Safeguards Approach to ACPF(Facility Level)

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1. Introduction

ACPF(Advanced Spent Fuel Conditioning Process Demonstration Facility) is under construction to effectively develop a long-term storage method of PWR spent fuel. To develop the long-term storage method, ACPF must carry out the separation of heat sources and high radioactive sources from spent fuel materials by chemical reaction. Due to the sensitivity of R&D activity and nuclear material used in ACPF, a safeguards system should be systematically considered and established to reduce the apprehension of diversion in the international society. The entire processes and the flow of nuclear material in ACPF are reviewed and analyzed to establish the safeguards system.

2. Methods and Results

The information on ACPF including work scope, experiment procedure, equipment, nuclear material, etc. is collected and analyzed to set the safeguards system at the facility level. The flow of nuclear material and the process of ACPF are considered in the analysis. Because the activities of ACPF are carried out both inside and outside of ACPF, the relationship among facilities and material balance are closely investigated.

2.1 Analysis on the relationship among facilities

Ten nuclear facilities that have their own functions are subject to IAEA safeguards in KAERI. Though each facility is operated independently, they are closely related to each other for R&D purpose. Various R&D activities are run and then integrated in ACPF as well as other facilities. In this section we review the activities carried out in other facilities. The activities run in ACPF are described later.

The activities of ACPF and the flow of nuclear material must be considered simultaneously as follows; ① Transfer of fresh natural uranium from/to other facility, ② Transfer of PWR spent fuel rod-cut from PIEF, ③ Transfer of specimen and samples to PIEF and IMEF for the various analysis and ④ Transfer of nuclear wastes produced from the process of ACPF to other facilities.

The transfer of fresh natural uranium from/to other facility is reviewed first. ACPF carries out an inactive test using fresh natural uranium prior to normal operation. Fresh natural uranium can be supplied from the R&D facility MBA or Nuclear Material Storage Facility in KAERI. After the inactive test, fresh natural uranium will be returned to the original facility.

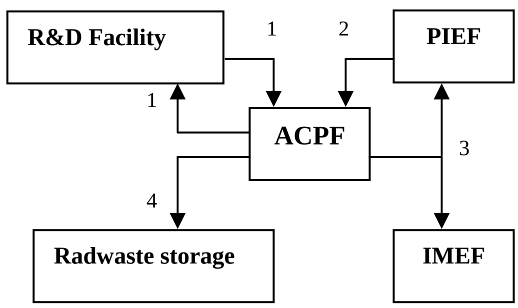
Currently, the PWR spent fuel rod-cut for DUPIC facility are coming from the PIEF. Those for the ACPF are expected to be supplied from the PIEF.

The transfers of specimen and samples to PIEF and IMEF for analysis are also expected since the mechanical, physical and chemical analyses are normally carried out in PIEF and IMEF .

In the case of transferring nuclear wastes that produced from the process of ACPF to other facilities, these material will be considered differently from the radioactive wastes which will be stored in the Radwaste storage building. The storage area of nuclear material wastes such as dirty scarps will be determined in the future.

On the other hand, the maintenance of equipment and the simulation of ACP process will be performed at the two different R&D laboratories, respectively, regardless of the nuclear material flow.

The relationship among facilities regarding the flow of nuclear material is shown in the figure 1.



1. Fresh natural uranium
2. PWR spent fuel rod-cut
3. Specimen and samples
4. Nuclear wastes

Figure 1. Schematic Diagram of Nuclear Material Flow

2.2. Determination of the Key Measurement Point on the main process of ACPF

The main process in ACPF consists of four sub-processes, decladding, voloxidation, reduction and casting, as shown in figure 2. Through these sub-processes, the form of nuclear material is changed from rod-cut to pellet, powder and metal ingot successively in the narrow hot cell. Various nuclear wastes are produced during each sub-process.

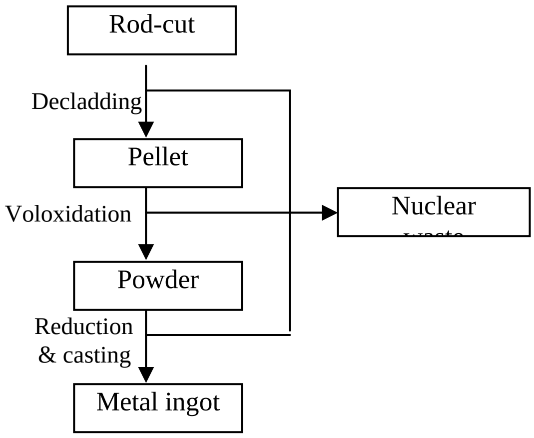


Figure 2. Material flow in ACPF

There are two methods to determine the key measurement point of ACPF; one uses the location of nuclear material and the other uses the physical form of nuclear material. Using the location as the key measurement point duplicates the document because the nuclear material classified by each location must be stratified in document. On the other hand, using the physical form may reduce errors in documentation because the application of physical form of nuclear material is a user-oriented concept that is similar to the material balance. Since the maintenance of material balance is the basis of R&D activities in ACPF, it is expected to be more effective to use the physical form of nuclear material than to use the location in determining the key measurement point.

2.3 Nuclear material accounting in ACPF

ACPF is developing ASNC(ACPF Safeguards Neutron Counter) under the support of LANL(Los Alamos National Laboratory) for the use of ACPF material accounting. ASNC has the same concept as the DSNC(DUPIC Safeguards Neutron Counter) that adopts a curium ratio technique. ASNC introduces a neutron coincidence measurement technology by a shift resister. The major source of neutron in the spent fuel is Cm-244. The fuel is irradiated at over 20,000 MWD/MTU of burnup and then cooled more than 3 years. ASNC determines Cm mass by measuring coincident neutrons emitting from the spent fuel. It can be achieved by measuring doubles rate using a shift resister. Doubles rate, R, is proportional to Cm mass (m_{Cm}) in spent fuel sample with relation of

$$R_{Cm} = k \cdot m_{Cm},$$

where k is a calibration constant which can be determined with standard sources such as Cf. Cm-ratio and mass ratio between Pu and Cm are employed to determine Pu mass in spent fuel. Pu mass of Cm ratio is predetermined by Cs-137 burn-up measurement and burn-up simulation of ORIGEN-2 code while Cm mass can be measured directly from ASNC. The amounts of U, U-235 and Pu are obtained from the following equation.

$$\text{Mass (U, U-235, Pu)} = \text{Mass(Cm-244)} \cdot \text{Cm ratio (U, U-235, Pu / Cm-244)}$$

This equation shows that nuclear material accounting in ACPF can be estimated with ASNC and computer code calculation.

3. Conclusion

The safeguards elements to effectively establish the safeguards system were reviewed and analyzed in consideration of the relationship among the relevant nuclear facilities, the main process in ACPF and the account for nuclear material in ACPF. Based on the safeguards elements, the conceptual safeguards system of ACPF was designed. Finally the last DIQ was prepared and submitted to IAEA in the cooperation of facility operators.

REFERENCES

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[2] Seoung Won Park, et al. “Development of Advanced Spent Fuel Management Technology” KAERI/RR-2427/2003