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Methodology for Physical Inventory Verification of Depleted, Natural and Low Enriched Uranium Conversion and Fabrication Plant in KOREA

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1. Introduction

The Korean nuclear fuel fabrication plant (KNFC) established to manufacture the nuclear fuels at the end of 1988 and has been supplying all domestic needs of the LWR and CANDU fuels. In the Agency's safeguards criteria, KNFC is classified as a bulk facility and is defined to be verified with one physical inventory verification (PIV) and two interim inspections should be carried out under the zone approach, which has been applied for LEU and NU fresh fuels. After the PIV is performed, KNFC should calculate the material unaccounted for (MUF) and report it to the authority and the Agency. This is significant element influenced by the accuracy of equipments for nuclear material accounting.

2. Physical Inventory Verification at KNFC

There is one PIV of a physical inventory taking by the operator (PIT) each calendar year, and the period between PIV should not exceed 14 months.

2.1 Examination of Records and Reports

The facility accounting and operating records supporting documents are examined for correctness and internal consistency. The list of inventory items (LII) received from the operator at the time of the physical inventory verification (PIV) is compared for consistency with the material balance report (MBR) and associated physical inventory listing (PIL).

2.2 Nuclear material verification

Based on the operator's itemized inventory list, all material, wherever applicable, will be item counted and ID checked. The verification methods, for LEU and NU, with medium detection probability as required by safeguards criteria, will be as follows:

- Powder, pellets and scraps are verified for gross, partial and bias defects in LEU strata and for gross and partial defects in NU strata
- Fuel rods and fuel bundles are verified for gross and partial defects and by serial number identification, where applicable for LEU strata and gross defects and serial number identification, where applicable for NU strata.
- Shipping containers with Fuel elements are tag checked by 100%. Then, the containers to be opened are randomly selected. The fuels in these containers are item counted and tag checked. After that, the items selected for LEU strata are randomly verified for gross and partial defects while the items selected for NU strata are verified for gross defect only. In both cases the serial number identification is checked.

2.3 Confirmation of the absence of borrowing of nuclear material (LEU and NU zone approach)

To confirm that nuclear material present for verification at one facility has not been borrowed from another facility, the NPP and the FFP take their physical inventories simultaneously. In addition, simultaneous interim inspections are performed at the fresh fuel storage of the NPPs when the inventory of the same nuclear material present at each NPP is 1 SQ or more.

2.4 Sample size calculation

Based on the safeguards criteria, all items should be verified to be able to draw conclusion about the population from which the sample is taken. The basic formula used for estimating the total number of samples (n) to be selected in each stratum is:

$$n = N(1-\beta^{1/d})$$

Where
n is the number of items in the stratum,
β is the non-detection probability,
d is [M/x], the number of defects in the stratum rounded up to the next integer,
M is the goal amount,
X is the average nuclear material weight of an item in the stratum.

2.4 Nondestructive Assay and Chemical Analysis

UF6 cylinders are verified with medium (INFCIRC 153) detection probability for gross, partial and bias defects. The bias defect measurement may be replaced by partial defect measurement performed with a relative standard deviation shown in Table 1 not greater than 0.06. IMCG, which is a combination of Inspector 2000 and HpGe detector, is applied for the verifications of the gross and partial defects.

Uranium compounds including UO2 powder, pellets and scrap are verified with medium (INFCIRC 153) detection probability for gross, partial and bias defects. IMCN, which is the verifier using Inspector 2000 and

NaI detector, is applied. MMCN, the verifier combined with mini MCA and NaI detector is used for the verification of UO2 powders, pellet scrap, and powder scrap. HM-5, which is used for the verification of PWR fuel assemblies and CANDU fuel bundles, was broadly used for the various NU strata.

Fuel Rods, fuel assemblies and other fuel items are verified with medium (INFCIRC 153) detection probability for gross, partial defects and by serial number identification where applicable. UNCL, Uranium Neutron Coincidence Collar, is applied for the verification of partial defects and HM-5 is used for the gross defects.

The items and bulk materials, which were calculated by sample size calculation and randomly chosen for the detection probability of bias defect, were collected and were analyzed to identify the precise content of U-235 and Uranium by TIMS and Mass spectroscopy.

Table 1 Delta - Values (Relative Standard Deviation)

Gross Defect		Partial Defect		Bias Defect	
Stratum	RSD	Stratum	RSD	Stratum	RSD
FF-	0.150	FF-	0.114		
FF1	0.150	FF1			
FR-	0.150	FR-	0.060		
MP-	0.200				
PD-	0.150	PD-	0.056	PD-	0.005
PL-	0.150	PL-	0.066	PL-	0.006
PL-		PL-	0.050		
SC-	0.150	SC-	0.085	SC-	0.024
SC1	0.150				
SC2	0.150				
SD-	0.150	SD-	0.200	SD-	0.200
UF-	0.150	UF-	0.050		
				PM-	0.028
				WS-	0.100

2.5 Design Information Verification

The Design Information is re-examined, at least once a year in the light of any facility modifications or changes in operating conditions, developments in safeguards technology or experience in applying verification procedures which might have a bearing on currently applied safeguards. Periodic verification of design information is performed to confirm its continued validity, according to established procedures. When modifications or changes in design information relevant to safeguards occur, such modifications or changes should be verified to establish the basis for adjustment of safeguards procedures, and the necessary adjustments are implemented. In addition, the calibration and condition of equipments should be examined since the amount of MUF might be increased due to an error from the equipments which are not calibrated or are broken.

3. Conclusion

The national inspections are simultaneously performed with IAEA inspections. They are performed for independent verifications and results from IAEA for all nuclear material strata. Furthermore, if necessary, an independent national inspection is performed to examine the status of facility.

Recently, IAEA applies short notice random inspection (SNRI) to KNFC to enhance the effectiveness and efficiency of safeguards. This inspection requires mailbox declarations from the facility operators so that it might increase the operators' burden. To the contrary, the application of this system is essential to enhance the transparency of nuclear industry. After PIV in 2006, the rehearsal for SNRI is planned and the operation of mailbox declaration is being prepared to apply the new system for IS approach.

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