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WASTE CLASSIFICATION OF 17 $\times$ 17 KOFA SPENT FUEL ASSEMBLY HARDWARE

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Metal waste generated from the pyroprocessing of 10 MtU of spent fuel was classified by comparing the specific activity of a relevant radionuclide with the limit value of the specific activity specified in the Korean acceptance criteria for a low- and intermediate-level waste repository. A Korean Optimized Fuel Assembly design with a 17 $\times$ 17 array, an initial enrichment of 4.5 weight-percent, discharge burn-up of 55 GWD/MtU, and a 10-year cooling time was considered. Initially, the mass and volume of each structural component of the assembly were calculated in detail, and a source term analysis was subsequently performed using ORIGEN-S for these components. An activation cross-section library generated by the KENO-VI/ORIGEN-S module was utilized for top-end and bottom-end pieces. As a result, an Inconel grid plate, a SUS plenum spring, a SUS guide tube subpart, SUS top-end and bottom-end pieces, and an Inconel top-end leaf spring were determined to be unacceptable for the Gyeongju low- and intermediate-level waste repository, as these waste products exceeded the acceptance criteria. In contrast, a Zircaloy grid plate and guide tube can be placed in the Gyeongju repository. Non-contaminated Zircaloy cladding occupying 76% of the metal waste was found to have a lower level of specific activity than the limit value. However, Zircaloy cladding contaminated by fission products and actinides during the decladding process of pyroprocessing was revealed to have 52 and 2 times higher specific activity levels than the limit values for alpha and ^{90}Sr, respectively. Finally, it was found that 88.7% of the metal waste from the 17 $\times$ 17 Korean Optimized Fuel Assembly design should be disposed of in a deep geological repository. Therefore, it can be summarized that separation technology with a higher decontamination factor for transuranics and strontium should be developed for the efficient management of metal waste resulting from pyroprocessing.

KEYWORDS : Spent Nuclear Fuel, Long-lived Waste, Source Term, Metal Waste, Pyroprocess, Disposal System Design

1. INTRODUCTION

As of November of 2010, there are twenty operational nuclear power plants in Korea. The annual spent fuel production is estimated to be approximately 700 tons of uranium. The stockpiled amount of spent fuel was found to be 10,761 tons at the end of 2009 [1]. Recently, the Korean government and nuclear industry have sought to propose a national policy for the safe management of spent fuel [2,3]. In 2007, the 3rd Comprehensive Nuclear Energy Promotion Plan [4], passed at the 254th meeting of the Atomic Energy Commission, was announced as an R&D plan for the development of a sodium fast reactor in connection with pyroprocessing for a sustainable stable energy supply and a reduction in the amount of spent fuel. Spent fuel amounts can be greatly reduced through a recycling process in which transuranics (TRU) are burned in a fast reactor and where cesium and strontium are discarded after sufficient interim storage to lower the eventual decay heat of radwaste at the final repository [5].

When the direct disposal of spent fuel is considered, the source terms of the assembly hardware are clearly not important because nearly 99% of the source terms are induced from actinides and fission products (FPs) in the irradiated fuel. However, in an advanced fuel cycle with the aforementioned type of recycling, the source terms of the assembly hardware, i.e., metal waste in the pyroprocess, can be important in the design of a disposal system.

The mass of a fuel assembly is 620-670 kg, where the mass of the structural components is 110-130 kg. Considering that the design basis accounted for 20,000 tons of spent fuel when the Korean reference disposal system was first proposed, approximately 6,000 tons of metal waste is expected to be created from the pyroprocessing of PWR spent fuel. Therefore, it is important to determine whether the metal waste can be treated as low- and intermediate-level waste (LILW), as waste beyond LILW has a higher disposal cost than LILW [6].

In this paper, metal waste generated from the pyroprocessing of a 17 × 17 Korean Optimized Fuel Assembly (KOFA) was classified by comparing the relevant specific activity with the limit value of specific activity specified in the Korean acceptance criteria for a LILW repository.

2. CHARACTERISTICS OF RADIATION SOURCE TERMS

2.1 17 × 17 KOFA Fuel Design

Figure 1 shows the 17 × 17 KOFA design. This assembly design was used at Kori units 3 and 4, Younggwang units 1 and 2, and Ulchin units 1 and 2. The materials, mass, and volume for each type of assembly hardware component corresponding to 10 tons of uranium are presented in detail in Table 1.

Fuel rods were tied using eight spacer grid plates, two of which were made of Inconel 718, as shown in Fig. 1. The remaining plates were made of Zircaloy-4. Fuel rods assembled with grid plates were attached to top-end and bottom-end pieces through a guide tube subpart. The bottom-end piece was casted out of SUS 321. The flow plate and leaf spring for the top-end piece were made of SUS 321 and Inconel 718, respectively. A Zricaloy-4 cladding confining fuel pallet and a plenum spring made of SUS 302 were also important parts of the assembly hardware. The compositions of all materials mentioned in this paper are presented in Table 2. All compositions were captured based on the ORIGEN2.1 user's manual [7] except that of SUS321, which was taken from the literature [8].

