Reprocessing methods available to states: who's afraid of nuclear waste?

by Jon Gilbertson

The only real problems associated with the disposal of nuclear wastes are political, not technical. To solve the nuclear waste problem today requires implementing a program that will put in operation by no later than 1988 the first underground depository to receive solidified high-level wastes from commercial reactor fuel. The technology to do this is at hand now and, in fact, has been available for well over a decade. What is lacking is the resolve at the national and state level to get the job done.

There are three basic parts to a nuclear waste management program: separating the radioactive fission product wastes from the spent fuel, recycling the unused uranium and plutonium fuel included in the spent fuel back into nuclear power reactors, and routing the wastes through a waste storage process.

The point is that we are not dealing with developing a new technology, such as nuclear fusion reactors, magnetohydrodynamic energy conversion systems, or advanced fission reactors. We are talking about burying something for a long time, using technologies that exist now and are known to work.

What are nuclear wastes?

Although all types of waste are important, the most important, and the one causing the major controversy now, is high-level waste; that is, waste that has high radioactivity levels. High-level wastes include all the fission products built up in spent fuel over an approximate three-year period of operation, as well as small amounts of some transuranic elements that are left over after the reusable uranium and plutonium have been removed for recycling.

The other source of nuclear waste within the fuel includes the radioactive elements created by a nonfission capture of a neutron in uranium or some other heavy element in the fuel. These are generally called the transuranic elements and include neptunium, americium, and curium, plus small amounts of plutonium and uranium that do not get separated out during the reprocessing operation. Although very small in quantity compared to the fission product waste, these transuranic elements are important because they have very long decay times and, therefore, require long-term storage.

It is only this small portion of the spent fuel, less than 4 percent, that is considered high-level waste and must be disposed of.

Since President Carter's 1977 decision to stop fuel reprocessing, the United States has been left with the situation where all spent fuel is considered to be nuclear waste material. This has increased the amount of waste products, radioactivity, and heat production levels to be handled, since all spent fuel (100 percent) must be treated as high-level waste. In addition, the prohibition of reprocessing essentially throws away 40 percent of required fuel for new fuel elements that could be recycled back into the reactor—a combination of uranium-235, plutonium-239, and plutonium-241.

The only competent way of dealing with nuclear waste is to integrate the waste products into a fully closed nuclear fuel cycle; that is, a fuel cycle with fuel reprocessing. In a closed fuel cycle, nuclear waste becomes a by-product to be disposed of in a straightforward manner.

To implement a program of safely and economically disposing of nuclear wastes in the United States, it is essential that the nation reinstitute a fuel reprocessing policy. Until that time, a temporary measure for waste disposal must be the finding or constructing of adequate storage areas, away from present reactor sites, simply to store the current and future spent fuel coming out of operating nuclear plants. This is only a stop-gap measure; the actual solution to the problem must involve reprocessing. Once fuel reprocessing is reestablished, it will be a simple matter of shipping these stored fuel bundles to the reprocessing plant.

Storage technology

There are two technical problems in handling and storing radioactive nuclear fission waste material. The first is the radioactivity from the decay of unstable elements by either alpha or beta particles and gamma rays. This radiation is dangerous to human beings from external or internal sources; therefore, it must be kept isolated from the biosphere for as long as the activity remains high.

The second problem is that radioactive decay produces energy in the form of heat, and this heat must be dissipated for as long a time period required in order to keep material temperatures below certain design limits. Both the shielding and the heat removal must be resolved simultaneously.

The most technically developed process for high-level waste disposal is to store the waste in concentrated liquid form at ground level for a cooling period of 5 to 10 years. At that point it can be solidified into small cannisters and buried in a deep underground location in thick, stable rock-salt strata. Liquid storage of the waste and eventual solidification all will take place on the reprocessing plant site in a completely controlled and monitored environment. For years storage of liquid wastes has been a state-of-the-art technology. In fact, the Department of Defense has used storage in this form since the early 1940s and has highly developed the technique.

This proposed solidification process uses an automated system that converts the liquid waste by evaporation to a fine powder, mixes it with a fine glassy frit material, and converts it to a solid glassy cylinder by heating the mixture to melting and then solidifying it. The solid waste cylinder is sealed in a stainless steel canister and shipped to an underground burial site in specially designed shipping casks.

The only part of this waste disposal process that does not yet exist is the deep underground burial site, which can be developed and constructed with state-of-the-art technology. The actual storage area would be located 600 meters underground, in the middle of a thick salt layer. The stainless steel canisters would then be placed inside other containers made out of high-conducting iron oxide concrete that was specially designed to protect against possible salt corrosion. This concrete canister would then be inserted in cylindrical holes drilled into the salt. Heat is transferred and dissipated by conduction from the waste products, through the containers, and into the surrounding salt medium. The canisters would remain there forever or could be removed during the early decades of operation. This capability for removal might be desirable if it were later decided to use the waste products, their radioactivity, or heat energy in a productive way, or if some modification of canister design were needed. Therefore, it is recommended that at least the first few storage facilities be designed with a retrievability option for the first 75 to 100 years.

Because we know more about rock salt formations and their interaction with nuclear wastes, the first one or two depositories should be located in such formations. Burial in other types of geological formations such as granite, basalt, and slate, has also been suggested. If for some unforeseen reason the rock salt depository does not appear to be operating according to design expectations during the first few decades of service, the canisters could be removed and transferred to this new rock formation-based depository. And having such a back-up capability should satisfy even the most critical opponents of nuclear power.

A fuller version of this article appeared in the August 1980 issue of Fusion, *Vol. 3, No. 10, the magazine of the Fusion Energy Foundation.*