Environment Monitoring in Radioisotope Production Facility

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Keywords : Radioisotope Production, Radiation Safety, Contamination Monitoring

1. Introduction

KOMAC of Korea Atomic Energy Research Institute (KAERI) operates a 100-MeV proton accelerator and provides high-quality proton beams to users, thereby supporting research in diverse fields. In addition to beam services, KOMAC has been conducting research on radioisotope production using the accelerator, with the aim of contributing to a stable supply of radiopharmaceutical and improving public health.

For production, a target containing specific elements is irradiated with protons from the accelerator, inducing nuclear reactions and subsequent activation. The target is then retrieved and subjected to chemical processing, including separation and purification, to obtain the desired radionuclide with high purity.

Since 2025, KOMAC has carried out several months of pre-operational activities and commissioning in preparation for full-scale operation of the radioisotope production facility, during which radiation safety management strategies were established and have been maintained to date. The objective of this study is to assess the radiological contamination status of the production facility using radiation monitoring results, and to provide fundamental data and insights for establishing enhanced radiation safety management frameworks at similar radioisotope production facilities.

2. Analysis

2.1 Exhaust Ventilation Monitoring

The production facility is designed to be maintained under overall negative pressure to prevent the spread of contaminated air to adjacent areas. Room air from the facility and air from the hot cells are exhausted respectively through independent duct lines to final stack, preventing backflow of the air into other zones.

Because unsealed radioactive sources are handled, there is potential for environmental contamination during exhaust. To mitigate this risk, each duct line is equipped with a filter bank consisting of pre-, medium-, HEPA, and charcoal filters. Contaminated air passes through these filters before the final stack. (Fig. 1)

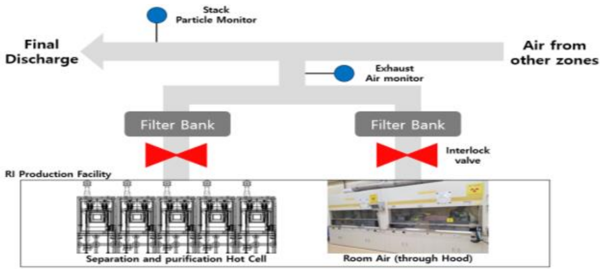

Fig. 1. A Schematic Diagram of the Exhaust System

There are monitoring and interlock functions to cope with abnormal conditions in which filtration alone may not be sufficient. Duct lines merge into a single duct before the final stack, where air monitor is installed to measure airborne radioactivity from the facility. When the activity concentration exceeds an alarm setpoint, an interlocked valve is actuated to stop the exhaust flow.

The alarm setpoint was derived from the Effluent Concentration Limits (ECL) by taking the most restrictive limit among the radionuclides (Al-26, 6 Bq/m^3) [1]. A Derived Release Limit was calculated by considering working hours and ventilation flow rate with the ECL, and 20% of this value was adopted as the setpoint so that the exhaust system operates with sufficient margin below the limit.

In addition, a stack particle monitor is installed at the final release point to measure the activity concentration in the air ultimately discharged from the accelerator facility, including the production facility. When its value exceeds the preset criterion, an interlock is activated to stop the operation of the accelerator.

2.2 Internal Workplace Monitoring

Radioisotope production is principally conducted in hot cells. However, the hot cell's penetrations are occasionally opened during target transfer after irradiation and during maintenance. In these processes, there is a possibility that contamination may spread into the interior of the facility. Therefore, contamination has been monitored periodically since pre-operation stage.

2.2.1. Surface Contamination Monitoring

Surface contamination monitoring was focused on areas where radioisotopes are handled and where samples or radioactive waste are frequently moved. Three measurement locations were selected as below.

1. The vicinity of the hot cells and fume hoods where chemical separation and purification of radioisotopes are performed,
2. The storage area where produced radioisotopes and residual materials are temporarily stored,
3. The contamination inspection room that workers pass through before entering general radiation-controlled areas.

Smear test, which is relatively less affected by ambient radiation, were used for measurement. The smear samples were counted using a low-level alpha/beta counter, and the measured values were then compared with surface contamination control levels established for the facility to determine whether contamination was present or not.

2.2.2. Airborne Contamination Monitoring

Airborne contamination was monitored at locations inside the facility where radioactive aerosols or other particulate materials are most likely to be generated, namely in the vicinity of the hot cells and fume hoods. At this point, a continuous air monitor is installed that samples room air and measures airborne radioactivity. The monitor readings are recorded continuously and displayed in real time, enabling operators to frequently check the values and respond in advance to any indication of airborne contamination. (Fig. 2)

Fig. 2. Continuous Air Monitoring in Production Facility

2.3 Monitoring Results

The facility began preparations for operation in March, and after commissioning, trial production of Cu-67 was achieved in November. According to the contamination monitoring results, both the workplace and the exhaust system remained below the relevant control limits throughout the period.

For surface contamination, the monthly mean values at three representative locations were generally low, remaining below the control levels and frequently near the minimum detectable activity level.

Indoor airborne contamination was also evaluated using the monthly mean values of the continuous air monitor. The alpha and beta concentration remained in a low range over the entire period. During the fourth quarter, when radioisotope production activities were carried out, a slight increase was observed at certain times. However, no exceedance of the preset alarm thresholds occurred.

The monthly mean concentration measured by the stack particle monitor showed low concentration overall. While the second half of the period exhibited a gradual increase compared with the pre-production stage, the values remained well within the alarm criteria, indicating a measurable but limited influence of commissioning and production activities on stack particle concentrations.

3. Conclusion and Future Work

In this study, monitoring data from a radioisotope production facility was analyzed, focusing on surface and airborne contamination from the pre-operational stage to trial production of Cu-67. Both workplace contamination and exhaust remained below the relevant control levels throughout the period, with stack concentrations staying at a small fraction of the alarm setpoints. These results indicate that the current operation of the facility is effective in maintaining radiological conditions with safety margins.

During the fourth quarter, when commissioning and trial production were carried out, a slight increase was observed in indoor airborne concentrations and stack particle concentrations. Although these levels were still far below the control limits and alarm setpoints, the trend suggests that increasing production activity can influence both workplace and discharge conditions. This implies that, in the event of future expansion of production capacity or diversification of products, it will be important to consider how to maintain and strengthen the monitoring system and criteria.

Based on the accumulated data, several directions can be considered for future work. First, long-term analysis integrating monitoring results with production indicators (such as irradiation parameters, the number of production operation, and work types) could be used to characterize and model changes in the radiological environment. Second, such analyses may serve as a basis for reviewing safety management strategies, including adjustment of monitoring frequency for high-risk tasks, optimization of alarm setpoints, and improvement of work procedures. Third, incorporating monitoring results and case studies into worker training programs may help enhance radiological safety awareness and further strengthen the safety culture at this and other similar radioisotope production facilities.

REFERENCES

[1] Nuclear Safety and Security Commission, Standards for Radiation Protection, etc., Notice No. 2025-3, (effective date: 23 April 2025), Annex 3 (Effluent Concentration Limits).