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PROTOTYPE TEST OF A NEW MOX POWDER TRANSPORT PACKAGING

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ABSTRACT

The Japan Atomic Energy Agency [JAEA] is planning to transport uranium and plutonium mixed oxide [MOX] powder for the prototype fast breeder reactor ‘‘MONJU’’ and experimental fast reactor ‘‘JOYO’’ from the commercial Rokkasho Reprocessing Plant [RRP] operated by Japan Nuclear Fuels Limited [JNFL] in Rokkasho-mura at the northernmost prefecture on the Japanese mainland of Honshu. The design and analyses for the new packaging for transporting the MOX from the RRP to the JAEA Plutonium Fuel Fabrication Facility [PFPF] in Tokai-mura, Ibaraki Prefecture, started in 2002.

The packaging configuration is approximately 1.4m in diameter and 2.2m in height; package weight is approximately 4 tons. The contents are storage canisters containing three MOX powder cans. The design concept is to have the simple and compact design satisfying the required technical standard as much as possible in consideration of operation limitation of its weight and size in the facilities.

The demonstration performance tests according to the requirements for Type BU-F package in IAEA TS-R-1, 2005 Edition were conducted using a 1/1 full scale prototype packaging from 2007 to 2009. It was confirmed to meet the technical standard. The research for the test facilities in advance has been carried out in consideration of test items. The test data to be measured and these positions have been investigated carefully too. The logic of the safety analysis method was confirmed by these test results. When designing and manufacturing the packaging, explanation to the basic policy of quality control and manufacturing detail and the examination relates to the quality control are done in the system of law in Japan. In the fabrication of the prototype packaging, the quality control was done in the fabrication of special material such as neutron shield and welding. And it was confirmed that the manufacturing difficulty would not be foreseen. In the paper, the test results and the logic of the safety analysis method are presented.

INTRODUCTION

The demonstration performance tests of a new MOX powder transport packaging were conducted using a 1/1 full scale prototype packaging. The drop test, thermal test and water immersion test were conducted based on the requirements for Type BU-F package in IAEA TS-R-1. The schematic drawing of package is shown in Fig.1. The packaging configuration is approximately 1.4m in diameter and 2.2m in height; package weight is approximately 4 tons. The contents are storage canisters containing three MOX powder cans. For the drop test, drop test I and drop test II were conducted. For the water immersion test, water immersion test I (prototype packaging immersed under a head of water of at least 15m for a period of not less than eight hours) and water immersion test II (prototype packaging immersed under a head of water of at least 200m for a period of not less than one hour) were conducted because the radioactive contents with activity greater than 10^5A_2.
The integrity confirmation test of contents and dismantling test was conducted after these test, and the integrity of containment confirmed that it was not impaired. It was confirmed to meet the technical standard by these test results.

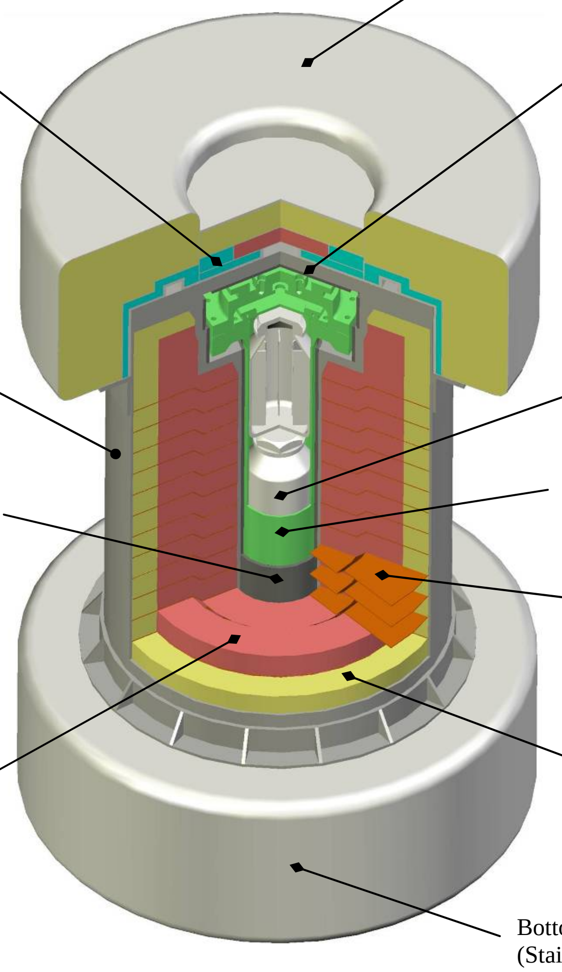


Fig. 1. Schematic drawing of package

SCHEDULE

The development schedule of a new MOX powder transport packaging is shown in Fig.2. Drop test, thermal test, water immersion test were conducted in 2009.

