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Title: GLOVEBOX DESIGN REQUIREMENTS FOR MOLTEN SALT OXIDATION PROCESSING OF TRANSURANIC WASTE

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GLOVEBOX DESIGN REQUIREMENTS FOR MOLTEN SALT OXIDATION PROCESSING OF TRANSURANIC WASTE

Abstract: This paper presents an overview of potential technologies for stabilization of ^{238}Pu-contaminated combustible waste. Molten salt oxidation (MSO) provides a method for removing greater than 99.999% of the organic matrix from combustible waste. Implementation of MSO processing at the Los Alamos National Laboratory (LANL) Plutonium Facility will eliminate the combustible matrix from ^{238}Pu-contaminated waste and consequently reduce the cost of TRU waste disposal operations at LANL. The glovebox design requirements for unit operations including size reduction and MSO processing will be presented.

INTRODUCTION

Los Alamos National Laboratory has processed $^{238}PuO_2$ fuel into heat sources for space and terrestrial uses for the past several decades. The 88-year half-life of ^{238}Pu and thermal power of approximately 0.6 watts/gram make this isotope ideal for missions requiring many years of dependable service in inaccessible locations. However, the same characteristic which makes ^{238}Pu attractive for heat source application, the high Curie content (17 Ci/gram versus 0.06 Ci/gram for ^{239}Pu), makes disposal of ^{238}Pu-contaminated waste difficult. Specifically, the thermal load limit on drums destined for transport to the Waste Isolation Pilot Plant (WIPP), 0.26 grams ^{238}Pu per drum for combustible waste (DOE, 1996), is impossible to meet for nearly all ^{238}Pu-contaminated glovebox waste.

Molten salt oxidation (MSO) processing provides a method for removing greater than 99.999% of the organic matrix from combustible waste. Rockwell International has used a bench-scale process to destroy chemical warfare agents (VX, GB, mustard), halogenated solvents (trichloroethane, chloroform), pesticides (malathion, DDT), herbicides (2,4-D), and polychlorinated biphenyl (PCB) compounds (Dustin, 1977; Yosim, 1980). In addition, Rockwell International has used the MSO process to destroy Pu-contaminated combustible (paper, plastic, and rubber) waste (Grantham, 1976). Lawrence Livermore National Laboratory (LLNL) has used a pilot-scale MSO processing unit to destroy organic solvents including mineral oil, toluene, and pyridine (Hsu, 1997). Naval Surface Warfare Center, Indian Head Division, has used the MSO process to destroy solid energetic materials (Heslop, 1998). The implementation of MSO processing at the LANL Plutonium Facility will substantially reduce the volume of combustible transuranic (TRU) waste for WIPP disposal. Potential sources of Pu-contaminated combustible waste for MSO processing include cellulose rags and plastics (i.e., polyethylene and polyvinyl chloride).

PROCESS DESCRIPTION

The implementation of an integrated processing operation including MSO waste treatment and aqueous chemical separation at the LANL Plutonium Facility will further reduce the cost of waste disposal operations. The processes for combustible waste treatment and Pu-238 aqueous recovery are described below.

