Introductions of US DOE Multi-modal Transportation Test(MMTT) and Korean MMTT

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1. Introduction

There is a high interest in domestic and foreign countries for safe transportation of spent nuclear fuel. The US DOE, Spain ENSA and Korea have successfully carried out a multi-modal transportation test(MMTT) using surrogate spent fuel assemblies as an international collaborative research. After this research, Korea is preparing for the road and sea transportation tests on the Korean transportation route.

In this paper, we introduce and briefly explain the transportation test conducted by the international joint research of USA, Spain and Korea. And, although it is still in the early stage, we would like to explain the current status of the transportation test project in Korea.

2. DOE-ENSA-Korea's MMTT(Multi-modal Transportation Test)

2.1 Summary of International MMTT

Every country that operates nuclear power plants is interested in safe storage and transportation of spent nuclear fuel from nuclear power plants. However, depending on the situation in each country, the transportation route of spent fuel is slightly different.

The US carries spent nuclear fuels mainly by rail. Spain uses heavy haul trucks to transport them to the roads. Korea expects that maritime transportation using ships will become a major mode. Therefore, the United States, Spain, and Korea carried out the international joint research transportation test in 2017 to acquire the data in the transport mode of interest of each country.

Several tests and researches had been conducted for the safety of spent fuel transport prior to the multi-modal transportation test conducted in 2017, but no test with an actual full-scale spent fuel cask was carried out.

An international team of researchers charged the three different surrogate nuclear fuel assemblies of the three countries to the actual spent nuclear fuel cask ENUN 32P in Spain. The sequence of the transport test is to transport the test cask using trailers along Spanish roads, to transport it by ship from Spain to the ports of Belgium and to the east side of the US, and to transport it by rail freight trains to Colorado. Detailed transport routes and summary are shown in Fig. 1, and Table I.

The KAERI, KORAD, KNF, and KINS participated in this international collaborative research. The Sandia National Laboratory (SNL), Pacific Northwest National Laboratory (PNNL) in the US and the Equipos Nucleares S.A, S.M.E (ENSA) in Spain participated.

The international MMTT team conducted this transportation test to evaluate the effects of vibration and shock on the spent nuclear fuel and the transport cask during normal transportation through various routes such as road, railway and sea. This test was conducted for nine months from April to December 2017 in the United States and Spain [1-3].

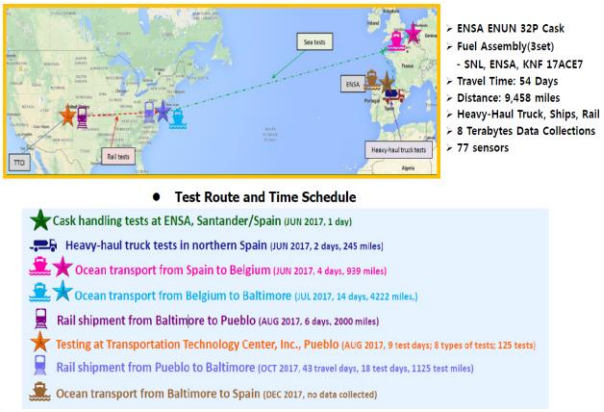

Fig. 1. Route and schedule of Multi-modal transportation test.

2.2 What Korea did in International MMTT

The Korea Atomic Energy Research Institute (KAERI) had expressed its willingness to participate in international joint research in the early days when the US and Spain joint research projects were being planned. The reasons were as follows.

The main mode of transportation of spent nuclear fuel in each country was different, which are the rail transport in the US, road transport in Spain, and maritime transport in Korea.

At the time of the initial joint research between the US and Spain, the US and Spain were not interested in transporting cask from Spain to the port of Belgium and from the port of Belgium across the Atlantic ocean to the US. This made them decide not to measure the signals in these paths.

KAERI believed that it was very important to measure and secure this data as the main mode of our country will be ocean transport. Therefore, KAERI persuaded the United States and Spain to allow Korea participate in this MMTT international project to measure the data for coastal transport and maritime transport.

In order to carry out the transportation business of the spent fuel transport in Korea in the future, it is essential to carry out the integrity evaluation of the spent fuel and the transport cask under normal condition of transport. Without the vibration and impact load data in the

normal condition of transport, the safety assessment cannot be performed. Also, if Korea is to conduct its own tests to measure such vibration and impact load data later, the cost will be astronomical. The KAERI anticipated this and expected to participate in this international joint research and obtain the data. Other nuclear related organizations in Korea also agreed.

