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The progress of considerations of cask decommissioning technology in Japan.

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Abstract

As the nuclear fuel cycle is fulfilled, the necessity has arisen of advancing technological development and standardization for implementing measures to decommission (disassemble, dispose of, etc.) used transport casks for spent fuel which have exceeded their service life.

It is important to identify the requirements necessary for development of reasonable measures for disassembling and disposing of used casks, and to get a projection for disassembling and disposing of the used casks. Therefore, we gathered existing knowledge and information on cask decommissioning technology. This paper describes the progress made in examining cask decommissioning technology in order to support future work.

Specifically, we investigated contamination of casks, which have been used in Japan, with radioactive materials, assessed activation of casks prior to disposal, and report on the results of classifying the generated waste material, amount of material, and other elements into specific categories.

Introduction

As the nuclear fuel cycle is fulfilled, it has become necessary to examine technological development, standardization and other issues for implementing measures to decommission (disassemble and dispose of) used transport casks for spent fuel which have exceeded their service life.

In Japan, the Japan Atomic Energy Agency (JAEA) announced a policy for decommissioning the Tokai Reprocessing Plant for spent fuel in 2014.

Since this policy was announced, the decommissioning (disassembling and disposing) of transport casks, which were used for transporting spent fuel for the Tokai Reprocessing Plant, has taken on real life.

In disassembling and disposing of transport casks, it is necessary to quantitatively know the extent to which transport casks have been contaminated and activated due to clads that separated from the spent fuel during transport and neutron rays generated by the spent fuel. Investigating the extent of the contamination and activation makes it possible to estimate the quantity of waste generated during decommissioning and infer the amount of time, money and other resources for disposal in the future.

In this report, we assessed the level of contamination by performing a numerical simulation using the QAD code based on actual measurements. Next, we calculated activation of the transport casks, using the QAD code. Finally, these results were used to estimate the amount of waste, which was separated into categories.

Selection of Target Transport Casks

The transport casks, which are mainly used in Japan, are the inner water circulation type. In this paper, we report on the HZ-75T model transport cask, which is more viable for disposal and decommissioning in Japan.

There are two of types HZ-75T used, one for BWR and one for PWR. Both are multi-layered structures which bodies are comprised of an inner cylinder, lead and intermediate cylinder. The PWR-type HZ-75T for is different in terms of the number of spent fuel rods that may be loaded compared to the BWR type, but the structure is almost the same. In this report, we assess the PWR type, which has been assessed as having greater neutron source strength from different specification of spent fuel.

Course Following to Derive Waste Levels

It is necessary to estimate the level of transport cask contamination due to detached radioactive clad from the spent fuel and the radio activation of the transport cask resulting from neutron rays from the spent fuel.

We estimated the amount of contamination using the smear method to take indirect measurements, and estimated the total level based on calculations using the internal dose measurement data.

Next, activation was calculated using the ORIGEN2 code, and the activation amount of each structural material was calculated.

We investigated the level of contamination from radioactive materials, activation during the cask service period, and classified the waste material and level into categories based on the results of the two calculations.

Selection of Transport Cask Measurement Points

In performing the assessment described in the following and later sections, the measurement points and classification of assessment areas were based the features of HZ-75T transport casks, and are shown in Figure 1. When selecting a measuring point, it is necessary to consider movement of the clad, which is the principle contamination. The transports casks are the internal water flow type, and we took into consideration that the casks had been handled standing up in facilities in our selection of measurement points,

In addition, near the internal water drain valve, which was used for cask integrity confirmation tests, was selected as a measurement point.