Molten Salt Oxidation

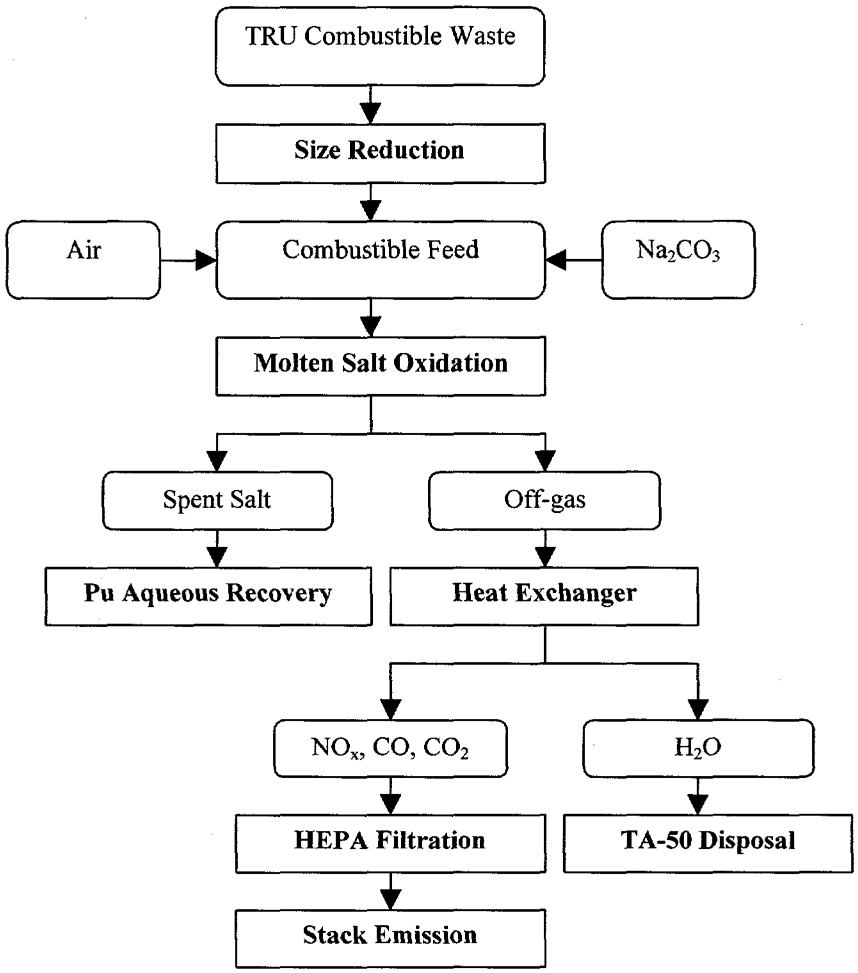
In the MSO process, a molten alkali salt (e.g., sodium carbonate) serves as a catalyst for the conversion of organic material and oxygen to water and carbon dioxide. Acidic species such as fluorine, chlorine, bromine, iodine, sulfur, phosphorous, and arsenic in the organic waste react with the molten salt to form the corresponding neutralized salts, NaF, NaCl, NaBr, NaI, Na_2SO_4, Na_3PO_4, and $NaAsO_2$ or Na_3AsO_4. Plutonium and other metals in the organic waste react with the molten salt and oxygen to form metal oxides or salts. These metal oxides and salts are commonly referred to as "ash." An ash content of less than 20 wt % must be maintained to preserve the fluidity of the salt melt. In addition, the concentration of sodium salts formed as a result of the acid neutralization reaction must be limited to less than 85 wt % to prevent an eventual loss of the acid gas removal capability. Because the ash and sodium salts are products of the overall oxidation reaction, the concentration of these products will increase in the molten salt as a function of the quantity of waste processed. Therefore, periodic disposal of the "spent" salt is required to maintain continuous operation of the MSO processing unit.

The process flow diagram for the MSO processing of Pu-contaminated combustible waste is shown in Figure 1. For the first step in the MSO process, solid organic waste is reduced in size to less than 0.5 inch in diameter using a cryogenic shredding apparatus. Following size reduction, the solid feed is transferred into the molten salt via a screw feeder transport system. Process air is also injected into the molten salt via the screw feeder transport system. The reaction temperature can be maintained at any desired level, typically in the range of 800°C to 900°C. The products of the oxidation reaction, carbon dioxide, steam, and excess air, exit the processing unit via the off-gas outlet. Off-gases from the processing unit are routed through a water- or air-cooled heat exchanger to prevent degradation of the HEPA filtration system. Entrained or condensed salts in the off-gases are subsequently collected in bag filters. In the final step of the process, the off-gasses are routed to the HEPA filtration system for particulate removal and subsequently released to the environment.

Pu-238 Aqueous Recovery

The spent salt is transferred to the aqueous chemical separation process for recovery of Pu-238. The Pu-238 in the spent salt can be dissolved in concentrated acid and separated from impurities (e.g., Si, Fe, Cr, Al, Ni, P, 234U, etc.) using ion exchange and oxalate precipitation methods. The final product of aqueous recovery, $^{238}PuO_2$, can be used as a fuel for heat source production.

