Drop Test of a Model for FBR Irradiation Fuel Shipping Cask

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INTRODUCTION

As one of the development programs of the cask for the post-irradiation examination of the FBR fuels, the drop tests were carried out using the half scale model of the cask. The objectives of the tests are to demonstrate that the cask body has ability to withstand the drop test conditions imposed for type BM-packages and maintain the tightness integrity and then to confirm the validity of the evaluation method for deceleration and deformation of shock absorbers used in safety analyses.
The another purpose of the tests is to obtain the initial conditions of the thermal test following drop tests, which is another one of the development programs.

We carried out successively the following four tests by using the half scale model.
1) 9 m horizontal drop test
2) 9 m vertical drop test turning lid downward
3) 1 m drop punch test onto lid
4) 1 m drop punch test onto body in horizontal position

This paper describes the test procedures, test results and their comparisons with the analysis results.

SPECIMEN AND FACILITY

The specimen was fabricated to be the 1/2 scale model of the actual cask. The shape and dimensions of the model are illustrated in Figure 1. The full length including the shock absorbers is 3,088mm, the outside diameter of the body is 792.5mm, the outside diameter of the shock absorber is 1,100mm and the total weight is about 5.5 tons.

The model was accurately simulated to be the actual cask including complex structures such as the valves, except the followings;

1) The holes for the instrumentation cables and the pressure gauges were provided at the upper flange.
2) The lug for hanging the specimen used for the vertical drop test was provided at the bottom plate.
3) The fins were made with the full sized thickness and pitch.

The drop tests were carried out at the drop test facility in Kashiwa city of Chiba prefecture. The facility is composed of a truck-crane with dropping device and a target which consists of a concrete block covered by a 8m by 8m by 32mm steel plate. The mild steel bar used for 1 m drop punch tests and its diameter was scaled to be 75mm according to the half scale model.

TEST PROCEDURES AND INSTRUMENTATION

The following measurements were performed during each drop test.

1) The deceleration, the strain and the head pressure of water in cavity were measured by using strain gage type accelerometers, strain gages and strain gage type pressure sensors, respectively. The measuring points are shown in Figure 2.
2) The drop velocities were measured by the phototubes.
3) The deformation of the shock absorbers and cask body were measured by using micrometers, slide calipers, rules and so on.
4) Before and after each drop test, the leakage tests were performed at the seals of the lid, the vent-valve and the drain valve by using the nitrogen gas pressurizing method, in order to confirm the tightness of the seals.
5) The high speed photography was used to observe the motion of the model during the impact.

The water was poured into the cavity of the model before each drop test and the amount of water was correspond to one of the actual cask.

TEST RESULTS

The maximum strains in each part of the model measured in every drop test are very small. Therefore, the structural integrity of the cask body was certified to be maintained under the drop test conditions.

The leak rates at seals measured before and after every drop test were comparatively less than the limit required for the actual cask design and therefore, it was demonstrated that the tightness integrity of the cask body were maintained in the drop test conditions.

Furthermore, no damage was observed in the lid bolts, O−rings and interior of cask body by visual inspection, after the lid and the valves were taken off, and then it was confirmed that the integrity of the seals was secured for the drop test conditions.

The results of puncture tests also showed that the deformation of lid and outer shell crushed onto the punch were negligibly small by the visual and measurement inspections.

COMPARISON WITH ANALYSIS RESULTS

Table 1 shows the comparison results of deceleration of the cask body and deformations of shock absorbers. The analysis is based on a convential theory using the Uniaxial Displacement Method and the deceleration and deformation of shock absorber are evaluated by a static calculation under the assumption that the drop energy of the cask is absorbed by the deformation of shock absorbers.

The values estimated by the analysis were well agreed with the test results for 9 m horizontal drop test, but the values estimated by the analysis were conservatively larger than test results by 20% for 9 m vertical drop test. It was confirmed that the evaluation method used in safety analysis of the actual cask gave a conservative estimation and the analysis results were well agreed with the test results.