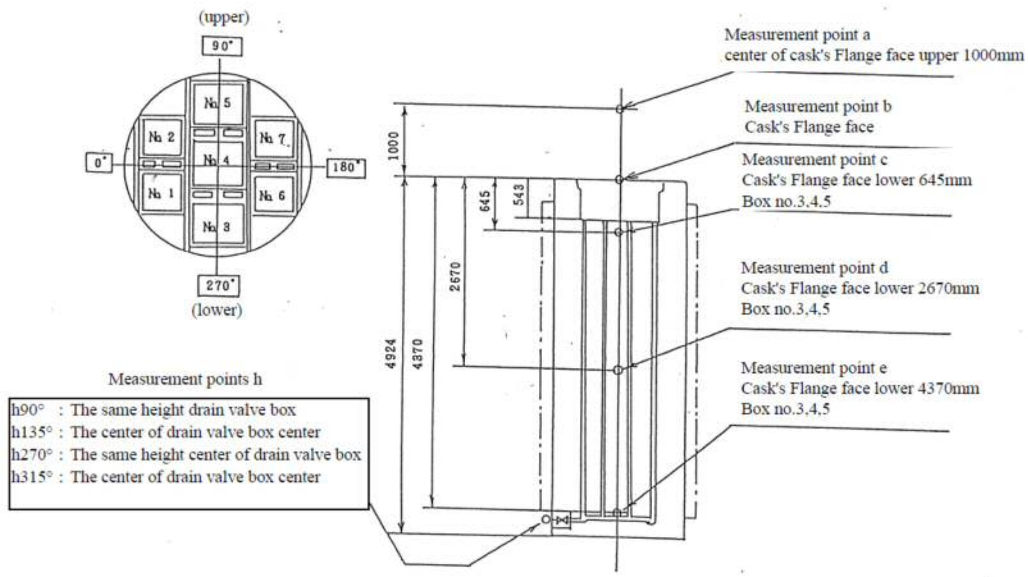

Figure 1. Transport cask measurement points

Investigation of Internal Contamination of Transport Casks

The internal contamination density and dose distribution were direction measured and assessed by using indirect measurements and dose measurements with the smear method. In addition, we assessed the total level of contamination.

(1) Assessment of internal contamination level

Samples were collected and analyzed of radioactive material that adhered to or accumulated on the inner surface and the basket surface of the transport cask. The smear measurements were performed after using a transport container had been used a total 7 times (prior to 8th fuel loading).

The measurement results are as shown in Table 1. The results of nuclide analysis are: 90% Co-60 and 10%Mn-54.

Table 1. Results of smear method measurements

	HZ-75T（PWR）＃1		
	After the 7th SF transport		
	Area (cm^2)	Radioactive surface contamination density($\mu Ci/cm^2$)	Radioactivity (μCi)
Internal cylinder and basket surface	4.4×10^5	1×10^{-1}（3.7×10^3 Bq/cm^2）	9.4×10^4（3.48×10^9 Bq）
Bottom	7.1×10^3	1×10^0（3.7×10^4 Bq/cm^2）	7.1×10^3（2.63×10^8Bq）
Total value	9.47×10^5	Ave. 1.6×10^{-1}（3.91×10^3 Bq/cm^2）	1×10^5（3.7×10^9 Bq）

(2) Assessment of internal dose rate based on dose measurement data

Dose at each point of the cask was measured with a GM survey meter and other tools. The measurement results are shown in Table 2. Next, using the QAD code, a numerical simulation was performed distributing the contamination sources (Co-60: 90%; Mn-54: 10%) inside the casks.

The dose equivalent rate from the calculation and the calculated measured dose equivalent rate coincided for the most part.

The amount of contamination of internal cask was 4×10^9Bq / cask.

Table 2. Results of internal dose measurements (unit:mR/h)

Transport cask measurement points	HZ-75T（PWR）＃1
	After the 7th SF transport
a	8.0
b	30.0
c	123.7
d	119.9
e	162.9

(3) Inspection Results

The results of smear measurement (1) and results of dosimetry calculation (2) were compared, and the level of radioactivity was almost equivalent.

Thus, it was confirmed the validity of the surface density shown in Table 1.

Investigation of Activation of Transport Casks

The ORIGEN2 code was used to calculate activation based on the neutron flux distribution of transport cask. The calculation procedure is shown in Figure 2.

