TYPES OF NUCLEAR WASTE

INTRODUCTION

The main emphasis of these curriculum materials is the development of a disposal system for spent fuel and high-level waste. To gain perspective, however, students should understand that spent fuel is not the only type of nuclear waste requiring disposal in the United States.

High-level nuclear waste results from defense activities. Low-level nuclear waste is generated at governmental and commercial sites. A type of nuclear waste called “transuranic waste” is also generated, primarily from defense activities. Transuranic nuclear waste is physically similar to low-level nuclear waste but is contaminated to a level requiring special handling, with long-lived radioactive elements higher than uranium in atomic number. A fourth type of nuclear waste requiring disposal is “mill tailings” generated by the recovery of uranium from mined uranium ore. Each type of waste will be disposed of in a way appropriate to its characteristics.

SPENT NUCLEAR FUEL

Spent fuel is fuel that has been used in and then withdrawn from a nuclear reactor. All spent nuclear fuel from commercial nuclear powerplants will be disposed of in a geologic repository for high-level waste. The U.S. does not reprocess commercial spent fuel. The spent fuel rods will be sealed in special metal canisters for disposal. In addition to commercial spent fuel, there is some Department of Energy-owned spent fuel and high-level waste, some Navy reactor spent fuel, and high-level waste that results from non-DOE research reactors. Ultimately, all of this spent fuel and high-level waste is destined for geologic disposal.

HIGH-LEVEL NUCLEAR WASTE

High-level nuclear waste is generated by the chemical reprocessing of spent nuclear fuel to recover uranium and/or plutonium. All high-level nuclear waste will be disposed of in a geologic repository. The waste, in liquid form after reprocessing, will be solidified into a glass or ceramic form and will be sealed in metal canisters for permanent disposal. In 1985, President Reagan made the decision that separate repositories for the disposal of defense high-level waste and commercial spent fuel and high-level waste are not necessary.

LOW-LEVEL NUCLEAR WASTE

All radioactive waste other than spent fuel, high-level waste, and transuranic waste is considered to be low-level waste. Low-level nuclear waste is generated at commercial nuclear powerplants, hospitals, industrial and agricultural facilities, and academic institutions. Depending upon its activity, the low-level waste is disposed of in various forms of shallow-land burials.

Low-level waste from all activities, except Federal defense or research and development activities, will be the responsibility of the State in which the waste is generated. Low-level waste will be disposed of in facilities developed by individual States or groups of States known as compacts. Specially designed aboveground facilities and shallow-land burial are being considered by States and compacts.

Low-level waste from defense activities and research and development activities of the Federal Government will be disposed of at Federal disposal sites, primarily where the waste is generated. It will not be disposed of at the commercial disposal sites States are responsible for.

TRANSURANIC NUCLEAR WASTE

Transuranic waste is physically similar to low-level waste but is contaminated with transuranic elements to a level requiring geologic disposal. Although the total activity of transuranic wastes are no greater than certain low-level wastes, geologic disposal is considered necessary because they lose radioactivity very slowly and remain hazardous for thousands of years.

Transuranic wastes result primarily from defense activities. Some transuranic waste is being stored in surface facilities but current plans call for most of this waste and transuranic waste generated in the future to be ultimately placed in deep geologic storage at the Waste Isolation Pilot Plant (WIPP) facility in New Mexico. The transuranic waste disposed at the WIPP facility will be in the form of solids sealed in metal canisters.

MILL TAILINGS

Mill tailings are naturally radioactive rock and soil that are byproducts of mining and milling uranium. They are generally disposed of where they are generated, at facilities where uranium ore is mined and milled. The Federal Government has responsibility for mill tailings at inactive milling facilities. Companies currently milling uranium must make sure their disposed tailings are in compliance with government and State regulations.

STORAGE OF SPENT FUEL

INTRODUCTION

After being removed from the reactor, the spent fuel is stored under water in a storage pool at the reactor site. Typically, about one-third of the fuel assemblies in a reactor are removed and replaced by fresh fuel once every fueling cycle. At present, utilities are using fueling cycles of 12 to 24 months, depending on the reactor type, fuel, and operating conditions.

The storage pools at reactors are designed to store a limited amount of spent fuel. Ultimately, if there is not enough space in the storage pool to accept additional spent fuel, the utility must either remove from the pool some of the spent fuel that has been stored there or stop operating the reactor. In some cases, if the utility is operating nuclear powerplants at several different sites, the spent fuel removed from the pool may be shipped to another site for storage in a pool that has space. This option is not available for most reactors, and it provides only a temporary solution.

