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Data Collecting Techniques and Required Structures of Surveillance Cameras on the Unattended Monitoring System applied at the Reference Pyroprocessing Facility in the ROK

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1. Introduction

The Unattended Monitoring System (UMS) applied to the Reference Pyroprocessing Facility (REPF) provides the effective tool to verify declared operational information through the Near-Real Time Accountancy (NRTA) and Mailbox Declaration System at the remote place in real time. The UMS applied at the REPF focuses on the containment and surveillance of nuclear materials (NM), especially the detection of NM movement at the transfer port connected to the hot cells or spent fuel pool storage. In this regard, collecting images of NM movements and functions of surveillance cameras are important factors to configure the UMS at the REPF considering the characteristics and design features of the REPF.

In this study, the techniques of collecting images or video clips and the required functions and structures of surveillance cameras of UMS are prepared.

2. Required Techniques and Structures on Surveillance Cameras of UMS

2.1 Techniques of Collecting Images or Video Clips with Surveillance Cameras

To efficient monitor the receipt or shipment of nuclear material from/to hot cells, continuous shooting video clips are considered rather than the taking the snapshots with the specific intervals using the conventional surveillance cameras applied to the current nuclear facilities. Continuous shooting video clips has strong advantage to monitor and evaluate the movement of nuclear material in the hot cell, but has difficulties on storing or transmitting data to the main server or even to the remote place such as the IAEA and KINAC headquarters. Therefore, taking account of limitation of data transmission, the assessment of necessity of continuous shooting video clips in real time is needed. In order to supplement the limitation of data transmission to the remote places and to efficient monitor the movement of nuclear materials throughout the continuous shooting video clips, it is suggested that shooting video clips are selectively triggered with sensors sensing the opening and closing the transfer port and with the high dose rate more than the set threshold from the portal monitors. It means that the triggering point for shooting video clips is set when the transfer port is opened and the portal monitor detects high dose rate to identify the irradiated nuclear material. On the other hand, the surveillance cameras take the snapshots with the specific interval same as the conventional surveillance cameras at the normal stage (Transfer port is closed, and the portal monitor shows the background dose rate.). This measure has advantages of collecting the optimized surveillance data for receipt/shipment/movement of nuclear materials. In addition, data volume for the video clip files in a short time is significantly small comparing to the data volume for the entire period so that the data transmission to the IAEA and KINAC headquarters is readily carried out. Nevertheless, malfunction of sensors connected to the transfer port or portal monitors should be considered at the early stage of system development.

To troubleshoot the difficulties on the data transmission of video clip files to the remote places (the IAEA and KINAC headquarters), the adjustment of time interval of shooting images in a short period is also considered. For instance, if the time interval of shooting images for surveillance cameras is set every 1~3 minutes, the images collected from the surveillance cameras might not be enough to monitor the movement of nuclear materials when the receipt or shipment of nuclear material is carried out. However, more surveillance data are collected to review the monitoring of movement of nuclear materials in the same condition if the time interval of surveillance cameras is set as 5~15 seconds. To prevent the significant increase of data volume for surveillance images with short time interval, the image collection mode with short time interval in the surveillance cameras can be triggered with sensors sensing the opening and closing the transfer port and with the high dose rate more than the set threshold from the portal monitors (the same method applied to the shooting video clips). In this measure, less surveillance data for the evaluation of receipt/shipment/movement of nuclear material are collected than collecting video clips. In addition, malfunction of sensors connected to the transfer port or portal monitors should also be considered at the early stage of system development.