The conditions are:

-Two cases are set for the number of years used: 30 years and 60 years.
-Transport casks are used 10 times a year, and one transport period is one month.
-The period of time until disposal is 0 years from the end of use.
-Elemental composite of the structural materials is shown in Table 3.
-Irradiation neutron flux is determined according to the design value of the transport cask.

The analysis results obtained using these conditions are shown in Table 4.

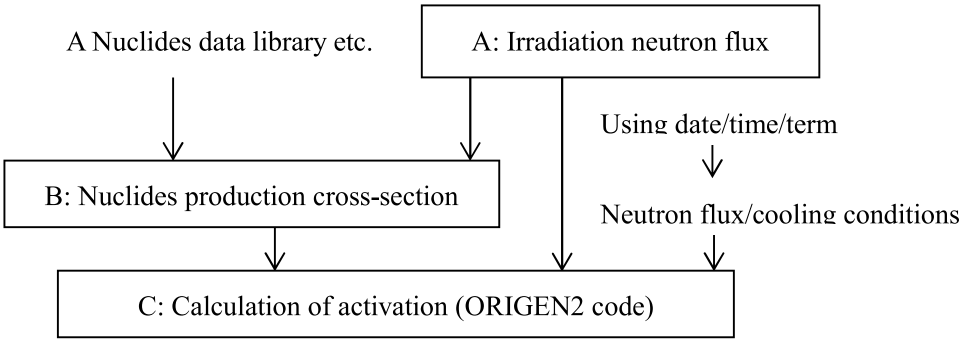

Figure.2 Flowchart of the activation calculation

Table 3. HZ-75T cask element composition

Elements	**Steel**	**Lead**	**Ethylene glycol**
C	0.08	-	21.32
Si	1.00	-	-
Mn	2.00	-	-
P	0.045	-	-
S	0.03	-	-
Ni	10.50	-	-
Cr	20.0	-	-
Cu	-	0.002	-
Mo	-	-	-
Nb	-	-	-
Pb	-	fraction	-
V	-	-	-
H	-	-	10.37
B	-	-	-
N	-	-	-
O	-	-	68.31
Al	-	-	-
Ag	-	0.002	-
As	-	0.002	-
Sb	-	0.005	-
Sn	-	0.005	-
Zn	-	0.002	-
Bi	-	0.005	-
Co	0.25	-	-
Fe	fraction	0.002	-
Total	100.0	100.0	100.0

Table.4 Calculation results of simulated cask activations

(①/No. of years used in transport: 60)

[Bq/ton]

		Inner cylinder	Middle cylinder	Outer cylinder	lid	Basket	γ ray shield	neuron ray shield
regulated	H-3	6.86E-08	4.60E-09	1.57E-10	2.84E-10	1.33E-07	6.43E-15	6.82E+00
	C-14	2.01E-02	6.25E-03	4.57E-04	8.43E-04	2.45E-02	0.00E+00	2.49E+01
	CL-36	8.42E-08	6.90E-07	3.13E-07	9.67E-08	2.32E-07	0.00E+00	0.00E+00
	CA-41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MN-54	5.18E+05	2.32E+04	1.43E+03	1.21E+03	1.18E+06	1.11E+01	0.00E+00
	CO-60	7.09E+06	4.80E+06	1.22E+06	6.68E+05	1.00E+07	7.47E-01	0.00E+00
	NI-59	9.42E+02	4.58E+03	2.02E+03	6.42E+02	1.97E+03	2.15E-14	0.00E+00
	NI-63	9.58E+04	5.29E+05	2.34E+05	7.42E+04	2.18E+05	1.55E+01	0.00E+00
	SR-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	NB-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TC-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	CS-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	CS-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	EU-152	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	EU-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
unregulated	C-15	4.10E-12	1.27E-12	9.31E-14	1.72E-13	4.98E-12	0.00E+00	4.42E+02
	N-16	1.05E-21	6.61E-21	2.95E-21	9.26E-22	2.56E-21	0.00E+00	2.60E+03
	AS-76	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.21E+04	0.00E+00
	AG-108	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.65E+03	0.00E+00
	AG-110	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E+05	0.00E+00
	SB-122	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E+04	0.00E+00
	SB-124	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E+04	0.00E+00
Total		1.88E+07	2.22E+07	8.02E+06	3.10E+06	2.97E+07	2.27E+05	3.11E+03

