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DEVELOPMENT OF THE SAFEGUARDS APPROACH FOR THE ROKKASHO REPROCESSING PLANT

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Abstract

The Rokkasho Reprocessing Plant (RRP), which is currently undergoing construction and commissioning by the Japan Nuclear Fuels Limited (JNFL), is scheduled to begin active operations in 2005. The planned operating capacity is 800t uranium per year containing approximately 8t of plutonium. The International Atomic Energy Agency (IAEA) and the Japan Safeguards Office (JSGO) are working with JNFL to develop a Safeguards Approach that is both effective and efficient. In order to accomplish this goal, a number of advanced concepts are being introduced and many currently applied safeguards measures are being enhanced. These new and improved techniques and procedures will provide for more sensitive and reliable verification of nuclear material and facility operations while reducing the required inspection effort.

The Safeguards Approach incorporates systematic Design Information Examination and Verification (DIE/DIV) during all phases of construction, commissioning and operation. It incorporates installed, unattended radiation and solution measurement and monitoring systems along with a number of inspector attended measurement systems. While many of the measurement systems will be independent-inspector controlled, others will require authentication of a split signal from operator controlled systems. The independent and/or authenticated data from these systems will be transmitted over a network to a central inspector center for evaluation. Near-Real-Time-Accountancy (NRTA) will be used for short period sequential analysis of the operator and inspector data which, when combined with Solution Monitoring data, will provide higher assurance in the verification of nuclear material for timeliness and of the operational status of the facility. Samples will be taken using a facility installed, but IAEA

authenticated, automatic sampling system and will then be transferred to a jointly used IAEA-JSGO On-Site Laboratory (OSL).

This paper provides an overview of the Safeguards Approach for the RRP, a review of completed and planned DIE/DIV activities and the current status of the development and installation of safeguards equipment and systems.

1. INTRODUCTION

The IAEA has been applying international safeguards to reprocessing plants around the world for more than 30 years. However, it has never before been challenged with designing a credible safeguards approach for a large commercial scale facility. This challenge was realized in the 1980s with the Japanese decision to construct the Rokkasho Reprocessing Plant (RRP) in northern Japan, with a throughput of 800t U/year. This far exceeded any previous IAEA experience. There was no model or guideline that could be used as a reference. Therefore, during the period of 1988 through 1992, a multinational forum, referred to as LASCAR (Large Scale Reprocessing) [1], addressed the more difficult and urgent issues being raised on how an effective safeguards approach could be implemented at such a facility and yet maintain an efficient use of resources. Some of the more challenging issues included evaluation of Shipper/Receiver Differences when using a continuous dissolver, implementation of Solution Monitoring and Near-Real-Time-Accountancy to enhance the level of assurance of verification methods and confirmation of operational status, and the installation of unattended measurement systems. LASCAR also emphasized the need for a comprehensive examination and verification of design information and the need to maintain continuity of knowledge on safeguards relevant features.

