LOW ENRICHMENT FUEL CONVERSION

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FOR IOWA STATE UNIVERSITY

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Progress Report
for Period August 1, 1991 - July 31, 1992

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ABSTRACT

The UTR-10 reactor at Iowa State University went critical on low enriched uranium (LEU) fuel on August 14, 1991. However, subsequent to the criticality experiments the fuel plates started to discolor. In addition, roll pins used to lift the fuel assemblies were discovered to be cracked. It was determined that these problems were due to chemical agents in the primary coolant water. The roll pins were replaced by solid stainless steel pins. The primary coolant was replaced and the reactor is currently in operation. Surveillance specimens will be used to monitor any possible future discoloration. The high enriched fuel (HEU) is being prepared for eventual shipment to a high enriched fuel receiving facility.

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INTRODUCTION: Progress during the reporting period proceeded primarily in the area of loading and testing of the low enriched fuel (LEU). This included criticality experiments as well as observations and analyses of fuel material problems.

CORE LOADING: The UTR-10 core loading with LEU fuel commenced on August 1, 1991. In the process of core loading, the fuel assemblies were assembled from LEU fuel plates (and dummy aluminum plates necessary for achieving the licensed excess reactivity) and associated assembly hardware. The process included tensioning of the upper and lower fuel support bolts. The fuel loading process involved many measurements until criticality was achieved. During the loading process in which previously loaded fuel assemblies were inspected, it was noticed that there were fuel cladding discolorations and spotting. This was noticed on August 12, 1991. At this point in the fuel loading process it was decided that close attention would be paid to the loaded fuel assemblies for any further deterioration of this phenomenon.

Initial criticality was reached on August 14, 1991. The critical core loading was 3446.58 g of ^{235}U for an excess of reactivity of $4 (10^{-4}) \Delta k/k$. One additional plate was added to the core to determine the differential fuel worth of $6.5 (10^{-5}) \Delta k/k$ of ^{235}U . At this time it was noticed that the fuel discoloration had increased.

FUEL DARKENING: Upon an inspection on August 23, 1991 it was noticed that the discoloration continued to increase especially in the areas of the fuel serial numbers. However, some areas on some fuel plates seemed to be immune to the discoloration. At this time we commenced into extensive investigations into the possible reasons for the discoloration. One possible cause was determined to be cyclohexylamine contamination in primary coolant. But this situation existed for many years and the previously removed HEU had not shown similar discoloration.

On August 20, 1991 reactor operations were terminated by the reactor manager until the causes of discoloration could be determined. Cladding samples were provided to the Iowa State University Materials Analysis and Research Laboratory for scanning electron microscopic analysis. Aluminum and oxygen peaks were identified and minor pitting and raised imperfections were seen with the analysis. X-ray diffraction analysis found bayerite and one other

unknown compound.

FUEL PROBLEM ANALYSIS: On September 15 members of the fuel materials division from Babcock and Wilcox, who fabricated the fuel, and of project management from EG&G, Idaho arrived for fuel plate inspections. During this inspection it was noticed that one of the roll pins in the fuel assembly lifting hardware of an inspected assembly was cracked. Subsequent to this inspection, a staff inspection of all fuel assemblies in the core revealed that all of the roll pins were cracked. Since the roll pins are used to lift the fuel assemblies, the Nuclear Regulatory Commission was notified about the fuel problems.

The roll pins in the discharged fuel assemblies of HEU were then inspected. Only one roll pin from 12 fuel assembly had displayed any cracks. These fuel assemblies had been in the core for more than 30 years. Therefore, we attempted to determine the reasons for the roll pin cracking of the LEU fuel. Experiments with uncracked roll pins in unused assembly hardware were exposed to reactor coolant. The roll pins in the experiments cracked. A detailed chemical analysis of the roll pins was performed without any abnormal results. The roll pins from the HEU fuel were compared with the roll pins for LEU fuel by metallurgical analysis without any significant differences in material compositions. Some slight differences in SiO_2 and carbon content were noted but the differences were deemed insignificant.

