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SAFETY TEST STATUS OF A RADIOACTIVE MATERIAL TRANSPORT PACKAGE IN SOUTH KOREA

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ABSTRACT

As a spent nuclear fuel storage spaces are not sufficient at some nuclear power plants(NPPS), transport packages of spent nuclear fuels were developed in order to transport within NPP site. Recently, Korean government decided the disposal site for a low level radioactive waste generated from NPPs. So it will be expected to transport these wastes frequently. And some kinds of the transport packages are developing for the purpose of a medical and industrial use. These radioactive materials should be transported with the transport package which is satisfied with requirements stated in Korean domestic regulations and IAEA safety series ST-1[1]. Safety test procedures have been established to produce design data and test results for license. It is important that package integrity such as leak rate and shielding is sustained after test. Moreover, acceleration, strain and temperature data are acquired in drop and fire tests to verify the analysis results. In this paper, it describes the safety tests status for type IP, A and B transport packages in Korea. It also introduced the safety tests facilities as well as the data acquisition system of acceleration, strain and temperature.

INTRODUCTION

Radioisotopes are produced for a medical and industrial use in Korea. The transportations for radioisotopes are increasing. As radioactive wastes generated from nuclear power plants have been stored almost to a limit of its storage capacity, the disposal site of a low and intermediate radioactive material was decided recently in Korea. Therefore, the development of transportation package is needed in Korea. Each transport package of the radioactive material has to be designed to have enough safety to fulfill the regulations and the technical standards in the regulations. In accordance with the IAEA safety standard series TS-R-1, a transportation package can be divided into type IP type A and type B. And in order to verify the validity of a package design, a safety test should be performed. In this paper, it is described that several kinds of safety test procedures of the transportation packages are established for the transportation of sealed source, radioisotopes, radioactive wastes and spent nuclear fuels in Korea.

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SAFETY TEST FACILITY OF RADIOACTIVE MATERIAL TRANSPORTATION PACKAGE

KAERI had the safety test facilities and equipments for radioactive material transport package in accordance with IAEA standards and Korean domestic regulations. The test facilities have been in operation since 1992. The main test facilities are capable of the drop test, fire test and water immersion test shown in figure 1 and table 1.

The drop test facility has been used to evaluate a package through the mechanical tests demonstrating a safety under the normal and accident conditions. A 15 m drop tower provides for a lifting and a dropping in any desired orientation from a height of 9 m or more. An electric hoist was installed with a capacity of 10 tons. The impact target is a steel plate of 4 m x 4 m x 0.1 m fixed on a steel reinforced concrete block of 1.5 m thickness.

The IAEA fire test requires an engulfing hydrocarbon fire lasting 30 minutes. KAERI has the fire test facility of open pool type and the pit size is 4 m x 3.5 m, which has the air and water mist systems and is possible to actually eliminate most of all smoke. A layer of kerosene is floated on the top of the water filled pool.

The purpose of water immersion test is to verify the integrity of containment system for the transport package under water immersion condition. Water immersion test facility consists of pressure vessel, water supply pump, high pressure pump and pressure gauge. Design pressure of water immersion test facility is 2 MPa and the dimension of pressure vessel has the inner diameter of 1.5 m and the height of 3.5 m.

In order to verify the FEM analysis results, the strains, accelerations and bolt forces could be measured by a data acquisition system, which is utilized as PXI-8186(National Instruments Co.) with the LabVIEW program. It comprises 14 channels for a strain and 18 channels for acceleration or force.

To sustain the validity and reliability of test results, ISO QA system are introduced to the safety test procedures of a transportation package. In measuring a temperature, leak rate and dimension, the uncertainty are applied to the measuring value considering the calibration data and measurement error.

