PROSPECT FOR SPENT FUEL TRANSPORTATION SYSTEM IN CHINA

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SUMMARY

With the arising of spent fuel from nuclear power plants, a national policy of a closed nuclear fuel cycle has been determined. Following being stored at reactor sites for at least 5 years (with maximum of 10 years), spent fuel will be transferred into an away-from-reactor wet centralized storage facility, waiting for reprocessing.

Therefore, China's spent fuel management activities would be involved in at-reactor storage, transportation, away-from-reactor storage and reprocessing, as well as certainly radioactive waste management.

The status of the nuclear fuel cycle will be briefly discussed and the potential spent fuel transportation system in China is discussed in detail, covering administration, flask, terminals and transportation by sea, rail and road.

INTRODUCTION

To match the policy of closed fuel cycle and meet the requirements of NPP operators, a preliminary feasibility study on the transfer of spent fuel from the Daya Bay NPP to the reprocessing facility was completed a few years ago. China is now launching an ambitious nuclear power program and more spent fuel need to be managed safely. Therefore, in the purpose of establishing an integrated system of spent fuel transportation in China, an extensive transport study covering from all existing and potential NPPs to reprocessing center has started since the late 1996.

The large scale transportation operation is anticipated to take place before 2003 when at-reactor pool of the Daya Bay NPP comes to its full storage capacity.

NUCLEAR POWER AND SPENT FUEL ARISING

There are three units with 2100 MWe in operation in China today. Qinshan Phase one, a prototype unit (PWR) with a capacity of 300 MWe, located in Zhejiang province, was first put into operation at the end of 1991. Then, two units(2×900 MWe) of the Daya Bay NPP in Guangdong province were put into electrical grid in 1993 and 1994 respectively. 62 tHM spent fuel has been annually discharged from these three units currently.

Accordingly, in this FIVE-YEAR (1996-2000) National Economy Development Plan, a total of 8 nuclear power units (Qinshan-II 2×600 MWe PWR, Qinshan-III 2×700 MWe

CANDU, Ling-ao 2×900 MWe PWR, and Lianyunang 2×1000 MWe VVER) with the capacity of 6600 MWe in total, will start to be constructed and are expected to start gradually commercial operation in the early next century. Construction of the two units of Qinshan-II NPP and the two units of Ling-ao NPP has started at June 1996 and May 1997 respectively. Furthermore, several large- or mid-scale NPP projects are being evaluated. It is anticipated that the total capacity of China's NPPs will come to 20 GWe by 2010 and 40 GWe by 2020. [2]

Based on the above, the accumulated amount of spent fuel will be quite limited, just about 400tHM till the year of 2000, but will be sharply increased in the early next century. It is expected that the annual arising and the accumulated amounts of spent fuel from NPPs would reach around 600tHM and 4000tHM respectively by 2010, while they will reach around 1000tHM/a and over 10000tHM respectively by 2020.

In addition, spent fuel containing different initial uranium enrichment up to 90% has been continuously discharged from research and test reactors in less amounts.

STORAGE AND REPROCESSING

AT-REACTOR STORAGE

There is always an attached pool at any Chinese reactor sites for interim storage of spent fuel and for unloading the whole irradiated core fuel in case of emergency. Spent fuel discharged from reactors is stored at the reactor pool for at least 5 years before transferring to the away-reactor-storage facility, in order to reduce significantly its radioactivity and handling costs.

In fact, this interim storage period would be likely extended to 10 years or more since the reactors' owner would like to put off delivery of spent fuel to postpone payment, or in case spent fuel could not be accepted by reprocessing contractor at that time. For example, in the Qinshan- I plant there are two pools with a capacity of 15 years' fuel discharge with general arrangement .

However, in respect with most of present and planned NPPs in China and even with a compact storage pattern, the maximum of 10 years of at-reactor storage of spent fuel has been generally estimated.

AWAY-FROM-REACTOR STORAGE AND REPROCESSING OF SPENT FUEL

A Centralized Wet Storage Facility(CWSF) project placed in Lanzhou Nuclear Fuel Complex (LNFC), Gansu Province, is being currently constructed with a capacity of 550tHM for the temporary storage of spent fuel, among which 500 tons for PWR fuel and 50 tons for the others, at the first stage. Beside the storage pools, CWSF is equipped with a set of systems, including a receipt and monitoring hall for flasks with a overhead crane of 130 ton capacity, a cooling and purification system for recycling of the pool water and attached utilities, (such as water making-up, power supply and ventilation).[1].

