U.S. DEPARTMENT OF
ENERGY

PNNL-19626

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Designing and Operating for Safeguards: Lessons Learned From the Rokkasho Reprocessing Plant (RRP)

SJ Johnson
M. Ehinger

August 2010

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161
ph: (800) 553-6847
fax: (703) 605-6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

PNNL-19626

Designing and Operating for Safeguards: Lessons Learned From the Rokkasho Reprocessing Plant (RRP)

SJ Johnson
M. Ehinger

August 2010

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Designing and Operating for Safeguards:
Lessons Learned From the Rokkasho Reprocessing Plant (RRP)

Shirley J. Johnson
Tucker Creek Consulting, PLLC, Divide, MT, USA
Michael Ehinger
Oak Ridge National Laboratory, Oak Ridge, TN, USA

Abstract

This paper will address the lessons learned during the implementation of International Atomic Energy Agency (IAEA) safeguards at the Rokkasho Reprocessing Plant (RRP) which are relevant to the issue of 'safeguards by design'. However, those lessons are a result of a cumulative history of international safeguards experiences starting with the West Valley reprocessing plant in 1969, continuing with the Barnwell plant, and then with the implementation of international safeguards at WAK in Germany and TRP in Japan. The design and implementation of safeguards at RRP in Japan is the latest and most challenging that the IAEA has faced. This paper will discuss the work leading up to the development of a safeguards approach, the design and operating features that were introduced to improve or aid in implementing the safeguards approach, and the resulting recommendations for future facilities. It will provide an overview of how 'safeguardability' was introduced into RRP.

Introduction

The implementation of international safeguards at the Rokkasho Reprocessing Plant (RRP) in Japan has been the largest challenge that the International Atomic Energy Agency (IAEA) has faced to date. A discussion of the lessons learned is presented below. However, the anticipated success of safeguards implementation by the IAEA is the culmination of experiences and lessons learned from efforts to provide effective and efficient international safeguards at reprocessing facilities over the past 30 years[i].

The lessons learned experience, from the perspective of both the IAEA and the operator started in 1969 with the first IAEA inspection of a reprocessing plant at the West Valley Reprocessing Plant in New York operated by Nuclear Fuel Services, Inc. (NFS). The US made a voluntary offer to allow the IAEA to follow some early fuel cores through fabrication, irradiation and subsequent reprocessing to help define international safeguards measures. It was in 1969 that these fuels reached the reprocessing stage of the fuel cycle. A significant lesson learned at West Valley was the need for a greater number of independent verification measurements, but it took many years of development to achieve some success in this area.

By the late 1970's the US had built the Barnwell Nuclear Fuel Plant, which was the first of the next generation large scale facilities with a capacity of 5t heavy metal (HM)/day with continuous operation for 200-250 days per year. The throughputs and measurement capabilities challenged the ability to meet IAEA detection goals. Also, there would no longer be short campaigns that would allow for periodic run-downs or wash-outs that permitted easier inventory taking to meet IAEA timeliness goals. Safeguards measurement and evaluation technologies advanced considerably at Barnwell through the later 1970’s and early 1980’s. The US laboratories developed ideas and some instrumentation that were deployed and tested at Barnwell. Although commercial reprocessing was suspended in the US in 1977, development of safeguards and non-proliferation measures continued at Barnwell until it was finally closed in 1983.

The first facility, and the smallest, to require an enhanced IAEA inspection regime was the Wiederaufarbeitungsanlage Karlsruhe (WAK) facility in Germany, with a through-put of around 30 t HM/year and a product of around 300 kg plutonium/year in the form of plutonium nitrate. WAK operated from 1971 to 1990 when decommissioning began. Although of relatively small size and throughput, there were a number of challenges that had to be met and problems to solve. The lessons learned from WAK, which would impact later and larger facilities were in the areas of:

- measurement of undissolved solids,
- first attempt at routine solution monitoring,
- open access to operating records,
- first attempt at in-field computerized data storage, calculations and evaluations and
- development of the K-edge[ii] and Hybrid K-edge Densitometers[iii] for in-field measurements.

The Tokai Reprocessing Plant (TRP) in Tokai, Japan was the next reprocessing plant to come under international safeguards[iv]. TRP has an operating through-put of around 100 t HM/ year, also with a product of plutonium nitrate. It began operations in 1978 and currently continues operations with a modified operating schedule. The United States convened the Tokai Advanced Safeguards Technology Experiment (TASTEX) to assist the IAEA with the development and implementation of safeguards techniques to meet the challenges of a continuous inspection regime.

