CONF-951006--34-Summary

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JAN 30 1995
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Depleted Uranium Start-up of Spent Fuel Treatment Operations at Argonne
National Laboratory-West

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At Argonne National Laboratory-West* (ANL-West) there are several thousand kilograms of EBR-II spent nuclear fuel. This fuel will be treated using an electrometallurgical process in the Fuel Conditioning Facility (FCF) at ANL-West to produce stable waste forms for storage and disposal. The process equipment is undergoing testing with depleted uranium (DU) in preparation for irradiated fuel operations during the summer of 1995.

The EBR-II spent fuel, which is metallic fuel containing bond sodium, is unique within the Department of Energy (DOE) complex. The sodium is fused within the fuel slug structure which swells extensively during irradiation. The presence of the sodium adds a reactive and therefore a hazardous component. Additionally, EBR-II core fuel used high enriched uranium (HEU). The treatment operations will neutralize the reactive sodium, stabilize the fission products, and recover the actinides in a stable form. The recovered HEU will be blended to form low enriched uranium. These operations will make use of existing equipment from the terminated Integral Fast Reactor (IFR) fuel cycle demonstration.

FCF contains two shielded hot cells. Irradiated spent fuel from EBR-II will be brought into the rectangular-shaped air-filled hot cell, where the fuel elements will be disassembled from the fuel assembly hardware. The elements will be transferred into an adjoining annular-shaped argon-filled hot cell. They will be chopped into segments and placed into fuel dissolution baskets which will be fed into an electrorefiner, where the bulk of the fission products will be separated from the actinide metals. The molten salt medium in the electrorefiner is a mixture of LiCl-KCl eutectic and actinide chlorides. Below this salt phase is a pool of

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molten cadmium that can serve as an anode, cathode, or just a collector for nonreactive metals. Uranium that is relatively free of TRU elements will be collected on steel mandrel cathodes (solid cathodes).

The products recovered from the electrorefining operations will be processed in a separate operation to distill adhering salt and consolidate the remaining actinide metals. The recovered ingots will be placed in a stable form pending a decision from DOE on the disposition of such materials. The separated fission products will be placed in stable waste forms for disposal.

During December 1994 and January 1995, the electrorefiner was loaded with 431 kg of LiCl-KCl and 531 kg of cadmium. The system was heated to 500°C. Level measurements and volume calibration operations were performed as increments of salt and cadmium were loaded. These measurements are used as part of the materials control and accountability (MC&A) plan for the electrorefiner. During irradiated fuel operations, the inventory and associated uncertainties of special nuclear material in the electrorefiner must be established using both the analytical samples of salt and cadmium and the volume of these liquids as calculated from level measurements. The uncertainties associated with the liquid volumes were determined from the calibration operations. The volume of the salt can be determined with a 0.3% two sigma relative uncertainty.

During March 1995, depleted uranium was placed in the electrorefiner for the first time. Fuel dissolution baskets with 20 kg of DU were loaded into the electrorefiner salt. Cadmium chloride was added to the salt, and the uranium was oxidized as follows:

The presence of UCl_3 facilitates the electrochemical transport of actinides in the salt medium.

After charging the salt with uranium, seven salt samples were taken over a two-month period to determine the sampling and analytical uncertainty for uranium and to verify that uranium concentration in the salt was stable and not affected by system impurities. The relative sample standard deviation for the uranium concentration in the salt samples is 0.23%, or 0.46% at two standard deviations. These results indicate that the uranium concentration in the salt is stable and that any error associated with the sampling and analysis is small.

During June 1995, the first electrotransport operations were performed. The feed was 14 kg of DU loaded in the FDBs. Two DU solid cathodes have been recovered. The first was a small product to verify that the system was functioning properly. After this product was viewed, it was placed back into the electrorefiner and electrochemically dissolved.

The next cathode recovered was removed from the electrorefiner and harvested from the solid cathode mandrel. This product will be processed through additional equipment in the cell to remove adhering salt and then sampled. The results from these samples combined with electrorefiner salt and cadmium samples will be used to demonstrate close-out operations for a batch of treated fuel. This data will be provided to DOE and will be used for a required MC&A audit before approval for treating irradiated fuel is granted. The data acquisition for the MC&A audit will be completed during July 1995, and the audit is expected to be complete during the first half of August 1995. Treatment operations with irradiated fuel will begin soon after.