It is anticipated that the CWSF with the first capacity would be put into active operation by 2000, and will be extended in the early next century with an additional 500tHM capacity. Then, CWSF could receive and store all the spent fuel from the Daya Bay NPP in the 20 years joint venture period. In farther future, the facility's storage capacity could be again expanded in modularization and linked with the industrial-scale reprocessing plant through a designated channel.

Now, a multipurpose reprocessing pilot plant (RPP) is also under construction. It is composed of a CWSF mentioned above, a main reprocessing facility (MRF) with a maximum throughput of 300 kg LEU/d, a hot cell laboratory (HCL) with nearly 1 kg HEU/d and a machinery testing workshop (MTW) as well as other auxiliary facilities[3].

Upon extensive experience of RPP obtained and the sufficient amount of spent fuel accumulated, a large-scale (perhaps 400 or 800 tHM/a) commercial reprocessing plant will be in commissioning around 2020.

TRANSPORT OF SPENT FUEL

China's NPPs (including existing and planning NPPs) mostly situate on the southeast coastal area of China while the reprocessing facility situates in the northwest, which is very far away from all NPPs, at least 3000 km of distance. For this reason, an issue on spent fuel transport has to be dealt with.

A feasibility study on transport of spent fuel from the Daya Bay NPP was completed a few years ago and a similar but extensive study has been conducted since the late 1996. The study results have shown that because of the absence of a rail access to the NPPs, a combined transport option by both sea and land would be preferable, using the large loading fuel flasks. Alternatively, a gate-to-gate transport option by road may be suitable in the first few years due to very limited business. However, it is necessary that an integrated spent fuel transport system, including flasks and its maintenance facility, a purpose-built marine terminal, ships, wagons etc., would be set up in next future.

REGULATORY SYSTEM

Transport regulations

To meet the needs of the safety transport of radioactive material, the Chinese Regulations for the Safe Transport of Radioactive Materials (GB 11806-89) was issued on November 21, 1989 and entered into force in July, 1990.

The Ministry of Railways, the Ministry of Communications and the General Civil Aviation Administration of China also adopt the technical requirements of transport documents of corresponding international transport organizations.

Chinese competent authorities

The Chinese competent authority involved in the management of radioactive material transportation consists of National Environmental Protection Agency (NEPA), China Atomic Energy Authority (CAEA), National Nuclear Safety Administration (NSSA), Ministry of Railways and Ministry of Communication as well as Ministry of Public Security.

NEPA is responsible for approval of shipments to ensure the public and environmental safety. The consignor is required to submit an application for approval of a shipment together with an Environmental Impact Report three months before transport. The Agency will organize an expert panel to review the Environmental Impact Report submitted. The shipment can not be carried out until the Environmental Impact Report is passed through the review and an application is approved.

NNSA is responsible for approval of package design, such as spent fuel flasks and fresh fuel containers. The Ministry of Railways and Ministry of Communications do their duties through implementing compliance assurance program to ensure that transport activities in all fields comply with GB 11806-89.

Ministry of Public Security and CAEA are responsible for the physical protection of nuclear material in international and domestic transportation.

TRANSPORT FLASK

R&D on transport flask for spent fuel has lasted for over 10 years in China. A small-sized flask, RY-1A with a 5t loaded-weight and maximum 12 HWRR/MTR fuel assemblies accommodated, has been developed by Beijing Institute of Nuclear Engineering (BINE). R&D on a medium-sized flask made of nodular cast iron with some 20t weight is nearly finished. A large-sized flask loading more than 10 PWR fuel assemblies is being considered.

Meanwhile, a purpose-built test facility capable of handling up to 50 ton weight flask equipped with various monitoring systems and tests, covering shielding, containment, dropping, penetration and fire etc., has been set up and is progressively perfected.

As for pre-cooled spent fuel from NPPs, a type of large capacity flask, capable of holding more than 20 PWR fuel assemblies with a weight of about 120 tons would be preferably chosen in view of economy. There could be 3 options to be taken for realization: (a) domestically R&D--cheap but spending long time and less certain; (b) imported from abroad--mature and rapidly available but expensive; (c) R&D in collaboration with foreign enterprise--assured, moderate in the cost and the term, and favorable to transit to domestic production in full. It seems that the last one is the most desirable. However, in case of no sufficient time to perform this option, purchase or rent from overseas could be a realistic approach.