As presented in Table 1, the total mass of the respective structural component is nearly 3.3×10^3 kg, most of which is due to the cladding and grid plate. It was assumed that the fuel rod could be cut after disassembling the top-end piece, bottom-end piece, grid plates, and guide tube during the pyroprocessing stage. Therefore, in this study, the structural components for only the Zircaloy-4 cladding and SUS 302 plenum spring were treated as waste contaminated by uranium, TRU, and FPs. It was also assumed that the 17 × 17 KOFA to be used for pyroprocessing had the following profile: an initial enrichment of 4.5 weight-percent (wt.%), a discharge burnup of 55 GWd/tU, and a decay time of 10 years.

2.2 Analysis Method

The inventory change from neutron activation in the structural component of a fuel assembly at time t is simply expressed by Eq. (1), indicating that the change rate of nuclide i is governed by the production rate from the neutron absorption of nuclide k and the decay of nuclide j, in addition to loss rate of nuclide i by neutron absorption and decay.

$$\frac{dN_i}{dt} = \sum_j \delta_{ij}\lambda_j N_j + \sum_k f_{ik}\sigma_k \phi N_k - (\lambda_i + \sigma_i \phi) N_i \quad (1)$$

Here, δ_{ij} denotes the fraction of radioactive disintegration by other nuclides, which leads to the formation of species i; f_{ik} is the fraction of neutron absorption by other nuclides, which leads to the formation of species i. The other nomenclatures have their own conventional meanings.

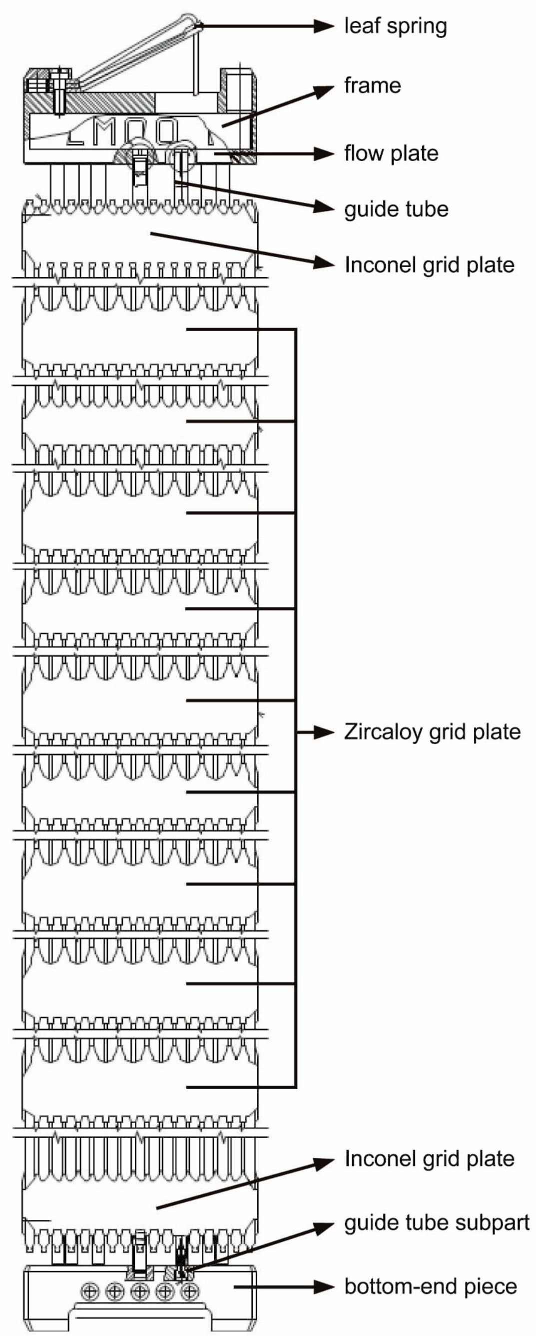


Fig. 1. Configuration of 17 × 17 KOFA

Table 1. 17 × 17 KOFA Specifications (basis: 10 MtU)

		Material	Mass (g)	Volume (cm^3)
Waste contaminated by U, TRU, and FPs (contaminated waste)				
Fuel Rod	Cladding	Zircaloy-4	2.460E+6	3.748E+5
	Plenum spring	SUS 302	5.401E+4	6.843E+3
	Subtotal		2.514E+6	3.817E+5
Waste without contamination (non-contaminated waste)				
Supporting Component	Grid plate and guide tube	Zircaloy-4	3.649E+5	5.664E+4
	Grid plate	Inconel 718	3.076E+4	3.755E+3
	Guide tube subpart	SUS 302	1.648E+4	2.086E+3
	Bottom-end piece (flow plate and angle)	SUS 321	1.246E+5	1.578E+4
	Top-end flow plate and frame	SUS 321	1.443E+5	1.826E+4
	Top-end leaf spring	Inconel 718	3.411E+4	4.170E+3
	Subtotal		7.152E+5	1.007E+5
Grand total			3.229E+6	4.824E+5