2.2 The Required Structures of Surveillance Cameras

The surveillance cameras installed in the hot cell to monitor the receipts and shipments of nuclear material from/to cells are required to have durability for a long time against the high radiation circumstance. To meet this requirement, radiation resistance test should be carried out at the early stage of surveillance camera development. The current surveillance cameras such as ALIS (All-In-One Surveillance, mains operated), ALIP (All-In-One surveillance, Portable battery operated), and DMOS (Digital Multi-Camera Optical Surveillance, between 6 and 16 cameras) are tested for the radiation resistance, and installed at the relatively low radiation area of containment building. But, in the high radiation circumstance like containment building at Kori Unit 2, for example, the surveillance camera is not able to be installed in operation due to the malfunction of surveillance camera influenced by high gamma and neutron environment. Therefore, applicability of surveillance cameras in the high radiation circumstances should be reviewed with the expected dose rate for the development or selection of surveillance camera. Shielding surveillance cameras in the specific place might be required if necessary.

In the case of surveillance cameras installed around the transfer port, single lens cameras are enough to monitor the movement of nuclear materials at the transfer port. On the other hand, dual lens cameras are more efficient to monitor adjacent 2 sensitive processes like electro-refining and electro-winning processes and to reduce the number of surveillance cameras in the hot cells due to the inaccessibility and limitation of room in hot cells. Moreover, the applicability of dual lens cameras composed of independent lens optimized with images and video clips should be reviewed if both images and video clips are needed to monitor the movement of nuclear material.

The miniaturization with light weight should be reviewed to optimize the readiness of installation and maintenance of surveillance cameras installed in the hot cells. The surveillance cameras applied to LWRs and CANDUs are not appropriate to install in the hot cells at the REPF due to the difficulties of replacement or maintenance. There was no previous example to replace and re-install surveillance cameras in the hot cells in any ROK nuclear facilities, was an example to remove and replace NDA detectors in the Post Irradiation Examination Facility (PIEF). In this activity, the facility operators conducted the clean out of whole hot cells, then the technician replaced and removed NDA detectors in the hot cells. Taking these efforts and difficulties into consideration, the surveillance cameras installed into the hot cells should be composed of a minimized module for instant transmission of images and video clips, and should be developed applied as a miniaturized module with light weight to be able to replace using cranes and tele-manipulators in the hot cells. For the readiness of removal, maintenance, and replacement, various types of methods for data transmission (e.g. data transmission throughout wireless network) should be considered. But the stabilized data transmission from the surveillance cameras to the main server method is the first priority to be considered.

The function of camera lens also plays a key role to deal with unexpected conditions. The REPF is composed of electrochemical processes and consumes an enormous amount of electric power to recycle spent fuels so that the power outage might be caused due to the electric power shortage. It is worthwhile to review the applicability of lens with ultra low illumination intensity to the surveillance camera module to collect images at the circumstance with very low illumination.

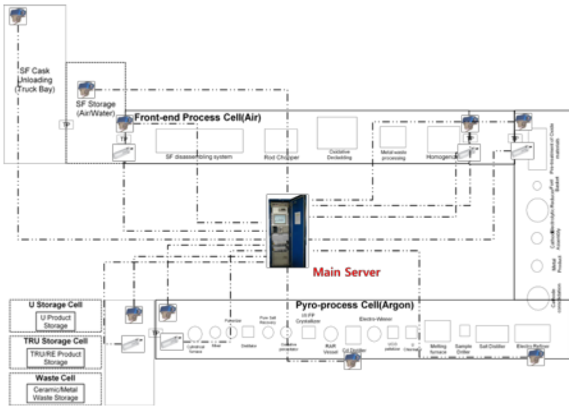

Fig. 1. Overall Scheme of UMS at the REPF

3. Conclusions

In this study, the techniques of collecting images or video clips and the required functions and structures of surveillance cameras of UMS are suggested.

The required parameters to prepare surveillance cameras applicable at the UMS are techniques of selective data collection (images or video clips), dual lens to cover wide range areas and independent roles (collection of images and video clips from each lens), structures (miniaturization with light weight), and function of lens (low illuminations). To make the UMS at the REPF more efficient, the development and authentication of surveillance cameras to meet the requirements mentioned in this study should be carried out.

REFERENCES

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