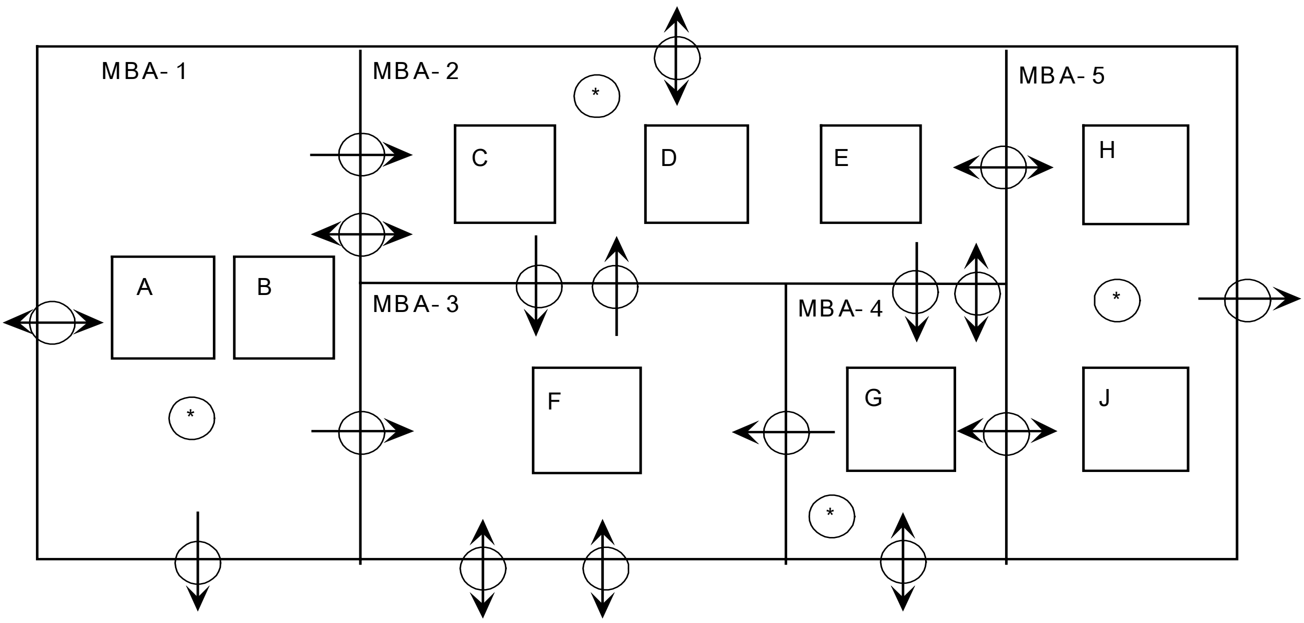
2. FACILITY DESCRIPTION

The Rokkasho Reprocessing plant has an operating throughput of 800t of uranium in irradiated LWR fuel per year. It is comprised of a Spent Fuel Receipt and Storage area (currently in operation), a Head-end, Main Process which includes uranium oxide conversion, U/Pu Co-denitration Conversion Process, mixed uranium/plutonium oxide (MOX) and Uranium Oxide Storage, and Waste Treatment and Storage areas. The Main Process employs a PUREX type separation process for the removal of fission products and the partitioning and purification of uranium and plutonium. Uranyl nitrate and plutonium nitrate are transferred to the Conversion Process. Where they undergo a co-denitration process and are converted into a MOX powder. The MOX powder is then transferred to the Product Storage area. Uranium not introduced into MOX is converted into UO_3 powder and also transferred to the Product Storage area. All solid and liquid radioactive wastes are treated and stored in the Waste Treatment and Storage area. This area includes the vitrification process for the high active liquid waste.

The RRP is currently undergoing construction. Water testing was started in 2001. Chemical and uranium testing is expected to begin in 2003, with active testing planned for 2004. Start of operation is scheduled for 2005.

3. ACCOUNTANCY STRUCTURE

A basic accountancy structure for the RRP is illustrated below. The facility has been divided into five Material Balance Areas (MBAs). These MBAs are subdivided into Inventory Key Measurement Points (IKMPs) based on types of material and the verification approach to be applied to Interim Inventory Verifications (IIV) for timely detection purposes and Physical Inventory Verification (PIV). Flow Key Measurement Points (FKMPs) have also been identified for all nuclear material streams or routes which cross MBA boundaries. These will be declared by the operator in an Inventory Change Report (ICR) and will be verified as required. In addition to flows that cross MBA boundaries, Other Strategic Points (OSPs) are being defined for verification of flows with-in the MBAs. These OSPs provide confirmation of the operational status of the facility and that it is as declared. These verification activities provide added assurance that there is no diversion of nuclear material into the SRD or MUF and that the facility is not being used for undeclared purposes.



MBA-1: Spent fuel receipt and storage area, Head-end area
MBA-2: Main process area (including U conversion and laboratories)
MBA-3: Waste treatment and storage area
MBA-4: MOX conversion area
MBA-5: Product storage area

IKMP A: Spent fuel receipt and Storage area
IKMP B: Head-End area
IKMP C: Nuclear material in main process area
IKMP D: Nuclear material in the analytical laboratory
* **:** Nuclear Loss
IKMP E: Nuclear material in the U conversion area
IKMP F: Nuclear material in the waste treatment and storage area
IKMP G: Nuclear material in the MOX conversion area
IKMP H: UO3 product material in the storage area
IKMP J: MOX product material in the storage area

4. VERIFICATION APPROACH

Verification methods and procedures are being developed for all flow and inventory points within the facility. To the extent possible, unattended measurement and monitoring systems are being developed and installed. Many of these systems will be independently controlled by the inspectorate. Those measurements which will rely on shared signals from operator controlled systems will require authentication measures to be introduced to assure the correctness of the data. Solution samples will be taken from the majority of the vessels using an authenticated, unattended sampling system. The samples will be sent for analyses in the On-Site Laboratory (OSL), which will be jointly used by the IAEA and JSGO. An overview of the extensive verification scheme is provided below.