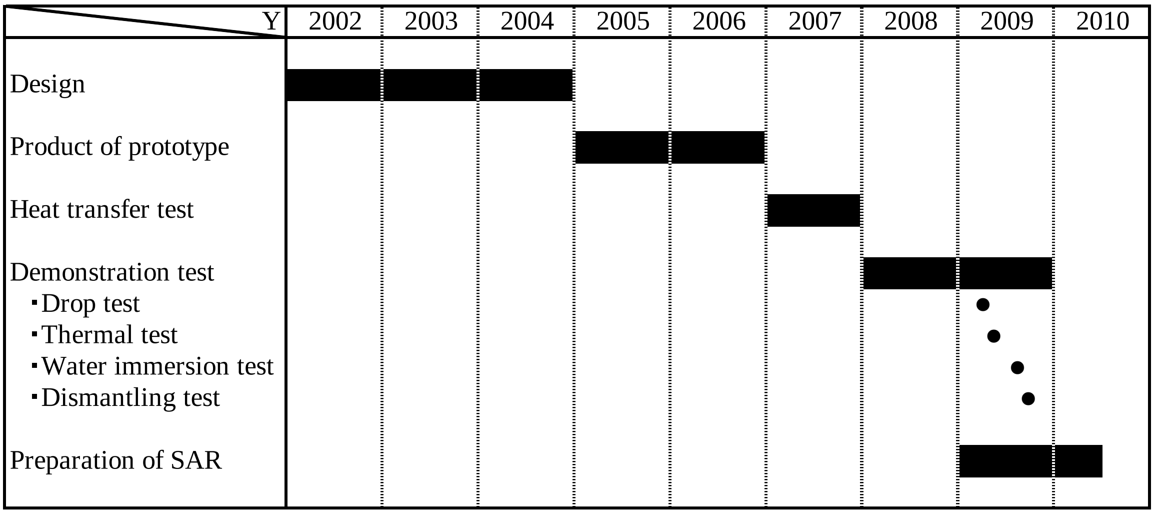


Fig. 2. Development schedule

TEST CONTENTS

The flow diagram of test is shown in Fig.3. The tests were conducted with a turn to show in the figure. The integrity of containment was confirmed by the leakage test of package which carried out before and after every test.

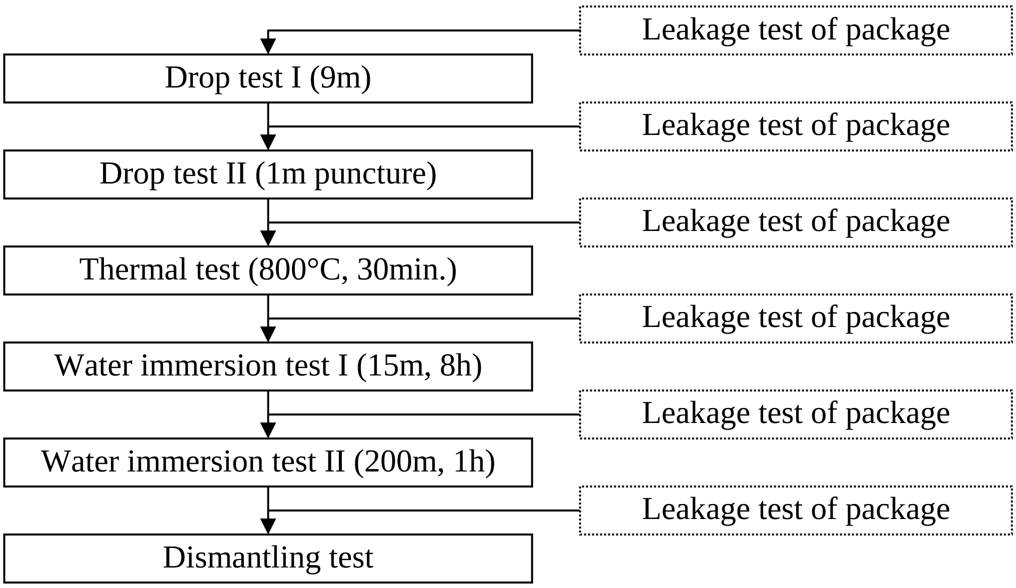


Fig. 3. Flow diagram

Drop test

For the drop test, drop test I (free drop from 9m) and drop test II (1m puncture) based on the regulations were conducted. As for the drop attitude, the vertical drop was chosen because the package suffered maximum damage by analysis results with LS-DYNA which general purpose transient dynamic finite element program. As for the drop test II, the center of gravity drop and eccentric drop were conducted. The acceleration transducers and strain gauges were installed on a main part of packaging, and recorded time history and measured deformations of the shock absorber. The integrity of containment was confirmed by the leakage test of package which were carried out before and after every test.