Table 2. Composition of Structural Materials

SUS 302		SUS 321		Inconel 718		Zircaloy-4	
element	fraction (wt.%)	element	faction (wt.%)	element	fraction (wt.%)	element	fraction (wt.%)
C	0.150	Fe	67.095	C	0.040	H	0.001
N	0.130	Cr	18.000	N	0.130	C	0.012
Si	0.999	Ni	10.000	Al	0.599	N	0.008
P	0.045	C	0.080	Si	0.200	O	0.095
S	0.030	Si	0.750	S	0.007	Al	0.002
Cr	17.977	Mn	2.000	Ti	0.799	S	0.003
Mn	1.997	P	0.045	Cr	18.975	Ti	0.002
Fe	69.684	S	0.030	Mn	0.200	V	0.002
Co	0.080	Ti	2.000	Fe	17.977	Cr	0.125
Ni	8.909			Co	0.469	Mn	0.002
				Ni	51.962	Fe	0.225
				Cu	0.100	Co	0.001
				Nb	5.546	Ni	0.002
				Mo	2.996	Cu	0.002
						Zr	97.907
						Sn	1.600
						Hf	0.008
						W	0.002

The terms multiplied by the neutron flux are important in the irradiation calculation when the production of nuclide *i* by the neutron absorption of nuclide *k* occurs, whereas they are meaningless in the decay calculation after discharge from a reactor. The cross-section terms in Eq. (1) should be the value weighted by the neutron spectrum of the reactor core while an activation analysis of the structural component residing in the inner core is being carried out. In contrast, the cross-sections weighted by the neutron spectrum of the relevant region should be used when an activation analysis of structural components such as the top-end and bottom-end pieces located in the outer core is being performed.

2.3 Production of Cross-section Library

The cross-section library generated using the neutron spectrum of the 17×17 Westinghouse assembly design, which has same design parameters as the 17×17 KOFA design, was utilized for the activation analysis of the cladding, grid plate, plenum spring, and guide tube. For the top-end and bottom-end pieces, the cross-section library was generated by weighting the neutron spectrum of each component with the *t-depl* sequence, specifically the KENO-VI [9]/ORIGEN-S [10] module in the SCALE code package. The *t-depl* sequence calculates the neutron spectrum for each region of the fuel assembly by KENO-VI and generates and updates the cross-section library needed for ORIGEN-S calculation by weighting the previously calculated neutron spectrum to the AMPX master library. The neutron flux needed to solve Eq. (1) was also calculated using KENO-VI, which uses a Monte Carlo method to transport neutrons for a criticality analysis. A three-dimensional model including the fuel rods and top-end and bottom-end pieces was established to estimate the regional flux of the assembly hardware. The estimated flux was then applied to ORIGEN-S for a buildup simulation of radionuclides.

Figures 2 (a) and (b) show the top-end and bottom-end pieces of the 17×17 KOFA design, respectively. A three-dimensional KENO-VI model to generate the cross-section library for the flow plate, frame, and leaf spring of the top-end piece is shown in Fig. 2 (c). As shown in this figure, the flow plate was modeled as a solid plate with a thickness of 0.85 cm expanded to the outer surface of the assembly. The SUS 321 frame in the top-end piece was modeled with a height of 4 cm and a width of 1.25 cm. The Inconel 718 leaf spring was modeled with a width of 1.25 cm and a height of 1.81 cm with the equivalent mass and volume of the actual geometry. The KENO-VI model used to generate the cross-section library for the bottom-end piece is shown in Fig. 2 (d). The bottom-end flow plate was modeled in the form of a solid plate with a thickness of 1.13 cm. The angle was modeled as a cube with dimensions of 3.51 cm ×3.51 cm×3.51 cm. The mass and volume of the explicit configuration of each component were preserved when the implicit geometry was formulated. Finally, all components were placed along the outermost region of the assembly, as shown in Fig. 2.

One quarter and one half of the entire assembly were modeled along the radial and axial directions, respectively, with a reflective boundary condition at five surfaces of the model. The plenum was described using the volume of the actual geometry. A water reflector with a thickness greater than 30 cm was also considered for each top and bottom region of the fuel assembly. Neutron leakage from only the end surface of the reflector was considered in each model.

