Field Demonstration of a Prototype Hand-held-type Gamma Imaging Device at a Customs Site

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1. Introduction

The Radiation Equipment Fab. Center at the Korea Atomic Energy Research Institute (KAERI) is conducting a key facility operation project to vitalize R&D in radiation technology. The Fab. Center supports various collaborative research projects by providing its infrastructure for developing core technologies, such as semiconductor sensors and radiation generators, to industry, academia, and research institutes. This study is one of the research outcomes leveraging the facilities and infrastructure of the Fab. Center, focusing on the field applicability of the prototype hand-held-type gamma imager (pHGI) [1] developed for security-sensitive environments such as customs sites.

Radiation inspection of imported cargo at airports and harbors is essential for the safety of both workers and the public. The Korea Customs Service employs radiation portal monitors for initial detection, after which on-site personnel use portable survey meters to identify the radioisotopes and localize the contaminated cargo. However, conventional survey meters are restricted to dose rate measurements and cannot localize radioactive materials, requiring personnel to physically approach the cargo. To overcome these limitations, the pHGI was developed as a multi-functional system integrating radiation imaging, automatic isotope identification, and real-time dose rate estimation [1, 2].

While the performance of the pHGI has been evaluated under controlled laboratory conditions at the Fab. Center, its applicability in an actual customs environment—where sources are concealed within cargo and surrounded by clutter—had not been verified. This paper presents a field demonstration of the pHGI conducted at an actual customs site, together with the integrated graphical user interface (GUI) program employed for the demonstration.

2. Methods and Results

2.1 Field demonstration conditions

The field demonstration was carried out at the express cargo logistics center of a customs office in Korea. A ^{137}Cs check source (~150 μCi) and a ^{22}Na check source (~80 μCi) were used. To reduce unnecessary radiation exposure, a dedicated shielding container was fabricated in-house, and the check sources were concealed within the container, which was then placed inside an ordinary cargo box.



Fig. 1. Developed prototype hand-held-type gamma imaging device.



Fig. 2. Experimental conditions for field demonstration.

Seven scenarios were designed to simulate realistic inspection conditions, including a source box placed in front of the device, at the lateral side, hidden behind stacks of boxes, located more than 2 m away among a large volume of cargo, measured while the device was hand-carried by an operator, and containing two co-existing isotopes. For each scenario, the isotope identification result, the radiation image, and the estimated dose rate were continuously updated on the GUI during measurement, with a nominal measurement time of 5 min.

2.2 Results

In all scenarios, the presence of ^{137}Cs was identified within the measurement time from the 662 keV peak in the energy spectrum, and the source was successfully localized in the radiation image. The estimated dose rates ranged from 0.22 to 1.95 μSv/hr depending on the source position and distance.

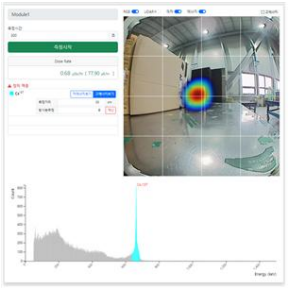


Fig. 3. Experimental results for the first case (single ^{137}Cs).

Notably, when the source box was placed at the lateral side of the device, the source fell outside the field of view (FOV) of the RGB camera. In this case, the extended visualization function of the integrated GUI program was used to obtain a radiation image over a 360° FOV, and the source was localized at 270° with respect to the front face of the device. This experimentally confirmed the 4π FOV of the pHGI under field conditions.

Even when the source box was concealed behind stacks of boxes or located more than 2 m away among a large volume of cargo, the isotope was identified and localized from a single measurement. In the latter case, the estimated dose rate was 0.22 μSv/hr, comparable to the natural background level, at which primary portal screening becomes challenging. Even under this weak-signal condition, the pHGI identified and localized the source, indicating that the device can complement portal monitors by resolving weak or distant sources under actual field conditions. In the scenario where the operator hand-carried the device, the source was also identified and localized in real time, confirming the operational feasibility of the device.

Finally, in the scenario where ^{137}Cs and ^{22}Na were concealed together, both isotopes were automatically identified from the 662 keV, 511 keV, and 1275 keV peaks, and each isotope was independently localized by selecting it from the isotope list. The dose rate under this condition was estimated to be 1.03 μSv/hr.

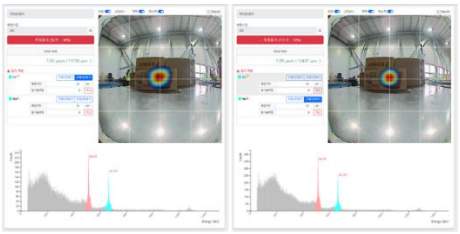


Fig. 4. Experimental results for the last case (^{137}Cs and ^{22}Na).

3. Conclusions

The applicability of the pHGI was experimentally verified through a field demonstration at an actual customs site. Under seven realistic scenarios, the pHGI identified the concealed isotopes, localized them in the radiation image, and estimated the dose rate during measurement through the integrated GUI program. In particular, sources concealed behind cargo, located outside the FOV of the RGB camera, and present at a dose rate comparable to the background level were successfully detected and localized. These results demonstrate that the pHGI, developed by leveraging the infrastructure of the Radiation Equipment Fab. Center, is applicable to radiation inspection at customs sites and is expected to enhance both the efficiency of the inspection work and the safety of the workers. Future work will focus on implementing a wireless connection and on improving the processing speed of the integrated GUI program.

Acknowledgement

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