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Continuous Air Monitoring in the Advanced Fuel Science Building

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1. Introduction

To meet the safety demand in the Advanced Fuel Science Building (AFSB) at the KAERI inside and outside, continuous survey of airborne radioactive particles is required along with an alarming system.

This paper shows the current status of the continuous air monitoring system which should ensure the effluent air leaving the AFSB does not negatively impact public safety and health.

2. ALI and DAC

Naturally occurring uranium consists of three isotopes, all of which are radioactive: U-238, U-235, and U-234 with weight % (activity %) 99.284 (48.9), 0.711 (2.2), and 0.0053 (48.9) respectively. U-238 and U-235 are the parent nuclides of two different decay series, while U-234 is a decay product of the U-238 series.

The natural, depleted, and low enriched uranium are stored, studied, and processed in the AFSB.

Uranium and most of its by-products, including thorium, radium, radon and most of the radon daughters emit alpha particles (see Table 1). Since alpha particles are less penetrating than other forms of radiation, uranium poses little health hazard as long as it remains outside the body. If inhaled or ingested, its radioactivity causes increased risks of lung cancer and bone cancer.

Table 1. Radioactive Characteristics of Uranium (adapted from Table 1.3 Common Alpha-Emitting Radioisotope Source [1])

Source	Half-Life in Year	Alpha Particle Kinetic Energy in MeV with Uncertainty	%
U-238	4.5×10^9	4.196 ±0.004	77
		4.149 ±0.005	23
U-235	7.1×10^8	4.598 ±0.002	4.6
		4.401 ±0.002	56
		4.374 ±0.002	6
		4.365 ±0.002	12
		4.219 ±0.002	6
U-234	2.5×10^5	4.7739 ±0.0009	72
		4.7220 ±0.0009	28

Uranium is also chemically toxic at high concentrations and can cause damage to internal organs such as kidneys. For many radionuclides the International Commission on Radiological Protection (ICRP) has calculated the relationship between intake (the activity taken into the body) and the committed equivalent dose resulting from that intake, and has established annual limit on intake (ALI). The ALI is the intake activity value of a radionuclide which if taken it to the body of an adult worker (reference man) by inhalation or ingestion in a year would result in a committed effective dose or a committed equivalent dose not exceeding the limit set by the regulatory body. The unit of the ALI is Becquerel (Bq).

Airborne radioactive particle concentration limits are expressed in DAC (Derived Air Concentration) and are isotope specific as shown in the Table 2. The exposure is expressed in DAC-hours, i.e. the concentration in Bq/m^3 multiplied by the exposure time in hours. In order to detect these activities, air is pumped through a filter at a speed of about 1 m^3/hr [2].

The DAC of a given nuclide is defined as the concentration of the given radionuclide in air which, if breathed inhalation rate 1.2 cubic meters of air per hour by the reference man for a working year of 2,000 hours, results in an intake of 1 ALI.

On-site workers' health and safety should not be compromised by airborne radioactive contamination. Because of the lethal nature, uranium has very low regulated upper limits in air as shown in the Table 2.

Since eating, drinking, and smoking are not permitted in the radioactive areas, the ingestion pathway is not of concern. The values of Table 2 for inhalation were therefore used.

Table 2. Values of ALI, DAC and Discharge Control Standard of Radioactive Materials for Inhalation (adapted from Table 3 of Notice 2002-23 [3])

Radio-nuclides	CF*	ALI	DAC	Discharge Control Standard of Ventilation
		Bq	Bq/m^3	Bq/m^3
U-238	F, **	3E+04	1E+01	1E-01
	M, **	1E+04	5E+00	3E-02
	S, **	4E+03	1E+00	1E-02
U-235	F, **	3E+04	1E+01	1E-01
	M, **	1E+04	5E+00	2E-02
	S, **	3E+03	1E+00	9E-03
U-234	F, **	3E+04	1E+01	1E-01
	M, **	1E+04	4E+00	2E-02
	S, **	3E+03	1E+00	8E-03

* Chemical form, ** equal to U-230

3. Continuous Air Monitoring

To detect air borne alpha-emitting uranium radionuclides in the AFSB, air is continuously monitored through the Analysis Window with a transuranic region 3.0 ~ 4.7 MeV covering the alpha particle energies of the Table 1 [4]. If the uranium activity exceeds a preset level, an alarm is issued. Then the alarm status is checked and the appropriate action is followed. We have two types of alarm; acute and chronic. The acute release is checked every 30 seconds and the chronic release every 30 minutes. Figure 1 shows a snapshot of the effluent air monitoring.

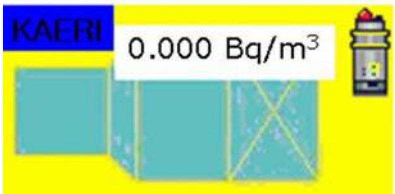

Figure 1. A snapshot showing an effluent air status.

The air monitoring detector has mechanical components requiring strict weekly, biannual, and annual preventive maintenance including the firmware update. The radiation monitoring information system consists is a hardware and software system with a commercial relational database management system (RDBMS) where the radiation measurement data is stored and analyzed. It requires a 24/7/365 operation.
With timely maintenance the effluent air has been successfully monitored and the safety and health of on-site workers and public has been secured.
Related research and development are required to level up the availability and extend the usable lifetime of the continuous air monitoring system.

4. Conclusion

The air inside the AFSB should be continuously monitored against uranium contamination and discharged after filtering to ensure that the effluent air leaving AFSB should not negatively impact public safety and health. Since the continuous air monitoring system has mechanical components, the timely maintenance is of prime importance. Until now the radiological environment of the AFSB has been safe enough. To secure continual safety, relevant research and development program is required.

REFERENCES

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