Water Immersion Facility Drop Test Facility Fire Test Facility

Figure 1. Safety test facility of radioactive material transport package

Table 1. Specification of test facility

.Test	Facilities/ equipment	Specification
Drop Puncture Penetration	Drop tower	- Hoist : 10 ton, auxiliary hoist : 2 ton - Tower : truss structure, height 15 m - Release mechanism : hydraulic power 10 ton - Drop steel target : 4 x 4 x 0.1 (W x L x t) m -Reinforced concrete : 5 x 5 x 1.54 (W x L x t) m
Water immersion	Pressure vessel	- Pressure vessel : 1.5 x 3.5 (Dia x H) m - Low Pressure Pump - High Pressure Pump : 2 MPa
Hot/cold	Constant temperature room	- Temperature range : -40 ℃ ~ 38℃ - Test room : 3 × 4 × 3 (W x L x H)m - 10 kW heater and low temperature valve
Thermal	Smokeless fire pit	- Fire pit : 4 x 3.5 x 0.4 (W x L x dept.) m - Fuel tank : 880 liter - Fuel feeding Pump - Water tank : 5 ton/30 min - Insulation wall : 400 mm - Blower : 20 m^3/min
Leakage	Vacuum bubble	- Precision : 1.35 %
	He Leak Detector	- 1.423E-08 mbar.ℓ/s

SAFETY TEST OF RADIOISOTOPE TRANSPORTATION PACKAGE AND SPECIAL FORM

As the radioisotopes are produced in Korean research reactor called Hanaro, a radioisotope transportation package is needed for the purpose of the domestic and foreign transport. Radioisotopes like Iodine-131, Gallium-67 and Thallium-201 are used for a medical therapy and diagnostics. These radioisotopes are generally transported as a liquid phase. Therefore, the stacking, 9 m drop, 1.7 m penetration test should perform as the additional test requirements of type A package. A type A package to transport liquids shall be provided with sufficient absorbent material or with a containment system. For the transportation package of the medical-use radioisotopes, the characteristics of shock absorbing materials and absorbent materials were evaluated. After drop and penetration tests, the vacuum bubble tests for a vial are performed as shown in figure 2 in order to confirm the prevention of loss or dispersal of the radioactive contents. According to IAEA ST-2[2], for liquid contents, one way of satisfying the requirements for ‘ no loss or dispersal’ would be to monitor the package on completion of vacuum test. A procedure and method of vacuum bubble test were established as a kind of quantitative method by ISO 9978[3].

Figure 2. Drop test and vacuum bubble test for radioisotope package

IAEA ST-1 describes that the impact, percussion, bending and heat test for special form are replaced by the sealed capsule tests according to ISO 2919[4]. A Korean regulation and ISO-2919 also specify that the sealed capsule should be classified and tested in accordance with the purpose of usage. Therefore, the equipments for the ISO 2919 tests of a sealed capsule were developed. The safety test of a Iridium-192 and a Selenium-75 gamma radiography sealed capsule was performed for the temperature, the external pressure, the impact and the puncture test as shown in figure 3, respectively. Different specimens may be used for each of the tests. For special forms which comprise radioactive material enclosed in sealed capsule, either a leaching or a volumetric leakage assessment shall be performed. So, a vacuum bubble and He gas evacuation test for the source capsule were applied as an appropriate leakage test in accordance with ISO 9978.

Figure 3. Impact/ puncture test and pressure test for sealed capsule

SAFETY TEST OF RADIOACTIVE WASTE AND SPENT NUCLEAR FUEL TRANSPORTATION PACKAGE

Radioactive waste generated from nuclear power plants should be transported to a disposal site and then a type IP transportation package are used in the case of a low and intermediate radioactive waste. Type IP-2 package is capable of preventing a loss of radioactive material and radiation shield after a free drop and stacking test. A drop test for the type IP-2 transport package under normal transport conditions was undertaken. In general, the type IP-2 transport packages are used as ISO containers which have end doors for a package closure. If the shielding thickness of the IP-2 transport package is thick, the weight of a transport package is heavier. Thus a bolted lid type may be safer or stronger than a door type. The closure mechanism of the bolted lid withstands a drop impact well. Therefore, it is important that the integrity of the lid and its bolts are sustained under a drop impact. The results of the type IP-2 package which undertook a vertical drop of 0.9 in height. An opening displacement of the lid and the torques of the lid bolts

are changed before or after the drop impact of the type IP-2 package. Also the thicknesses of the shielding material are measured before or after the drop impact. The acceleration, strain and the bolt tension are measured during the test as shown in figure 4. The accelerations and the bolt strains measured from a test are measured for comparing with the results from a finite element analysis.