REMEDIES: At this point we decided that there was some contaminant in the primary reactor coolant causing the fuel discoloration and the roll pin cracking. All 530 liters of primary coolant were replaced. New IRN-150 resin was added to the coolant deionizer. Experiments with the new coolant and clean fuel plates were continued. Some darkening was observed but not to the extent noticed with the previous coolant.

New lifting pins made of solid stainless steel of the same composition as the lifting cone hardware were fabricated. However, the fuel assemblies needed to be lifted and removed from the core for replacement of the pins. Since all of the roll pins were cracked, we had to develop a new tool to lift the fuel assemblies which did not rely on the roll pins. The tool was designed and fabricated. Procedures were developed for the lifting of the fuel assemblies. Finally, all roll pins were replaced on December 12, 1991.

A sampling holder for holding samples of fuel cladding was designed and fabricated. The holder sits upon one fuel assembly and is removable with our long handle fuel assembly tool. The cladding samples in the holder experience the same coolant environment as the fuel cladding. Therefore, we can remove the samples at certain intervals to observe the cladding surface changes. This will reduce any radiation exposures that the operation staff would

receive during direct fuel assembly inspections. The Reactor Use Committee recommends the frequency of inspection and methods of inspection. Both photographic and microscopic examinations will be made. As of July 13, 1991 the samples had received 2467 minutes of coolant submersion without any noticeable degradation. It has been determined that reactor operations are again normal, as compared to HEU operations, after several high power runs.

HEU FUEL: We had anticipated the shipment of the HEU fuel plates during the first half of the 1991 calander year. However, because of problems with the fuel reprocessing facility operated by Westinghouse Idaho Nuclear Company, we were unable to ship the fuel to this facililty. Therefore, we have entered negotaiations with the Savannah River Laboratory for shipment of the HEU fuel to that facility.

We have developed a fuel plate holding fixture to be used with the 6M container for fuel shipment. We deveoped procedures for loading the fuel plates onto the plate fixture and spent considerable time practicing the loading procedures. However, the fixture was not approved by Westinghouse Idaho Nuclear Company. We have not gone far enough into the negotiations with the Savannah River Laboratory for their approval of the fixture.

Measurements of the radiation levels from the HEU fuel are continuing. These measurements are necessary to make estimates of the number of shipments needed for the shipment of the fuel. Since the fuel is in the form of fuel plates, the number of plates per shipment will primarily depend on the Department of Transportaion regulations.

CORE EXPERIMENTAL MEASUREMENTS: The original proposal for the conversion project addressed the experimental tasks needed to verify that the technical specifications are not violated, and to investigate the reactor characteristics most likely to be affected by the conversion to LEU fuel. The technical specifications concerns are handled by routine maintenance procedures that are a normal component of the surveillance program. Measurements of reactor characteristics are aimed at the ratio of delayed neutron fraction to prompt neutron lifetime and the effect of neutron flux spectrum hardening.

Measurements to assess the effects of flux spectrum hardening were performed by exposing metal foils to neutrons in the most frequently used experimental facilities, the rabbit tube and the thermal column beam port, while the HEU fuel was in use. A flux wire holder for performing these experiments with the LEU fuel has been developed. The holder will fit between the LEU fuel plates even though the spacing between plates is only 0.43 cm.

REMAINING WORK: There are certain remaining tasks to be performed with the new LEU fuel. The tasks to be accomplished by May 31, 1993, the contract termination date, are the following:

- * Develop procedures for fuel transport according to regulations and submit fuel details to Savannah River Laboratory.
- * Ship the HEU fuel plates.
- * Verify calculated results for reactor parameters such as rod worths, shutdown margin, etc. by experimental measurements to complete the initial startup report required by the Nuclear Regulatory Commission.
- * Perform the flux mapping measurements.

REFERENCES:

1. Rohach, A. and Hendrickson, R. "Low Enrichment Fuel Conversion for Iowa State University". Department of Energy progress report DOE/ER/75360--3. August, 1991.

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