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PROPOSED PLANS FOR THE USE OF SOLUBLE NUCLEAR ABSORBERS AT THE IDAHO CHEMICAL PROCESSING PLANT

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Soluble neutron absorbers are proposed for criticality safety control in future processes at the Idaho Chemical Processing Plant. Solutions of neutron poisons have been used in the past for criticality control in processing various reactor fuels. No problems were encountered in the safe use of the neutron poisons although dissolution of different types of fuel occasionally required reevaluation of the poison concentrations. Proposed plans include the uses of soluble neutron poisons in the Rover fuel dissolver, the Fluorinel dissolver, and in increased concentrations in the electrolytic dissolver. The purpose of this paper is to present these proposals and to discuss the criticality safety aspects.

Use of a neutron poison partially relaxes the restrictions of geometry, volume, vessel size, and fissile material concentration. In general, this allows for greater production rates and flexibility in operations. In addition, soluble poisons can sometimes improve overall solution characteristics and provide additional margins of safety. Some disadvantages of nuclear poisons include requirements for additional equipment for poison monitoring, requirements for additional sampling and analysis, and possible solution stability problems or negative effects on other processes. Soluble poisons were chosen for use in future processes because the advantages are considered to outweigh the disadvantages.

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The Rover Fuels Processing Facility provides a headend system designed specifically for reclaiming uranium from graphite matrix nuclear rocket fuels. Residual ash from fluidized bed burners is charged to the dissolver and is dissolved and complexed in a four step process: 1) nitric acid dissolution; 2) water dilution; 3) hydrofluoric acid dissolution; and 4) fluoride complexing. Quantities of reagents are determined by the mass of the ash charged, and all of the solutions contain a minimum of 3.5 g/L of boron to assure criticality safety. The dissolver heating and cooling water contain a minimum of 5 g/L boron which protects against criticality in case of dilution of the dissolver solution by a leak between the dissolver and the cooling or heating jackets. Solution stability for process or upset conditions was proven in laboratory tests.

The criticality safety of the Rover Fuels Processing Facility is assured by means of engineering design, soluble nuclear poison (boron) and administrative controls. A k_{eff} of 0.93 was calculated for a full dissolver containing uranium at 1159 g/L, boron at 2.64 g/L and nitric acid. Interactive effects of other vessels, each in the most reactive condition, will raise the maximum K_{eff} to 0.953. To insure the neutron poison concentration, the dissolution reagents must pass through a nuclear poison detection system (NPDS) before entering the dissolver. The NPDS will automatically close shutoff valves between the feed tanks and the dissolver if the solution is below the required concentrations. A single failure anslysis of the NPDS concludes that no single system failure or human error will result in an out-of-limits borated solution being transferred to the dissolver.

The Fluorinel Dissolution Process is a specially designed system for processing of a number of metal-clad and oxide fuels. A soluble nuclear poison, cadmium, is essential for providing the required production rate and flexibility. Fuel batches are dissolved by 1) removal of the fuel cladding, 2) dissolution of the fuel material, and 3) dissolution of the residual components. Removal of the cladding destroys the fuel element geometry and the fissile material and residual components will fall to the bottom of the dissolver. The residual components constitute only a small fraction of the total volume of the fuel assembly and do not affect criticality safety.

Criticality in the Fluorinel dissolver could result from exceeding the critical mass or from an inadequate poison concentration. The minimum critical mass for uranium oxide dispersed in a water solution containing 24 g/L cadmium is approximately 19.0 kg of uranium-235. This is based upon a homogenized sphere of uranium oxide and poisoned dissolver solution at optimum density with a 30.48 cm thick reflector of poisoned dissolver solution. The mass limit chosen for the dissolver is 10.5 kg of uranium-235 giving a k_{eff} of 0.88. Accumulation of a critical mass is prevented by positive identification of fuel units, administrative controls, procedures, and design of equipment to preclude double batching. Criticality due to an inadequate poison concentration could result from an inadequate starting concentration, dilution or precipitation of the poison. All reagents added during the dissolution cycle contain cadmium at 24 g/L. Equipment design including automatic control systems with nuclear poison detectors, administrative controls and procedures will protect against low nuclear poison concentrations. Laboratory studies have shown solutions of 24 g/L cadmium to be stable under any expected process or upset conditions except the presence of concentrated sulfuric acid.

The electrolytic dissolution facility is an existing facility at the ICPP for dissolution of stainless steel fuels. Gadolinium is used as a soluble neutron absorber in the nitric acid dissolving reagent and the cooling system. Stainless steel fuels planned for processing in the future will require reevaluation and adjustment of the gadolinium concentration to retain adequate criticality safety. Equipment design, administrative controls, sampling and procedures are used to assure criticality safety.