THE EXPERIENCE OF SPENT FUEL TRANSPORTATION IN KOREA

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SUMMARY

In 1991 and 1995, more than 310 spent fuel assemblies had been transported from Kori nuclear power plant #1, in which plant the storage capacity of spent fuel approached its limit, to nearby Kori nuclear power plant #3 and #4. Consequently Kori nuclear power plant #1 could have secured the storage capacity of spent fuel for 8 years operation.

This transportation project had been carried out for the first time in Korea. The transportation system includes KSC-4 transportation casks, auxiliary equipment and vehicles which had been developed locally. Also considerable amount of modification to the existing plant equipment and facilities had been performed.

KSC-4 transportation cask was Type B(M), and had been developed by Korea Atomic Energy Research Institute (KAERI) and licensed in accordance with Korean law and IAEA regulation. It had been designed and manufactured to store 4 PWR fuel assemblies each with max. burnup of 38,000 MWD/MTU and enrichment of 3.2 w/o, and its empty weight was 37 metric tons.

Auxiliary equipment including a cask lifting device, high pressure water decontamination equipment, cask internal decontamination equipment, a crane connection device, scaffolding structure and spent fuel handling tool had been designed and manufactured. The vacuum drying equipment for dry cask transportation had also been made. A portable pool water purification system which purifies the water in the spent fuel storage pool had been fabricated and utilized to lower the surface contamination level of transportation cask.

A quality assurance programme (QAP) had been established and strict quality control had been performed through whole progress of the project. The QAP was applied from design and manufacture of all equipment and devices, to the operation of spent fuel loading, transportation and unloading so as to achieve the required safety and reliability of the transportation operation.

In the course of all 80 transportation cycles, no accident of any kind occurred. For each transportation cycle the inspection was performed by the Korean regulatory body, Korean Institute of Nuclear Safety(KINS).
This paper describes the component of the transportation system and experiences of transportation project.

TRANSPORTATION SYSTEM

The onsite transportation system of spent fuel consists of the components shown in Fig. 1. A detailed description of each component is provided as follows:

○ KSC-4 Shipping Cask
The KSC-4 shipping cask has been licensed as a Type B(M) cask and has the capacity of carrying 4 PWR fuel assemblies. The cavity where spent fuel assemblies are loaded was designed to be cooled by a wet or dry method. This cask consists of body, lid, impact limiter and tie-down device. Total weight of the cask is 37 metric tons, and the dimensions of OD and height are 1,350 mm and 4,820 mm, respectively. Boral, lead and NS-4-FR are used as the material of poison plate, gamma shield and neutron shield, respectively. The design criteria of cask is shown in Table 1.

○ Lifting Yoke
A Lifting yoke is used to lift or lower the cask and has been designed, tested and manufactured according to ANSI 14.6.

○ Decontamination Equipment
The cask surface is cleaned in a decontamination pit located inside the reactor building by using decontamination equipment. The decontamination equipment consists of a scaffolding structure and a high pressure water jet device. This device produces a high pressure water jet of 180 bar to remove contaminated particles attached to the surface of the cask.

○ Internal Vacuum Drying Equipment
This equipment dries completely the internals of cask under vacuum condition. A vacuum of 3mm Hg is maintained during drying operation.

○ Portable Pool Water Purification System
To remove the suspended contaminated particles contained in the spent fuel storage pool of Kori unit 1, a portable pool water purification system has been provided in addition to the existing purification system. It has been designed and manufactured to be able to remove very small particle down to 1 μm. The flow rate of this system is 48 m^3/h and the differential pressure indicator installed across the filter indicates the time of filter replacement. As a result of running the portable purification system, the purity of spent fuel storage pool has been dramatically improved.

○ Vehicle
The transportation vehicle includes a tractor and trailer as shown in Fig. 2. Design capacity of trailer is 70 metric tons. Its three axles are provided to evenly distribute the heavy load of the transportation cask and tie-down fixture.

OPERATION PROCEDURE

It took 4 days to complete one turnaround of spent fuel transportation at the Kori site and Fig. 3 illustrates the flow of main operation steps.

❍ Empty cask reception
In the cask reception area of Kori unit 1, the empty cask is lifted and moved to decontamination pit, where leak test is performed before spent fuel loading. After leak test the empty cask is moved into spent fuel loading pit.