(②/No. of years used in transport: 30)

[Bq/ton]

		Inner cylinder	Middle cylinder	Outer cylinder	lid	Basket	γ ray shield	neuron ray shield
regulated	H-3	1.15E-08	7.70E-10	2.64E-11	4.76E-11	2.23E-08	0.00E+00	5.73E+00
	C-14	1.01E-02	3.13E-03	2.29E-04	4.22E-04	1.23E-02	0.00E+00	1.25E+01
	CL-36	2.21E-08	1.81E-07	8.20E-08	2.54E-08	6.07E-08	0.00E+00	0.00E+00
	CA-41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	MN-54	5.18E+05	2.32E+04	1.43E+03	1.21E+03	1.18E+06	1.11E+01	0.00E+00
	CO-60	6.96E+06	4.71E+06	1.20E+06	6.55E+05	9.85E+06	7.33E-01	0.00E+00
	NI-59	4.71E+02	2.29E+03	1.01E+03	3.21E+02	9.86E+02	4.28E-15	0.00E+00
	NI-63	5.33E+04	2.94E+05	1.30E+05	4.13E+04	1.21E+05	8.62E+00	0.00E+00
	SR-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	NB-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	TC-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	CS-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	CS-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	EU-152	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	EU-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
unregulated	C-15	2.05E-12	6.37E-13	4.66E-14	8.60E-14	2.50E-12	0.00E+00	4.42E+02
	N-16	1.40E-22	8.30E-22	3.70E-22	1.16E-22	3.31E-22	0.00E+00	2.60E+03
	AS-76	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.21E+04	0.00E+00
	AG-108	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.63E+03	0.00E+00
	AG-110	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E+05	0.00E+00
	SB-122	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E+04	0.00E+00
	SB-124	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E+04	0.00E+00
Total		1.86E+07	2.19E+07	7.90E+06	3.05E+06	2.94E+07	2.27E+05	3.09E+03

Classification and Derivation of Waste

(1) Amount of waste and categorization

We classified waste according to the following conditions based on the results of our investigation of the contamination and activation of used transport casks.

-The periods of use considered are 30 years and 60 years.

-The structure classification has an inner cylinder, intermediate cylinder, γ-ray shield, outer cylinder, neutron shielding body, lid, and basket.

-Because the inner cylinder and basket are considered to be contaminated, they are assessed by adding together the radioactivity due to activation and the contamination. Sites other than the inner cylinder and basket are assessed only using radioactivity due to activation.

-Decontamination: Decontamination is performed at the time of disposal, but contamination is not measured before and after decontamination.

For this reason, the decontamination efficiency target value DF100 is used for reprocessing.

- Disposal categories: Waste is classified according to Table 5.

-Radioactivity concentration of major species: The disposal classification determination uses the total value of each nuclide of the nuclide concentration and contamination radioactivity concentration. If even one nuclide exceeds the level, the classification is moved to a higher level.

-Material: Disposal may be regulated by domestic laws and regulations for heavy metals, etc.

-The level of contamination of the inner cylinder and basket find radioactivity per unit mass (t) by first multiplying radioactivity surface density of Table 1 and then dividing by the weight.

-The nuclide composition ratio was converted using the radioactivity inventory representative nuclide composition ratio, etc. of the reactor internal contamination.