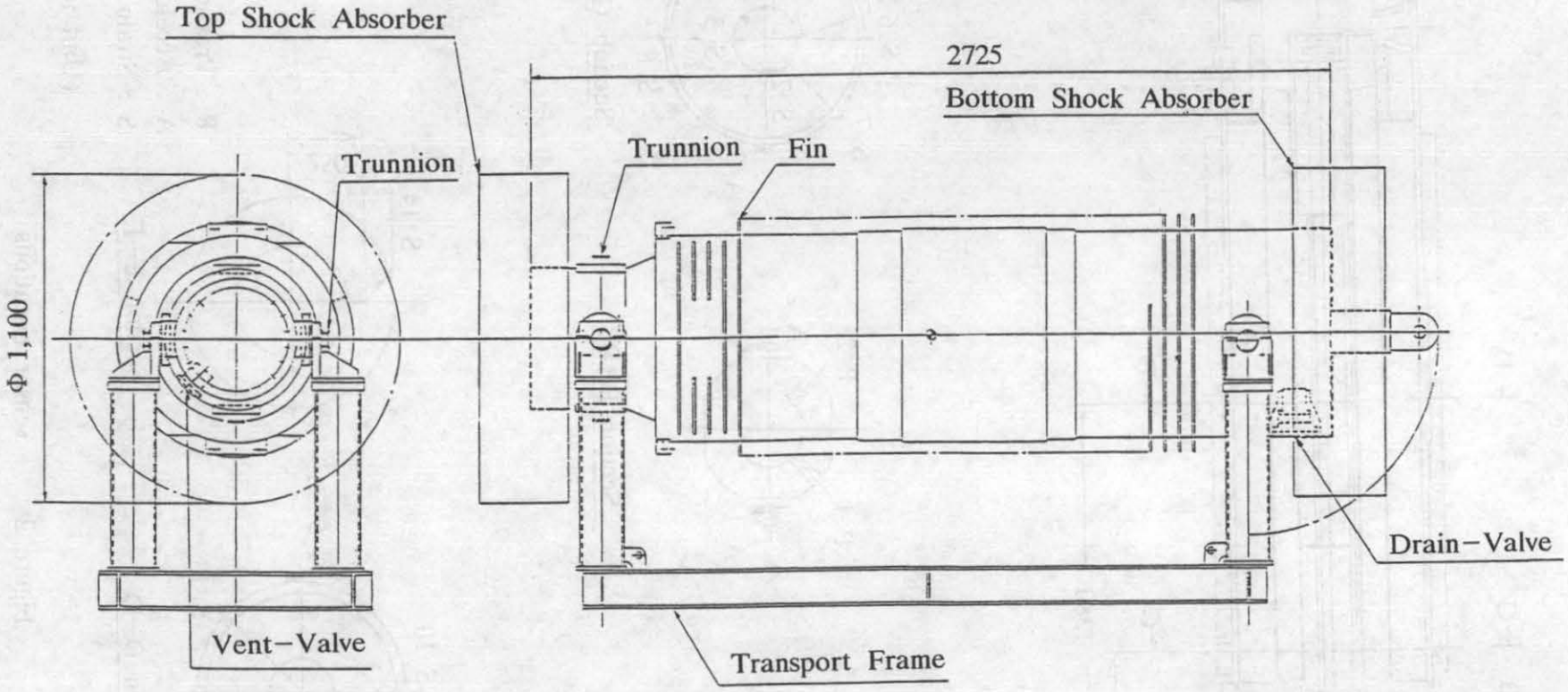
CONCLUSIONS

As the results of the drop test, the following conclusions were obtained;

1) It was confirmed that the maximum strains measured in each part of the model were very small in every drop test and the structural integrity of the cask body was maintained under the drop test conditions.
2) It was demonstrated that the tightness integrity of the cask was maintained