❍ Fuel loading
Identification number of the spent fuel to be transported is confirmed and the fuel is loaded into the cask by fuel handling tools.

❍ Decontamination and leak test
The cask with fuel loaded is transferred to the decontamination pit and the surface of cask is cleaned by using the high pressure water jet. After decontamination, a pressure test is performed to check the leak tightness of the cask.

❍ Transport inspection
The cask is transferred to the cask reception area and laid down on transportation vehicle, and the transport inspection is performed by regulatory body KINS (Korean Institute of Nuclear Safety).

❍ Road transport
After the transport inspection, the transport supervisor and radiation protection supervisor board the transportation vehicle and drive it at onsite speed limit of 8 km/h.

❍ Fuel unloading and storage
When the cask is received at Kori unit 3, it is lifted and transferred into spent fuel unloading pit of Kori unit 3 fuel building. The surfaces of the cask are cleaned in the decontamination pit. The identified fuel is unloaded and stored in a selected spent fuel storage rack. The unloaded cask, after decontamination, is returned to the empty cask reception area of Kori unit 1. These operations completed one spent fuel transportation cycle.

FREQUENCY OF TRANSPORTATION

KSC-4 transportation cask has a capacity of carrying 4 PWR fuel assemblies. During first transportation period between 1990 and 1991, 39 spent fuel transportation cycles had been completed and the same number of transportation cycles had been carried out during second period between 1994 and 1995. A total of 312 fuel assemblies were transferred in these two time periods.

LICENSING OF TRANPORTATION

The transportation cask has been designed and manufactured in accordance with the requirements of Korean law and IAEA regulation. Transportation inspection by the regulatory body is required when spent fuel is transferred. Fig. 4 illustrates the licensing

procedures for the design and manufacture of the transportation cask.

First, the capacity and specification of spent fuel to be transported is determined and a conceptual design is performed to satisfy the design criteria and operation requirements. Basic design of shielding, criticality, thermal and structural integrity under normal and accident condition is carried out. To verify the safety of the cask design, a 1/3 scaled model is made and verification tests are performed. These tests include a 9m free drop test, a fire test under 800°C for 30 minutes, a 15m water immersion test and a 1m puncture test, etc.

A SAR(Safety Analysis Report) is prepared based upon analyses and safety verification tests and submitted to KINS to get approval for manufacturing. During manufacturing progress, inspection is witnessed by KINS to confirm adherence to all related quality assurance requirements.

CONCLUSION

A complete transportation system including KSC-4 transportation cask, cask handling devices, transport vehicle has been developed in Korea. The spent fuel of Kori unit 1, where the storage capacity of spent fuel approached its limit, has been transported to nearby Kori unit 3 by using the KSC-4 cask. Consequently Kori unit 1 secured the storage capacity of spent fuel for 8 years operation.

This kind of spent fuel transportation project has been performed for the first time in Korea. The successful completion of the transportation project has provided the foundation for technology independence in commercial spent fuel transportation field. This technology would be utilized for the operation of interim storage facility or onsite dry storage system of spent fuel in the future.

REFERENCES

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Lee H.Y. et al. Final Report/Kori On-site Transportation Project, KAERI-NEMAC/TR-41/96, 1996

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Table 1. Design Criteria

Items	Design basis
Fuel type	17x17 PWR Assembly
Max. burn-up	38,000 MWD/MTU
Cooling time	3 years
Decay heat	7.0 kW
Max. enrichment	3.2 w/o U-235
Radioactivity	1.89×10^6 Curie