The TASTEX program recommended a number of significant new ideas, including the following:

- the use of electromanometers for significantly more accurate volume measurements,
- the use of resin bead technology for sample preparation to allow transport of independent samples for analysis at remote IAEA laboratories,
- exploration of K-edge densitometry for plutonium product concentration measurements,
- implementation of near-real-time-accountancy (NRTA) for timely safeguards assessments,
- implementation of solution monitoring for additional assurance,
- implementation of containment and surveillance (C/S), and
- exploration of NDA techniques.

In 1987 the IAEA introduced the TRP Improvement Plan[v]. The Improvement Plan addressed near- and long-term improvement needs, some of them extensions of the work done under TASTEX. It highlighted the fact that the IAEA had an insufficient understanding of the plant operations, that safeguards had not been a priority in either the building nor the operations of the plant, and that the IAEA had had little to no input in the early design of the plant. The early attempts at retro-fitting safeguards into the facility had been either unuseable or inadequate and in need of strengthening. The most important lessons learned which are relevant to future facility designs are in the following areas:

- design information examination and verification (DIE/DIV),
- solution measurement and monitoring systems (SMMSs),
- sample taking and sample integrity,
- waste measurement and monitoring systems,
- shipper/receiver difference (SRD),
- near-real-time-accountancy (NRTA), and
- provision of operator data.

The work and dedication of the Japanese state authority and operator, and the IAEA have continued to improve the safeguards system at TRP. However, these past experiences point to the most valuable lesson learned: establish a dialog and a cooperation early on, which allows the safeguards systems to be designed with the facility and not superimposed at the end of construction and commissioning.

The Greatest Challenge to IAEA Safeguards - The Rokkasho Reprocessing Plant

The IAEA and the Department of Safeguards had never before been challenged with designing a credible safeguards approach for a large commercial scale reprocessing facility. This challenge was realized in the 1980s with the Japanese decision to construct the Rokkasho Reprocessing Plant (RRP)[vi,vii] in northern Japan, with a throughput of 800t HM/year. This far exceeded any previous IAEA experience. There was no model or guideline that could be used as a reference, only WAK and TRP as starting points.

The IAEA began actively addressing the planned construction of RRP during 1987. The JNFL Project Office was formally established within the Division of SGOA in 1991. It was established for the purpose of designing and introducing a safeguards approach for the Rokkasho Reprocessing Plant. The Project objectives were to plan, coordinate and integrate all activities necessary to ensure that an effective and efficient safeguards system would be implemented at RRP on a schedule consistent with construction and commissioning of the plant and with resource expenditures within the IAEA, JNFL, Government of Japan and Member States funding capabilities. This posed quite a number of challenges both technical and political.

There was a concern within the international community as to whether the IAEA could meet these challenges. As a result of these concerns a multinational forum, referred to as LASCAR (Large Scale Reprocessing)[viii], was established to address 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. This forum, which was funded in large part by the Government of Japan during the period of 1988 through 1992, was made up of more than 50 experts in safeguards and reprocessing technologies. The participants included government, laboratory and industry representatives from five countries – France, Germany, Japan, the U.K. and the U.S.A. – and representatives from the Commission of the European Communities and the IAEA. The primary findings and recommendations were in the areas of:

1) Design Information provision and verification – Early submittal of design information by the operator/State to the IAEA allows for early consultations on safeguards requirements for equipment and verification measures, and allows for early determination of resource requirements. Provision of design information and verification continues through-out the life time of a facility.

2) Advanced nuclear material accountancy methods – In order to meet the IAEA timeliness requirements, techniques such as Near-Real-Time Accountancy (NRTA) should be applied. However, improved accuracy and measurement uncertainties are needed. Also for timeliness, measurement methods are needed that can provide on-line analysis or maintain continuity of knowledge of material flows. The use of unattended process monitoring systems is recommended.

3) Containment and surveillance (C/S) measures – Independent C/S measures should be applied where ever possible to maintain continuity of knowledge of material and facility operations and to reduce remeasurement requirements, particularly in storage areas. Dual C/S should be applied in order to eliminate remeasurement requirements of difficult to access material.

4) Authentication of operator’s instruments – Although installation of independent safeguards measurement and surveillance systems are preferable, due to resource and space restriction use of the operator’s instruments by the IAEA may be desirable and sometimes unavoidable. However, proper authentication measures must be implemented.