A number of utilities may be faced with a shortage of storage capacity for their spent fuel. The storage capacity can be increased by increasing the capacity of the storage pools or by providing dry storage outside the pool. In-pool capacity can be increased by changing the racks that hold the spent-fuel assemblies inside the pool or by consolidating the fuel rods into more compact arrays.

INCREASING IN-POOL CAPACITY BY RERACKING

Initially, the racks that hold spent-fuel assemblies in the storage pools were not designed to maximize the amount of spent fuel that can be stored in a pool. (When the pools were built, it was expected that the spent fuel would be removed and reprocessed.) The storage capacity of a spent-fuel pool can be increased by *reracking* the pool. Reracking means changing the arrangement of the racks that hold the spent fuel assemblies.

SAFETY FACTORS IN RERACKING

According to the Nuclear Regulatory Commission (NRC), facilities for spent fuel storage must be designed to prevent, by a safe margin, the occurrence of a “critical mass,” even under accident conditions. In a nuclear reactor, the fissionable fuel is arranged in such a way that, under operating conditions, a critical mass is achieved in the fuel and a chain reaction occurs in which one neutron from each fission causes another atom to fission. The reactor is then said to have “gone critical” or to have achieved *criticality*. An inadvertent criticality in a spent fuel storage facility could overheat the fuel, cause significant damage to the fuel rods, increase the emission of radiation, and possibly release excessive amounts of radioactive elements.

In terms of criticality, the amount of fuel that can be stored inside a given storage pool depends on both the geometric arrangement of the fuel and on the materials used in the storage racks. In reracking, the single most important factor is the spacing between the spent-fuel assemblies. Usually the racks provide more spacing than is needed to preclude a potential for criticality, and therefore, more spent fuel can be accommodated if the standard racks are replaced with racks providing closer spacing.

The ability of the pool to safely support the weight of additional spent fuel is also considered. Other factors that are considered are the ability to meet the NRC's seismic criteria, heat generation and pool cooling, shielding from radiation, water cleanup, and ability to accommodate in-service inspection.

Reracking is usually the initial choice of utilities for increasing storage capacity at reactor sites. The technology for reracking is fully developed and reracking is usually the least expensive of all available options.

INCREASING IN-POOL CAPACITY BY ROD CONSOLIDATION

Rod consolidation is another option for increasing in-pool capacity. It involves mechanically removing the fuel rods from the hardware that holds them together in a spent fuel assembly and rearranging them in a more compact array inside a metal canister. At-reactor consolidation is performed under water in the spent fuel storage pools. As with reracking, structural strength and seismic characteristics of the storage pool are considered to determine whether this option can be used. With consolidation, potential for neutron chain reaction is lower than it is in reracking for the storage of intact spent-fuel assemblies. This is because a closely packed array does not enhance a nuclear chain reaction.

DRY-STORAGE CONCEPTS

In addition to expanding in-pool capacity, the capacity of at-reactor storage can be increased by providing dry storage. Dry storage can be in various types of casks, modules, or vaults located outside the pools. Such dry-storage concepts include metal casks, concrete casks, horizontal concrete modules, modular concrete vaults, and dual-purpose casks. Dry storage can accommodate either intact spent-fuel assemblies or canisters of consolidated spent fuel.

AGE OF SPENT FUEL FOR DRY STORAGE

All spent fuel will be stored first in the spent fuel pool where its radioactivity and rate of heat generation diminish. The spent fuel that would be stored in any of the dry-storage systems would be fuel that has been stored in a spent fuel pool for at least one year, and most likely several years.

Thus, if dry storage is to be used at a reactor site where the spent fuel pool is filled to capacity, it will be necessary to remove from the pool spent fuel that has been stored under water for at least a year and transfer it to dry-storage facilities. The spent fuel could be removed by loading it into a storage cask under water inside the pool, lifting the loaded storage cask from the pool, and transferring the cask to the dry-storage facilities. A transfer cask could be used for removing the spent fuel from the storage pool, moving it to the dry-storage facilities, and loading it into the dry-storage cask, module, or vault. Removal and transfer operations would be scheduled to take place when no other operations are required or are under way in the storage pool.

LICENSING CONSIDERATIONS

Except for the consolidation and storage of small amounts of spent fuel, the methods for increasing at-reactor storage will require licensing by the Nuclear Regulatory Commission (NRC). Licensing considerations are important because licensing can be a long process.

Both spent fuel pool storage and dry storage can be used at the same reactor site, but they are subject to different NRC regulations. This is because the spent fuel pool is considered to be an integral part of the nuclear powerplant. Dry storage facilities, on the other hand, are independent facilities that are not considered to be an integral part of the plant.

Source: Final Version Dry Cask Storage Study (DOE/RW-0220), February 1989.