2.4 Irradiation Data

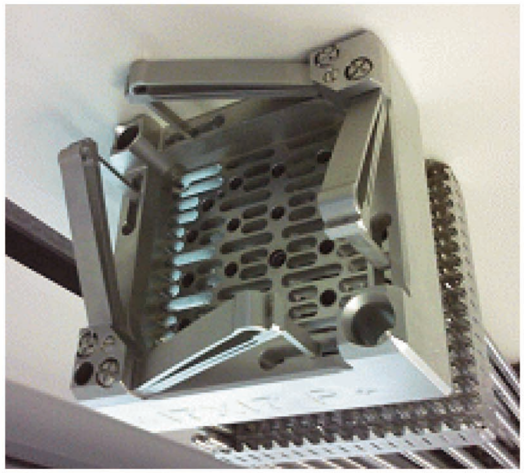
For operational history, three cycles, each with a specific power of 37.5 W/gU, 488.9 days of core residence, and 60 days of downtime for an overhaul, were considered to make the assembly design reach 55 GWd/tU of the discharge burnup. Based on calculations with the previously mentioned model, the volume-average neutron flux was found to be 4.57×10^{13} n/cm^2-sec for the structural components of the Zircaloy-4 cladding, grid plate, guide tube, guide tube subpart, and plenum spring residing in a core. It was also revealed that the volume-average neutron fluxes for the top-end leaf spring, top-end flow plate and frame, and bottom-end piece were 3.86×10^{11}, 1.09×10^{12}, and 2.02×10^{13} n/cm^2-sec, respectively.

2.5 Characteristics of Metal Waste

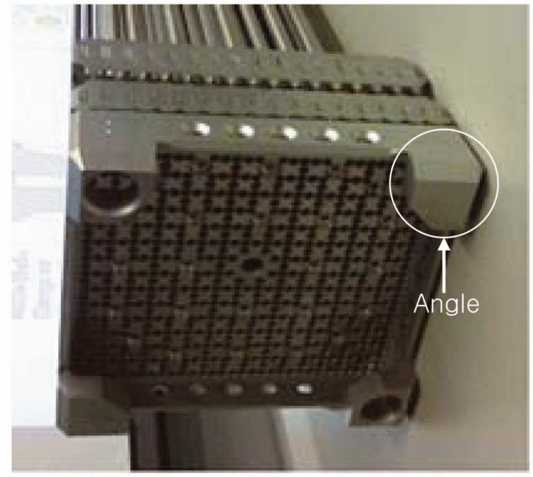
2.5.1 The Mass of Each Type of Waste

As mentioned earlier, the mass of each structural component was calculated based on the amount produced from the processing of 10 tons of uranium using the 17×17 KOFA design. Uranium loading for the 17×17 KOFA design was assumed to be 440 kg, which makes 10 tons of uranium with 22.7 assemblies. The waste amounts contaminated by U, TRU, and FPs (hereafter called ‘contaminated waste’) and only neutron-activated waste without contamination (hereafter called ‘non-contaminated waste’) were 2.51 tons and 0.72 tons, respectively. The contaminated waste consisted of 2.46 tons of Zircaloy-4 cladding and SUS 302 plenum springs. Non-contaminated waste consisted of 365 kg of Zircaloy-4 grid plates and guide tubes, 30.8 kg of Inconel 718 grid plates, 124.6 kg of SUS 321 bottom-end pieces, 144.3 kg of SUS 321 top-end flow plates and frames, and 34.1 kg of top-end leaf springs.

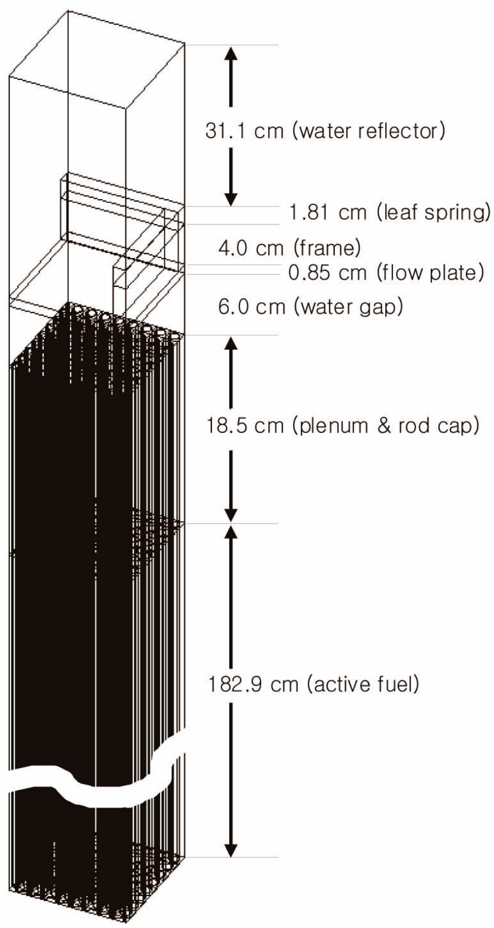
Actinides and FPs as contaminants weighing 0.407 kg and 126.1 kg, respectively, were included in the metal waste based on the material flow of the pyroprocessing step, as proposed in June of 2009 [11] by the Korea Atomic Energy Research Institute (KAERI). According to the material flow, the fraction of uranium in metal waste is 4.4×10^{-5}. Additionally, the fractions of TRU, cesium, strontium, technetium, and rare earth elements in the metal waste are each 1×10^{-5}.