5) Data Acquisition and Transmission – Data acquisition and evaluation must be computerized. A modern distributed data collection system is recommended with inclusion of access by inspectors to the operator accountancy systems.

6) On-site laboratory – In order to reduce sample shipping costs and to provide timely analyses of safeguards sample, it is recommended to include an on-site inspectorate analytical laboratory.

7) Research and development – The IAEA, State and operator should determine their on-going needs for research and development tasks.

Although the recommendations made by LASCAR had some impact on the design and operation of RRP, they had a much larger impact on the basic design of the safeguards approach. However, the recommendations, which were based on experience and knowledge at that point, presented some unforeseen difficulties in their actual implementation. The cost and technological challenges for some measures have gone beyond those anticipated by the members of the forum.

The challenges and subsequent lessons learned from the implementation of safeguards at RRP fall into the following areas:

- general design and operating features,
- capabilities for and ease of design examination and verification,
- designing in a materials control and accountancy system,
- designing in measurement systems,
- designing in process monitoring and C/S,
- designing in sampling and analytical capabilities, and
- designing in system security and authentication.

General design and operating features

A number of general plant design features could be modified or optimized to provide easier access for verification of nuclear material and operational status, and to provide more transparency that the process operations are as declared. A few general points, based on the RRP experience, are elaborated on in the following sections:

- permanent installation of verifiable tank calibration systems,
- provision of remote viewing capabilities into strategic cells,
- improvement of the design of accountancy vessels taking into consideration internal structures, homogenization capabilities, environmental controls and sampling systems,
- minimization of un-measureable inventory,
- re-evaluation of current sampling systems and their effects on the validity of samples taken, including such factors as tamper vulnerability, evaporation and simultaneous sampling capabilities,
- provisions for transparency and minimization in nuclear material and chemical recycle capabilities,
- clear separation and well defined waste handling and treatment areas,
- installation of independent inspectorate owned and controlled systems, and
- allowance for easier inspector access to safeguards relevant operating information.

Capabilities for and ease of design examination and verification

Preliminary design features of the RRP were provided to the IAEA at a very early stage, which allowed for early visits to the site and resource planning for continued design information examination and verification activities[ix]. This early provision of design information should have also allowed for discussion of design changes or modification to accommodate safeguards. However, in the case of RRP, design changes were very difficult to make because of the operator's contractual agreements. Also, the IAEA was not capable at this early stage to detail their safeguards requirements, nor were they clear on what their safeguards approach would be. This, however, is to be somewhat expected and requires the close and continuing discussion between operator, state and IAEA with a more intense focus on the safeguards approach early on.

The provision of design information that is highly sensitive due to commercial and/or proliferation concerns must be minimized. However, it should be expected that this situation will occur, in which case the information should be stored at the facility in a controlled area and under both IAEA and the state seals. Verification of sensitive design features can often be done indirectly during testing or by verifying the surrounding equipment.

The first high accuracy accountancy measurement in a reprocessing plant is of the dissolved fuel in the Input Accountability Tank (IAT). To better understand the operation and measurement capabilities of the IAT, the Japanese built an exact copy at a demonstration facility prior to construction and installation in the plant. Even with the early testing, some problems were found during commissioning and costly and time consuming modifications had to be made to the interior structure. However, this is a pre-construction effort that should be highly encouraged, with the IAEA and state authorities taking an active part in verifying the test results.

It was impossible to carry out 100% verification of all the safeguards relevant design features. Therefore, priorities were established and verifications carried out at varying degrees from 100% to a low random level, depending on the safeguards importance. The biggest challenge was to maintain continuity of knowledge (CoK) of the verification activities and results and to assure that changes were not made later. Therefore, in-cell designs were randomly re-verified just prior to permanent closing of the cells. Critical pipe runs were traced and documented. Those having potential re-entry access could theoretically be re-verified in the future, although with great difficulty. New or improved verification tools are needed to access these ‘difficult to access’ locations. Or these access needs should be taken into consideration in the facility design. In-cell viewing capabilities could aid in re-verifying design features of strategic process areas.

After the IAEA reviewed the design information for the vessels that the operator’s control system would monitor and that the operator must calibrate, it was concluded that a little less than 100 vessels would be safeguards relevant. The IAEA then participated in the calibration of these vessels as part of the design verification exercise. The vessels selected were categorized by importance. In the less important cases, the IAEA used operator collected calibration data to develop its own calibration equations. For the more important vessels, at least one calibration pass was witnessed by the inspectors with independent data recording. For the most important vessels, three calibration passes were subject to full inspection. The work was cumbersome, slow and resource demanding. In many cases, calibration equipment was set up inside the cells that would later be sealed during operation. Recalibration and calibration checks in the future will need to be made through external lines that were not necessarily those used in the original calibrations. The installation and use of permanent calibration systems during the initial calibrations would provide for more controlled and reproducible conditions during future calibration activities.