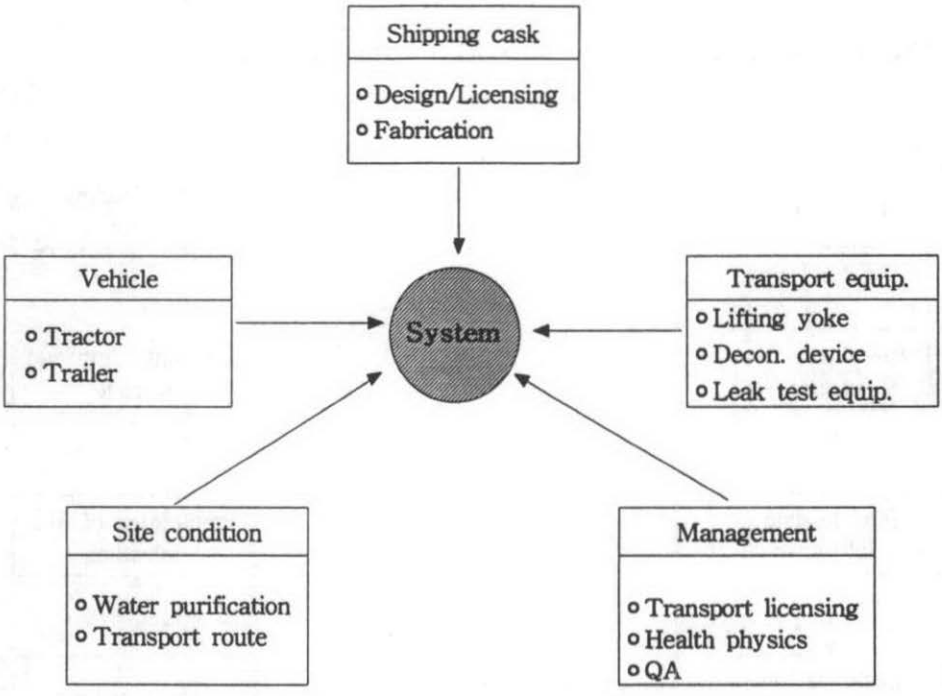

Fig. 1 Spent Fuel Transport System

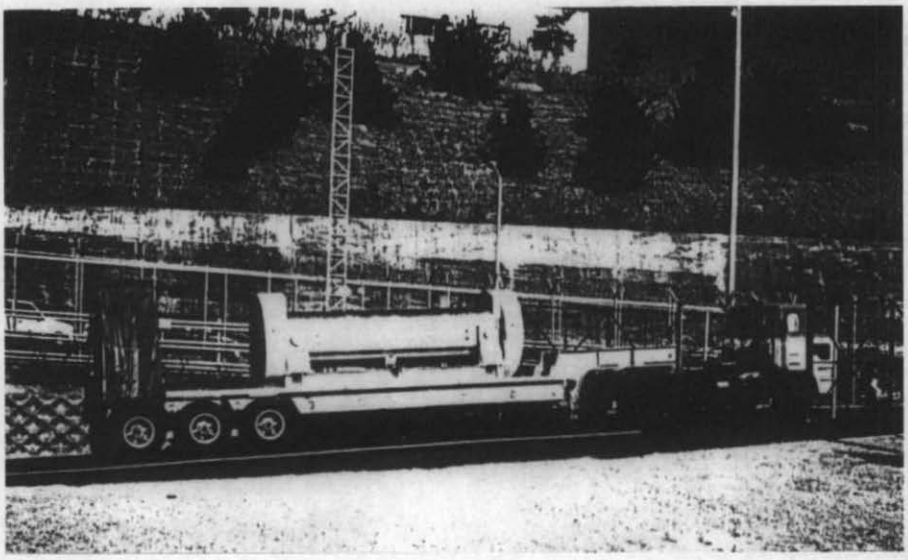

Fig. 2 Transportation Mode of KSC-4 Shipping Cask