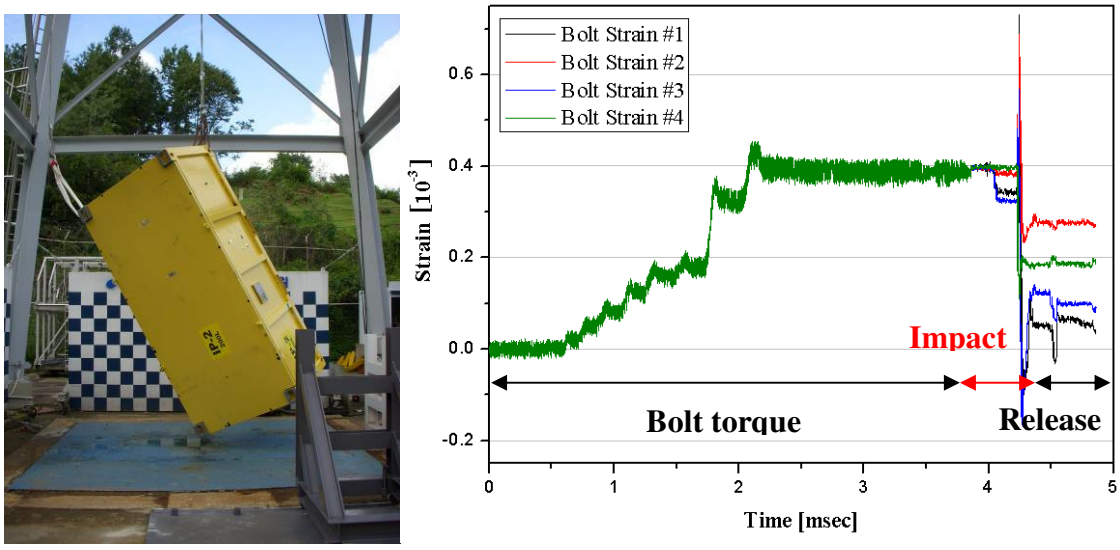

Figure 4. Drop(0.9 m) test model and acceleration data of IP-2 package

Spent nuclear fuel transportation cask called CASTOR/KN-12 was developed due to the saturation of spent fuel storage pool in some PWR nuclear power plants. Transportation contents of this cask is 12 spent nuclear fuel assemblies considering high burn-up and high enrichment. Free drop impact tests were performed according to the test requirements of domestic MOST notice and IAEA ST-1. Structural safety were evaluated by means of dropping a 1/3 scaled model of this cask from 9 m height to unyielding surface or from 1 m height to pin as shown in figure 5. For the verification for computer calculation, the displacements, accelerations and strains and the structural behavior were measured as shown in figure 6.

Figure 5. Drop(9 m) test and puncture test of spent nuclear fuel package

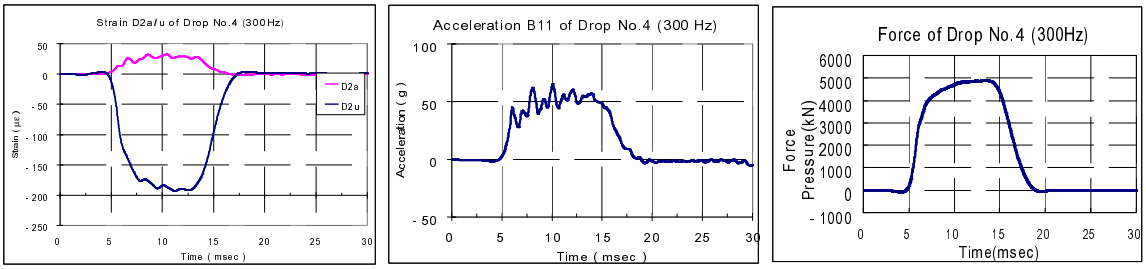

Figure 6. Strain, acceleration and force of puncture test for spent nuclear fuel package

SUMMARIES

Since Korea Atomic Energy Research Institute had provided a safety test facility for radioactive material transportation package in 1992, it contributed to develop many packages to transport the radioisotopes, radioactive wastes and spent nuclear fuels in Korea. Test procedures had been established for the developments and licensing preparation of all type packages such as special form, type IP, type A and type B. As ISO QA system was introduced to the safety test of radioactive material transportation package, a reliance of test results was enhanced.

REFERENCES

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[3] ISO 9978:1992(E), “Radiation protection - Sealed radioactive sources - Leakage Test Methods,” 1992

[4] ISO 2919:1999(E), “Radiation protection - Sealed radioactive sources - General requirements and classification,” 1999..