Thermal test

For the thermal test, the prototype packaging was exposed to the temperature of 800°C for a period of 30 minutes based on the regulations. The gas furnace test facility was used to provide the heat fully engulfing the prototype packaging. The thermocouples were installed on a main part of packaging, and time history of temperature was recorded through a test period. The integrity of containment was confirmed by the leakage test of package which carried out before and after test.

Water immersion test

For the water immersion test, water immersion test I (15m, 8h) and water immersion test II (200m, 1h) based on the regulations were conducted. The vacuum of double O-ring for packaging body is monitored and recorded through a test period. The pressure vessel was used for test facility, and prototype packaging immersed. The integrity of containment was confirmed by the leakage test of package which carried out before and after every test.

Dismantling test

For the dismantling test, the main damaged part was cut and inspected the damaged conditions of inside of the package. The neutron shield (resin) was analyzed by using the specimen that was picked up from the damaged part.

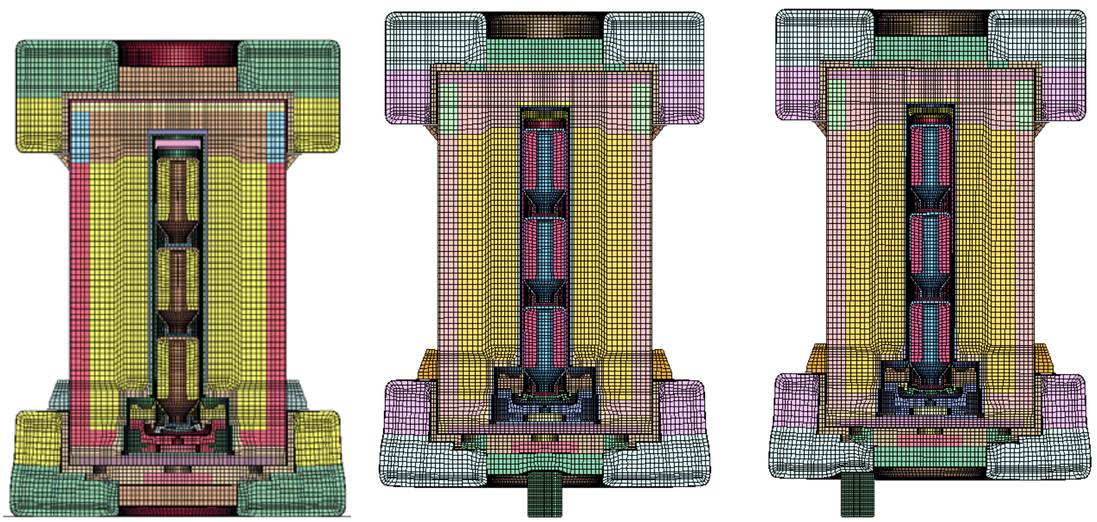
TEST RESULTS

Drop test

Table.1, gives test results of drop test. The analysis model of drop test is shown in Fig.4. The general purpose transient dynamic finite element program (LS-DYNA) was used for the drop analysis. The 1/2 analysis model of the package was used for the finite element model in consideration of symmetricalness. The typical pictures of drop test are shown in Fig.5. The integrity of containment confirmed that it was not impaired by the leakage test of package which carried out before and after every test. The integrity of package was confirmed that it was not impaired from drop test results. The validity for the logic of safety analysis method was confirmed by these test results because about the same results were provided at test results and analysis results.

Table 1. Test results of drop test

	Deformation of shock absorber (mm)		Acceleration (G)		Stress of lid (N/mm^2)	
	Test result	Analysis result	Test result	Analysis result	Test result	Analysis result
Drop test I	41	41	349	345	95	122
Drop test II (center)	19	20	94	84	143	216
Drop test II (eccentric)	47	51	33	39	-	-



Drop test I Drop test II (center) Drop test II (eccentric)

Fig. 4. Analysis model of drop test

Fig. 5. Drop test

Thermal test

Table.2, gives test results of thermal test. The temperature record of thermal test is shown in Fig.6. The thermal analysis program (TRUMP) was used for the thermal analysis. The integrity of containment was confirmed that it was not impaired by the leakage test of package which carried out before and after test. The integrity of package was confirmed that it was not impaired from thermal test results. The validity for the logic of safety analysis method was confirmed by these test results because the analysis results are safer side than test results.