At the request of the JNFL Project Office, the 3-D Laser Range Finder for DIV (LRFD)[x] was developed by the JRC in Ispra, Italy. This equipment provided a capability for recording a verified design feature in digital form and to later verify that there had been no changes. It also allowed for dimensional measurements of piping and internal cell structures using the digital laser results. A pending need is to modify the system so that it can be taken back into the areas that are now contaminated for verification of no changes or verification of declared changes.

Designing in a materials control and accountancy system

Large commercial reprocessing and conversion plants put a heavy burden on the facility's materials control and accountancy (MC&A) system. In order to meet IAEA requirements for implementing an enhanced and demanding safeguards approach, the facility's safeguards office must have real time access to operating and accounting data. This requires on-line measurement systems, continuous data transmission, and real-time calculations and reporting to the state authority and the IAEA. The design of the MC&A system must be considered in the early design of the facility and must be coordinated with the plant operations design and the requirements of the state authority and the IAEA. The measurement systems, the data acquisition systems, the data transfer systems and the data calculation and reporting system must be specified and included in the original design and construction. Equally important is that the state authority and the IAEA must also provide design specifications and requirements for their data collection and evaluation systems. The three systems - operator, state and IAEA - must work as integrated, but independent, systems. As was learned by all three parties at the RRP, it is a costly and frustrating experience, with less than optimal results, when the data handling systems are designed after the plant is almost built.

In order to demonstrate the complexity of these data handling systems, and based on the IAEA's experience in developing the Integrated Inspector Information System (I3S)[xi] for RRP, the following IAEA requirements should be considered in developing such a Data Collection and Evaluation (DC&E) system.

- Data should be transmitted from the various inspector measurement, monitoring and surveillance stations within the facility to a central data base, possibly in the local inspector's office and/or at IAEA Headquarters.
- Data should include State of Health (SoH) information from the various systems.
- Operator declarations (OPDs) should be received directly from the operator or state accounting systems.
- OPDs should include not only accounting data and source details, but also schedules and relevant operational information.
- Analytical results on verification samples should be received directly from the IAEA analytical laboratory, whether it is an on-site lab (OSL) or the Seibersdorf Analytical Lab (SAL) near Vienna.

- All data and information must be encrypted or secured in some manner for transmission.
- The inspector data system should not be physically connected to any facility operational systems to prevent any threat of interference with plant operations.
- Software should be capable to doing reviews and extensive pre-evaluations of data in an automated and real-time mode.
- The system should automatically call attention to possible data discrepancies, schedule changes and completion of actions, and should announce irregularities in the SOH.
- The system should allow for interactive reviews and 'drill-down' capabilities to facilitate inspector reviews and investigation of possible discrepancies.
- Report-ready summaries and evaluations should be available at various stages of the verification process.
- Design specification for the software integration of the data collection and evaluation systems must be started as an integral part of the development of a safeguards approach. The I3S for the RRP was started much too late, which required a change in OPD formatting and data transmission procedures. Both were costly changes.
- The handling of operator proprietary information must be addressed early and built into the design of the DC&E.

Designing in measurement systems

There are more than 50 measurement and/or monitoring systems installed in RRP providing hundreds of signals, and approximately 70 camera surveillance systems. This is not only a large financial burden but a significant demand on human resources for the preparation of user requirements, installation, testing and maintenance.

In order to reduce on-site inspector presence unattended measurement and monitoring systems need to be installed. However, high maintenance requirements can defeat this end. Efforts are needed to produce systems which have improved reliability and robustness, with increased sensitivity. Whether they are operator or inspector systems, they must also have the capability of transmitting data to a central data collection computer. Additionally, the extensive use of installed cameras needs to be reduced. Even with the improved review software, the required inspector time is extensive. In RRP, a number of cameras were installed to maintain continuity of knowledge where the development of more creative and automated systems might have solved the problem while reducing inspector work.