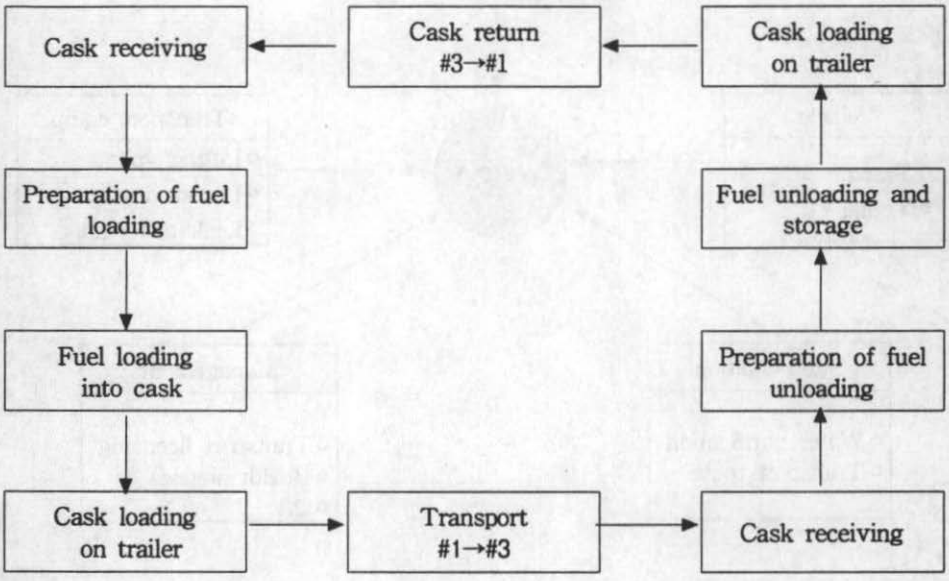

Fig. 3 Working Procedure of Spent Fuel Transshipment

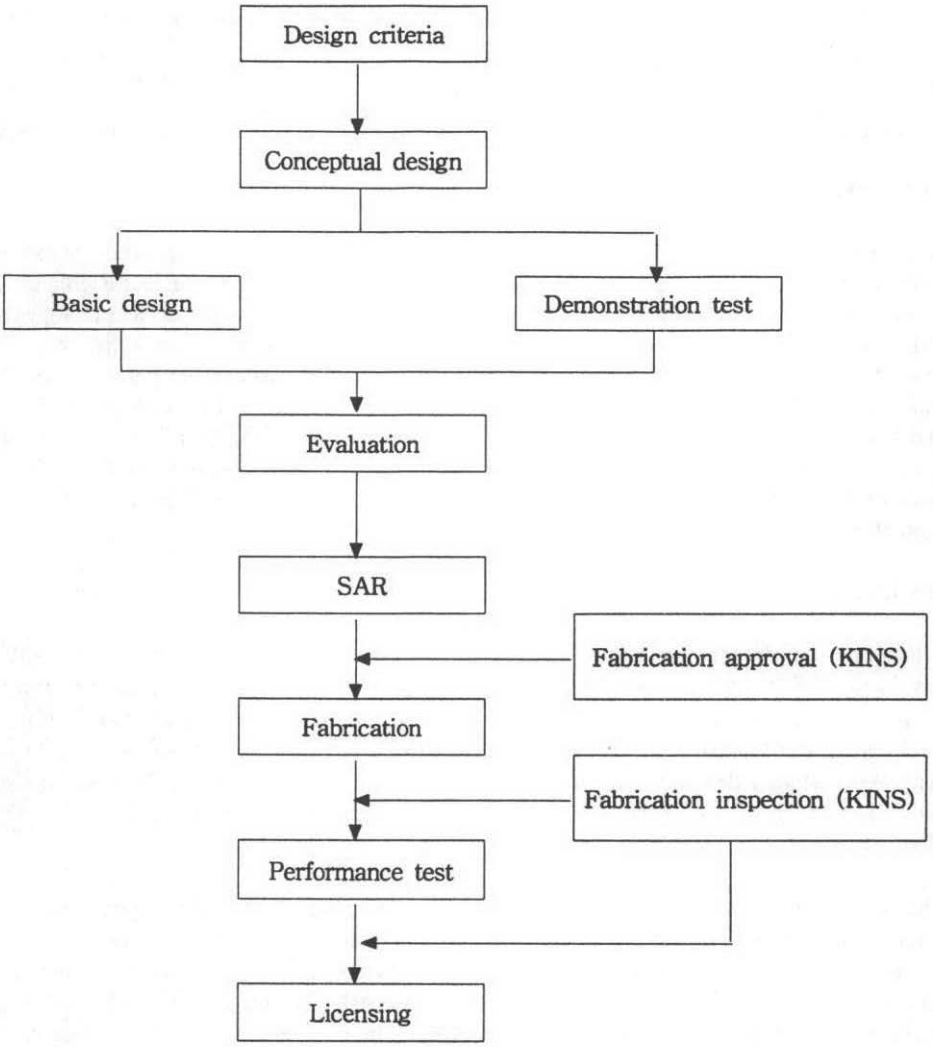

Fig. 4 Cask Design and Fabrication Procedure