Table 5. Categorized radioactive waste

Low level waste (high dose rate β, γ ray)
Low level waste
Very Low level waste
Clearance
Non-radioactive waste

H-3	: 3.07×10^{11}	Nb-94	: 8.51×10^{7}
C-14	: 8.51×10^{9}	Tc-99	: 1.85×10^{7}
Cl-36	: —	I-129	: 2.78×10^{5}
Ca-41	: —	Cs-137	: 1.04×10^{11}
Ni-59	: 8.80×10^{9}	Eu-152	: —
Co-60	: 2.78×10^{12}	Eu-154	: —
Ni-63	: 1.11×10^{12}	All α	: 5.55×10^{8}
Sr-90	: 1.67×10^{10}		

H-3	: 3.0×10^{8}	Nb-94	: —
C-14	: 1.1×10^{7}	Tc-99	: —
Cl-36	: —	I-129	: —
Ca-41	: 1.5×10^{7}	Cs-137	: 1.0×10^{7}
Ni-59	: —	Eu-152	: 3.6×10^{7}
Co-60	: 8.1×10^{8}	Eu-154	: —
Ni-63	: 7.2×10^{8}	All α	: 1.7×10^{6}
Sr-90	: 4.7×10^{5}		

H-3	: 2.00×10^{8}	Cs-134	: 5.00×10^{5}
Mn-54	: 1.00×10^{6}	Eu-152	: 4.00×10^{5}
Co-60	: 4.00×10^{5}	Eu-154	: 4.00×10^{5}
Sr-90	: 1.00×10^{6}	All α	: 2.00×10^{5}
Cs-137	: 1.00×10^{5}		

Fractional sum <1 is clearance level boundary.

(2) Classification Results and Discussion

Based on the results, inner cylinder, intermediate cylinder, lid and basket were classified as very low-level radioactive waste. In addition, only shielding was classified as clearance.

The results for each component material are shown in Table 6. Detailed results including the nuclide classification are shown in Tables 7 and 8.

The main source of contamination of the basket is Mn-54 with a half-life of 312.2 days.

Therefore, if more than one year has passed since use, the basket may be determined to be clearance level and easily handled. Co-60, which is present at all points, has been assessed a high value on analysis. In the future, improvements in analytical precision may reassess component material, which has been classified as very low-level radioactive waste, to the clearance level.

Cask	Component	Material	Weight (ton)	Waste level	Level classification determinant nuclide
HZ-75T	Body	ASTM A240	4.1	VLLW	Co-60
	Internal cylinder	ASTM A240	2.2	VLLW	Co-60
	Gamma ray shield	lead	36.6	CL	-
	Outer cylinder	ASTM A240	9.1	VLLW	Co-60
	Neutron shield	Ethilen aqua	3.4	CL	-
	Cask rid	ASTM A336	2.4	VLLW	Co-60
	Fuel basket	ASTM A240	3.9	VLLW	Co-60

Table 6. Waste categories of cask components

Table 7. Calculation results of waste categories of cask components 1/2 (details)

