi. Using a safety factor of two results in an equilibrium hydrogen pressure of 35 psi which corresponds to a temperature limit of 830°C. This temperature in the Texas A&M reactor results in a pulse reactivity insertion of 2.27$. This temperature limit was evaluated by the staff and found to be acceptable at Texas A&M (NUREG-0947, March 1983). There has been no further fuel damage at Texas A&M with this limit in place.

After the event at Texas A&M, WSU administratively limited pulse reactivity insertion to 2.00$ although the Technical Specification limit is 2.50$. WSU is replacing this administrative limit with a Technical Specification change similar to that approved at Texas A&M. There has been no indication to date of fuel damage in the WSU TRIGA. The WSU TRIGA has a water-followed transient rod while the reactor at Texas A&M has a air-followed transient rod. While the water-followed rod would allow neutron flux peaking in the adjacent fuel elements, the water may also increase the amount of cooling to the adjacent elements, reducing the potential for damage. As of July 1989, the mixed standard and FLIP fuel core at WSU has accumulated 366 megawatt-days of operation. WSU calculated the average power density in the core that limits fuel temperature during a pulse to 830°C, and then, using the Fuchs-Nordheim variable heat capacity model, determined this power density results in a pulse reactivity insertion limit of approximately 2.20$.

WSU will calculate the maximum allowed pulse reactivity insertion annually for existing cores. This will allow for changes in power density that result from fuel burnup. The maximum allowed pulse reactivity insertion will also be calculated for new or modified cores.

In addition to these changes, the WSU Radiation Center Associate Director and the NRC WSU Project Manager discussed and agreed to a change in paragraph 2.C.(1) of Facility Operating License No. R-76 to add that operations in the pulse mode will be conducted in accordance with the limitations of the Technical Specifications. This clarifies the license to include all modes of operation.

The staff believes that the fuel damage mechanism proposed is reasonable. The staff agrees that a safety factor of two in equilibrium hydrogen pressure is adequate and concludes that a maximum fuel temperature limit of 830°C for pulsing operation is acceptable.

3.0 ENVIRONMENTAL CONSIDERATION

This amendment involves changes in the installation or use of facility components located within the restricted area as defined in 10 CFR Part 20. The staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and there is no significant increase in individual or cumulative occupational radiation exposure. Accordingly, this 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 amendment.

4.0 CONCLUSION

The staff has concluded, based on the considerations discussed above, that: (1) because the 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 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 amendment will not be inimical to the common defense and security or the health and safety of the public.

Principal Contributor: Alexander Adams, Jr.

Dated: January 23, 1990