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Safety Evaluation of Type B Transport Package for Radioactive Waste under Accident Conditions

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1. Introduction

This paper focuses on evaluating safety performance of type B transport package for radioactive waste under accident conditions. The package was designed to contain radioactive wastes such mainly as spent filters produced in nuclear power plant. The regulations stipulate that the containment of package keep safe despite a series of accident cases like drop, fire and immersion of package. Safety tests were carried out with the conditions specified in IAEA Safe Standard(ST-1) on transport of Radioactive Material. Test model was constructed by full scale under the code of ASME VIII. Test results show that leakage rates of transport package after accidents are to meet allowable ones.

2. Regulations

The regulations on transport package for radioactive waste specify that type B package shall meet normal and accident conditions, which is based on IAEA Safety Standards(ST-1) on the transport of radioactive material[1]. Accident conditions is that package shall have the leakage rates below A_2 after four accident scenarios such as drop from 9m height, puncture from 1m height, fire under 800°C during 30minutes and immersion for the conditions of 8hours and 150 kPa in a row. This package was designed and tested to meet the safety requirements in IAEA Safety Standards(ST-1).

3. Test Model

Test model contains one DOT-17H drum generated in nuclear plant as shown Figure 1. It was constructed by full scale. Maximum weight is 4.5ton including 400kg contents. To prevent damages of package from 9m drop and puncture tests, the overpack was covered with 80mm thickness, which was made of polyurethane form. The connection between lid and main body of package was bolted by 12bolts made of high strength steel(A193.B7). To keep integrity of containment, double O-ring, which is to aim to prevent radioactive material from leakaging after accidents, was installed on the surface between lid and main body of package. Both of materials for lid and central part of package are SS400 and A105 respectively. In the process of manufacture, shop tests such as pressure test, load, leakage were performed in accordance with the standard for radioactive package[2].

Figure 1. Transport package with overpack used for test model

5. Safety Tests

5.1 Drop Test

The test model was dropped from 9m heights in the side direction of 15 angles with the surface. To acquire the data such as accelerations and strains, 14 strain gages and 10 accelerations were attached in the model as shown Figure 2. The height, lower and upper size of a drop structure with H-beam-typed shape is 15m, 8m x 8m and 4 x 4m.

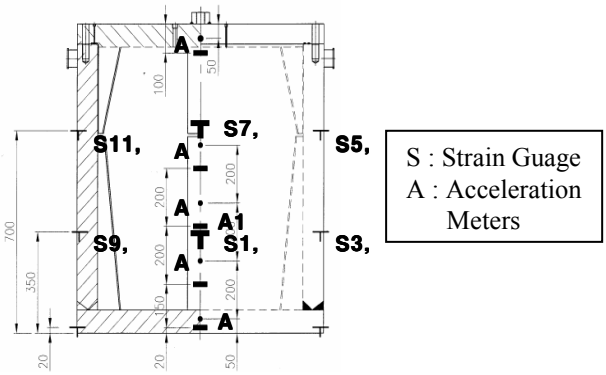

Figure 2. Test model and locations of sensors

5.2 Puncture Test

The model was dropped from 1m height onto a bar rigidly perpendicularly on the target, which is solid mild steel of circular section with 15cm in diameter and 20cm long. This test shall be conducted after 9m dropping.

5.3 Fire Test

The fire test shall be kept 30 minutes under fire temperatures of 800℃. After fire test, the temperatures of the package around O-ring should be below 250℃ which was designed to keep containment safe. 3M-Mat

of 8mm thickness encompass the outside of overpack to ban package temperatures from rising due to flame heat.

5.4 Immersion Test

The regulations require that package be immersed under a head water of at least 15m(equivalent pressure 150kPa) for a period of 8 hours. The package shall have no water infiltration into it after test. The test diagram is as shown in Figure 3.

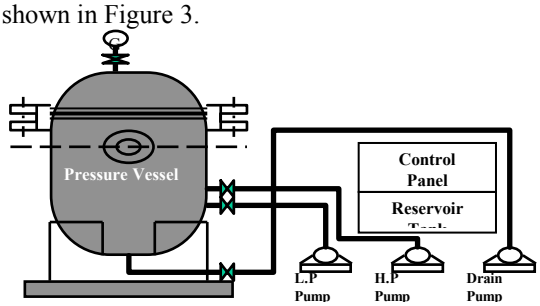

Figure 3. Diagram of immersion test for transport package

6. Test Results

6.1 Drop Test

The Figure 4 shows the deformations of the overpack after dropping onto the target. The biggest deformations in overpack were found on the targeting area in lower part of package. No damages were found in the package. The maximum forces were 146g in first impact, and 130g in second one as expected in analysis.

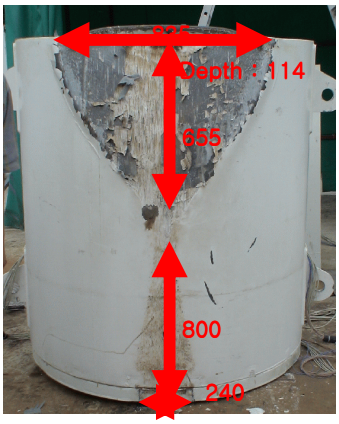

Figure 4. The appearance of overpack after 9m drop

6.2 Puncture Test

The Figure 5 shows the deformations of the overpack after puncturing onto the bar. The deformations were 70mm, which is one-thirds of the thickness of overpack. No damages or deformations were not found in the package under accidents because the overpack contains most of the impacts.

Figure 5. The appearance of overpack after 1m puncturing.

6.3 Fire Test

The maximum temperatures are 53℃ and 173℃ in the package and overpack respectively. Just 20℃ were increased in the package after fire test. The temperatures in the overpack near the lifting equipment were the maximum because of the least thickness. The Figure 6 shows the flame burning the package. O-ring was designed with allowable temperature of 250℃, so it would not be affected from these temperatures rise.

Figure 6. Fire test under 800℃ flame temperatures and 30 minutes

6.4 Leakage Test

To finally confirm the safety of package in the accident, leakage test was conducted after fire test in accordance with ANSI N14.5[2]. The measured values were 3.98E-5 ref ㎤/s, and allowable ones were 4.55E-2 ref ㎤/s respectively. The results met allowable rates in accident conditions.

6.5 Immersion Test

It was found that there is no water infiltration into the package after immersion.

7. Conclusions

Safety tests of type B package were performed under accident conditions such as 9m drop, puncture, fire, and immersion. Leakage rates after fire test were below allowable ones under the accident conditions. Therefore, The package is to meet the requirements related to safety standards under the accident conditions.

REFERENCES

[1] IAEA Safety Standard Series No. TS-R-1, 2005, Regulations for Packaging and Transportation of Radioactive Material.

[2] ANSI N14.5, 1997, for Radioactive Materials Leakage Tests on Packages for Shipment.