

Risks on UF₆ Sampling Operation

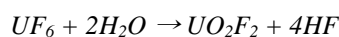
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1. Introduction

Korea Atomic Energy Research Institute (KAERI) has a plan to transform the depleted UF₆, which has been stored about 185 tons in 16 48Y cylinders since 1980s, into a more stable form, U₃O₈ [1]. In order to achieve this plan, the integrity of those cylinders was checked by ORANO in 2018 [2]. The isotopic composition of U-235 is known to about 0.2 %. However, the stabilization by de-fluorination of depleted UF₆ (D-UF₆) needs the safety analysis related to transportation of those cylinders to processing facility and the risk analysis for sampling operation, and the documentation for authority approval. Therefore, some risks during the UF₆ sampling operation, which is an essential process to check the isotopic composition and 48Y cylinder condition for safety analysis regarding to transportation, have been reviewed in this article.

2. Sampling Process

The sampling of several grams of D-UF₆ from the 48Y cylinder, which has more than 10 metric tons at sub-atmospheric pressure, is not simple. If there was an infiltration during the storage for last decade, water contained in air would react with UF₆ and produce HF, according to the following reaction:



The HF has an effect of increasing internal pressure of cylinder, which means that sampling process should prepare even such kind of risk.

2.1 Sampling Process

The schematic diagram of D-UF₆ sampling process has been shown in Fig. 1. The sampling process contains i) pre-sampling steps such as vent line and vacuum pump operation, connection of sampling bottle to 48Y cylinder, cylinder valve opening, and cylinder pumping using cold trap, ii) sampling steps such as D-UF₆ transfer from cold trap to sampling bottle, cold trap emptying by heating, and cylinder valve and bottle closing, and iii) post-sampling steps such as disconnection of cylinder and bottles, shutdown of equipment, and leak-tightness test of cylinder valve.

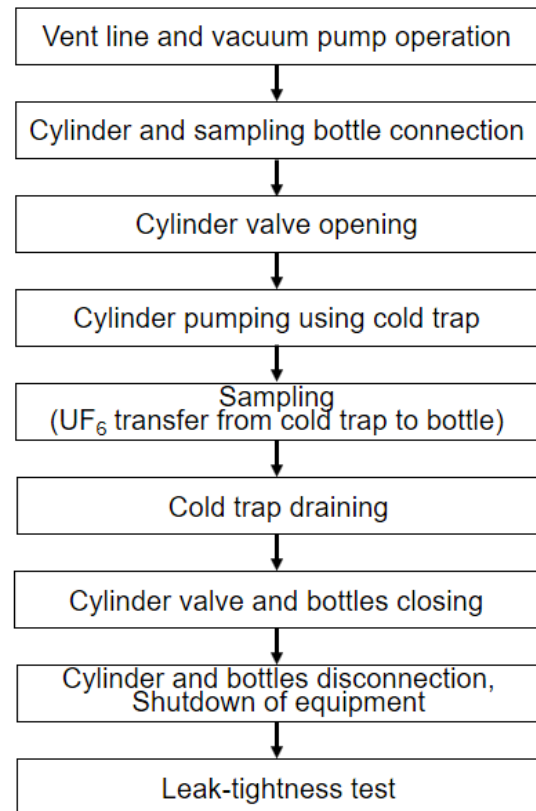


Fig. 1. Schematic diagram of D-UF₆ sampling process

3. Risks on Sampling Operation

3.1 Radiological Spectrum

The uranium spectrum of D-UF₆ in 48Y cylinders is expected as follows:

- ²³⁵U isotopic abundance equal to 0.5%
- ²³⁶U isotopic abundance equal to 0.01%
- ²³⁴U isotopic abundance equal to 0.0035%
- ²³⁸U isotopic abundance equal to 99.4865%

The activity per unit mass of D-UF₆ is about 25 kBq/g, considering 30 years ageing [3].

3.2 Risk Identification

Three kinds of risk classifications such as nuclear risks, internal non-nuclear risks, and external non-nuclear risks, can be considered [3].

3.2.1. Nuclear risks

The risks related to nuclear materials are as follows:

- 1) Risk of dispersion of radioactive and toxic substances
- 2) External exposure risk
- 3) Criticality hazard

The critical hazard is not taken into account since ^{235}U isotopic abundance is less than 1%.

3.2.2. Internal non-nuclear risks

The internal non-nuclear risks are as follows:

- 1) Fire
- 2) Handling risk
- 3) Explosion risk
- 4) Chemical risk
- 5) Risk linked to loss of utilities
- 6) Flooding risk

Here, the explosion and flooding risks are not taken into account due to absence of chemical components related to explosion and negligible quantity of liquid, respectively.

3.2.3. External non-nuclear risks

The external non-nuclear risks are as follows:

- 1) Seismic risk
- 2) External flooding risk
- 3) External fire risk
- 4) Lightning risk
- 5) External explosion risk
- 6) Risks related to extreme climatic conditions
- 7) Risks related to aircraft crash

Except the seismic risk, the other risks are not taken into account because they are covered by the existing nuclear safety baseline and short-term operation period (approximately 3 months).

Table I: Risk identification during UF_6 sampling operation

Classification	Details (consideration, Yes or No)
Nuclear Risks	<ul style="list-style-type: none"> • risk of dispersion of radioactive and toxic substances (Y) • external exposure risk (Y) • criticality hazard (N)
Internal non-nuclear risks	<ul style="list-style-type: none"> • fire (Y) • handling risk (Y) • explosion risk (N) • chemical risk (Y) • risk linked to loss of utilities (Y) • flooding risk (N)
External non-nuclear risks	<ul style="list-style-type: none"> • seismic risk (Y) • external flooding risk (N) • external fire risk (N) • lightning risk (N) • external explosion risk (N)

	<ul style="list-style-type: none"> • risks related to extreme climatic conditions (N) • risks related to aircraft crash (N)
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3. Conclusions

The risks during sampling operation of D-UF_6 , which is stored in 48Y cylinder and will be transformed to more stable form, U_3O_8 , were identified. Total 16 risks out of three kinds of classifications were considered, as listed in Tab. I., however only 7 risks among them are now being analyzed in detail.

REFERENCES

- [1] Choi, J.-W. et. al., "Consideration on the Stabilization Method of D-UF_6 ", KAERI/RR-4267/2017 (2017).
- [2] Choi, J.-W. et. al., "Construction and Operation of Practical Scale Decontamination Waste Treatment Facilities", KAERI/RR-4330/2017 (2017).
- [3] G. Marge, "Safety Evaluation", Deliverable from ORANO as a service result, Draft Version, France (2020).