LETTERS TO THE EDITOR

LET'S GOLD-PLATE NUCLEAR WASTE

Not only must nuclear waste disposal be safe, but the public and government officials must be convinced that it is safe. Presently, spent fuel from nuclear power reactors is stored underwater, with continuous surveillance and decontamination equipment to deal with leaks. This can be only a temporary solution.

Eventually, the spent fuel may be dissolved and chemically processed to separate plutonium and uranium from the fission products. The liquid waste containing the fission products and the small but non-negligible amount of actinides is not suitable for long-term safe storage and must be solidified as a calcine or as mixed oxides incorporated in a silicate or phosphate glass matrix. Calcine is a powder with a large surface area and only moderate resistance to leaching or dissolution in water. Some glasses do have very low solubility in water and are cast in large bodies with relatively low surface-to-volume ratios. If leachability (g/cm^2 dissolved per year) and surface area remained small, there would be little concern for radioactive contamination of groundwater from buried high-level waste. However, how can anyone prove that these glasses will remain intact and low in leachability over the hundreds to thousands of years considered necessary, especially under irradiation by the contained radioactive substances?

A second barrier is needed, the canister containing the solidified waste (or spent fuel elements until reprocessed). Stainless steel has been proposed for solidified glassy waste but is not expected to survive corrosion of hundreds to thousands of years. If the canisters are imbedded in salt, as proposed for deep geologic disposal, stainless-steel canisters may leak in a few months.

There is only one substance that the public recognizes to be extremely corrosion resistant in nature: gold. It dissolves only in aqua regia and a few other reagents (not found in nature). Gold nuggets or flakes are found in water or rock millions of years old. Gold-plated or gold-clad canisters can be built and tested for leaks and will not corrode. Since gold is expensive and soft, plating or cladding of a structural material is proposed instead of pure gold. The structural material can be designed for any pressure buildup or mechanical stress. The melting point of gold is relatively high, 1063°C, and gold is an excellent heat conductor, and hence temperature resistance is good. If greater resistance is deemed necessary, gold plating could be combined with tantalum, which has excellent corrosion resistance and a higher melting point (2996°C). An external coating would be required to protect the gold plating from abrasion.

The quantity of gold needed depends on the density of the waste. Presumably, spent fuel rods could be compacted by removing the spacing plates, or the UO_2 pellets could be removed from the cladding. A 1000-MW(electric) reactor [3 GW(thermal)] discharges some 30 MT of spent fuel per year, $\sim 10^7$ cm^3 or less, depending on density. Assume for heat transfer purposes and criticality safety that the canisters are 30 cm in diameter, with a fuel rod length of 360 cm or a volume of 2.5×10^5 cm^3 each. Then, up to 40 canisters per year per reactor would be needed. If the fuel is reprocessed and solidified, it has been calculated that ~30 canisters per year would be generated from a 1000-MW(electric) reactor. Let us take the largest number, 40. Surface area is 3.5×10^4 cm^2 each. Assuming a gold-plating thickness of 0.0025 cm and gold density of 19 g/cm^3, 1.7×10^3 g of gold per canister is needed or 6.8×10^4 g for 40 canisters. Gold value is now around $140 per troy ounce or $4.50/g. Thus, the value of the gold in 40 canisters is $306 000. If the waste is buried in a nonrecoverable situation, the cost of the gold over the 40-yr plant life is $12.2 million, not very significant compared to the $1000 million capital investment in the plant.

Actually, the gold is not consumed and could be recovered if a better method of waste disposal were invented. Also, after several decades, the heating will have decayed, so larger containers would be feasible. Handling and transportation might limit container size to, say, 300 cm in diameter and 360 cm long. Volume is 100 times that of the 30-cm-diam canisters, so only 16 of the large containers would be needed over the life of the 1000-MW(electric) plant. The surface area is 4.8×10^5 cm^2, the gold-plating mass is 2.28×10^4 g for 0.0025 cm thickness, and the gold value is $102 600 per canister or $1.64 million total. Permanent disposal would be economically acceptable, even if thicker plating were used. The containers should be buried in reinforced concrete vaults to protect them from explosions and meteors.

Gold-plated nuclear waste containers, properly protected, should last for thousands of years. Equally important, it should be possible to convince the public and government officials that the storage is safe, because they know that gold lasts.

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