PERIODIC INSPECTION OF PACKAGING FOR RADIOACTIVE MATERIAL IN KOREA

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ABSTRACT

The safety of packagings is very important. Maintaining, designing and manufacturing of packagings shall be well controlled. The safety of transport for radioactive material can be secured by managing packagings according to the maintenance program. The integrity of packagings shall be soundly maintained at any time. According to Korea regulations of transport for radioactive material, the specified packagings shall be inspected by a regulatory authority, the Korea Institute of Nuclear Safety(KINS), every 5 year term. The KSC-4 spent fuel cask was inspected by KINS. The inspection items were also reviewed. Through the periodic inspection of the KSC-4 spent fuel cask its integrity was confirmed. Inspection procedures and improving items are suggested.

INTRODUCTION

Due to the potentiality of accidents, the transportation safety of radioactive material has become extremely important in these days of frequent occurrence of traffic accidents. Because serious effects can be brought to both mankind and enviroments in case of radioactive material leakage by the accidents occurred during transportation, it is essential for the transportation to be done safely through the complete check of safety requirements in every process, i.e. design, manufacturing, packaging and transportation process, etc.

The most important means of accomplishing the safety in radioactive material transportation are packagings safety. It is necessary to do maintence and packagings have to be used always with soundness. The casks maintenance is carried out according to the approved maintenance program voluntarily, but competent authority must confirm its implementation in view of the compliance assurance[1]. So a periodic inspection system of competent authority is introduced to improve the safety of transportation and the confidence of the public through this confirmation process.

Regulations of periodic inspection for packagings are established in the atomic energy laws of Korea[2]. Cometent authority of Korea is the Ministry of Science and Technology(MOST). KINS, entrusted by MOST, is an institute of technical expertise which performs regulatory functions such as safety reviews, inspections, and technical standards development for nuclear power plants and radiation facilities. KINS carried out the periodic inspection of the KSC-4 cask for spent fuel assemblies[3] according to the regulations.

This paper discribes the regulations of periodic inspection for packagings in the atomic energy laws of Korea and the experience about the inspection of the KSC-4 cask. Inspection procedures and items to be improved are suggested.

REGULATIONS

The periodic inspection for packagings is prescribed at the Article 90-3 of Atomic Energy Act, the Article 239-3 of Enforcement Decree and the Article 98 of Enforcement Regulations. According to these regulations, licensee can continuously use packagings in case of maintaining the soundness of the packagings

through a periodic inspection by competent authority. Inspection targets are packagings for Type B(U) packages, Type B(M) packages, Type C packages, all packages containing fissile material and packages containing 0.1 kg or more of uranium hexafluoride. These packagings shall be inspected every 5 years periodically. Inspection contents are an internal and external examination, nondestructive inspection for weldments, load test for lifting attachments and tie-down devices, hydrostatic test, leakage test for containment system, radiation shielding integraty, thermal transfer inspection, contamination inspection, and package rests on the conveyance. Licensee submittes an application form of inspection attached the record of the in-service inspection and maintence to the KINS. The KINS inspects the packaging. The criteria for pass is to keep the soundness at that time of manufacturing.

INSPECTION METHODS

It is very important to secure the safety of packagings. Licensee shall strictly control to secure the safety of packagings in accordance with the quality assurance program approved by competent authority. In-service inspections and maintenance procedures are specified in the quality assurance program. All packagings shall be routinely examined to ensure that they remain in a safe, usable condition, and shall be periodically inspected, tested and maintained throughout their service life at intervals not to exceed the period specified in the procedures. Inspections and maintenance shall be carried out by qualified person and documented on an inspection and maintenance form prepared specifically for each packaging. And all pacgkaings specified as periodic inspection target in regulations shall be periodically inspected at terms not to exceed 5 years by competent authority.

The KINS carries out the periodic inspections of packagings. The approved quality assurance program of packagings and its implemenation by licensee shall be reviewed. And also in-service inspection and maintenance history shall be reviewed through the inspection and maintenance form documented. And each packaging then is inspected. The inspection items are followings ;

