DROP TEST OF IP-2 PACKAGING FOR LLW TRANSPORT

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SUMMARY

In the current transportation of LLW to disposal facilities in Japan, the transport container was designed for the loading condition of 5 tons in total weight and 500kg of homogeneous solidified waste in the maximum weight drum.

However the maximum weight of the waste drum will be 1000 kg in the transportation program of miscellaneous solid waste beginning in the year 2000.

For this increase of weight, drop tests of the current transport container were performed to ensure the applicability under the requirement of transportation.

The followings were found as a result:

- The LLW transport container is acceptable for total package weight less than 8 tons.
- For the case of the total package weight less than 5 tons ,waste drums exceeding 680 kg in weight must be positioned in the four drums in the central part of the transport container.
- For the case of the total package weight exceeding 5 tons, drums over 900kg are required to be positioned in the four drums in the central part of the container.
- After each drop test, it was confirmed that the radiation level of the surface of package didn't increase more than 20 %.

INTRODUCTION

LLW transport containers have been utilized under the following loading condition in Japan:

Weight of full loaded container < 5 tons

Weight of waste drums to be loaded into the container < 500 kg

The current disposal facility in Japan has been accepting only homogeneous waste drums whose weight is less than 500 kg.

However, disposal of miscellaneous wastes are scheduled to begin in 2000, and the

maximum weight of the waste drum is expected to increase to 1000 kg. The waste drums, which are classified as LSA-II, are required to be transported by the current LLW transport container as industrial package Type 2 (IP-2).
The purpose of this drop test is to study the applicability of the current LLW transport container for the cement solidified miscellaneous waste drums.

Drop tests were performed under the following seven conditions with a vertical and corner drop for each case, for a total of fourteen drops.

① Containing 1000kg×4 waste drums, 1.2m drop
② Containing 1000kg×6 waste drums, 1.2m drop
③ Containing 1000kg×8 waste drums, 0.9m drop
④ Containing 700kg×8 waste drums, 0.9m drop
⑤ Containing 700kg×6 waste drums, 1.2m drop
⑥ Containing 1000kg×6 waste drums, 0.9m drop
⑦ Containing 850kg×8 waste drums, 0.9m drop

Weight and dimensions of each package were measured before and after each drop.

Technological criteria for industrial package Type 2

When IP-2 are applied to the tests to withstand normal conditions of transport under Japanese regulations, the following requirements shall be applied.

- No dispersal of the radioactive contents
- No significant increase of radiation level on the package surface

Based on the following view points, conformity of the requirement for IP-2 technical criteria was evaluated in this test.

① Confirmation of "no dispersal of the radioactive contents"
- No penetration to the inside after dropping
- Less than 10 mm of lid opening against 12 mm allowance for the bolt-tightening on packing before and after drop.

② Confirmation of "No significant increase of radiation level"
- Less than 20% increase of surface dose rate of package by waste drum transfer

The corner drops resulted in some penetrations, and the above evaluation item "No penetration to the inside after dropping" became a problem, however, the opening of the lid was less than 10 mm. On the other hand, in the vertical drops, some lid openings of greater than 10 mm were observed, but no penetration occurred. Then, the following weight control conditions for miscellaneous solidified waste drums were implemented:

- Corner drop : Evaluation of penetration presence
  → Decision of weight control conditions of packages
- Vertical drop : Evaluation of lid opening
  → Decision of weight control conditions of waste drums

Corner drop test

(1) Test result

Some penetration occurred in the following two conditions of the total of seven cases of corner drop.

- Containing 1000 kg×6 waste drums 1.2 m drop
- Containing 1000 kg×8 waste drums 0.9 m drop

The penetration occurred due to large deformation of the corner metal fitting on the drop side.

(2) A study on total weight of packages

The deformation size of the corner metal fitting will be proportional to potential energy of the package. The relations of penetration presence and potential energy of packages are shown in Table 1.

Table 1 The relations of penetration presence and potential energy

	Containing conditions	Total weights (tons)	Drop height (m)	Potential energy (kJ)	Penetration presence
Condition ①	Containing 1000 kg ×4 waste drums	5.17	1.2	60.8	No
Condition ②	Containing 1000 kg ×6 waste drums	7.19	1.2	84.6	Yes
Condition ③	Containing 1000 kg ×8 waste drums	9.21	0.9	81.2	Yes
Condition ④	Containing 700 kg ×8 waste drums	6.92	0.9	61.1	No
Condition ⑤	Containing 700 kg ×6 waste drums	5.48	1.2	64.5	No
Condition ⑥	Containing 1000 kg ×6 waste drums	7.24	0.9	63.9	No
Condition ⑦	Containing 850 kg ×8 waste drums	8.07	0.9	71.2	No

As shown in table 1 , the penetration occurred under the drop conditions with more than 81 kJ, but no penetration occurred on less than 71 kJ.
From this result, we concluded that the maximum package weight was 8 tons.