Table 2. Test results of thermal test

	Test result (°C)	Analysis result (°C)
Near the O-ring of lid	112	177
Side of inner shell	177	218
Bottom of inner shell	108	111
Near the O-ring of storage canister	98	100

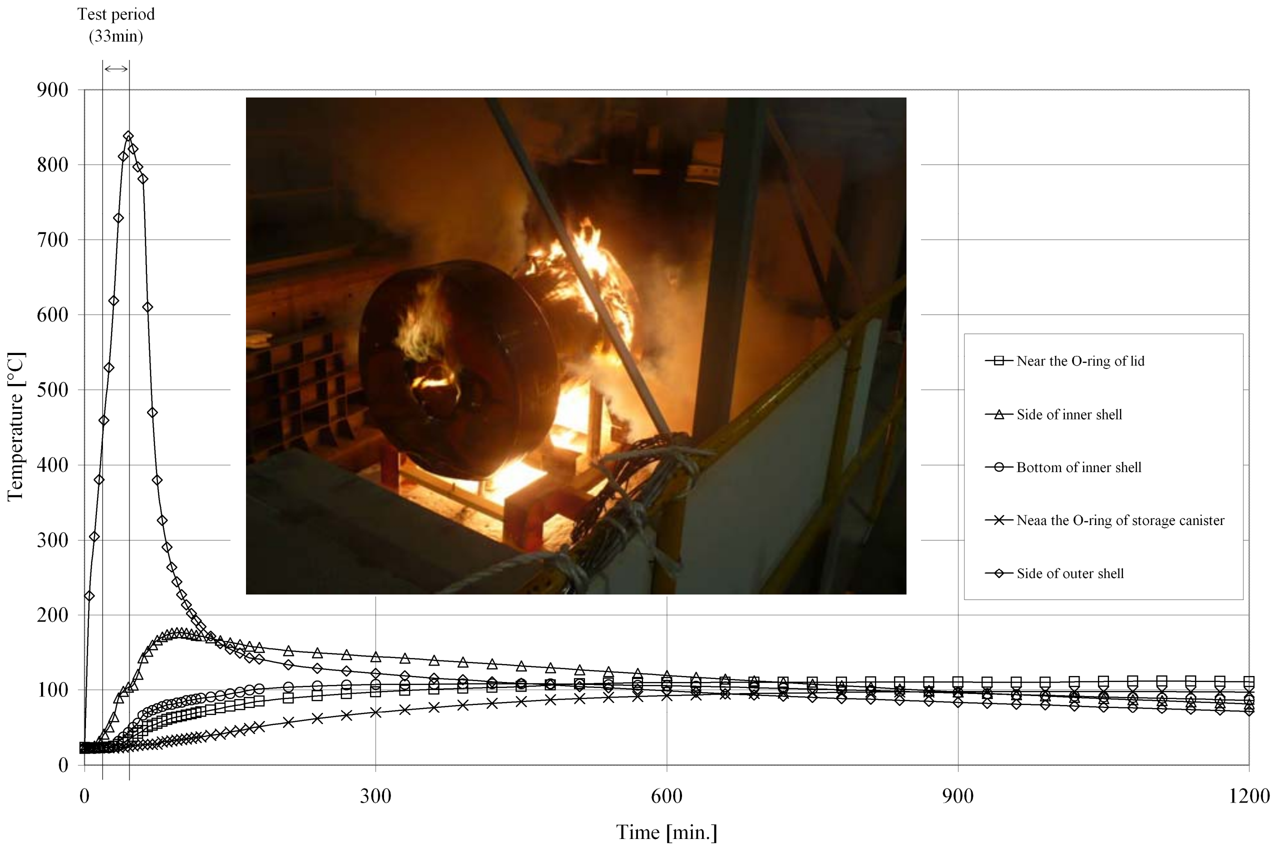


Fig. 6. Temperature record

Water immersion test

The integrity of package was confirmed that it was not impaired from results of water immersion test I (15m, 8h) and water immersion test II (200m, 1h). The integrity of containment confirmed that it was not impaired by the leakage test of package which carried out before and after every test.

Dismantling test

The main damaged part was cut and inspected the damaged conditions of inside of the package. The result of dismantling test is shown in Fig.7. As a result of inspection, the containment system, neutron absorber and storage container were not deformed. The confinement system was kept its function. At the shock absorber for packaging body, the parts of surface and near the fin were carbonized. The neutron shield (resin) did not change in quality and discoloration was not observed. And the resin specimens that picked from the damaged part were analyzed about density and chemical composition (C, H and N). Table.3, gives analysis results of neutron shield. Because neutron shield is not affected by the heat influence according to the table, the performance of the shield is maintained.

Fig. 7. Result of dismantling test

Table 3. Analysis results of neutron shield

	Density (g/cm^3)	**C (%)**	**H (%)**	**N (%)**
At production	1.05	70.1	11.1	1.6
At dismantling test	1.05	70.4	11.0	1.8

Note) The values are average of the measurement result.

CONCLUSIONS

The demonstration performance tests of a new MOX powder transport packaging were conducted. It was confirmed to meet the technical standard by test results.

The validity for the logic of safety analysis method was confirmed by these test results.

And it was confirmed to the confinement system is kept by the result of dismantling test after the test based on the regulations.

REFERENCE

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