TRANSPORT BY SEA

There is a dock for unloading huge and massive equipment in the Daya Bay NPP border on the sea but no fixed crane on the dock. It is considered that fitting out a gantry crane with a heavy capacity is unnecessary since handling spent fuel flasks is not frequent. Consequently, flask handling has to be carried out with a self-provided crane on a transport ship or a rental floating crane. Qinshan site also has its own wharf available for spent fuel flask handling. But in Liangyungang NPP, no specific wharf is considered. For the future planned NPP sites, it is not sure whether a wharf will be established.

In view of the fact that a purpose-made ship with the dual-hulls and -bottoms is more reasonable and safer than renting a general ship, and that there is no this kind of ship does not exist in China, a conceptual plan of the ship fitted with a fixed crane, carrying maximum 10 flasks, and with a 2500 displacement tonnage, has been put forward.

Lanshan Port in the southeast of Shandong Province, 100 km away from Lianyungang city, Jiangsu Province is considered as an ideal transshipment port, based on the detailed comparison and analysis of a few candidate ports in the aspects of geological conditions and population density, etc.. It is an existing hazardous goods port, situated in the middle of Chinese coast.

There are two candidate docks in the port possibly used for the spent fuel transit. When the amount is not much, the planned civil engineering material wharf of 35000t can be used as the temporary marine terminal, using floating crane for the flask transfer. With the spent fuel arising increased, a specific marine terminal can be set up at a selected site, and a rail-mounted cantilever crane with a 150 ton capacity shall be equipped in the terminal, enabling flask to be loaded from the ship onto the special rail wagons and vice versa. A rail spur links the terminal with the main rail line.

The sea route of about 3000 nautical miles away from the Daya Bay plant has been identified. The navigation conditions has been carefully investigated, including proper sailing season, haven choice, and prevention of striking on the rocks, as well as the emergency response and salvage access in the event of a ship sinking.

TRANSPORT BY RAIL

Type B(U) of package for spent fuel, which must comply with all the regulations laid down by IAEA, will be transferred to the concave-type wagons with a 150 ton loading capacity and twelve axles. China has the capacity of fabricating the wagons but there would be a possibility of importing them from abroad alternately.

After being marshaled and after a short staying, a specific train composed of two flask-loaded wagons and some necessary auxiliary cars will be driven according to a designated transport scheme.

A running route between the marine terminal and the termination, Lanzhou Nuclear Fuel Complex (LNFC), has been preliminary selected on the principle of avoiding big- and middling-cities, densely populated regions and the rail routes with the heavy traffic as possible. The transport distance is more than 2600 km while it would take about a week for single trip to travel.

TRANSPORT BY ROAD

Two shipments of spent fuel assemblies of HWRR (Heavy Water Research Reactor) from China Institute of Atomic Energy (CIAE), Beijing, to LNFC for interim storage and following being reprocessed, were actually carried out by road. This shipment was performed using 6 RY-1A flasks (Maximum 12 HWRR fuel assemblies accommodated each), serving as dual-purpose application to both transportation and dry storage in July 1995. Other 9 RY-1A flasks have been transported in June 1996. Transported was a total of 180 HWRR fuel assemblies, containing 756 kgHM. The results has shown that this movement is quite efficient, and during implementation there were no incidents--either industrial or radiological which impact on safety.

A further study on the road transport of spent fuel from NPPs is made in the feasibility study, the route from the marine terminal or from Daya Bay NPP to the reprocessing plant have been investigated, which shows that road transport may be a realistic alternative when the whole combined mode is not ready and the spent fuel not much.

CONCLUSION

With the development of nuclear power, more spent fuel will be produced. It is anticipated that the annual arising and accumulation of spent fuel will be: about 600 tHM and several thousand tones by 2010, and, around 1000 tHM and more than ten thousand tones respectively by 2020 .

To manage the spent fuel safely and protect the human beings and environment, a closed fuel cycle strategy has been determined. The fuel will be transferred to the away-reactor-storage pool, waiting for reprocessing and recycling of the usable material in it, after being stored in at-reactor-storage pool for at least 5 years (typically maximum of 10 years). A pilot reprocessing plant is under construction, and a large scale commercial reprocessing plant will be succeeded around 2020.

To match the fuel cycle strategy, a conceptual system for spent fuel transportation is put forward. The study results that a combined mode with both sea and land (rail or road) is reasonable via a marine terminal, using large payload flasks in a long run. But a gate-to-gate transportation by road may be suitable in the first few years when business is limited.

But, transport of spent fuel ,especially from nuclear power plants, is a quite new mission to us. There is still a lot of work to be done for establishing an integrated system of spent fuel transport, reasonable in safety and economy.

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