	Components	Material	Weigt [ton]	liquid area [cm2]	decontamination DF	Transport period (year)	Radioactivity (Bq/ton) nuclide	H-3	C-14	CA-41	MN-54	CO-60	NI-59	NI-63	SR-90	NB-94	TC-99	I-129	CS-134	CS-137	EU-152	EU-154	All α	total	category
HZ-75T	neuron ray shield	Ethylene glycol aqua	4.069	150,000	100	30	activate	1.15E-08	1.01E-02	0.00E+00	5.18E+05	6.96E+06	4.71E+02	5.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E+07	
							contami	4.87E+02	5.02E+03	1.92E+02	1.92E+02	3.12E+05	5.73E+03	6.40E+03	6.34E+01	5.85E+02	8.29E-02	4.34E-05	2.41E+00	9.08E+01	5.31E-03	3.31E+00	0.00E+00	1.36E+06	
							total	4.87E+02	5.02E+03	1.92E+02	5.18E+05	7.27E+06	6.20E+03	5.97E+04	6.34E+01	5.85E+02	8.29E-02	4.34E-05	2.41E+00	9.08E+01	5.31E-03	3.31E+00	0.00E+00	2.00E+07	
							judement	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	VLLW
						60	activate	6.86E-08	2.01E-02	0.00E+00	5.18E+05	7.09E+06	9.42E+02	9.58E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.88E+07	
							contami	4.87E+02	5.02E+03	1.92E+02	1.92E+02	3.12E+05	5.73E+03	6.40E+03	6.34E+01	5.85E+02	8.29E-02	4.34E-05	2.41E+00	9.08E+01	5.31E-03	3.31E+00	0.00E+00	1.36E+06	
							total	4.87E+02	5.02E+03	1.92E+02	5.18E+05	7.40E+06	6.67E+03	1.02E+05	6.34E+01	5.85E+02	8.29E-02	4.34E-05	2.41E+00	9.08E+01	5.31E-03	3.31E+00	0.00E+00	2.02E+07	
							judement	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	VLLW
	Lid	ASTM A240	2.19	–	–	30	activate	7.70E-10	3.13E-03	0.00E+00	2.32E+04	4.71E+06	2.29E+03	2.94E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.19E+07	
							contami																		
							total	7.70E-10	3.13E-03	0.00E+00	2.32E+04	4.71E+06	2.29E+03	2.94E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.19E+07	
							judement	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	VLLW
						60	activate	4.60E-09	6.25E-03	0.00E+00	2.32E+04	4.80E+06	4.58E+03	5.29E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E+07	
							contami																		
							total	4.60E-09	6.25E-03	0.00E+00	2.32E+04	4.80E+06	4.58E+03	5.29E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E+07	
							judement	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	VLLW
	Basket	Lead	36.64	–	–	30	activate	0.00E+00	0.00E+00	0.00E+00	1.11E+01	7.33E-01	4.28E-15	8.62E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.27E+05	
							contami																		
							total	0.00E+00	0.00E+00	0.00E+00	1.11E+01	7.33E-01	4.28E-15	8.62E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.27E+05	
							judement	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	CL
						60	activate	6.43E-15	0.00E+00	0.00E+00	1.11E+01	7.47E-01	2.15E-14	1.55E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.27E+05	
							contami																		
							total	6.43E-15	0.00E+00	0.00E+00	1.11E+01	7.47E-01	2.15E-14	1.55E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.27E+05	
							judement	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	CL
	Outer cylinder	ASTM A240	9.121	–	–	30	activate	2.64E-11	2.29E-04	0.00E+00	1.43E+03	1.20E+06	1.01E+03	1.30E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.90E+06	
							contami																		
							total	2.64E-11	2.29E-04	0.00E+00	1.43E+03	1.20E+06	1.01E+03	1.30E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.90E+06	
							judement	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	VLLW
						60	activate	1.57E-10	4.57E-04	0.00E+00	1.43E+03	1.22E+06	2.02E+03	2.34E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.02E+06	
							contami																		
							total	1.57E-10	4.57E-04	0.00E+00	1.43E+03	1.22E+06	2.02E+03	2.34E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.02E+06	
							judement	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	VLLW

Table 8. Calculation results of waste categories of cask components 2/2 (details)

