HIGH-LEVEL WASTE MANAGEMENT

AT THE ICPP

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ABSTRACT

The Idaho Chemical Processing Plant (ICPP) is the only U.S. facility which puts the high-level liquid waste (HLLW) resulting from spent fuel processing into a solid calcine form, which is then placed into interim storage in large stainless steel bins. The different types of spent fuels processed at the ICPP result in some variations in the HLLW. Fuels routinely reprocessed include aluminum, stainless steel, and zirconium-based fuel, the latter comprising the majority of fuel. Both hydrofluoric and nitric acid are used in the zirconium fuel dissolution, and the first cycle extraction raffinate is an acidic HLLW. This waste is stored in stainless steel tanks in a small tank farm until a calcining campaign is performed. Some of these wastes are blended to produce a suitable feed solution to the waste calciner. The resulting solid calcine form is placed into storage in the stainless steel bins. Alternate strategies are being evaluated to immobilize the calcined waste and provide for permanent disposal. The purpose of this paper is to describe briefly the waste stream processing system, the strategies for minimizing the future generation of high-level waste (HLW), and the plan for immobilization of the calcine product to a form suitable for permanent disposal.

BACKGROUND

The primary mission of the ICPP is to reprocess Department of Energy fuels for the recovery of uranium. The fuels are principally enriched fuels of all types, which require several different dissolution processes, viz., mercury-catalyzed nitric acid for aluminum alloys, hydrofluoric acid for zirconium-based fuel, electrolytic dissolution in HNO_3 for stainless steel, and pyrolysis for graphite fuels followed by dissolution in HF and HNO_3. A new three-train dissolution facility using the fluorinel process has just been completed and is in test. The solvent extraction systems begin with a single-cycle Purex process using TBP, followed by a two-cycle Redox process using hexone and aluminum nitrate nanohydrate. The product from the third extraction cycle is concentrated and fed into a denitrator producing calcined UO_3, which is packaged and shipped to DOE facilities. A new extraction facility is being designed to increase capacity using three cycles of the Purex process. Figure 1 shows the materials flow pattern at the ICPP.

The majority of the fuels processed are alloys which require complete dissolution of the fuel elements. This factor plus the addition of fluoride complexants necessary to produce an acidic waste stream result in large HLLW volumes varying from 60,000 to 2,500,000 liters per metric tonne of uranium processed. It is also necessary to store the HLLW from different fuel processing separately so the proper blend can be achieved for efficient calcining. The three principal types of HLLW contain zirconium, aluminum, or sodium as primary metallic constituents.

WASTE CALCINING FACILITY (WCF)

The first pilot waste calcining facility was designed and constructed to demonstrate the operating principles of calcination, and at the same time achieve a volume reduction in waste storage from the liquid to the solid calcine form, thus eliminating the need for a large tank farm. The WCF required direct contact maintenance, with the concomitant problems in contamination control and personnel exposures. The throughput was not designed to meet long-range projections for HLLW generation based on processing plans. It was put into operation in 1963 and operated until 1981 when it was replaced by a New Waste Calcining Facility (NWCF). During this time more than 4 million gallons of liquid waste were converted into about 77,000 ft^3 of calcine. Figure 2 shows the basics of the ICPP calcining process.

NEW WASTE CALCINING FACILITY

Using the lessons learned from the WCF, a New Waste Calcining Facility was designed, constructed, and put into operation in 1982. The design of the NWCF incorporated remotability concepts in operation and maintenance, and was also designed to exceed the projected generation rate of HLLW for the long-range future. The performance of the NWCF has been highly satisfactory and has exceeded design throughput rates. To the present time, the NWCF has solidified about 1.5 million gallons of waste, achieving an average volume reduction of about 8:1. The NWCF performance has demonstrated the capability to fulfill the need for long-term processing of HLLW.

Most of the lessons learned from NWCF operation relate to auxiliary system and equipment performance.

Heating, Ventilation, and Air Conditioning (HVAC) System

- Vapors from decontamination and cleaning are not cleared rapidly enough, thus limiting work rate.

- Flowmeters are not accurate because neither straightening vanes nor proper straight piping runs were provided.

