Salt Distillation

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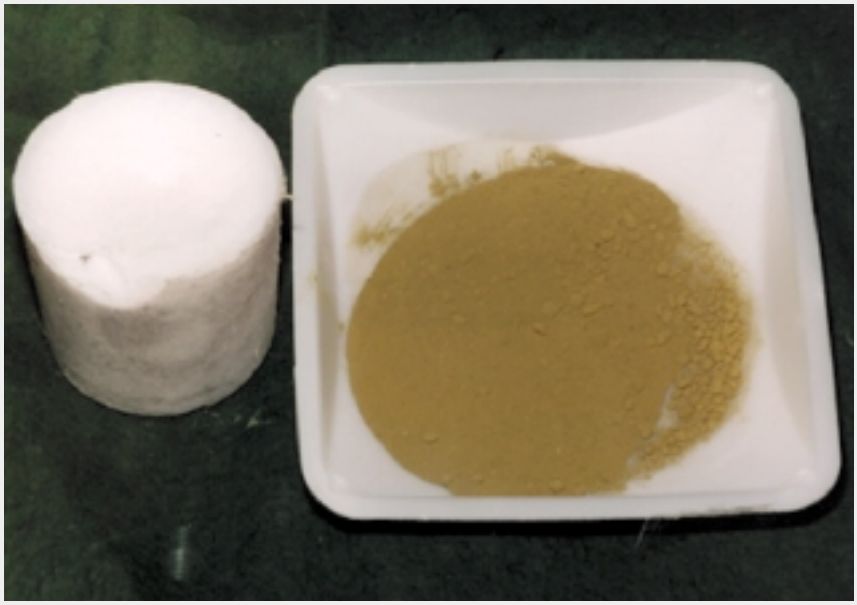
The basis for a vacuum distillation separation is the large difference in vapor pressure between chloride salts and actinide oxides. Contaminated salts are heated in a furnace under high vacuum. The salts vaporize and leave the furnace, while the non-volatile plutonium compounds remain behind. The salt is recovered by allowing the vapor to strike a cold plate, where it condenses.

Because the vapor pressures of the various residue components are known, we can calculate the rate of deposition and the remaining plutonium concentration in distilled salts. The results are shown in Table I for a distillation process carried out at 850°C. Measured deposition rates have been found to be slower than these calculated values—sometimes by orders of magnitude. Nevertheless, experiments have shown that below 900°C, all of the chloride salts except calcium chloride can be distilled at acceptable completeness and rates. Column 2 in the table reveals that the best separation can be achieved between plutonium dioxide and the chloride salts. Efficient separation will not be obtained if plutonium trichloride, $PuCl_3$, is present in the system. But the residual salts can be pretreated by an oxidation process that will convert all plutonium species to plutonium dioxide, thereby eliminating this separation problem.

The calculated plutonium concentrations in the distilled salts (column 3) represent low theoretical limits. In practice, it has been found that plutonium contamination levels of distilled salts are determined by contamination in the glove-box environment in which the process is carried out. The product contamination levels are on the order of several parts per million (ppm).

Table I. Calculated Deposition Rates and Distillate Plutonium Concentrations for Salt Residue Constituents at 850°C

Compound	Log of Vapor Pressure (torr)	Calculated Deposition Rate ($g\ hr^{-1} \times 100\ cm^2$)	Calculated Pu Concentration (ppm)
NaCl	–0.063	4100	5.3×10^{-10}
KCl	0.23	9100	2.4×10^{-10}
$MgCl_2$	0.27	11000	1.9×10^{-10}
$CaCl_2$	–2.9	9	2.4×10^{-7}
Pu	–8	$1 \times 10^{-3.7}$	
PuO_2	–15.7	1×10^{-12}	
$PuCl_3$	–1.8	178	
PuOCl	–8	$1 \times 10^{-3.7}$	



The salt distillation process will separate residual plutonium from pyrochemical chloride salt residues. The products from a test run are shown in the photograph. The large volume of recyclable chloride salt distillate stands next to the tray containing the small volume of nonvolatile actinides. The TRU waste volume reduction is greater than 95 percent.