HLW Vitrified Waste Sample Transport Package

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INTRODUCTION

The Japan Atomic Energy Research Institute (JAERI) is currently engaged in a study of High Level Waste Vitrified Waste (HLW) at the Waste Safety Test Facility (WASTEF). For this study, transportation of HLW sample is needed, nevertheless there is no packaging which can be utilized for transportation of HLW in Japan. JAERI, with Transnuclear, Ltd., had planned to design and fabricate a package named VFC-88Y-2T type for the transpont of a HLW glass sample. Design, safety evaluation and licensing work of the package has been completed. The Japanese certificate for the package design, as type B(U) and non-fissile package, was issued and the packaging fabrication will be completed shortly. In designing the package, consideration was given to make the package structure as simple as possible in order to facilitate handling and decontamination in a hot cell.

In analyzing the package integrity, the emphasis is placed on evaluation of HLW sample under the accidental conditions because there are few examples of HLW transport.

1. OUTLINE OF THE VFC-88Y-2T TYPE PACKAGE

Content

The content of the package is a borosilicate glass sample. The safety analysis is performed based upon conservative assumptions, thus allowing various kinds of glass samples to be loaded for actual usage. Main characteristics of glass samples to be used in the analysis are as follows;

Weight : up to 810g

Activity : up to 1.18 $\times 10^3$ Ci (43.6 TBq)

Decay heat : up to 3.9W

Size : ϕ50mm × H150mm(max)

Packaging

Cutaway view of the packaging is shown in Fig.1.

In order to achieve quality assurance and also to facilitate manufacturing, the body of the package was made from a forged stainless steel with a hole bored in the central section. As a result, the structure incorporates a body with a bottom which has no welded joint.

In addition, a double containment system was employed, which consists of an inner capsule containing the glass sample and the cask body (exterior container). Lid closure system consists of two parts, namely the cask lid and lid cover. The cask body has no projection except for the parts required for tie-down, and is provided with boles and a tie-down device to avoid direct primary impact under the drop test conditions. The cask body, bottom, and lid function as shields. Shock absorbers are not provided, however a protective cover is located over the cask lid.

Materials of the packaging were selected taking into account their characteristics at -40 ℃. Therefore main parts of the packaging are of forged stainless steel (SUS F 304) and gaskets are made of silicon rubber. Main features of the packaging are as follows;

Weight : 2.3ton

Outer dimension : ϕ750mm ×H705mm

HLW is loaded into an inner capsule and then the inner capsule with HLW is loaded into the cavity of the packaging. Loading and unloading operations can be carried out in a hot cell.

2. SAFETY EVALUATION

To show that the package design complies with transport regulations, structural, thermal, containment and shielding analyses were performed assuming normal and accidental conditions. It was concluded that the design of the package satisfies the requirements, that is, leakage of radioactive materials and dose rate around the package are less than the allowable values.

Due to the following reasons, compatibility of the package under the normal conditions can be shown by the conventional methods.

- Since the main body is formed by forged stainless steel mono block, its strength is very high.

—Due to double-lid system, containment integrity is assured.

—Decay heat is small, so maximum temperature is not too high.

On the other hand, the following features must be taken into account when evaluation under the accidental conditions is carried out.

—The package does not have shock absorbing cover.

—The content of the package is HLW and evaluation methed of HLW behavior especially under the drop test conditions is not known.

Therefore, how to evaluate the leakage and dispersion of HLW from the package under the accidental conditions is very important. The following presents a discussion on this point.

Sequence of Evaluation Under The Accidental Conditions

The evaluation of the leakage of radioactive materials from the package under the accidental conditions is carried out by the following four steps;

STEP I : Drop test of full scale inner capsule with a cold HLW sample inside

STEP II : Computer calculation of the package behavior under 9m and 1m drop

STEP III : Thermal evaluation under fire test by computer code

STEP IV : Containment evaluation

STEP I

Demonstration drop tests in vertical, horizontal and oblique positions from a height of 9m onto a rigid flat target are conducted using full scale inner capsule containing non-radioactive HLW sample. Purposes of these drop tests are to determine a damage from impact on the inner capsule with HLW and whether or not small HLW particles are dispersed from the inner capsule. The inner capsule is not loaded into packaging and this condition is severer than the actual drop test with packaging.

STEP Ⅱ

To confirm that the containment integrity is maintained under the drop test conditions (9m drop onto flat surface and 1m drop onto mild steel bar), the behavior of the package under the 9m and 1m drop tests is evaluated using DYNA-3D computer code which is a three-dimensional non-liner impact response analysis code based on the positive solution finite element method.

STEP Ⅲ

Temperature of each part of the package under the fire test condition is calculated by TRUMP computer code which is a differential calculus code.

STEP Ⅳ

Taking into account the results obtained in STEPⅠ through STEP Ⅲ, leak rate of radioactive materials from the package is calculated and compared with regulational limitation.

Evaluation Results

Evaluation results are summarized in Table1.

With respect to the results, the following can be pointed out :

－9m drop cracked the HLW, nevertheless it was demonstrated that small particles were not dispersed from the inner capsule.

This was confirmed by visual inspection after the 9m drop test of the inner capsule with HLW.

—Concerning the acceleration of inner capsule/HLW (STEP I) and package (STEP II), the former was larger than the latter. Therefore, drop test using inner capsule/HLW gave severer impact than the test using whole package.

—It was not necessary to take into account the particle dispersion, and cousequently, leak rate of radioactive material was calculated, assuming only volatilized nuclides, such as Cs, had a possibility of leakage.

3. CONCLUSION

It was shown that HLW sample can be transported in compliance with transport regulations. This experience can be applied for larger size package for commercial base HLW because the principles are the same.

