Discussion Paper

Rethinking Spent Nuclear Fuel Management Systems for Security and Safeguards

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The risks associated with the misuses of spent nuclear fuel (SNF) are the manufacture of nuclear and radiological weapons (dispersed radiation sources). Because SNF may be misused by terrorists (nonstate organizations) or nation states, SNF management systems must be designed to minimize these risks. While these risks were not major considerations in the development of the existing U.S. system, they were primary considerations in the development of the German SNF management system. Therefore, the German system, updated for newer technologies and changing conditions in the U.S., may provide the best template for an economic high-security SNF system. While existing SNF systems can and are being modified to meet changing requirements, a SNF system designed from the beginning to meet all the requirements can offer superior performance at lower costs.

Two major security considerations were the basis of the German SNF system: aircraft collisions into SNF storage facilities and highly competent terrorists. In the middle of the Cold War, more military flights took place over Germany than anywhere else in the world. For a period of time, on average, one military aircraft was lost during training and operations each week. Because of the small geographical area of West Germany and the large number of reactors, the safety design requirements for reactors and SNF included the ability to withstand aircraft collisions. At the same time, the German government was fighting a highly competent, efficient domestic terrorist group—the Baader Meinhof gang. This imposed additional security requirements for the SNF system.

The German system consists of (1) storing short-cooled SNF inside reactor containment buildings and (2) then transferring the SNF to metal dual-purpose (storage and transport) casks. Both the reactor containments and casks are designed for resistance to aircraft collisions and terrorist attacks. The use of large casks (>70 tons) eliminates the risks of SNF theft by helicopter or truck. The casks have exterior cooling fins but have no internal air-cooling channels that provide a potential access route for various explosives. Dual-purpose casks minimize handling. Economics favors multipurpose casks. Multiple handling of SNF or multipurpose canisters (containers with multiple SNF assemblies) is extremely expensive because under German requirements, such handling must be done within a containment structure designed to withstand the full range of assaults.

Recent advances in technology could enhance the capabilities of such a system. The option exists for a multifunction cask used for storage, transport, and disposal. Including SNF disposal further reduces risk and may significantly reduce total system costs. This was not an option when the German system when was designed because (1) the original repository design had only hoist access and (2) the hoist technology was insufficient for such heavy casks. However, such a system is a viable option for the Yucca Mountain Repository because a rail system is to be used to transport disposal casks from the surface facility to the underground disposal drifts. New methods may allow the low-cost fabrication of casks made of cermets (ceramics embedded in steel). Cermets are a traditional material used in tank armor. Last, new methods have been developed to improve cask cooling that allow transfer of shorter-cooled SNF to multifunction casks. These methods do not involve air-cooling channels or other mechanisms that reduce cask capability to withstand some types of assault. In the context of nonproliferation, such a system provides easier tracking of SNF and an added barrier for diversion. Large casks can be designed to require significant time to open, are observable from earth orbit, can have individual continuous monitors, and restrict options for rapid transport.

The economics of a fully integrated high-security SNF system will be significantly better than the current SNF management system. The existing SNF infrastructure was designed for low-burnup SNF, storage for several years, and transport to a reprocessing plant when security and safeguards were not major issues. However, the SNF system has evolved into a system for high-burnup SNF that requires significant storage of SNF at the reactor and will require significant storage of SNF at the repository before disposal to reduce decay heat before disposal. With the existing system, SNF is transferred several times from different pools, casks, and hot cells.

A schematic of one such system is shown in Fig. 1 below. The SNF is placed in a multipurpose cermet cask used for storage, transport, and disposal. Specialized overpacks are used for storing short-cooled SNF and for final disposal. The overpacks are needed to meet the contradictory requirements for storage of short-cooled SNF (high-surface-area-cask to remove decay heat) and disposal (low-surface-area cask to minimize corrosion over time). Other options exist as well.

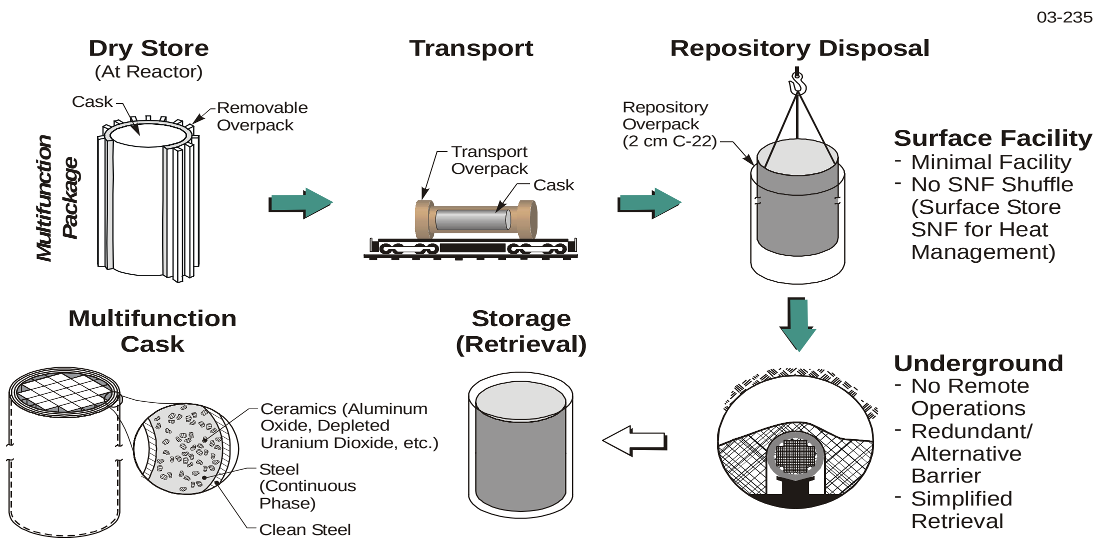

Fig.1 Cermet Multipurpose Cask System,
Including Optional SNF and DU Retrieval