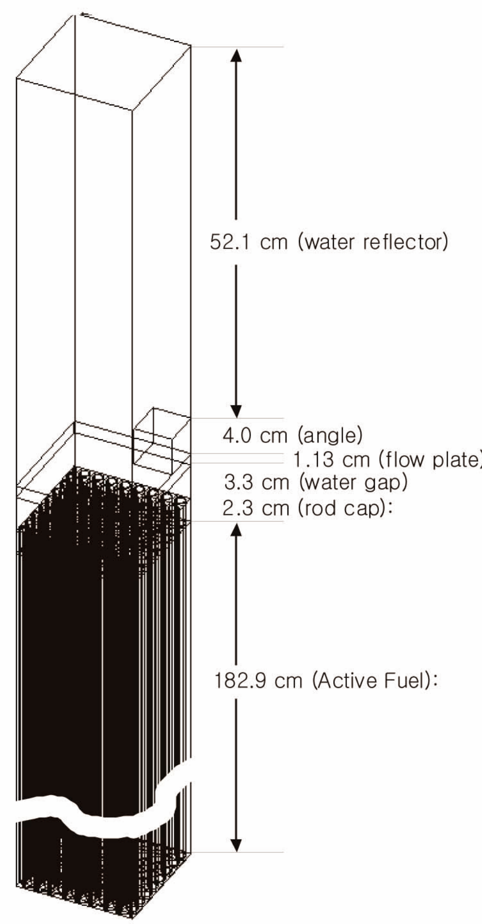
(a) configuration of the top-end piece



(b) configuration of the bottom-end piece



(c) model of the top-end piece



(d) model of the bottom-end piece

Fig. 2. KENO-VI Model Used to Generate the Cross-section Library

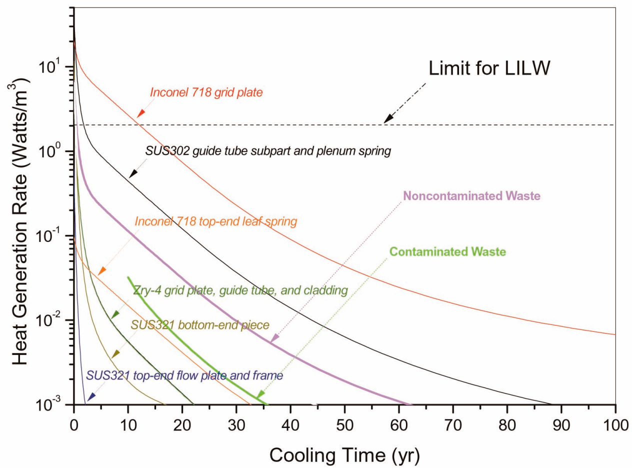


Fig. 3. Heat Generation Rate of Each Structural Component as a Function of Time

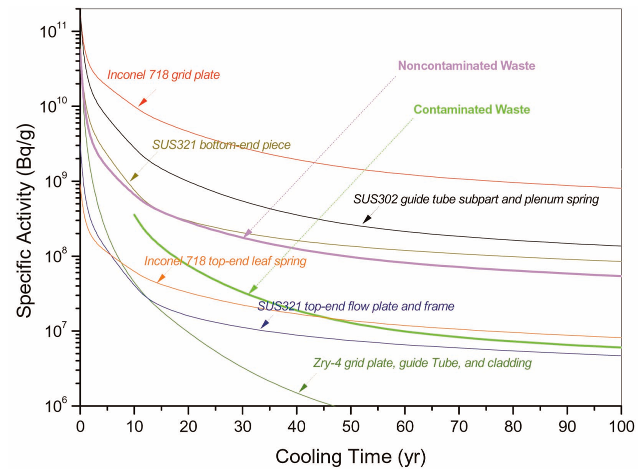


Fig. 4. Specific Activity of Each Structural Component as a Function of Time

2.5.2 Decay Heat of Each Waste

In Korea, waste exceeding 2 kW/m^3 and 4,000 Bq/g for alpha-emitting nuclides with a half-life of longer than 20 years is classified as high-level waste according to the relevant MEST notice [12]. The decay heat characteristics for each structural component comprising the assembly, without considering the contamination, are shown in Fig. 3. As shown in the figure, all waste types except the SUS 321 top-end flow plate and frame, Inconel 718 top-end leaf spring, and SUS 321 bottom-end piece exceed 2 kW/m^3 at the time of discharge from the reactor. However, all waste types except the Inconel 718 grid plate maintain a decay heat below 2kW/m^3 after a 12 year-cooling time.

