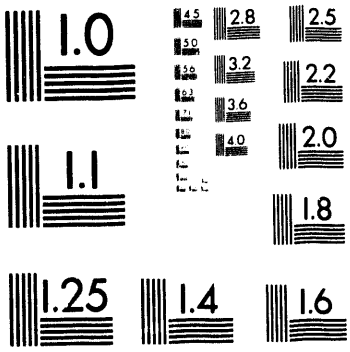
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DEVELOPMENT OF RADIONUCLIDE SEPARATION TECHNOLOGIES FOR PROCESSING OF IDAHO CHEMICAL PROCESSING PLANT SPENT FUEL AND HLW CALCINE

by A. L. Olson, T. A. Todd, L. F. Ermold, D. A. Knecht, and G. W. Hogg
Westinghouse Idaho Nuclear Company, Inc.
P. O. Box 4000
Idaho Falls, ID 83415
USA

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SYNOPSIS

Irradiated nuclear fuel has been reprocessed at the Idaho Chemical Processing Plant (ICPP), which is a part of the Idaho National Engineering Laboratory (INEL), since 1953 to recover uranium-235 and krypton-85 for the U.S. Department of Energy (DOE). The resulting acidic high-level liquid radioactive waste (HLLW) has been solidified to a high-level waste (HLW) calcine since 1963 and stored in stainless-steel bins enclosed in concrete vaults. Residual HLW and radioactive sodium-bearing waste are stored in stainless-steel underground tanks contained in concrete vaults. Several different types of unprocessed irradiated DOE-owned fuels are also stored at INEL. In April, 1992, DOE announced that spent fuel would no longer be reprocessed to recover enriched uranium. As a result of the decision to curtail reprocessing the ICPP Spent Fuel and Waste Management Technology Development plan has been implemented to identify acceptable options for disposing of the (1) sodium-bearing liquid radioactive waste, (2) radioactive calcine, and (3) irradiated spent fuel stored at the INEL. The plan was developed jointly by DOE and Westinghouse Idaho Nuclear Company, Inc.,(WINCO).

The removal of reprocessing as the basis for management of spent fuel and resulting high level waste has required a new approach to management of this material. The ICPP Spent Fuel and Waste Management Technology Development Program is one of the means to developing a new technical basis for high level waste management. The plan proposes a schedule for beginning design and construction of new facilities during 2003 to 2008 and hot start-up by 2006 to 2014, assuming requested funding. This paper will describe the results of testing new approaches in radionuclide separation in the processing the spent fuel and HLW calcine to reduce HLW volume for disposal.

The DOE currently has approximately 768 metric tons (MT) total mass of material labeled as "special fuel" stored at the INEL. This material is so labeled because no specific spent fuel processing technique or recycle facility is available within the DOE complex. There are over 90 identified types of special nuclear fuel at the INEL and over 100 types in the DOE complex. About 108 metric tons (MT) of graphite based fuels, 240 MT of Naval propulsion fuels, and 420 MT of various (zirconium, aluminum, and stainless steel based) fuels are stored at the INEL.

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The calcined waste is stored near-surface in stainless-steel bins within concrete vaults. The bin sizes are approximately 4-m diameter by 12.5 to 18.5-m high. Some of the bins are cylindrical and others are of an annular configuration. Currently there is an inventory of 3,600 m^3 HLW calcine at ICPP with various compositions resulting from past reprocessing primarily of aluminum and zirconium-clad fuels. The amount of alumina, zirconia, zirconia-Na, and fluorinel-Na calcines is approximately 560, 1250, 950, and 600 m^3, respectively. The remaining 240 m^3 calcine inventory consists of calcines from processing other minor fuels and start-up bed material.

Spent fuel and calcine immobilization processes which are currently under development at the ICPP include technologies to reduce the volume of HLW requiring disposal using both aqueous and non-aqueous processes. Aqueous methods include solvent extraction, ion exchange, extraction chromatography, and precipitation/co-precipitation for removal of transuranic nuclides, Sr, Cs, Tc, and I. A non-aqueous process scheme involves the removal of specific inert materials (Al_2O_3, ZrO_2, and B_2O_3), hazardous materials (Hg, Cd, Cr), radioactive fission products (Cs, Sr, I, Tc), and actinides (Pu, Am, U, Np). The process involves selective volatilization of Cs, Cd and possibly I and Tc by heating the calcine to approximately 1000°C. The calcine and possible spent fuel, composed primarily of oxides, would then be reacted with chlorine to chlorinate components such as Al, Zr, B and Hg. These compounds will easily volatilize at temperatures under 600°C. Another technology, common in plutonium purification operations, would involve direct reduction of actinides to the metal state by using a metal reductant in a molten salt. Proposed aqueous and non-aqueous processing schemes for spent fuel and three different calcine types will be given. Theoretical calculations and experimental results will be presented. These technologies have the potential to reduce the volume of ICPP HLW disposed in a repository, by a factor of 10 to 100.

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