Drop Tests of Type IP-2 Transport Packages for Radioactive Waste

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1. Introduction

Two kinds of a type IP-2 transport package with a bolted-lid type for a radioactive waste have been developed for an on-site transportation in domestic nuclear power plants. If a type IP-2 were subjected to a free drop test and a stacking test under the normal conditions of a transport, it would prevent (a) loss or dispersal of the radioactive contents and (b) a more than 20 % increase in the maximum radiation level at any external surface of the package.[1~3] For a stacking test, the type IP-2 transport packages are verified by a finite element analysis.[4] The free drop tests under the normal conditions of a transport of the type IP-2 transport packages are performed. After conducting the drop tests, the torques to unfasten the bolts are measured and the gap between the body and the lid are checked so that a loss or dispersal of the radioactive contents are evaluated. To examine an increase in the maximum radiation level, the thickness of the shielding material by using the ultrasonic thickness gauge is measured.

2. The Type IP-2 Transport Package

The first type IP-2 transport package which has a 35 mm thickness wall as a shielding material is called the IP-2-a transport package. The IP-2-a transport package is designed to transport eight radioactive waste drums, whose radiation level is 20~200 mRem/hr and size and weight are 620 mm X 890 mm and 400 kg, respectively. Packaging capacity is 3.2 ton and the total weight is about 9.42 ton. The internal dimensions are 2,980 mm X 910 mm X 1,940 mm and the external dimensions of the package are 3,320 mm X 1,217 mm X 1,849 mm and thirty-two bolts are used to contain the lid.

The second type IP-2 transport package which has a 80 mm thickness wall as a shielding material is named the IP-2-b transport package. The IP-2-b transport package is designed to transport four radioactive waste drums, whose radiation level is 200~2,000 mRem/hr. Packaging capacity is 1.6 ton and the total weight is about 9.97 ton. The internal dimensions are 1,540 mm X 910 mm X 1,540 mm and the external dimensions of the package are 1,939 mm X 1,264 mm X 1,970 mm and twenty-four bolts are used to contain the lid.

To avoid a streaming radiation in the shielding path and to reinforce the structural integrity for the side drop test, a 5 mm and 10 mm step between the bottom and the flange on the lid is made for the IP-2-a and IP-2-b transport packages, respectively.

3. A Drop Test

3.1 The IP-2-a Transport Package

Three drop tests for the IP-2-a transport package are performed for the bottom-vertical, the top-vertical and the horizontal directions. After the bottom-vertical drop test and the top-vertical drop test, the square pipes which are deformed and impacted for the horizontal drop test are changed by using a new square pipe. The bolts are fastened with 200 N·m. The drop height is 0.9 m which is regulated in the regulations for the weight of a transport package which is from 5,000 kg to 10,000 kg.

Figure 1 shows the top-vertical drop of the IP-2-a transport package. The square pipes near the corner fitting are mainly deformed.

Table 1 shows the torque to unfasten the bolt, the change of the gap between the body and the lid and the decrease in the shielding thickness for a free drop test for the IP-2-a transport package. The bolts are not failed and unfastened for all of the free drop tests. The maximum and average torques to unfasten a bolt are 153 and 57 N·m, 260.5 and 162.6 N·m and 427.5 and 244.4 N·m for a bottom-vertical drop test, a top-vertical drop test and a horizontal drop test, respectively. The torque to unfasten a bolt for a bottom-vertical drop test is the smallest. For a horizontal drop test the torque to unfasten a bolt is the largest because of a deformation of the bolt and the flange.

The changes of the gap between the body and the lid for a bottom-vertical drop test, a top-vertical drop test and a horizontal drop test are 0.76 mm, 0.46 mm and 3.7 mm, respectively which occurred by a deformation of the square pipe of the body and the lid. The height of a step, 5 mm, is higher than the change of the gap, and the bolts are not failed and the rubber gasket is working so that there is no loss or dispersal of the radioactive contents.