	Components	Material	Weigt [ton]	liquid area [cm2]	decontamination DF	Transport period (year)	Radioactivity (Bq/ton) nuclide	H-3	C-14	CA-41	MN-54	CO-60	NI-59	NI-63	SR-90	NB-94	TC-99	I-129	CS-134	CS-137	EU-152	EU-154	All α	total	category
	neuron ray shield	Ethylene glycol aqua	3.368	–	–	30	activate	5.73E+00	1.25E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.09E+03	
							contami																		
							total	5.73E+00	1.25E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.09E+03	
							judement	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	CL
						60	activate	6.82E+00	2.49E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.11E+03	
							contami																		
							total	6.82E+00	2.49E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.11E+03	
							judement	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	CL
	Lid	ASTM A336	2.4	30,000	100	30	activate	4.76E-11	4.22E-04	0.00E+00	1.21E+03	6.55E+05	3.21E+02	4.13E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.05E+06	
							contami	1.65E+03	1.70E+04	6.52E+02	6.52E+02	1.06E+06	1.94E+04	2.17E+04	2.15E+02	1.98E+03	2.81E-01	1.47E-04	8.19E+00	3.08E+02	1.80E-02	1.12E+01	0.00E+00	4.63E+06	
							total	1.65E+03	1.70E+04	6.52E+02	1.86E+03	1.71E+06	1.97E+04	6.30E+04	2.15E+02	1.98E+03	2.81E-01	1.47E-04	8.19E+00	3.08E+02	1.80E-02	1.12E+01	0.00E+00	7.68E+06	
							judement	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	VLLW
						60	activate	2.84E-10	8.43E-04	0.00E+00	1.21E+03	6.68E+05	6.42E+02	7.42E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E+06	
							contami	1.65E+03	1.70E+04	6.52E+02	6.52E+02	1.06E+06	1.94E+04	2.17E+04	2.15E+02	1.98E+03	2.81E-01	1.47E-04	8.19E+00	3.08E+02	1.80E-02	1.12E+01	0.00E+00	4.63E+06	
							total	1.65E+03	1.70E+04	6.52E+02	1.86E+03	1.73E+06	2.01E+04	9.59E+04	2.15E+02	1.98E+03	2.81E-01	1.47E-04	8.19E+00	3.08E+02	1.80E-02	1.12E+01	0.00E+00	7.73E+06	
							judement	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3	VLLW
	Basket	ASTM A240	3.85	1,300,000	100	30	activate	2.23E-08	1.23E-02	0.00E+00	1.18E+06	9.85E+06	9.86E+02	1.21E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.94E+07	
							contami	4.46E+03	4.60E+04	1.76E+03	1.76E+03	2.86E+06	5.25E+04	5.86E+04	5.81E+02	5.36E+03	7.60E-01	3.97E-04	2.21E+01	8.32E+02	4.86E-02	3.03E+01	0.00E+00	5.59E+06	
							total	4.46E+03	4.60E+04	1.76E+03	1.18E+06	1.27E+07	5.35E+04	1.80E+05	5.81E+02	5.36E+03	7.60E-01	3.97E-04	2.21E+01	8.32E+02	4.86E-02	3.03E+01	0.00E+00	3.50E+07	
							judement	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	3	VLLW
						60	activate	1.33E-07	2.45E-02	0.00E+00	1.18E+06	1.00E+07	1.97E+03	2.18E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.97E+07	
							contami	6.51E+02	6.71E+03	2.57E+02	2.57E+02	4.17E+05	7.65E+03	8.55E+03	8.47E+01	7.82E+02	1.11E-01	5.79E-05	3.23E+00	1.21E+02	7.09E-03	4.42E+00	0.00E+00	4.08E+06	
							total	6.51E+02	6.71E+03	2.57E+02	1.18E+06	1.04E+07	9.62E+03	2.27E+05	8.47E+01	7.82E+02	1.11E-01	5.79E-05	3.23E+00	1.21E+02	7.09E-03	4.42E+00	0.00E+00	3.38E+07	
							judement	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	3	VLLW

Conclusions

We investigated transport cask contamination by performing indirect measurements using the smear method. The results of nuclide analysis showed that Co-60 was approximately 90% and Mn-54 approximately 10 %. A numerical simulation based on the dosimetry results produced results almost similar to those using the smear method. Next, the activation level was calculated for each component by means of numerical simulation using the ORIGEN2 code.

Based on the investigation of the activation level and contamination state of contaminated objects, the waste generated during disassembly and disposal of HZ-75T transport casks was classified placing the inner cylinder, intermediate cylinder, lid and basket as very low-level radioactive waste. In addition, only shielding was classified as a clearance.

The amount of waste per transport cask was 21.7 tons of very low-level radioactive waste and 40 tons of clearance level.

In the future, we will conduct further investigation and examinations in concert with decommissioning, and we will work to create optimal disposal scenarios along with the establishment of standards and other criteria.

References

1） Commissioned research report
Study on dismantlement and decommissioning of spent fuel transport cask (Phase 1)
FY1999 first half (final report)　May 1999 Nuclear Fuel Transport Co., Ltd.