**Managing Nuclear Wastes**

Some may consider a career in managing nuclear waste as being just about the worst job anyone would ever want, but hundreds of technically trained people have spent years working to solve the problems associated with nuclear power. The major part of the continuing challenge is political. Nuclear power plants generate about 23% of the electricity in the United States. Most of the high-level nuclear waste (HLW) that is generated from nuclear power plants—in the form of spent nuclear fuel (SNF)—is generated where many people live, in the eastern half of the United States. The safest place for a repository is away from people, in a dry, remote location, probably in the western United States, where there are fewer people (and fewer votes!).

SNF constitutes about half of the HLW in the United States. The other half comes from the construction and existence of nuclear weapons. All HLW is a federal responsibility. About 90% of the radioactivity in nuclear waste is from HLW. The largest volume of nuclear waste is low-level waste (LLW), and that is mostly the responsibility of the state (or group of states) in which it is generated. LLW is rather awkwardly defined, being everything that is neither HLW nor defense waste and consists of wastes from hospitals; pharmaceutical labs; research labs; and the moon suits, tools, and the like from nuclear power plants. In the eastern United States, most of the LLW is in the form of the plastic beads that make up the ion-exchange resins used in nuclear power plants to clean various loops of water used in power production.

Plutonium wastes from the Los Alamos National Laboratory in northern New Mexico were trucked for the first time to the federal Waste Isolation Pilot Plant in Carlsbad in March 1999. The 270 kg of waste consisted of plutonium-contaminated clothing and metal cans, packed in boxes and stainless steel containers. Most of the material was from the laboratory’s manufacture of nuclear batteries used in NASA’s deep space probes and will be buried in the depository carved out of ancient salt caverns about half a mile (0.8 km) below ground.

Most current attention is focused on SNF for two reasons. It is highly radioactive and it can be seen as a “local” problem because it is made where electric customers live. Europe has reprocessing plants to recover the unused fissionable material for new fuel, but the United States disallowed the practice in the 1970s. This partially explains why spent fuel rods have been piling up at US nuclear plants.

Research focused on Yucca Mountain, Nevada, at the western edge of the National Test Site, for its suitability as a nuclear waste repository for SNF and some defense waste. In July 2002, after both houses of the US Congress voted to override a veto by the State of Nevada, President George W. Bush signed the bill making Yucca Mountain the central repository for the nation’s nuclear waste. Many political leaders and residents of Nevada strongly opposed this plan, and they seriously question that nuclear waste can be safely kept out of the human environment for 10,000 years, as is required under the federal Nuclear Waste Policy Act.

The numbers describing SNF are barely comprehensible to most people. The volume of all existing SNF could cover a large football stadium to a depth of 4 or 5 feet, but no sensible person would want to confine that much heat and radioactivity to one place. Another description is the 70,000 metric tons of SNF generated to date in power plants, a figure that means little unless one understands thousand-kilogram quantities and knows the density of fission products. The plans for Yucca Mountain are that it will hold, in its many miles of tunnels and caverns, all the SNF so far generated and expected to be generated in the next few years.

The SNF portion of HLW can be understood by chemists who see in it nearly every element on the periodic chart of the elements. After a 235U nucleus undergoes fission and releases its excess nuclear binding energy, it leaves a pair of new atoms. These fission products are like newly born forms of the elements that are already well known and, like newborns, are unstable until they mature. There are about 1000 isotopes of about 100 different elements in SNF, and most are radioactive. They decay into stable elements at different rates, giving off alpha, beta, and gamma emissions. It will take about 7000 years until the SNF will be only as radioactive as the rocks and minerals that make up our planet.

These fission products are housed in long titanium rods, each about the diameter of a pencil, that constitute the fuel assembly in a nuclear power plant. Workers wearing gloves can handle fuel assemblies before fissioning occurs. But after removal from a nuclear reactor, the fuel assembly is stored in a cooling pool of water beside the reactor for at least 10 years. If the power plant has a small cooling pool, on-site storage of the oldest fuel assemblies occurs in specially constructed concrete casks until the federal government takes ownership and finds a suitable place for it. Fuel rod consolidation is sometimes practiced to save space because much of the space in a fuel assembly was present so power plant water could easily pass and pick up the heat generated by the fission process.

Other options that have been considered for HLW include outer space ejection and burial in deep ocean trenches. The consensus worldwide is that deep geological isolation is the best option. The United States leads in studying a specific site, Yucca Mountain. In other countries, even those generating a larger percentage of their power with nuclear power, the small volumes awaiting burial allow them more time to choose a location.

From the cost-benefit analyses of all the ways we make and use electrical power to the way the wastes are handled, one can find an issue or a career. Here are a few key issues to study and discuss:

▶ *Transportation of the waste to its repository*. Should it be done by rail or by truck? Should there be public notification of the time of transport? Are there response measures in place in case of an accident?

▶ *The site’s seismicity*. Will there be significant volcanic or seismic activity near the site in the next 10,000 years?

▶ *Hydrology*. Is there enough evidence to ensure that radionuclides will not seep into groundwater to any significant degree?

▶ *Public education*. Should conservation be taught, and should teachers promote or discourage the role of nuclear power in our nation’s power mix?

▶ *Other technical options*. Should one investigate nuclear physics options that might transmute the long-lived radioisotopes into ones with shorter half-lives regardless of the costs?

▶ *Weapons disarmament*. Should the plutonium from “disarmed” nuclear weapons eventually be turned into nuclear fuel or made useless immediately and buried with other HLW?