The decay heat characteristics of the respective contaminated waste and non-contaminated waste are also shown in Fig. 3. Although the contaminants are included in the metal waste, the contaminated waste was revealed to have a decay heat of less than 2 kW/m^3. Therefore, it can be concluded that no high-level waste is produced among the metal waste from the pyroprocessing using the 17×17 KOFA design.

2.5.3 Radioactivity of Each Waste

Although none of the metal waste exceeded the decay heat limit value, the waste exceeding the acceptance criteria for LILW in the aforementioned MEST notice [13] clearly cannot be accommodated in the Gyeongju repository.

As shown in Fig. 4, the specific activity of the Inconel 718 grid plate revealed the highest value, at 1.7×10^{11} Bq/g upon discharge, resulting in a still higher value of 9.8×10^9 Bq/g after 10 years, although this decayed to 6% of the initial value. The radioactivity change for the key nuclides in the Inconel 718 grid plate is shown in Fig. 5. At the beginning, ^{60}Co was a major leading nuclide, accounting for 17% of the total radioactivity. However, ^{63}Ni, with a

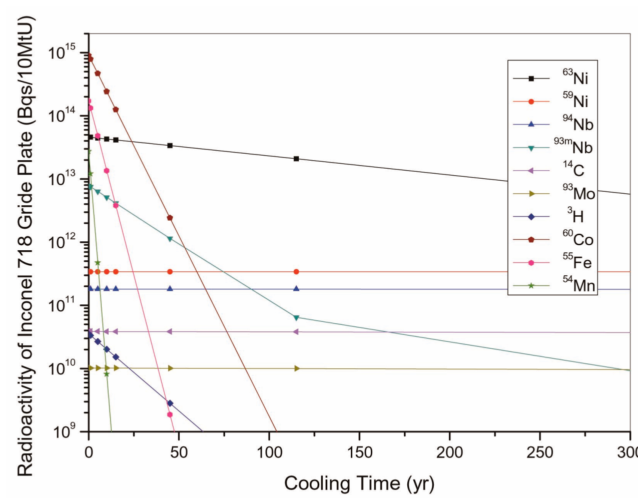


Fig. 5. Radioactivity for Major Nuclides in An Inconel 718 Grid Plate as a Function of Time

half-life of 100.1 years, comprised 25% of the total radioactivity 30 years after discharge, which indicates that waste classification is not affected significantly by the decay time. The specific activity was compared with that of each nuclide specified in MEST Notice 2009-37, as shown in Fig. 6. The Inconel 718 grid plate, accounting for 1% of the metal waste, cannot be placed in the Gyeongju repository because the specific activities of ^{94}Nb, ^{59}Ni, ^{63}Ni, ^{99}Tc, and ^{14}C exceed the limit values. This is especially true for ^{94}Nb, where the exceeding ratio is 5.3×10^4, as shown in Fig. 6.

The Zircaloy-4 grid plates, which account for 11.3 % of the metal waste, can be deposited in the Gyeongju repository. However, the SUS 302 guide tube subparts occupying 0.5% are not permitted to go to the Gyeongju repository due to the higher specific activity of ^{59}Ni, ^{63}Ni,

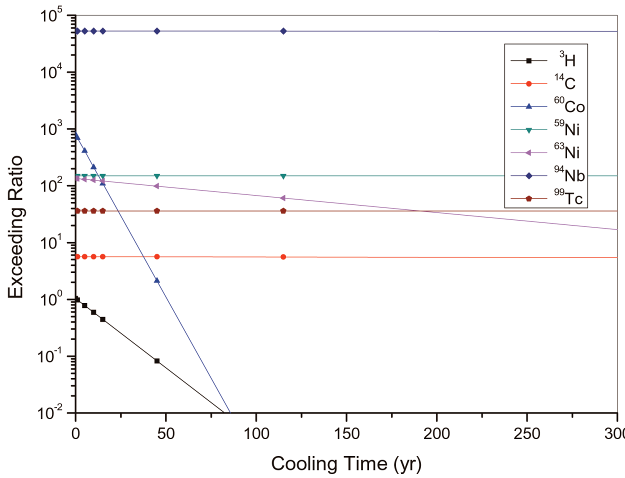


Fig. 6. Exceeding Ratio of Specific Activity to the Limit Value in An Inconel 718 Grid Plate