4.1. MBA 1 – Spent Fuel Receipt and Storage, and Head-End Areas

4.1.1. Verification of inventory changes

Spent fuel assemblies received into the facility, unloaded from the transport cask and transferred into the storage ponds are currently being verified using the Integrated Spent Fuel Verification System (ISVS). This system consists of time synchronized CCTV cameras and radiation detectors. Batches of dissolved spent fuel (Input Batches), for transfer to the Main Process, will be verified for volume using a Solution Measurement and Monitoring System (SMMS). Uranium and plutonium will be verified by sampling using an Automatic Sampling Authenticated System (ASAS) or analysis by Hybrid K-Edge Densitometry (HKED). Solid waste in the form of leached hulls and fuel end-pieces will be verified indirectly by determining the Cm-244 using the Rokkasho Hulls Monitoring System (RHMS) and then relating this to the U:Pu:Cm-244 ratios in the dissolver solutions. Statistical evaluations of the Shipper/Receiver Differences (SRD) will be based on the shipping reactor declarations and the nuclear material verified in the Input Batches and associated with waste from the Head-End Process.

4.1.2. Verification of inventory for timeliness

The spent fuel inventory is under the continuous monitoring of the ISVS. Dissolver solutions in the Head-End Process will be verified during the monthly IIV using the SMMS, density correlations, sample taking using ASAS and analyses.

4.1.3. Verification of flow within the MBA

The flow of spent fuel assemblies from the storage pond transfer channel to the shear machine and the movement of the hulls/end pieces drums through the RHMS measurement to storage will be monitored using the Integrated Head-End Verification System (IHVS). This system consists of a number of Camera/Radiation Detectors (CRDs) mounted in the cell walls, with additional CCTV units installed in the shear cell. The ID of spent fuel assemblies and hulls drums will be verified and recorded by the IHVS. Solutions (including fines) flowing through the Head-End Process will be monitored by the SMMS.

4.1.4 Verification of physical inventory

A Physical Inventory Verification (PIV) is carried out once per year, during which the spent fuel is verified using an Improved Cerenkov Viewing Device (ICVD). The Head-End Process will be verified as 'cleaned-out' using the SMMS and sample taking, as necessary.

4.2. MBA 2 – Main Process Area

4.2.1. Verification of inventory changes

Receipts of 'Input Batches' that have previously been verified in MBA 1, will be verified using the SMMS. The shipments of PuN batches to the Conversion Area, will be verified for volume using the SMMS and by sample taking, using ASAS, for HKED. Uranyl nitrate shipped to the Conversion Area will not be verified, however, UO_3 may be verified by NDA using a Uranium Bottle Verification System (UBVS) and C/S measures. High Active Liquid Waste (HALW) batches which are shipped to Waste Treatment will be verified for volume using the SMMS and sample taking using ASAS. Plutonium will be analyzed using a Pu-VI spectrophotometric method and uranium, if necessary, using Isotope Dilution Mass Spectroscopy (IDMS). Low Active Solid Wastes (LASW) that are shipped to the Waste Storage Area will be verified using the Waste Crate Assay System (WCAS), which is based on passive neutron counting to measure the Pu content.

4.2.2. Verification of inventory for timeliness

An IIV will be carried out on a monthly basis during which the volume of all vessels will be verified using the SMMS and samples will be taken according to a random sampling plan for destructive analyses. Un-measurable inventories will be estimated using established process design algorithms. The MUF and MUF-D will be evaluated on an interim basis using Near-Real-Time-Accountancy (NRTA) methods.

4.2.3. Verification of flow within the MBA

Assurance that the process flows and facility operations are as declared will be achieved through solution monitoring using the SMMS. The SMMS will include not only sensors for temperature and for pressures to determine solution levels and density, but also neutron sensors on the extraction systems. In addition, random samples will be taken during the month and analyzed by the appropriate methods in the OSL. Short period (5 – 15 days), sequential evaluations of the MUF and MUF-D will be performed using NRTA methods.

4.2.4. Verification of physical inventory

A PIV will be carried out once per year, during which the clean-out status and remaining solutions will be verified using the SMMS and by random sample taking and analysis.

4.3. MBA 3 – Waste Treatment and Storage Area

4.3.1. Verification of inventory changes

Canisters of vitrified HAW will be verified using a Vitrified Canister Assay System (VCAS) prior to termination of safeguards on the material. The VCAS will determine the Cm-244 content of the canister from neutron emission. By using the ratio of Pu:U:Cm-244 established by sample taking and analysis in the feed material to the meltor, an indirect determination of the nuclear material content in the canister will be made. The neutron radiation data will be integrated with cameras that monitor the measurement station and verify the canister ID.

4.3.2. Verification of inventory for timeliness

During the monthly IIV, liquid waste inventories will be verified using the SMMS and by random sample taking using the ASAS. Analyses in the OSL will use a Pu-VI spectrophotometric method.