(3) Study on drop height

The drop height under normal condition is regulated as follows :

- Package weight less than 5 tons : 1.2 m
- Package weight less than 10 tons and more than 5 tons : 0.9 m

The relation of package weight and potential energy under this test condition is shown in Figure 1.
As the test condition (potential energy) for all packages less than 8 tons is in conformity with the regulation, we conclude that penetration for packages less than 8 tons will not occur.

Vertical drop test

(1)Test result

Maximum lid openings occurred at the opposite side of drop direction (B side edge) in the vertical drop. The feature of lid opening is shown in Figure. 3. The lid would be pushed up by waste drums on the upper side of the tightening bolt. The relation between test condition and lid opening under each vertical drop are shown in Table 2. The relations between potential energy of waste drums and lid opening are shown in Figure. 2.

Table 2 The relation of test condition (vertical drop and lid opening)

	Containing condition	Drop height	Weight of waste drum		Potential energy of waste drum	Lid opening (Maximum)
			Position 4	Position 5		
Condition0	500 kg×8 waste drums	1.2 m	502 kg	502 kg	11.81 kJ	5.0 mm
Condition 1	1000 kg×4 waste drums	1.2 m	—	—	—	—
Condition 2	1000 kg×6 waste drums	1.2 m	1012 kg	—	11.9 kJ	11.3 mm
Condition 3	1000 kg×8 waste drums	0.9 m	1011 kg	1003 kg	17.8 kJ	12.2 mm
Condition 4	700 kg×8 waste drums	0.9 m	724 kg	722 kg	12.8 kJ	6.5 mm
Condition 5	700 kg×6 waste drums	1.2 m	730 kg	—	8.6 kJ	10.2 mm
Condition 6	1000 kg×6 waste drums	0.9 m	1019 kg	—	9.0 kJ	7.3 mm
Condition 7	850 kg×8 waste drums	0.9 m	867 kg	866 kg	15.3 kJ	8.5 mm

Condition 0 : A datum in confirmation test of homogeneous solidified drum

(2) Study of maximum waste drum weight in the cases containing 8 drums

In the cases containing 8 drums, 2 waste drums pushed up the lid on the upper side of tightening bolts, as shown Figure. 3. A proportional relation between the potential energy summed up by 2 waste drums and the lid opening has been found, as shown in Figure. 2. In this relation, an approximation was performed by minimum involution, and we found the potential energy of waste drums at the standard value of lid opening to be 16.1 kJ. Therefore, some adjustment of waste drums weights contained in the outside positions (container position : 1, 4, 5, 8) are necessary so as not to exceed 16 kJ of potential energy. In order that the lid opening is less than the standard value under regulated drop condition, the following limited average weight of waste drums at outside container positions (1, 4, 5, 8) will be necessary.

- In case of less than 5 tons (1.2 m drop) of package weight : 680 kg
- In case of more than 5 tons (0.9 m drop) of package weight : 900 kg

(3) Study of maximum waste drum weight in the cases containing 6 drums

In the cases containing 6 drums, waste drum weight on the upper side of tightening bolts has been evaluated. As shown in Figure 3, the relation of the potential energy is not proportional because the complex forces by the drums in the case of ⑥ compared to the case of 8 drums caused a variety of data . Therefore, the datum of ⑥ was abandoned, and the relation of potential energy of waste drums and lid opening in the cases containing 6 drums was evaluated. In the result, the potential energy of waste drums at the standard value (10 mm) of the lid opening was 8 kJ. In order that the lid opening is less than the standard value (10 mm) under regulated drop condition, the following limited average weight of waste drums at outside container positions (1, 4, 5, 8) will be necessary.

- In case of less than 5 tons of package weight (1.2 m drop) : 680 kg
- In case of more than 5 tons of package weight (0.9 m drop) : 900 kg

These data are in conformity with the cases containing 8 drums.

CONCLUSION

Total weight of package shall be limited to a maximum of 8 tons in case of using LLW transport package more than 5 tons, and the weights of drums containing miscellaneous solidified waste shall be limited.