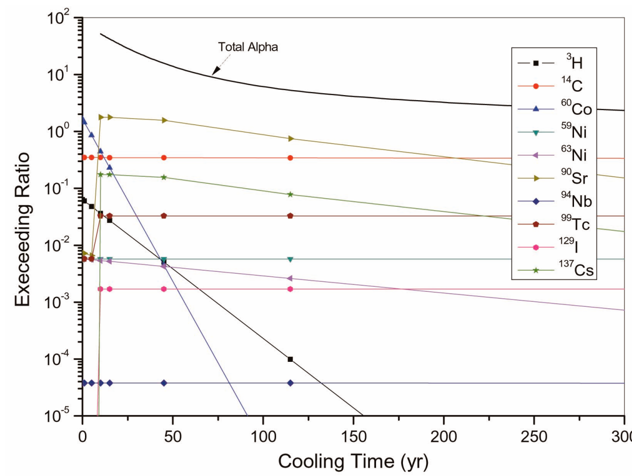


Fig. 7. Exceeding Ratio of Specific Activity to the Limit Value of Contaminated Zircaloy-4 Cladding

and ^{14}C. The bottom-end piece, top-end flow plate, and top-end frame comprised of SUS 321, comprising 8.3% of the metal waste, cannot be accommodated in the Gyeongju repository from the time they are discharged from the reactor because ^{59}Ni exceeds the limit value. The leaf spring, made of Inconel 718 and amounting to 1% of the metal waste, exceeds the limit value from the time of discharge from the reactor.

Zircaloy-4 cladding, comprising 76.2% of the metal waste, is disposable in the Gyeongju repository after several years of cooling time, under the assumption that the waste is not contaminated and that recoiled radionuclides from fission at the surface of the fuel pallet are not present. SUS 302 plenum springs, accounting for 1.7% of the metal waste, are not allowed at the Gyeongju repository due to the higher specific activities of ^{14}C, ^{59}Ni, and ^{63}Ni, each of which exceeds the limit values.

2.6 Classification of Metal Waste

The results showed that 12.5% of the total metal waste, including the Inconel 718 grid plates, Inconel 718 leaf springs, SUS 321 top- and bottom-end pieces, SUS 302 plenum springs, and SUS 302 guide tube subparts, cannot be accommodated at the Gyeongju repository without considering the amount of contaminants. However, it is clear that the Zircaloy-4 cladding and SUS 302 plenum springs will be contaminated by the actinides and FPs in the irradiated fuel during the pyroprocessing step. As shown in Fig. 7, the Zircaloy-4 cladding exceeds the total alpha specific activity by 52 times after a 10-year cooling time compared to the limit value of 3,700 Bq/g, when the previously mentioned level of contamination based on the material flow proposed at KAERI [11] is considered. Even when the waste decays for an additional 300 years, it still has alpha specific activity that is two times higher than the limit value. For the FP contaminants, only ^{90}Sr exceeds the limit value until 80 years after discharge from the reactor.

As mentioned earlier, a contamination factor of 1×10^{-5} for TRU and strontium was applied in the source term characterization in this study. Technology that can deal with 100 and 2 times higher decontamination factors for TRU and strontium, respectively, is necessary for the disposal of contaminated Zircaloy-4 cladding at the Gyeongju repository. The ratios of the specific activity to the limit value of radionuclides related to the acceptance criteria at 10, 50, and 100 years after discharge from the reactor are listed in detail in Tables 3, 4, and 5, respectively, for all structural components.

Finally, the types of metal waste that can be placed in the Gyeongju repository were found to be only the Zircaloy-4 grid plates and guide tubes, yielding 11.3% of the total metal waste. In addition, 88.7% of the metal waste consisting of Inconel 718 grid plates and top-end leaf springs, SUS 321 top- and bottom-end pieces, SUS 302 guide tube subparts and plenum springs, and Zircaloy-4 cladding cannot be placed in the Gyeongju repository. It should be noted that the contaminated waste can be decontaminated after the completion of pyroprocessing. Therefore, separation technology with a higher decontamination factor for TRU and strontium should be developed for the efficient management of the metal waste produced from pyroprocessing.

3. CONCLUSIONS

In this paper, metal waste types generated from the pyroprocessing stage of 10 MtU of spent fuel were classified by comparing the specific activity of the relevant radionuclide with the limit value of specific activity

Table 3. Ratio of the Specific Activity to the Limit Value of the Acceptance Criteria at 10 years after Discharge

	^{3}H	^{14}C	^{60}Co	^{59}Ni	^{63}Ni	^{90}Sr	^{94}Nb	^{99}Tc	^{129}I	^{137}Cs	total alpha
Zircaloy-4 grid plate, guide tube, and cladding	0.04	0.35	0.44	0.01	0.01	0.01	0.00	0.01	0.00	0.00	
SUS 302 guide tube subpart, and rod spring	0.59	5.63	36.21	25.70	21.55	0.00	0.00	0.00	0.00	0.00	
Inconel 718 grid plate	0.59	5.64	211.49	149.85	125.73	0.00	52,982.11	36.02	0.00	0.00	
SUS321 bottom end piece	0.00	0.00	0.09	17.55	0.12	0.00	0.00	0.00	0.00	0.00	
SUS321 top-end flow plate and frame	0.00	0.00	0.00	1.02	0.77	0.00	0.00	0.00	0.00	0.00	
Inconel 718 leaf spring	0.00	0.06	1.17	1.75	1.31	0.00	183.11	0.07	0.00	0.00	
Contaminated Zircaloy-4 cladding	0.04	0.35	0.44	0.01	0.01	1.77	0.00	0.03	0.00	0.17	51.71