(a) Contamination inspection : The external surface contamination of the packaging shall be inspected. The radiation level resulting from the fixed contamination on surfaces is less than 5 μSv/h at the surface.
(b) Internal and external appearance inspection : An internal and external appearance for each packaging including impact limiters shall be visually inspected. There are no any deffects such as crack, excessive distortion, bent , broken or torn parts.
(c) Weldments inspection : Weldments of each packaging including package rests on a conveyance shall be nondestructively inspected. The deffects indicated by an inspection shall not exceed the defects permitted by a related criteria.
(d) Load test for lifting devices : Lifting decices of each packaging shall be subjected to a test load equal to 150 % of the gross package weights. After sustaining the load for a period of not less than 10 minutes, critical areas, including major load-bearing welds, shall be subjected to visual inspection for defects, and all components shall be inspected for permanent deformation.
(e) Hydrostatic test : Each packaging shall be hydrostatically pressured to a test pressure equal to 125 % of its maximum normal operating pressure, and the pressure shall then sustain for a period of not less than 10 minutes while the packaging is inspected for leaks. No leaks shall be permitted.
(f) Leakage test for containment system : Containment system of each packaging shall be subjected to a leakage test. The leakage test of the containment system need not include the testing of inaccessible joints and seams but shall include all components such as closures, valves and pipe fittings. The release rate limit shall be not more than $A_2 \times 10^{-6}$ per hour.

(g) Radiation shielding evaluation : Radiation shielding performance shall be evaluated with the same method which a packaging was subjected the measurement of the acceptance tests in its fabrication or an equivalent method. Radiation shielding performance is evaluated in comparing the design values and its measurements in fabrication.
(h) Thermal transfer evaluation : Thermal transfer performance shall be evaluated with the same method which a packaging was subjected the measurement of the acceptance tests in its fabrication or an equivalent method. Thermal transfer performance is evaluated in comparing the design values and its measurements in fabrication.

EXPERIENCE OF THE PERIODIC INSPECTION FOR KSC-4 CASK

The KSC-4 cask was designed to carry 4 PWR spent fuel assemblies and its weight contained radioactive contents is 37.4 tons. The cask consists of a cask body including a closure and two impact limiters. The cask body is a cylindrical shell type. Radiation shielding materials, lead for gamma and resin for neutron, are located in between shells. Figure 1 shows the configuration of the KSC-4 cask and Table 1 shows the design specification of the cask. The KSC-4 cask has been used in domestic transportation in Korea. 376 PWR spent fuel assemblies were transported by using the cask from one nuclear power plant to the others since the cask had been fabricated in 1991.

KINS carried out the periodic inspection for the KSC-4 cask. The approved quality assurance program for the KSC-4 cask and its implemenation by licensee was reviewed. In-service inspection and maintenance history was reviewed through the inspection and maintenance form documented. Quality assurance implemented according to the quality assurance program. Inspections and maintenance were carried out according to the procedures. Consequently the reviewing results were satisfied.

An independent inspection facility for cask is not prepared in Korea at present. So the periodic inspection of the KSC-4 cask was carried out at the facilities of the Kori nuclear power plant.

(a) Contamination inspection : The contamination on the external surfaces of the KSC-4 cask was inspected. The non-fixed contamination was not exceed 4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emiters and 0.4 Bq/cm^2 for all other alpha emiters. The radiation level resulting from the fixed contamination on the surfaces was not exceed 5 $\mu Sv/h$.
(b) Internal and external appearance inspection : The basket, impact limiters, valves, bolts, package rests on the conveyance were visually inspected. There were no any deffects such as crack, excessive distortion, bent, broken or torn part.
(c) Weldments inspection : Trunnions, joints of the bottom impact limiter, weldments of the outer shell of the KSC-4 cask and package rests on the conveyance fabricated for the cask peculiarly were inspected with PT according to ASME Sec.V, NF5350[4]. Any defects were not found.
(d) Load test for lifting devices : The KSC-4 cask has 4 trunnions as lifting devices. Two trunnions are attached at the top of the cask body and the rest are attached at the bottom of the cask body. Total 58 tons of the weight block, 150 % of the cask weight, was applied at the trunnions for 10 minutes according to ANSI N14.6[5], and then 4 trunnions were inspected with PT according to ASME Sec.V, NF5350. The results were satisfied because any defects were not fount at trunnions and the joints part of the cask body and trunnions. Figure 2 shows the load test for lifting devices.