The financial burden for accountancy and safeguards systems is beyond the capabilities of the IAEA in a large commercial reprocessing plant. Therefore, the burden needs to be shared with the state and the operator. Also, physical restraints may dictate that installed systems must be shared, that is jointly-used by the IAEA and the state, and possibly even the operator. This introduces an added complexity to assuring that all parties can reach independent conclusions. Early consultation between all parties and the system developers must start during the design phase. All joint-use systems must have security and/or authentication measures incorporated into their design. And all systems, whether solely for IAEA use or joint-use, must have third party vulnerability tests to assure non-tampering and validity of the acquired data. The majority of the joint-use systems in RRP had little, if any, authentication features in their original design and installation. Retrofitting or modifying the systems to meet IAEA requirements increased the total costs significantly. Early coordination with the system developers and valid vulnerability testing could have avoided much of the extensive retrofitting of authentication measures.

The issue of system maintenance (repair and preventative) must be also addressed in the design. With most facilities being remotely located from the IAEA Headquarters, the inspectors must be able to carry out diagnostic examinations of the systems while in the field. Or the systems themselves must provide sufficient diagnostics in their Statement of Health (SoH) that technicians in Headquarters can provide remote instructions to the inspectors. A modular design with click-out/click-in components, which can be kept on-site, would assist the inspectors in timely repairs to a system.

Designing in process monitoring

It was recognized by the international LASCAR forum that the available verification measurements would have inadequate sensitivity and reliability to statistically detect the diversion of a significant quantity of nuclear material in a timely manner or the misuse of a commercial scale reprocessing plant. Therefore, enhanced safeguards measures would be needed to strengthen the accountancy verification activities and to provide added assurance of “Operations as Declared”. For this reason process monitoring became the ‘center piece’ of the safeguards approach for RRP. The majority of the safeguards systems in RRP were installed with the purpose of continuously monitoring the flow and storage of nuclear material from the spent fuel storage and head-end of the separations process to the back-end of the MOX conversion process and storage. This continuous front-to-back process monitoring provides the needed assurance that the verification of inventory change and inventory declarations is true and correct.

A major objective of introducing a process monitoring system was to assist in meeting the IAEA timeliness goals. One of the RRP facility design features that make it difficult to meet these goals is the sampling system which has limited capabilities for sampling multiple vessels simultaneously. Therefore, at the declared monthly Cut-off Time (CoT) for the Interim Inventory Verification (IIV) for timeliness, it is impossible to take a statistically adequate number of random samples to verify the inventory. It was therefore necessary to introduce a more frequent in-process inventory verification approach that requires fewer samples, but are taken approximately every 10 days (3 times/month). The CoT is also scheduled at a time when most of the inventory is located in verifiable vessels.

In conjunction with process monitoring, the LASCAR forum recommended the introduction of Near-Real-Time-Accountancy (NRTA). In order to implement NRTA at a large throughput facility, the operator’s accountancy system must be able to provide almost-immediate inventory declarations, any-time-any-place, even if based on process control data. The RRP operator conducted extensive planning and simulation tests to refine the procedure for the in-process inventory taking. However, the lack of flexibility in the sampling system was always a hindrance. In future facilities, the best approach for the operator to take almost-immediate inventories and for inspectors to verify those inventory declarations is with the development and installation of in-vessel measurement and monitoring systems. The in-vessel solution measurement (volume and density) and monitoring systems[xii] have proven to be invaluable for obtaining real-time data and for monitoring the flow of solution, but they do not provide the elemental concentrations that are needed.

Another difficult task for the operator in preparing an inventory declaration is being able to determine the in-process unmeasureable inventories (UMI), such as pipes, pumps, pots, evaporators, separators, etc. The algorithms for the declaration and verification of UMI must be determined as part of the design. In order to determine the hold-up inventory and the associated algorithms, the RRP operator built a scale model extraction test facility with a pulse-column and a continuous plutonium evaporator system. This was a valuable and appreciated effort by the operator. However, inventory hold-up in piping cannot be determined so easily. It is recommended that facilities be designed compactly and without excessive piping, where possible.

Another application of process monitoring that has strengthened the safeguards approach at RRP and should continue to be introduced into future facilities is Flow Sheet Verification (FSV). Currently this is only being applied to the flow of neptunium (Np) through the process but could be applied to other characteristic elements. However, in order for FSV to provide the inspector with the assurance that the process is being operated as declared, the operator must establish and declare the expected flow sheet for that element. This includes the waste streams.

Designing in system security and authentication

In order to conserve financial resources and with physical space and access constraints in the plant, it was recommended by the LASCAR forum that measurement and monitoring systems be installed and used jointly, where possible, by the IAEA and the state inspectorates, and in some instances with the operator. This proved to be a difficult and expensive endeavor at the RRP due to IAEA security and authentication requirements.