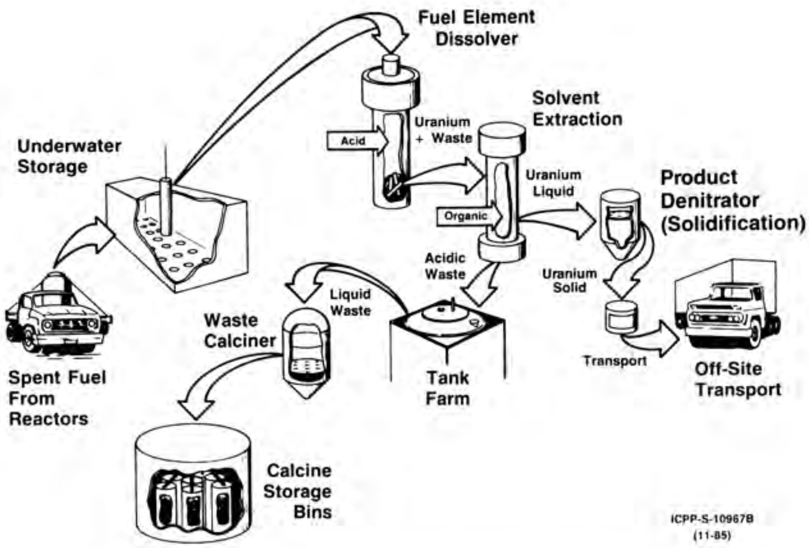

Fig. 1. Materials Flow Pattern at the ICPP.

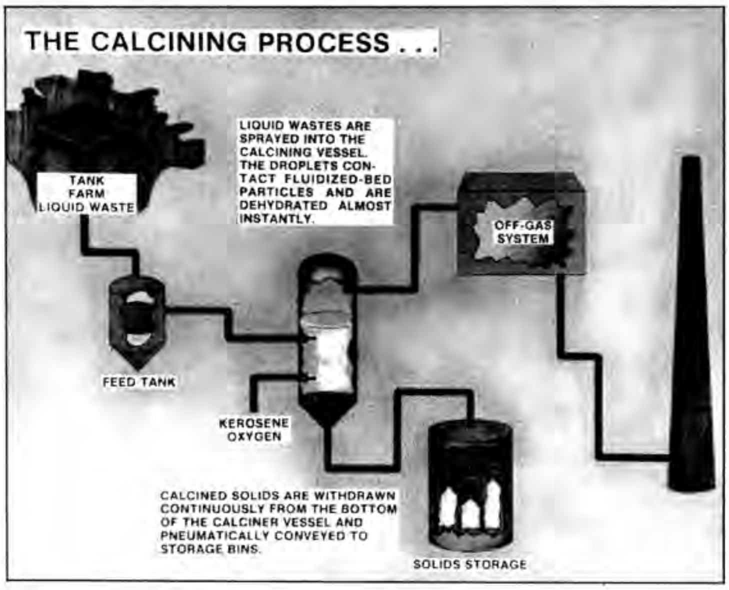

Fig. 2. ICPP Calcining Process.

Master/Slaves and PAR's

- Some valves could not be reached.
- The cell floors couldn't be reached to pick up dropped items.
- A significant spare parts and maintenance effort is necessary to keep equipment in working order.
- Field of vision during use is sometimes poor. Mirrors or CCTV cameras could be of substantial help.

Feed Nozzle Wear

- Additional operational experience determined the injection nozzle wear rate; future operation will schedule their replacement before nozzle wear affects calciner performance.

The granular calcine product has been and will continue to be stored in a retrievable mode in the bins. The particles are pneumatically transferred from the calciner to the bins located within near-surface concrete vaults. Each bin is about 3 m in diameter and 12 to 18 m tall. Four to seven bins are located within a single concrete vault. Design lifetime of the bins is 500 years but sampling of corrosion coupons placed within loaded bins indicates a much longer lifetime. Each vault contains from 700 to 1550 m^3 of calcined waste. Figure 3 shows one of the bin sets.

PLAN FOR THE LONG-TERM MANAGEMENT OF ICPP HLW

Over the years, the calcination process coupled with bin storage has been a safe technique for solidifying and storing ICPP high-level wastes. However, it is recognized that various regulatory concerns may require that all high-level wastes be further immobilized for final disposal offsite. The Defense Waste Management Plan (DWMP) of June 1, 1983, presents the national plan for disposal of defense HLW, including those generated and stored at the Idaho National Engineering Laboratory. The goal of the DWMP is to end interim storage and to achieve permanent disposal by immobilizing and preparing HLW for shipment to a geologic repository. New and readily retrievable existing HLW would be processed for disposal to a repository, while other waste would be stabilized in place if the short-term risks and costs of retrieval and transportation outweigh the environmental benefits of disposal in a repository.