For futher improvement, the followings will be carried out.

—Distribution of HLW particle diameter after 9m drop test will be measured.

—Experimental data will be collected during actual transportation in a future.

Table 1 RESULTS OF EVALUATION UNDER THE ACCIDENTAL CONDITION

	VERTICAL DROP	HORIZONTAL DROP	OBLIQUE DROP
STEP I DEMONSTRATION OF 9M DROP TEST OF INNER CAPSULE - MAX. G LOAD (G) - DISPERSION OF GLASS PARTICLE	 6, 420 NOT OBSERVED	 9, 390 NOT OBSERVED	 4, 950 NOT OBSERVED
STEP II CALCULATION OF PACKAGE BEHAVIOR UNDER 9M AND 1M DROP BY DYNA-3D CODE 9M - MAX. G LOAD (G) - PERMANENT DEFORMATION OF CONTAINMENT BOUNDARY 1M - PERMANENT DEFORMATION OF CONTAINMENT BOUNDARY	 4, 800 NONE NONE	 2, 750 NONE NONE	 1, 130 NONE ——
STEP III CALCULATION OF TEMP. OF PACKAGE UNDER FIRE CONDITION - MAX. TEMP.	GASKET 216℃ GLASS 218℃ (Less than allowable value)		
STEP IV CALCULATION OF LEAKAGE OF RADIOACTIVE MATERIALS	-GLASS PARTICLES REMAINED INSIDE CAPSULE -ONLY VOLATILIZED NUCLIDES HAVE POSSIBILTY TO LEAK -RESULTS Cs-134 : 3.32×10^{-6} Ci/week, Cs-137 : 1.26×10^{-5} Ci/week (LESS THAN ALLOWABLE VALUE)		

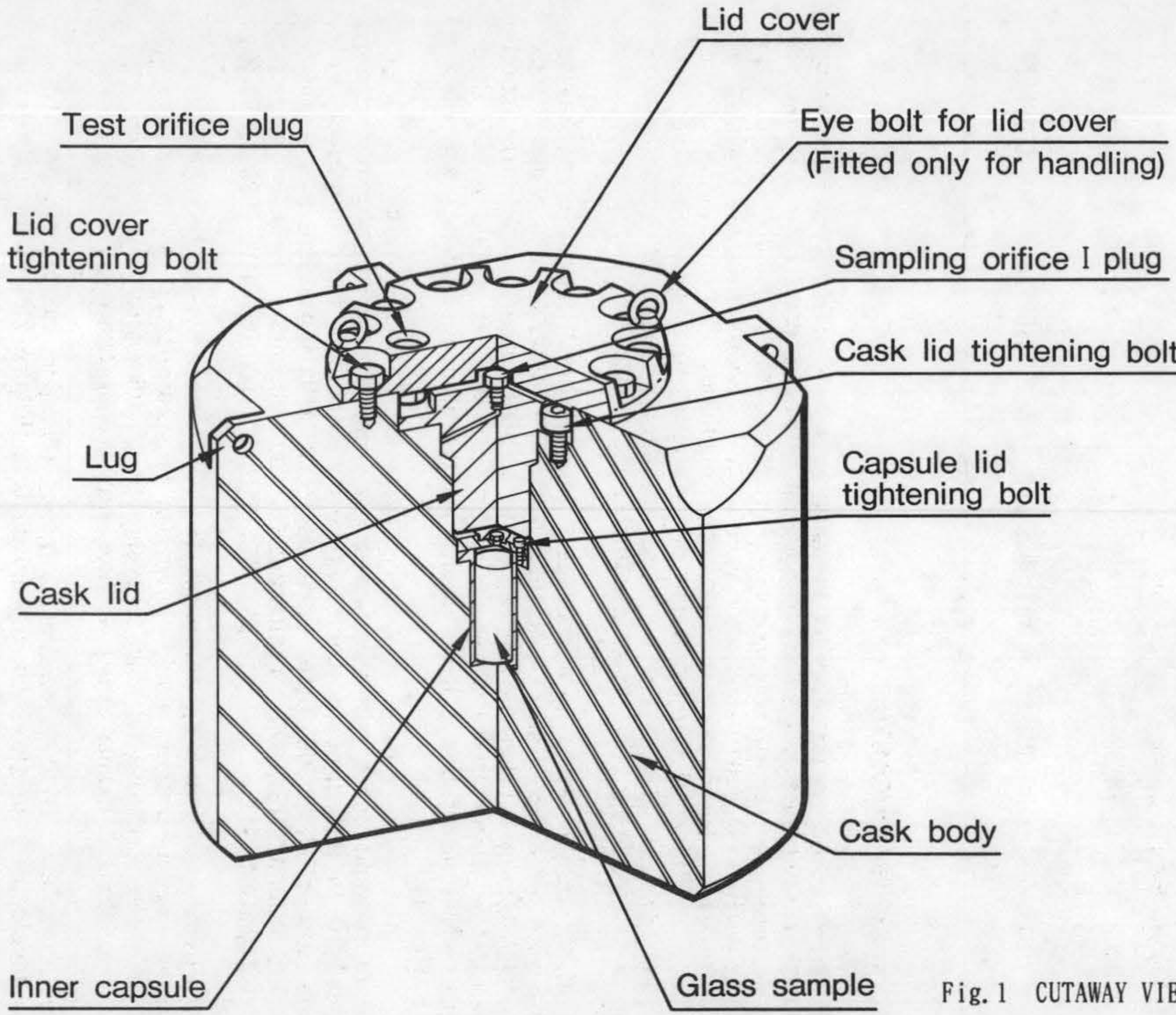

Fig. 1 CUTAWAY VIEW OF THE PACKAGE