The thickness of the shielding material is measured before and after a test by using an ultrasonic thickness gauge. Compared with the thickness of a wall, 35 mm, the decrease of the thickness of the shielding material (average value: 0.01~0.02 mm) is insignificant so that a loss of the shielding integrity is negligible in terms of the overall shielding integrity.

The IP-2-a transport package maintained the structural integrity for a free drop test under the normal conditions of a transport. And Seo et al.[4] showed that the IP-2-a transport package maintained the structural integrity for a stacking test by using a finite element analysis. The type IP-2-a transport package is verified as a type IP-2 transport package.

Figure 1. The top-vertical drop test of the IP-2-a transport package.

Table 1. The torque to unfasten the bolts, the change of the gap between the body and the lid and the decrease in the shielding thickness for a free drop test of the IP-2-a transport package.

		A bottom-vertical drop	A top-vertical drop	A horizontal drop
The change of the gap (mm)		0.76	0.46	3.70
A torque to unfasten a bolt (N·m)	Max.	153	260.5	427.5
	Ave.	57	162.6	244.4
The failure of the bolts		No	No	No
A decrease in the shielding thickness (mm)		0.01	0.02	0.01

3.2 The IP-2-b Transport Package

For the IP-2-b transport packages a horizontal drop test and a side-oblique drop test are executed in sequence with a 0.9 height. For a side-oblique drop test the model of the IP-2-b transport package is inclined with 20°. The bolts are also fastened with 200 N·m.

Table 2 shows the torques to unfasten the bolt, the changes of the gap between the body and the lid and the decreases in the shielding thickness for the horizontal and side-oblique drop tests for the IP-2-b transport package. The bolts are also not failed and unfastened. The maximum and average torques to unfasten a bolt are 414.5 and 269.5 N·m and 435 and 337.8 N·m for a horizontal drop test and a side-oblique drop test, respectively. The torque to unfasten a bolt for a horizontal drop test is smaller than that for a side-oblique drop test. For a horizontal drop test, a few bolts are mainly deformed so the torques to unfasten a few bolts show a larger value. But for a side-oblique drop test more bolts are deformed than for a horizontal drop test so that the average value for a side-oblique drop test is larger that for a horizontal drop test.

The changes of the gap between the body and the lid are 9 mm and 0.23 mm, respectively. The gap between the body and the lid is not the gap between the flange of the body and the lid. There is a rubber gasket between the flange of the body and the lid. The changes of the gap between the body and the lid for a horizontal drop test, 9 mm, showed the effects of a deformation of the square pipe of the lid which happens because of the corner fitting. The height of a step, 10 mm, is higher than the change of the gap, and the bolts are not failed and the rubber gasket is working so that there is no loss or dispersal of the radioactive contents.

Compared with the thickness of a wall, 80 mm, the decrease in the thickness of the shielding material measured for the free drop tests of the IP-2-b transport package(0.01~0.02 mm) is insignificant so that a loss of the shielding integrity is negligible in terms of the overall shielding integrity.

The IP-2-b transport package maintained the structural integrity for a free drop test under the normal conditions of a transport.

Table 2. The torque to unfasten the bolts, the change of the gap between the body and the lid and the decrease in the shielding thickness for a free drop test of the IP-2-b transport package.

		A horizontal drop	A side-oblique drop
The change of the gap (mm)		9.00	0.23
A torque to unfasten a bolt (N·m)	Max.	414.5	435.0
	Ave.	269.5	337.8
The failure of the bolts		No	No
A decrease in the shielding thickness (mm)		0.02	0.01

5. Conclusion

The free drop tests of two kinds of the type IP-2 transport packages are executed under the normal conditions of a transport. The torques to unfasten the bolts and the gap between the body and the lid are measured so that a loss or dispersal of the radioactive contents is evaluated. To examine an increase in the maximum radiation level, the decreases in the thickness of the shielding material measured are insignificant so that a loss of the shielding integrity is negligible in terms of the overall shielding integrity.

REFERENCES

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