In an international collaborative test, the SNL and PNNL in the US were responsible for the overall test preparation and instrumentation, while the Spanish ENSA provided shipping cask. Korea provided a surrogate fuel assembly made from modification of 17ACE7, and consulted on the selection of instruments, attachment locations, and data measurement methods for measuring the surrogate fuel assemblies. In addition, the reliability of the measured data was verified in each of the main tests, and the direction of the multi-modal transport test was negotiated through technical consultation.

Table I: Summary of MMTT

Items	Description
1. Four transport Modes	. Heavy-haul truck transport . Inter-coastal transport . Ocean transport . Rail transport
2. Test period	. April to December in 2017 . Transport hours: 54 days
3. Total distance	. 9,458 miles
4. Test cask	. ENUN32P, DPC
5. Fuel assemblies	. Three fuel assemblies from the US, Spain, and Korea
6. Data size	. Data measuring days: 54 days . 8 Terabytes

3. Korean MMTT preparation statue

3.1 Summary of International MMTT

There were twists and turns in decision of the transport cask test model to be used for the transportation test in Korea. At the time of initial project planning, KORAD21 developed by Korea's unique technology, was planned to be used, but KORAD21 cask could not be manufactured with limited budget.

KAERI tried to contact to Doosan to utilize an OCL cask which remained after canceling the contract between Doosan and OCL. However, the original client, OCL did not allow to use their cask for this test. After that, KAERI decided to use the modified TN-68 from Seahbesteel, which signed MOU with ORANO.

At present, test cask model is not definitely decided since there is a suggestion to simplify the KORAD21 cask to lower the production cost, and to use it as a test model.

For the spent nuclear fuel assemblies, two fuel assemblies provided by KNF will be used. The rest assemblies will be replaced by concrete mass blocks considering the mass balance.

However, since the US DOE has indicated its willingness to participate, and may provide a surrogate spent nuclear fuel assembly from the United States if South Korea agree. Negotiations with the US DOE are under way and are proceeding in a positive direction.

Therefore, if the US will announce its intention to participate in the Korean transport test, Korea's MMTT will be a transport test including 3 fuel assemblies (17ACE7, KSNP type, US Fuel Assembly).

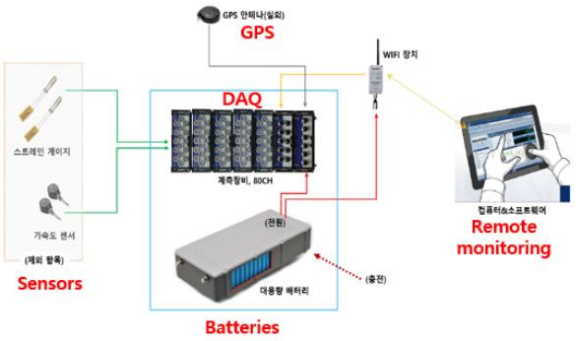

Fig. 2. Data acquisition system diagram.

3.2 Data Acquisition System

Data must be measured stably during road and sea transport tests. The test environment of this test is required to introduce a data measurement system with shock resistance and waterproof and dustproof grade in extreme environments (dust, salt water, vibration and impact load). Also, since sensors must be attached to all of load transfer paths, data measurement systems must provide multiple channels (64 channels of acceleration, 32 channels of strain). We are currently working on the introduction of HBM's SomatXR as a data acquisition system to meet these specifications. If the US nuclear fuel assembly is introduced, additional signal amplifiers could be needed due to the increased number of channels.

Battery-based measurements should be made for smooth data measurements in coastal and maritime transport environments where power is not supplied for an extended period of time. A large capacity battery should be installed.

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REFERENCES

[1] McConnell, P., et all, “Surrogate Fuel Assembly Multi-Axis Shaker Test to Simulate Normal Conditions of Rail and Truck Transport,”SAND2016-4576R, 2016.
[2] McConnell, P., et all, “ENSA ENUN 32P Rail-Cask Transport Tests Start June 2017,”Spent Fuel and Waste Science and Technology, 2017.
[3] Saltzstein, S., Woo-seok Choi, et al, “ENSA/DOE Multi Modal Transportation Tests Preliminary Results,” NEI Used Fuel Management Conference, May, 2018.