Table 3 shows the limited weight condition for the case of drums containing miscellaneous solidified waste in LLW transport package.

Table 3 Limited condition of weight in LLW transport package

<table>
<tr><th>Containing condition / Total weight of transport package</th><th>Containing 4 drums</th><th>Containing 5, 6 drums</th><th>Containing 7, 8 drums</th></tr>
<tr><td rowspan="2">Less than 5 tons</td><td rowspan="2">No limit of weight, if contained in the center</td><td colspan="2">No limit if less than 680 kg of waste per drum</td></tr>
<tr><td colspan="2">Containers more than 680 kg in the center positions</td></tr>
<tr><td rowspan="2">Not less than 5 tons
Less than 8 tons</td><td rowspan="2">(Less than 5 tons)</td><td rowspan="2">No limit</td><td>No limit if less than 900 kg of waste per drum</td></tr>
<tr><td>Containers more than 900 kg in the center positions</td></tr>
<tr><td>Over 8 tons</td><td colspan="2">(Less than 8 tons)</td><td>Improper</td></tr>
</table>

REFERENCE

Regulations for the Safe Transport of Radioactive Material. 1985 Edition(As Amended 1990).Safety Series No.6,Vienna,1990.IAEA

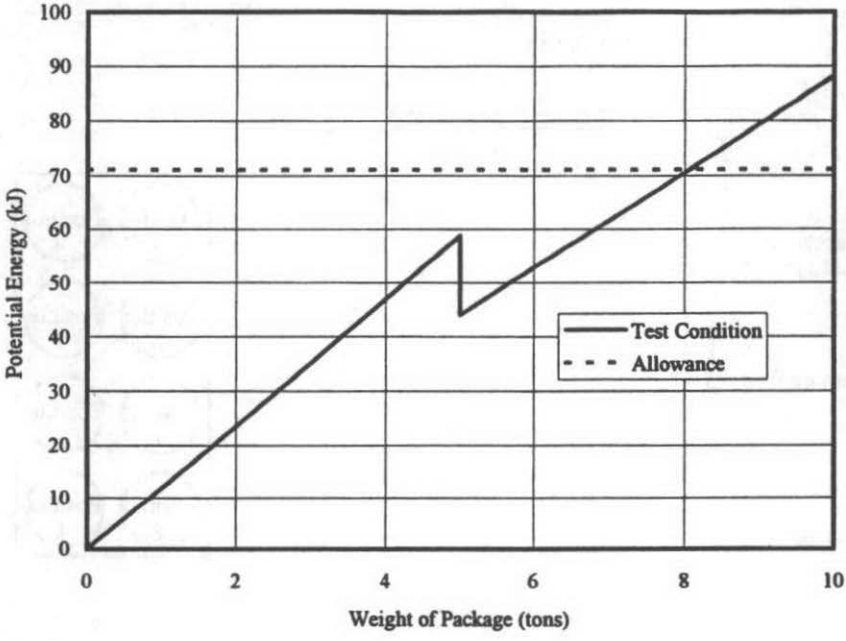

Figure 1 Potential Energy in test condition

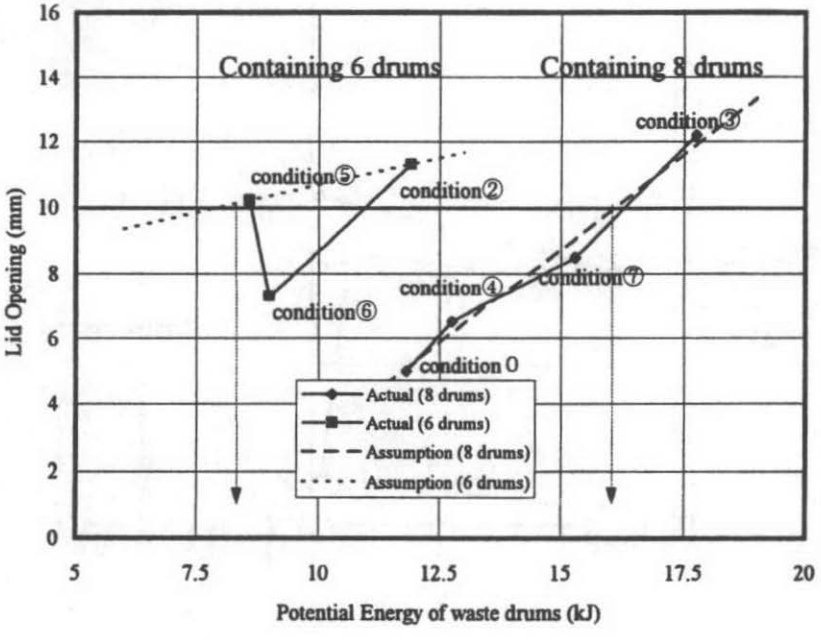

Figure 2 Relation of waste drums potential energy and lid opening

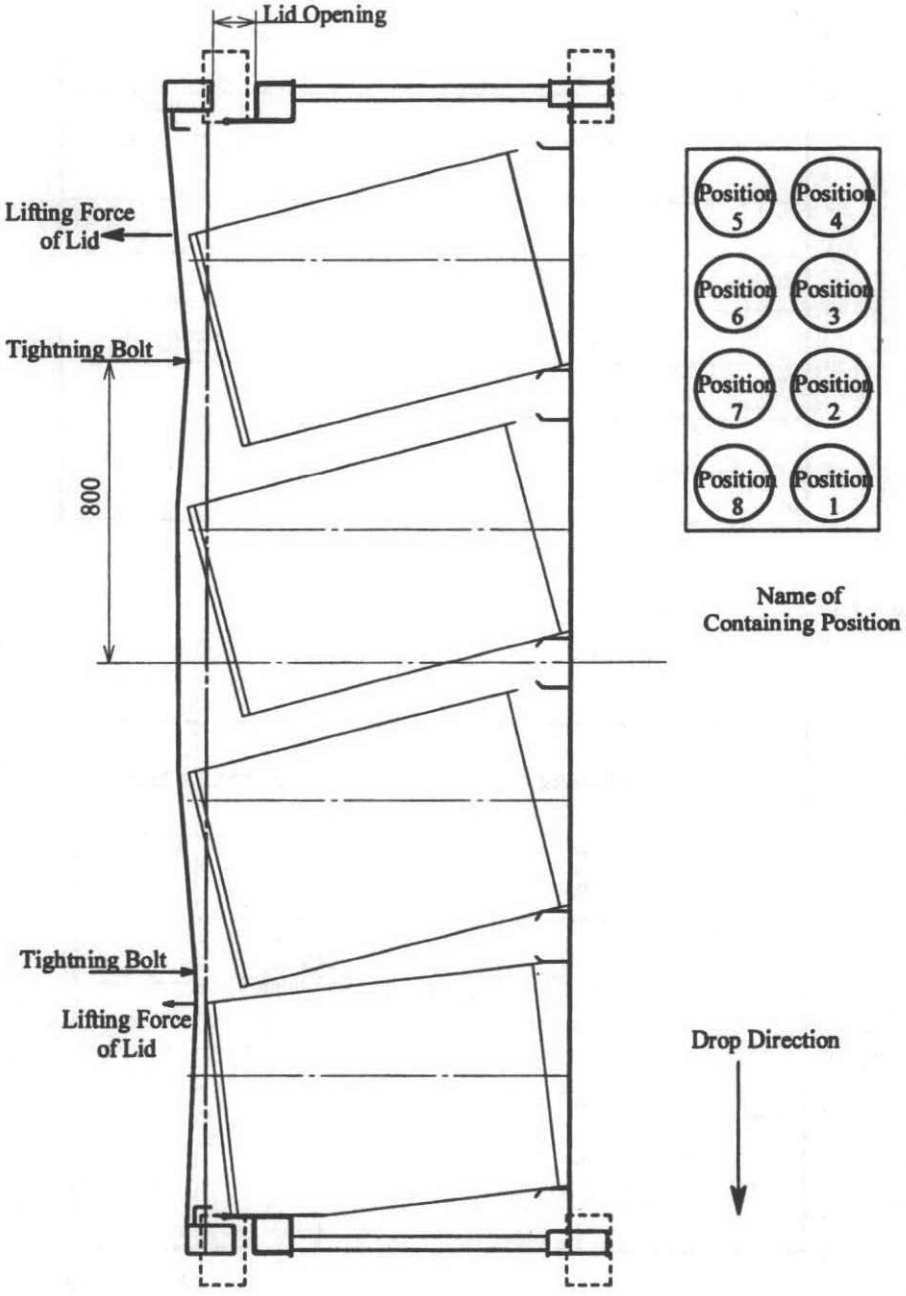

Figure 3 Feature of Lid Opening at Vertical Drop Test