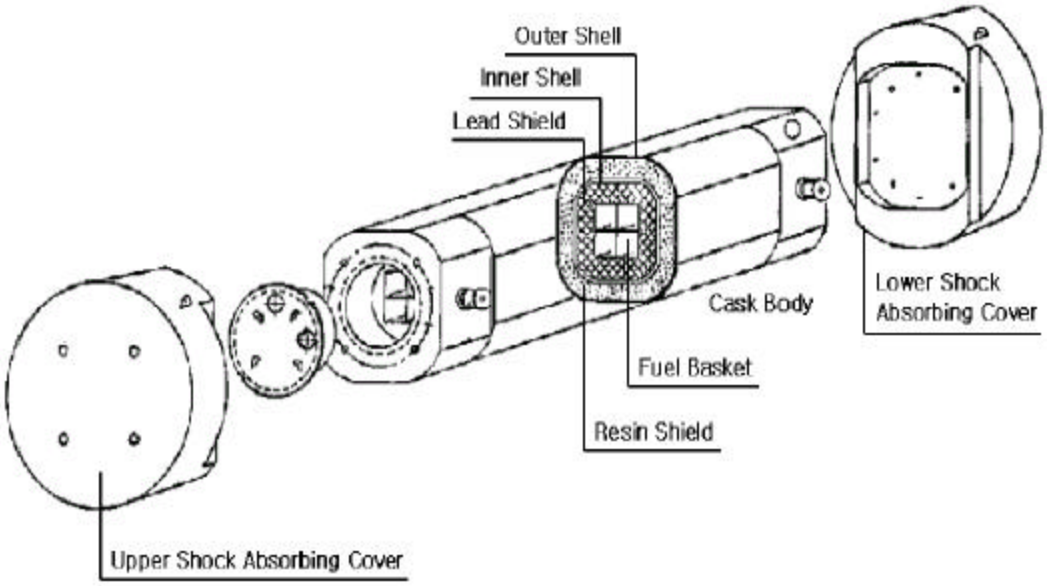

Figure 2 Configuration of the KSC-4 cask

Table 1 Design specification of the KSC-4 cask

Classification	Design features
Dimension	
- length of the cask body	4,845 mm
- outside diameter of the cask body	1,194 mm
- cavity length	489 mm
- cavity diameter	4,280 mm
Structural material	SA240 Type 304
Shielding material	Lead for gamma, Resin for neutron
Capacity	4 PWR(17x17) spent fuel assemplies - average burn-up : 38,000MWD/MTU - cooling time : 3 years
Weight	
- cask (including impact limiters)	34 tons
- total weights (including contents)	37.4 tons

(e) Hydrostatic test : 6.0 kg/cm^2 of the test pressure, 125 % of the maximum normal operating pressure (4.7 kg/cm^2), was hydrostatically applied inside the cask for 10 minitues according to ASME Sec.III, NB-6200[6]. There were no leaks. Figure 3 shows the hydrostatic test.

(f) Leakage test for containment system : Containment system of the KSC-4 cask was tested by using helium sniffer probe method according to ANSI N14.5[7]. Helium gas was filled with the

maximum operating pressures, and then sustained for 15 minutes while the cask was inspected for leakage. The release rate was measured at the boundary of the containment system. The maximum permissible leakage rate was 2.9 x 10^{-5} atm cm^3/sec and the measured leakage rate was 2.0 x 10^{-5} atm cm^3/sec. The result was satisfied. Figure 4 shows the Helium leak test.

(g) Radiation shielding evaluation : At fabrication a gamma scanning test using co-60 source (1.5 Ci) was carried out to evaluate the radiation shielding soundness, but at this inspection 4 PWR spent fuel assemblies were used to directly measure the radiation levels on the external surface of the KSC-4 cask because the gamma scanning test couldn't carry out due to interference of the basket in the cask. Also the radiation levels at the external surfaces were calculated and compared with the design values and the direct measurements. The measured radiation levels were max. 0.05 mSv/h. The radiation shielding was keeping with good soundness. Figure 5 shows the radiation level measurements of the external surface of the cask.

(h) Thermal transfer evaluation : At fabrication the heat sources of 10 kW in total were used to evaluate the thermal transfer ability, but at this inspection 4 PWR spent fuel assemblies (the same as above) were used to directly measure the temperature cask using thermocouple on the external surface of the KSC-4 cask because the heat sources couldn't carry out due to interference of the basket in the cask. Also the thermal analysis was carried out and compared with the design values and the direct measurements. The measured temperatures were max. 33.6 °C. The results of the analysis and the direct measurements were good agreement within 15 %. Figure 6 shows the temperature measurements.

The periodic inspection for the KSC-4 cask was successfully carried out by KINS. Consequently its safety was reaffirmed and the cask has been used at present in Korea.

(a) bottom (b) top

Figure 2 Load test for lifting attachments(trunnions)

Figure 3 Hydrostatic test

Figure 4 Helium leak test

Figure 5 Radiation level measurement

Figure 6 Temperature measurement

CONCLUSIONS

It is important to secure the safety of packaging. First of all, all packagings shall be routinely examined to ensure that they remain in a safe, usable condition, and shall be priodically inspected, tested and maintained in accordance with the quality assurance program including inspection and maintenance processures approved by competent authority. Regulations about periodic inspection of the packaging were reviewed. The KSC-4 spent fuel cask was inspected by KINS and the reasonable results were obtained. We have found it necessary to develop new methods for the inspections of radiation shielding and thermal transfer ability because the same methods as the acceptance test of fabrication can not be applied on the periodic inspection.

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