Table 4. Ratio of the Specific Activity to the Limit Value of the Acceptance Criteria at 50 years after Discharge

	^{3}H	^{14}C	^{60}Co	^{59}Ni	^{63}Ni	^{90}Sr	^{94}Nb	^{99}Tc	^{129}I	^{137}Cs	total alpha
Zircaloy-4 grid plate, guide tube, and cladding	0.01	0.35	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	
SUS 302 guide tube subpart, and rod spring	0.08	5.61	0.36	25.67	16.91	0.00	0.00	0.00	0.00	0.00	
Inconel 718 grid plate	0.08	5.62	2.12	149.81	98.67	0.00	52,923.53	36.02	0.00	0.00	
SUS321 bottom end piece	0.00	0.00	0.09	17.55	0.12	0.00	0.00	0.00	0.00	0.00	
SUS321 top-end flow plate and frame	0.00	0.00	0.00	1.02	0.59	0.00	0.00	0.00	0.00	0.00	
Inconel 718 leaf spring	0.00	0.06	0.01	1.75	1.03	0.00	182.87	0.07	0.00	0.00	
Contaminated Zircaloy-4 cladding	0.01	0.35	0.00	0.01	0.00	1.57	0.00	0.03	0.00	0.16	13.55

specified in the Korean acceptance criteria for a low- and intermediate-level waste repository. A KOFA design with a 17 × 17 array, an initial enrichment of 4.5 wt.%, discharge burnup of 55 GWD/MtU, and a 10-year cooling time was considered.

Initially, the mass and volume of each structural component of the assembly were calculated in detail. A source term analysis was then performed using ORIGEN-

Table 5. Ratio of Specific Activity to Limit Value of Acceptance Criteria at 300 years after Discharge

	^{3}H	^{14}C	^{60}Co	^{59}Ni	^{63}Ni	^{90}Sr	^{94}Nb	^{99}Tc	^{129}I	^{137}Cs	total alpha
Zircaloy-4 grid plate, guide tube, and cladding	0.00	0.33	0.00	0.01	0.00	00.00	0.00	0.01	0.00	0.00	
SUS 302 guide tube subpart, and rod spring	0.00	5.43	0.00	25.62	2.61	0.00	0.00	0.00	0.00	0.00	
Inconel 718 grid plate	0.00	5.44	0.00	149.46	15.21	0.00	52,454.93	36.00	0.00	0.00	
SUS321 bottom end piece	0.00	0.00	0.09	17.55	0.12	0.00	0.00	0.00	0.00	0.00	
SUS321 top-end flow plate and frame	0.00	0.00	0.00	1.02	0.09	0.00	0.00	0.00	0.00	0.00	
Inconel 718 leaf spring	0.00	0.05	0.00	1.75	0.16	0.00	181.21	0.07	0.00	0.00	
Contaminated Zircaloy-4 cladding	0.00	0.33	0.00	0.01	0.00	0.13	0.00	0.03	0.00	0.02	2.23

S for those components. The activation cross-section library generated by the KENO-VI/ORIGEN-S module was utilized for the top-end and bottom-end pieces. A cross-section library for the 17×17 Westinghouse assembly design was used for structural components residing in the core.

As a result, Inconel grid plates, SUS plenum springs, SUS guide tube subparts, SUS top- and bottom-end pieces, and Inconel top-end leaf springs were not acceptable for the Gyeongju LILW repository, as these types of waste exceed the acceptance criteria. In contrast, Zircaloy grid plates and guide tubes can be placed in the Gyeongju repository. Non-contaminated Zircaloy cladding, accounting for 76% of the metal waste, was shown to have a lower specific activity value than the limit value. However, Zircaloy cladding contaminated by actinides and FPs during the decladding stage of pyroprocessing was revealed to have 52 and 2 times higher specific activity levels than the limit value of specific activity for alpha and ^{90}Sr, respectively. Finally, the types of metal waste suitable for disposal in the Gyeongju repository were found to be limited to Zircaloy-4 grid plates and guide tubes. Moreover, it was found that 88.7% of the metal waste of the 17×17 KOFA design should be disposed of in a deep geological repository, if additional decontamination processes are not included. Therefore, it can be summarized that separation technology with a higher decontamination factor for TRU and strontium should be developed for the efficient management of metal waste resulting from pyroprocessing.

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