FIGURE 1
PROCESS FLOW DIAGRAM FOR MSO PROCESSING



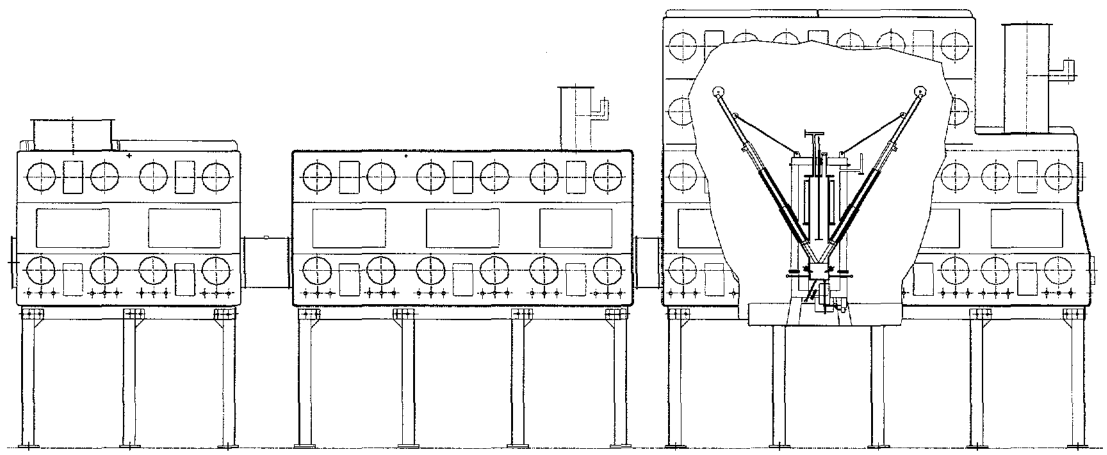
EQUIPMENT DESIGN

The glovebox design for the size reduction and MSO process is shown in Figure 2. The complete glovebox line for the waste treatment process will consist of three gloveboxes. The size reduction process will operate in a double-sided glovebox equipped with six workstations. The MSO process will operate in a double-sided glovebox equipped with eight workstations. The glovebox for the size reduction process will be connected directly to the facility dropbox and the glovebox for the MSO process will be connected directly to the glovebox for the size reduction process. The equipment design for the size reduction and MSO processes is described below.

Cryogenic Shredder

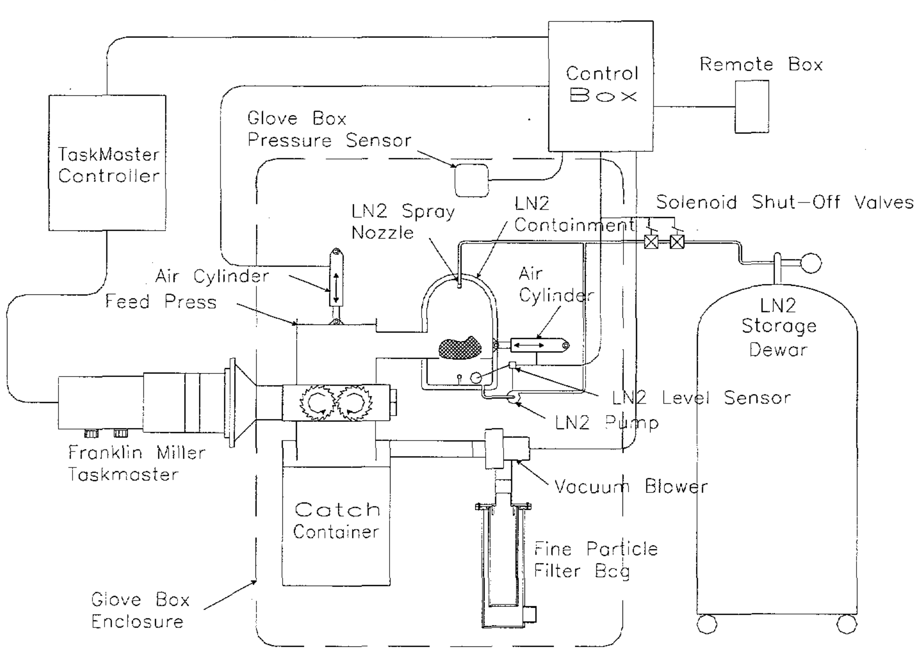
As shown in Figure 1, the MSO process will require a size reduction step for feed preparation. The screw feeder solid transport system will restrict the size of the feed to < 0.5 inch. Therefore, the solid feed (i.e., plastic bottles, filters, and tubing) for the MSO process must be reduced in size using a cryogenic shredding process. The conceptual design for the size reduction process is illustrated in Figure 3. For the first step in the process, the bulk feed material is sprayed with liquid nitrogen in order to produce brittle feed material for the mechanical shredding process.

