Progress of Design of Containment and Surveillance System for Pyroprocessing Safeguards

Se-Hwan Park *, Dae-Yong Song, Bong Young Kim, Seong-Kyu Ahn, and Jeong-Hoe Ku
Korea Atomic Energy Research Institute, Yuseong-gu, Daejeon, 34057, Korea
*Corresponding author: ex-spark@kaeri.re.kr

1. Introduction

Pyroprocessing has been developed for the reuse of the spent fuel at Korea Atomic Energy Research Institute (KAERI). Since the effective and efficient safeguards in the pyroprocessing facility is essential to realize the pyroprocessing facility in Korea, the safeguards technologies has been developed and the safeguards system has been designed in parallel with the process technology development.

Nuclear material accountancy (NMA) plays most important role in safeguards of the nuclear facility. KAERI has designed the conceptual safeguards systems, especially based on NMA, of Reference Engineering-scale Pyroprocessing Facility (REPF), and conceptually designed Korea Advanced Pyropricessing Facility (KAPF). Based on the calculation of the Material Unaccounted For (MUF) and MUF uncertainty of the NMA systems, the NMA system is shown to be effective in detecting the diversion of the nuclear material in the pyroprocessing facilities.

Containment and Surveillance (C/S) is also important in the safeguards of the nuclear facility, especially in the pyroprocessing facility. When KAERI developed the safeguards systems, the C/S system was also designed to enhance the safeguardability in the pyroprocessing facility.

In the present work, a method to upgraded the system requirement of C/S system is proposed and the C/S system is being upgraded.

2. C/S system requirement development

The C/S system concepts for the safeguards in reprocessing plants were developed in the previous works [1, 2, 3]. A containment boundary concept was introduced in their work, and all the nuclear materials were usually assumed to be positioned inside the containment boundary. Nuclear materials were transferred through penetrations, which were placed in the containment boundary. The penetration was the position where both the nuclear material diversions and the detection of nuclear material diversion occured. Diversion detection probabilities or diversion detection thresholds in the penetrations were assigned to assess the effectiveness of the C/S system.

In the present work, the C/S equipment, which can be appled to the C/S system of pyroprocessing facility, were selected at first. They are the neutron monitor, gamma monitor, seal and surveillance camera. The C/S equipment can be divided into 2 groups. The frist group contains the quantitative equipment, such as neutron monitor, and gamma monitor, the performance of which can be expressed quantitatively. The second group contains the qualitative ones, such as seal and surveillance camera, the performance of which can be represented qualitatively. The performance of the C/S system is evaluated only considering the quantitative C/S equipment. The sensitive diversion paths are extracted. After that, the C/S system performance is revised including the qualitative C/S equipment.

The process materials are transferred through the transfer points such as transfer tunnel, transfer port or transfer hatch. The transfer point corresponds to the penetration in the previous work [1]. The each hot cell of the pyroprocessing facility correspond to the containment boundary [1]. The diversion materials are also transferred through the transfer points. The transfer points are divided into two groups. The first group includes the transfer points, where the process material or diversion material are transferred between the hot cells, and the second group includes the transfer points, where the process material or diversion material transferred outside the facility.

The quantitative C/S equipment are assumed to be placed to the first group transfer points, and the neutron yield, gamma dose rate and mass of transfer material are calculated for the three cases, 1) process material transfer, 2) diversion material transfer, and 3) the simultaneous transfer of process material and diversion material. The calculation is based on pre-conceptually designed KAPF facility model [4]. From the calculation, the difference of neutron yield and gamma dose rate per mass between the diversion case and non-diversion case are obtained. Transfer points can be categorized based on the easiness of diversion detection with the quantitative C/S equipment.

After the categorization of the transfer points and analyze the effectiveness of the quantitative C/S equipment, the effectiveness of the qualitative C/S equipment are included to the design the C/S system of the pyroprocessing facility.

3. Summary

C/S places important role to meet the IAEA safeguards goal efficiently in the pyroprocessing facility. The system requirement of C/S system is developed by including the containment boundary and penetration concept. The effect of the quantitative C/S equipment is assessed and the penetration points are categorized depending on the diversion detection easiness with the quantitative C/S equipment. The C/S system is upgraded including the qualitative C/S equipment. This work will help to validate the efficiency of C/S system in the pyropriocessing safeguards.

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