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The assessment system based on virtual decommissioning environments to reduce abnormal hazards from human errors for decommissioning of nuclear facilities

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1. Introduction

In general, decommissioning is under the hazardous environments with high radioactivity and high difficulty [1].

Decommissioning of nuclear facilities has to be accomplished by assuring the safety of workers. So, it is necessary that before decommissioning, the exposure dose to workers has to be analyzed and assessed under the principle of ALARA (as low as reasonably achievable). Furthermore, to improve the proficiency of decommissioning environments, method and system need to be developed.

2. Methodology

2.1 3D mapping of decommissioning environments

To simulate several scenarios of decommissioning, testing environments were designed on a virtual reality. A lot of scenarios were developed in 3D virtual environments to evaluate through simulation as shown in Fig. 1.

These figures show that a reactor is being mapping as 3D data. The raw data of dose distribution can be gained from MCNP (Monte Carlo N-Particle Transport) code.

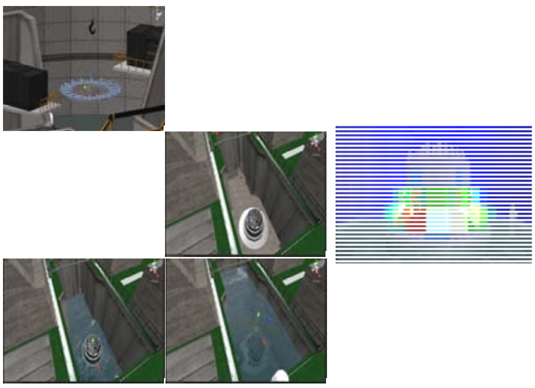

Fig. 1. The virtual environment of decommissioning.

2.2 Method of concurrent assessment of exposure to workers

Safety assessment can be accomplished with dose distribution and exposure dose from human errors as shown in Fig. 2. The dose distribution means the radioactivity of working environments. The exposure dose from human errors means the additional radioactivity generated from several errors by workers.

The exposure dose from human errors mainly consists of physical human errors, procedure human errors, and operation human errors. The physical human errors mean falling and dropping accidents of a worker during working of a high place and stairs. The procedure human errors mean accidents from not keeping the procedure of a decommissioning scenario. And the operation human errors mean accidents in handling hands-on equipment and remote equipment.

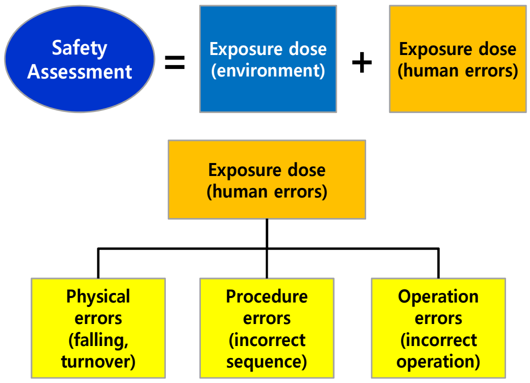

Fig. 1. The virtual environment of decommissioning.

2.3 Configuration of assessment system

Fig. 4 presents the configuration of assessment system. The hardware consists of a head mounted display (whereafter 'HMD'), a monitoring device, and a graphic server. The software is Unity3D and (Monte Carlo N-Particle transport). The HMD is a device that taken on the head of worker and enable worker experience decommissioning scenario under virtual environment. It visualizes real-timely the same structure and equipment as working place. The monitoring device is to check the changes of structures and equipment and track the worker's location in view of third person according to changes of decommissioning scenarios. The graphic server is hardware that structures and equipment of nuclear facilities are databased on and serve to provide HMD and monitoring device with the changed data as routes of worker change. The handling directions of the HMD are yaw, pitch and roll.

When worker puts the HMD on his head, the graphic server of virtual training system is being operated. The graphic server receives data of worker's direction changing. The graphic server exchanges data management unit with the detected numerical data. The graphic server provides the HMD with pictures of direction response and the monitoring device with pictures of worker's location and behavior. In this situation, worker is in first person mode and recognizes decommissioning scenarios with HMD as ones of working in place. On the other hand, Manager is in third person mode and could keep up with location of worker and situation of working.

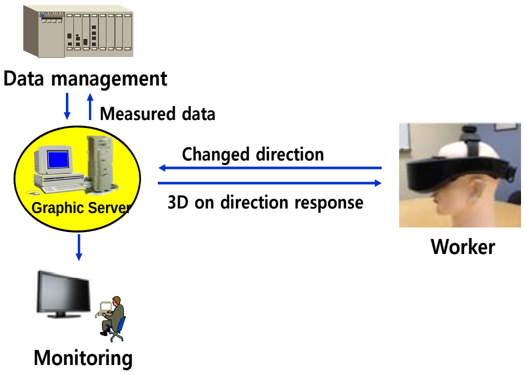

Fig. 3. Configuration of assessment system.

2.4 The performance test of the assessment system

The assumption on testing of system is that the worker's falling accident rises during installation of cavity pool seal. Once a subject puts the HMD (Head Mounted Display) on his head, he can look at the cavity pool seal lifted by a crane. The subject starts to go down from the upper floor to the below cavity pool, the other subject supports moving of the one subject as shown in Fig. 4. The other subject plays a role in supporting the one fallen subject in case of an accident. At this time the working time and radiation exposure of the subject are for the first time measured. During installing and checking of the cavity lines around the cavity pool seal, an accident of the one worker's falling takes place. The other subject observing the moving of the one subject goes down to the accident spot on a ladder and both of them gets to the upper floor. In the end, the accumulated working time and radiation exposure of the subjects are measured and displayed on the HMD in first mode and on the monitoring device in third mode.

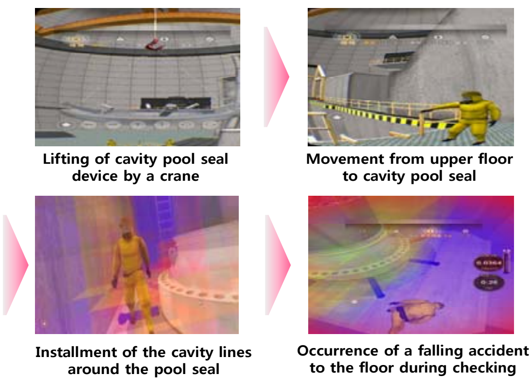

Fig. 4. Performance text of the assessment system.

3. Conclusions

To establish the plan of exposure dose to workers during decommissioning of nuclear facilities before decommissioning activities, it is necessary that assessment system is developed.

This system has been successfully developed so that exposure dose to workers could be real-time measured and assessed in virtual decommissioning environments.

It can be concluded that this system could be protected from accidents and enable workers to improve his familiarization about working environments. It is expected that this system can reduce human errors because workers are able to improve the proficiency of hazardous working environments due to virtual training like real decommissioning situations. In the end, the safety during decommissioning of nuclear facilities will be guaranteed under the principle of ALARA.

REFERENCES

[1] K. S. Jeong, B. S. Choi, J. K. Moon, D. J. Hyun, J. H. Lee, I. J. Kim, G. H. Kim, J. S. Seo, The digital mock-up system to simulate and evaluate the dismantling scenarios for decommissioning of a NPP, , Annals of Nuclear Energy, Vol.73, p. 198-, 2014.