Enforced Risk Criteria for SF Recycling Facilities in US and Its Availability in Korea

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1. Introduction

KAERI is being developed pyroprocessing technology for spent fuel recycling. For this it is necessary to develop a facility with hot cells, which can handle the processes safely [1]. In this paper the enforced risk criteria suggested by the US NRC for spent fuel recycling facilities and its bases are introduced and also studied for its availability in Korea.

2. Enforced Risk Criteria of the US NRC and its Bases for SF Recycling Facilities

2.1 Enforced risk criteria of the US NRC for SF recycling facilities

The US NRC recommends and regulates fuel cycle facilities to follow the Integrated Safety Analysis (ISA) method through the code 10CFR70 [2, 3]. The main reason to use the ISA method is that the fuel cycle facilities have some chemical processes which are different from the nuclear reactors.

Recently the US NRC is studying and suggesting the risk criteria (the consequence thresholds, likelihoods, and qualitative risk bins for risk indexing method) for SF recycling facilities as following Table 1 and 2 [4-7].

Table 1. Consequence thresholds

	Workers	Offsite Public	Environment
Very High Consequence Event	RD>>1Sv CD>endanger life	RD>1Sv CD=endanger life	Radioactive release >500,000 x Table 2 of 10CFR20, Appendix B
High Consequence Event	RD>1Sv CD>endanger life	RD>0.25Sv sol U intake>30mg CD=long-lasting health effects	Radioactive release >50,000 x Table 2 of 10CFR20, Appendix B
Intermediate Consequence Event	RD>0.25Sv CD=long-lasting health effects	RD>0.05Sv CD=mild transient health effects	Radioactive release >5,000 x Table 2 of 10CFR20, Appendix B
Low Consequence Event	Accidents of lower radiological and chemical exposures than those above in this column	Accidents of lower radiological and chemical exposures than those above in this column	Radioactive releases producing lower effects than those referenced above in this column

Table 2. Qualitative risk bins

		Likelihood (Events Per Year)			
		Very Highly Unlikely (<1E-6)	Highly Unlikely (<1E-5)	Unlikely (<1E-4)	NOT Unlikely (>1E-4)
Consequence	VHCE	Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
	HCE	Acceptable	Acceptable	Not Acceptable	Not Acceptable
	ICE	Acceptable	Acceptable	Acceptable	Not Acceptable
	LCE	Acceptable	Acceptable	Acceptable	Acceptable

2.2 Bases of the enforced risk criteria for the ISA [7]

The SECY-11-0163 of the US NRC [7] reports that spent nuclear fuel materials and Mixed Oxide (MOX) fuel prepared from reactor-grade plutonium have higher dose conversion factors: some 200,000 times greater than low enriched uranium (LEU) materials. Thus, a potential scenario at a facility involving LEU materials might have low consequences, but the same type of event at a reprocessing facility could potentially have consequences orders of magnitude larger because of this greater radiotoxicity of materials (as shown in Table 3), thus requiring additional safety controls to achieve the same level of safety.

Table 3. Comparison of unit mass dose conversion factors (specific and relative inhalation doses)

Isotope/Mixture	Specific Inhalation Dose, rem/gram	Relative Dose, Ratio to "Ideal LEU"
Uranium-234 (U-234)	8.21E5	1.64E4
Uranium-235 (U-235)	2.58E2	5.16
Uranium-238 (U-238)	3.91E1	7.81E-1
Depleted Uranium (DU) U-235: 0.25%, U-234: 0.00194%, balance U-238	5.55E1	1.11
Natural Uranium U-235: 0.71%, U-234: 0.0055%, balance U-238	8.58E1	1.72
Low-Enriched Uranium (LEU) U-235: 5%, U-238: 95%	5.00E1	1 (reference)
LEU: U-235: 5%, U-234: 0.0055%, balance U-238 (similar to laser enrichment product)	9.72E1	1.9
LEU: U-235: 5%, U-234: 0.03873%, balance U-238 (similar to GC/gaseous diffusion plant enrichment product)	3.68E2	7.36
High-enriched uranium: U-235: 80%, U-234: 0.88%, balance U-238	7.44E3	1.49E2
Mixed oxide (MOX): plutonium (Pu)-239: 5%, U-238: 95%	9.55E5	1.91E4
MOX: weapons Pu, 5% Puf, balance DU	1.27E6	2.54E4
MOX: reactor Pu, 5% Puf, balance DU	1.00E7	2.01E5
MOX: reactor Pu, 5% Puf, 0.25% Am- 241, balance DU	1.40E7	2.81E5
Spent nuclear fuel: 60,000 MWD/MTIHM Only fission products considered are Cs-135, Cs-137, and Sr-90 isotopes	1.11E7	2.2E5
Cs-135, Cs-137, and Sr-90 isotopes from 60,000 MWD/MTIHM spent nuclear fuel	2.05E6	4.1E4

Inhalation doses are based upon 50-year committed effective dose equivalent (see ADAMS Accession No. ML102720167, slide 5).
Specific data for isotopes are from EPA-520/1-88-020, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," September 1988

3. Availability of the US NRC's enforced risk criteria in Korea and Conclusions

In Korea SF recycling facilities are regulated as one of fuel cycle facilities under the nuclear safety law. But the safety analysis methods are nearly same and use the technical criteria with nuclear power plants. But in US the fuel cycle facilities are regulated by a different safety analysis method, such as the ISA, and use some different risk criteria. The ISA method suggested by the US NRC and the enforced 4x4 matrix risk criteria based on the Table 3 will be good references to help the improvement of the Korean nuclear safety law for licensing of SF recycling facilities. The consequences, likelihoods, and unit mass dose conversion factors as shown in Table 3 should be also reevaluated to comply with the Korean nuclear safety law.

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REFERENCES

[1] Gil-Sung You, et al., Concept and safety studies of an integrated pyroprocess facility, Nuclear Engineering Design, No. 241, pp. 415～424, (2011).

[2] US NRC, "Integrated safety analysis guidance document, " NUREG-1513 (2001).

[3] US NRC, "Standard review plan for the review of a license application for a fuel cycle facility," NUREG-1520-rev.2 (2015).

[4] US NRC, "Regulatory option for licensing facilities associated with the Global Nuclear Energy Partnership," SECY-07-0081 (2007).

[5] US NRC, "Regulatory structure for spent fuel reprocessing," SECY-08-0134 (2008).

[6] US NRC, "Update on reprocessing regulatory framework summary of gap analysis," SECY-09-0082 (2009).

[7] US NRC, "Draft regulatory basis for licensing and regulating reprocessing facilities," SECY-11-0163 (2011).