FIGURE 2
GLOVEBOX LINE FOR MSO PROCESSING



MSO-V2 GLOVEBOX LINE

FIGURE 3
CONCEPTUAL DESIGN FOR CRYOGENIC SHREDDING PROCESS

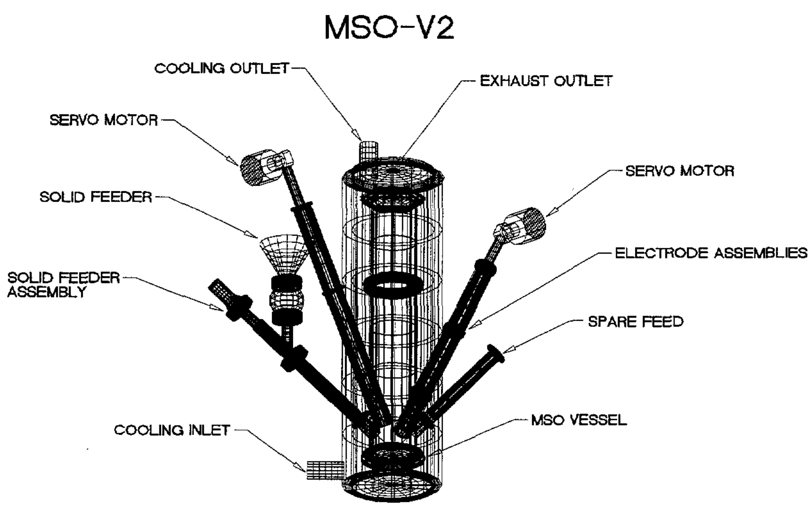


A safety interlock system consisting of a glovebox pressure sensor, liquid nitrogen pump, and solenoid shut-off valve will control the flow of liquid nitrogen into the glovebox. For the second step in the size reduction process, a mechanical ram will transfer the brittle feed material to a mechanical shredder. For the final step in the size reduction process, the rotating metal teeth in the mechanical shredder will reduce the size of bulk feed to < 0.5 inch. The feed material for the MSO process will be collected in a container located below the mechanical shredder. A vacuum system will collect the material fines in a filter bag.

MSO Processing Unit

Equipment for the MSO process will be purchased from a commercial vendor. Molten Salt Oxidation (MSO) Corporation has developed and patented a prototype unit for MSO processing (Wernly, 1997). The design of the MSO-V2 unit is shown in Figure 4. The features of the MSO

FIGURE 4
MSO CORPORATION MSO PROCESSING UNIT



MSO prototype include the following: 1) capability for processing 2 kg bulk feed/hr, 2) internal heating by electrodes, 3) metal alloy (Inconel 600) construction of primary reaction vessel, 4) multi-zone cooling of reaction vessel to maintain inner salt layer (skull) during operation, 5) provision for salt layer to protect primary reaction vessel at temperatures in excess of 900°C, 6) utilization of Phase Change (PC) valve to drain primary reaction vessel on demand, and 7) complete automation of system operation. The feasibility of installation and operation of the MSO-V2 unit in a glovebox at the LANL Plutonium Facility is illustrated in Figure 2.

SUMMARY

Implementation of size reduction and MSO processing technology at the LANL Plutonium Facility will eliminate the generation and storage of ^{238}Pu-contaminated combustible waste. MSO processing units are now available for glovebox application. The integration of MSO processing and aqueous chemical separation offers a method for recovering Pu-238 from the combustible waste stream.

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