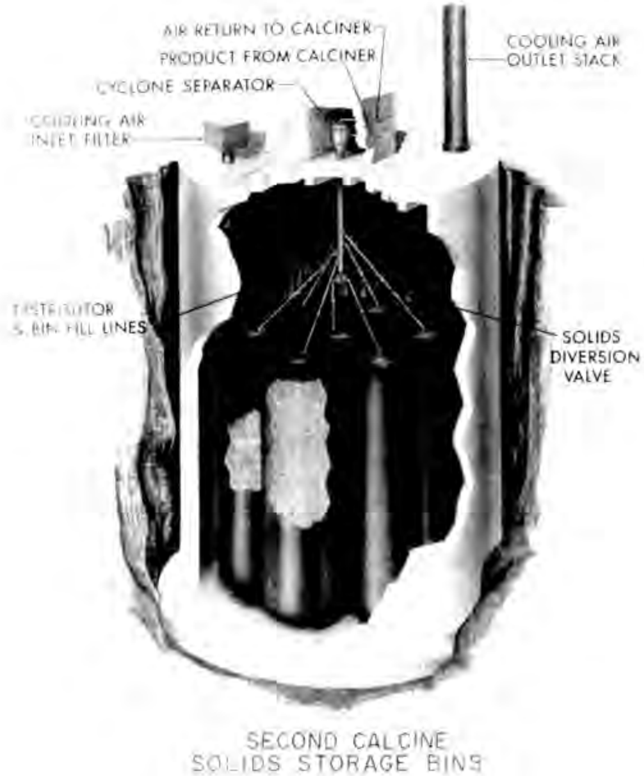

Fig. 3. One of the Bin Sets.

Thus, along with significant efforts to minimize the future generation of all HLW at ICPP, three basic strategies are currently under evaluation as shown in Fig. 4.

1. Immobilize all ICPP HLW for disposal to a repository;

2. Immobilize all ICPP HLW for disposal to a near-surface facility onsite; or

3. Immobilize all newly produced HLW for disposal to a repository plus stabilize existing stored HLW for disposal at a near-surface facility.

While a decision on a strategy and process for long-term ICPP HLW management will not be made until the 1990s, the DWMP presents a reference plan: the annual output of ICPP HLLW will be immobilized in no more than 500 canisters per year and sent to a repository after FY 2008. Existing stored calcine would be immobilized and disposed of as plant capacity permits.

It is recognized that a process has been selected to create glass for HLW from both the Savannah River Plant (SRP) and West Valley. A glass process has been considered for ICPP HLW; however, such a process is not directly applicable because of the significant difference in waste composition as compared to wastes at the other sites. The very high concentrations of fluoride, zirconium, cadmium, and calcium (all absent from the SRP and West Valley wastes) alter the process that would be applicable at ICPP if large volumes of immobilized HLW are to be avoided. Based on available technology, if ICPP HLW were converted into a glass, at least 1700 canisters of waste would be produced per year after FY 2008, which is well above the DWMP goal of fewer than 500 canisters per year.

Rather, several alternative process methods which could reduce solid waste volumes to below the volume specified in the DWMP are being evaluated. These options include:

(a) Producing a high waste loading, high density glass/ceramic or ceramic waste form in the waste immobilization step;

(b) Eliminating the use of inert materials such as soluble neutron poisons (i.e., boron and cadmium) in the fuel dissolution process; or

(c) Using new processes prior to immobilization in which inert materials are separated by an in-line neutralization process or by a TRUEX actinide separation process.

The potential reductions resulting from these options are summarized in Table I.

TABLE I

HLW Volume Reduction at ICPP

Method	Canisters/yr produced (after 2008)	% reduction compared to glass waste form option
Converting HLW to glass waste form	1700	--
Converting HLW to ceramic or glass/ceramic waste form	600	65
Converting to ceramic or glass/ceramic waste form and using critically safe dissolvers	400	75
Neutralizing acid HLLW prior to immobilization	350[a]	80
Actinide separation prior to immobilization	200[b]	88

a - Would also produce about 9500 m^3 of low-level concrete waste requiring disposal

b - Would also produce about 9500 m^3 of LLW requiring disposal

Alternative Long-Term High-Level Waste Management Strategies for the ICPP

Alternative Strategies	Process Options			
	Waste	Immobilization Process	Shipment	Disposal
1. Dispose of Waste in a Geologic Repository	Calcine and liquid waste	Volume reduction and glass/ceramic		Repository
2. Dispose of Waste in a Near Surface Facility	Calcine and liquid waste	Calcination and bin hardening or glass/ceramic		Near surface or
3. Dispose of Annually Generated Waste in a Geologic Repository and Dispose of Existing Calcine in a Near Surface Facility	Annually generated liquid waste	Volume reduction and glass/ceramic		Repository
	Existing calcine	Bin hardening		Near surface

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Fig. 4. HLW Reduction Strategies at ICPP.

CONCLUSION

Management of ICPP HLW by storage in a small tank farm followed by calcination and then interim storage in stainless steel bins has proven to be a safe and practical process. For the long term, a research and development plan has been developed to implement a strategy and process(es) for ultimate disposal of ICPP HLW on the schedule consistent with the DWMP and in consonance with the objective to reduce the volume of HLW generated in the U.S.