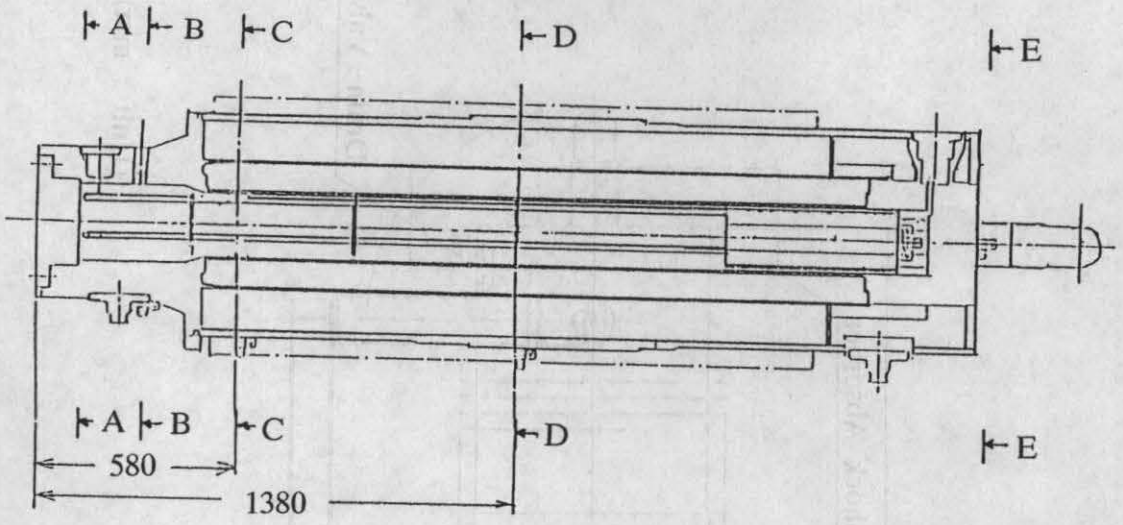
under the drop test condition because the leak rates at seals measured before and after every drop test were comparatively less than the limit required for the actual cask.

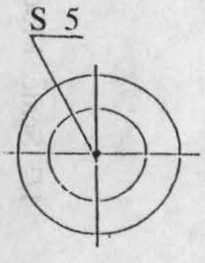
3) No damage was observed in the lid bolts, O−rings and interior of cask body by visual inspection and no injurious matter was observed in the outers of cask body by the visual and measurement inspections.
4) It was shown that the evaluation method of deceleration and deformation of shock absorbers used in safety analysis gave conservative estimation and the analysis results were well agreed with the test results.
5) The deformations of lid and outer shell crushed onto the punch were observed to be negligibly small, and the structural integrity of the cask under drop tests was verified.



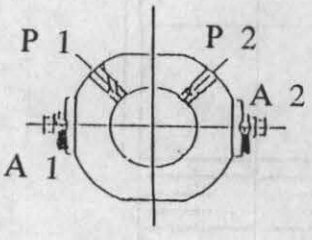
(Unit : mm)

Figure 1 1/2 Scale Model



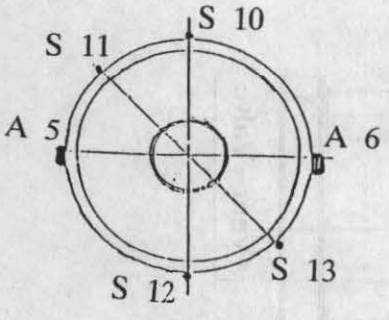


Section A–A

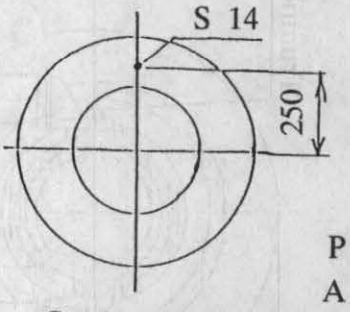


Section B–B

Sectiob C–C



Section D–D



Section E–E

P : Pressure Sensor
A : Accelerometer
S : Strain Gage

(Unit : mm)

Figure 2 Sensor Locations

Table 1 Comparison of Deceleration and Deformation of Shock Absorbers

Drop Condition	Deformation of S.A. (mm)		Max. Deceleration (G)	
	Test	Analysis	Test	Analysis
9 m Horizontal	110	110	104 ~ 117	117
9 m Vertical	22	26	334 ~ 392	448