Spent fuel management today

by V. Onufriev*

Spent fuel management comprises operations in the handling and storage of spent fuel elements, from the time they are discharged from the reactor until they are either reprocessed or otherwise disposed of. Because decisions concerning reprocessing and/or the ultimate disposition of spent fuel are often delayed, ever-increasing amounts (especially of water reactor fuel) are accumulating in storage. This accumulation is occurring not only in states which are advanced in the use of nuclear energy for electricity production, but in those which are still at an early stage of development in the nuclear field.

International co-operation in the storage and transportation of spent fuel is the concern of the IAEA, which convened an Expert Group on International Spent Fuel Management to study these topics in the period from 1978 to 1982. Technical and economic aspects of spent fuel management were considered at the International Conference on Nuclear Power Experience held in Vienna in September 1982. The last previous international forum to deal specifically with these questions had been an International Symposium on Spent Fuel Storage, organized by the Nuclear Energy Agency (NEA) of the OECD and the IAEA, held in Madrid in 1978. Some aspects of the dry storage of spent fuel were discussed at an IAEA Specialists' Meeting in Las Vegas in 1980, and at an NEA Specialists' Workshop in Madrid in 1982. Technical, economic, and environmental aspects of spent fuel storage, transportation and reprocessing were considered at an IAEA Seminar held in Madrid in September 1983**, reviewed here.

National programmes on spent fuel management

Only a few countries presented articulated policies on spent LWR fuel management: Czechoslovakia, France, Italy, the UK, and the USA. There are still two options: storage and reprocessing of spent fuel (on a limited basis), and storage followed by final disposal. "Storage" in this context means, in general, intermediate storage lasting about ten years or more pending a decision on reprocessing; pragmatic policies still insist on preserving the option of final disposal of spent fuel, pending the long-term future development of plutonium utilization or other alternatives.

France and the UK confirmed their decision to reprocess spent fuel, but are at the same time increasing their storage capacities. Italy plans to start operation of a commercial reprocessing plant at the end of the 1990s and in the meantime to increase AR (At-Reactor) and AFR (Away-from-Reactor) storage capacity. Czechoslovakia has decided to overcome a current deficiency in storage capacity by constructing additional AFR pools for interim storage during the next ten years.

The USA is focusing on the development of geologic repositories; taking into account the potential for delay in commissioning of the first such facility, monitored retrievable storage facilities will be preserved as a long-term option.

Reprocessing of spent fuel

Only three spent LWR fuel reprocessing plants are in operation today: in the Federal Republic of Germany, at Karlsruhe (35 tonnes per year); in Japan, at Tokai-Mura (200 t/y); and in France, at La Hague (400 t/y). Installations in commission today have reprocessed a cumulative total of about 1400 tonnes of spent LWR fuel.

There are some plans to increase reprocessing capacity in the 1990s in France, the Federal Republic of Germany, Japan, and the UK. Total world reprocessing capacity excluding the centrally-planned economies is expected to be about 5000 t/y in the 1990s, when cumulative arisings of spent LWR fuel will total about 200 000 tonnes.

Intensive research and development programmes are being conducted in France, the Federal Republic, Italy, the UK, and other countries with the following objectives:

- to design plants with reliable units and remote maintenance systems to guarantee large reprocessing capacity;
- to minimize the volume of active wastes, and to develop safe waste containment techniques;
- to ensure the safety of the operators and the control of fissile materials.

Safety and environmental aspects of reprocessing and storage of spent fuel

A detailed analysis of this subject was presented, drawing on past experience and projecting future trends at the British Nuclear Fuels Ltd reprocessing plant at Sellafield (UK). Liquid effluent discharges, always within statutory limits, were reported to have decreased

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continuously during the past ten years; and commissioning of a site ion-exchange treatment plant known as SIXEP is further improving performance. The implementation of new processes, including the treatment of actinide effluents, is expected to reduce significantly discharges from the THORP reprocessing plant which is to be built at the site. It is interesting to note similar trends at the La Hague plant in France: the total discharges of the UP3 and UP2-800 plants are to remain at the same level as those of the present UP2 plant.

The evolution of experience in the radiation exposure of workers has been similar. It is worth emphasizing the importance of variations in dose limits recommended by the International Commission on Radiological Protection (ICRP). Comprehensive analysis shows that the consequences of such variations on the design and operation of present and future plants can be multiple, affecting permitted levels of effluent discharge as well as requirements for waste conditioning. The concept of a "de minimis" level of individual dose, taking into account natural background levels of radiation, was found very interesting and pragmatic.

With respect to the operation of storage pools, it was shown that, taking into account accumulated experience and research and development work concerning cooling, purification of pool water, mechanical structure, and seismic protection, it is quite possible to build and operate satisfactorily installations meeting increased demands for safety. But the cost of the necessary modifications is rather high.

Wet storage

Wet storage is today the main, and essential, technology linking reactor and reprocessing plant or place of final disposal.

World experience has shown that it is possible to store spent fuel in water pools for 20 years and more, starting immediately after discharge of the fuel from the reactor. It is still possible to improve the design and safety of storage pools, and to lower the production of effluents. Progress is also being made in increasing the effective capacity of storage pools by, for instance, rod consolidation.

Water storage of defective fuel rods, which had not shown significant crack evolution for several years, was reported. That means that there is practically no risk of a rapid increase in the contamination of pool water. This result has important implications for the design of the water purification circuits of storage facilities, and for their safe and easy operation. The necessity to take care of stress corrosion risks in the design and construction of pools was confirmed.

Dry storage

Major emphasis in the consideration of dry storage was directed to casks and vaults with natural convection cooling. Long-term operational experience of spent Magnox fuel storage in vaults has been gained at Wylfa, in the UK. There are a few experimental dry-well storage facilities in Japan and the USA. The Canadians have been investigating concrete canisters for several years for spent CANDU fuel. Cask storage has had several proponents, and 16 cask types were reported as now delivered or on order. However, it is worth noting that "hot" experience of dry storage in casks is rather limited and there is not yet a commercial-scale cask-type storage facility.

There was considerable discussion of the costs of both wet and dry storage, as well as of the various possibilities for dry storage. The main lesson to be learnt was that it is always very difficult to make comparisons of the costs of projects in different countries, especially when the assessments may have been done at different times, and used only estimated costs.

There does seem to be some uncertainty in the maximum temperature at which Zircaloy-clad fuel can be stored in a dry environment. Initial experiments carried out by Kraftwerk-Union, in the Federal Republic of Germany, indicate that this temperature could be as high as about 500°C, but the data need to be confirmed by other experiments.

Transportation

Transport of spent fuel is a mature and relatively safe technology. It has a strong and developing basis in international commerce as it is a necessary process in the fuel cycle, with or without reprocessing. Transport modes comprise road, rail, and sea.

Shipping casks are now available in a weight range up to 110 t. Shipment may be either wet or dry, but the casks are generally filled with nitrogen gas. Currently there are 50 casks of the TN and LK series in use, and 25 more are under construction. Lesser numbers of other cask types are also in use.

Extensive experience of sea, rail, and road transportation of spent fuel in accordance with the IAEA Regulations for the Safe Transport of Radioactive Materials has been accumulated. There has been no serious accident involving radiation release and pollution.