4.3.3. Verification of flow within the MBA

The SMMS will provide verification of the feed rate of HALW to the meltor. Samples will also be randomly taken from the HALW feed to confirm the U:Pu:Cm-244 ratios to be used with the VCAS.

4.3.4 Verification of physical inventory

A PIV will be carried out once per year, during which the declared clean-out and inventory in the liquid waste treatment area will be verified using the SMMS and sample taking and analysis, as required.

4.4. MBA 4 – MOX Conversion Area

4.4.1. Verification of inventory changes

PuN batches that have previously been verified in MBA 2, will be verified as received using the SMMS. The MOX powder canisters will be verified prior to transfer to storage using a Plutonium Canister Assay System (PCAS). The PCAS is based on high level neutron coincidence counting and high resolution gamma spectroscopy. A camera located near the PCAS will record the canister ID. In addition, samples of MOX powder will be taken for destructive analyses by IDMS. If the performance of the PCAS can be optimized to meet the requirements for bias defect testing, the number of samples can be significantly reduced. Wastes being shipped to the Waste Storage Area will be verified using the Waste Drum Assay System (WDAS), which is based on passive neutron multiplicity counting and high resolution gamma spectroscopy.

4.4.2. Verification of inventory for timeliness

During the monthly IIV, the Pu containing solutions will be verified by SMMS and random sample taking for HKED analysis. Plutonium in the MOX conversion lines will be verified using a Plutonium Inventory Measurement System (PIMS), which is based on a total neutron counting technique. The MUF and MUF-D will be evaluated on an interim basis using NRTA methods.

4.4.3. Verification of flow within the MBA

Assurance that the process flows and facility operations are as declared will be achieved by monitoring the solutions using the SMMS. The flow of MOX powder through the conversion lines will be monitored using the PIMS.

4.4.4. Verification of physical inventory

A PIV will be carried out once per year at which time the conversion area will be cleaned out. The PIMS will be used to verify the clean out and to measure any residual material. Solutions remaining in vessels will be verified using the SMMS and sampled for analysis, as required.

4.5. MBA 5 – Product Storage Area

4.5.1. Verification of inventory changes

Receipt of MOX canisters will be verified using a series of neutron detectors and surveillance cameras. The neutron detectors combined with surveillance will be located so as to detect the passage and direction of travel of a filled or empty MOX canister as it moves from the PCAS measurement station to the MOX storage room. Shipments of MOX product from the facility have not yet been addressed.

4.5.2. Verification of interim inventory

The verification approach for MOX in storage has not been finalized. Some of the options include the use of Dual C/S, random sampling for destructive analysis or random measurement using the PCAS, if bias defect detection capabilities can be met.

4.5.3. Verification of physical inventory

Physical verification of uranium and plutonium in storage will be carried out once per year. The methods to be used will be determined by the level of prior verification of the material and the use of C/S methods.

5. DATA NETWORK

An integrated Data Collection and Evaluation System (DCES) will be installed. By using a network structure, the DCES will collect measurements from instruments, sensors and surveillance devices installed throughout the facility and transmit them to a Raw Database (RDB). The RDB will be a joint, read-only database which is controlled and used by the IAEA and JSGO. The data will be time synchronized and, when combined with operator provided data and OSL results, will be processed at the separate IAEA and JSGO evaluation stations.

6. DESIGN INFORMATION EXAMINATION AND VERIFICATION

A systematic and comprehensive approach has been taken in implementing Design Information Examination and Verification (DIE/DIV) activities. During construction the activities have focused on: building layouts; cell design; equipment design; installation and testing; piping and pipe penetrations; active trenches; and vessel calibrations. During commissioning, many of these systems and equipment will be tested further for measurement performance. The inspector effort required to implement DIE/DIV activities is expected to significantly increase during 2002 through 2004. Design information examination and verification activities will continue throughout the lifetime of the facility to assure that the Safeguards Approach continues to be appropriate and that there are no undeclared modifications.

7. CONCLUSION

An effective Safeguards Approach is being developed which incorporates measurement systems that are of the highest sensitivity and reliability and which will provide independent and/or authenticated verification results. The application of NRTA for short period sequential analysis will provide a timely indication of potential diversion into MUF. The effectiveness is further increased with the use of surveillance, solution and radiation monitoring systems, and continuing DIE/DIV activities, which provide added assurance that the facility is operating as declared. Efficiency is introduced into the Safeguards Approach by the use of unattended measurement and sampling systems, a network based integrated data collection and evaluation system and the availability of an On-Site Laboratory.

REFERENCE

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Report of the LASCAR Forum: Large Scale Reprocessing Plant Safeguards, IAEA, STI/PUB/922, Vienna, 1992