When installing measurement or monitoring systems in a facility for joint-use the following authentication points must be considered[xiii]:

- Assurance that data has originated from a known source and has not been altered, removed or substituted.
- Assurance that data from joint-use systems cannot be used in such a way as to influence the accountancy and operational declarations of the operator to the inspectors.

- Assurance that the state cannot use knowledge of the systems and the data in collaboration with the operator to defeat the implementation of reliable IAEA safeguards measures and investigations into possible discrepancies.

- For unattended systems, a level of assurance that is comparable with other safeguards measures. This assurance should be equal to that expected by the international finance and intelligence communities who require assurance that sensitive information has originated from a known source and has not been altered, removed or substituted.

There are a number of methods that can be used to provide acceptable security and/or authentication of installed systems.

Installed technical methods-

- Hardware: tamper indicating enclosures (TIE), or sealed tamper indicating enclosures (STIE), seals, camera surveillance, safeguards conduit, and motion, heat, or radiation sensors.
- Software: IPsec, 'sign and forward' (SnF), varying levels of password control, delayed data access for operator/State, and other methods of data encryption.

Procedural methods-

- Portable cable testers, Optical Time Domain Reflectometer (OTDR), and portable pressure gauges.
- Cross-correlation of data from a number of sources. This could be various sources for the same piece of data. Or it could be related data from various sources, such as adjoining vessels.
- Sealed standard containers and sealed sources.
- Short notice random sample taking for independent analyses.
- Short notice random visits by inspectors (observations or measurements).

Another aspect of joint-use systems that should be taken into consideration is the IAEA policy on data sharing. Neither the operator nor the State should normally receive the IAEA verification data prior to receipt of the Operator Declaration (OPD), since receipt of the verification data could influence the operator in the preparation of the OPD. Therefore, the operator's accountancy measurement and reporting system must be as efficient and responsive as possible.

As a result of the lessons learned at RRP, concerning the implementation of joint-use systems and the resulting sharing of data, the use of independent and solely owned measurement and monitoring systems may be a better choice when possible.

Designing in sampling and analytical capabilities

The operator's sampling system installed in the RRP is shared by the inspectorates. In order for the inspectorates to jointly use the system, an Automatic Sampling Authentication System (ASAS)[xiv] was developed and installed by the IAEA. The ASAS assures the integrity of the empty and full inspector sampling vials and tracks them from the inspectorate On-Site Laboratory (OSL)[xv] to the process sampling bench and back to the OSL. It also provides assurance that the correct vessel is being sampled. Although the RRP sampling system far exceeds any system previously available, it could be improved. The automated system has limited capabilities for sampling multiple vessels simultaneously and the scheduling of samples requires significant advanced planning. This is a serious complication and limitation when trying to implement a safeguards approach that requires random, short-notice taking of samples for analyses.

For future large commercial facilities, the IAEA, state and operator will need to evaluate on an individual basis as to whether to design in a joint-use (IAEA/state) inspectorate On-Site Laboratory (OSL). The OSL which was built in the RRP provides a number of benefits:

<u>For the inspector -</u>

- Improved control of inspector samples and reduced chance of tampering.
- Timely analytical results of equal quality to those of the IAEA's Seibersdorf Analytical Laboratory (SAL) near Vienna.
- Large sample aliquots can be handled as compared to the dried samples sent to SAL.
- Waste can be recycled to the RRP process.
- Reduction in the cost of shipping samples to SAL.

<u>For the operator -</u>

- Reduction of resource requirements for preparation of inspector samples.
- Significant reduction of paper work required for the shipping of inspector samples to SAL.
- Reduction of operator responsibilities for handling of inspector samples and chances of mishaps.

Other factors for consideration

There are a number of other questions that should be asked when designing and operating a plant with the goal of enhancing its 'safeguardability'.

- Where will this plant be located? What is its proximity to Vienna and to the IAEA safeguards laboratory? What is the local availability of technical services? Will it be built in a NWS or a NNWS?
- Will the plant safety and security arrangements be able to accommodate short-notice or no-notice random inspection?
- How can the 'planting and growing' of a safeguards culture be assured amongst the operating staff?
- What will be the educational and experience level, and the training requirements for both the operator and state safeguards staff?

Conclusions

The most relevant lessens learned from the Rokkasho Reprocessing Plant, and all previous efforts by the IAEA to deploy international safeguards, is that the involvement and dialog between all interested parties must start from the earliest stages of a facility's design. This is important for the design of both the operator and inspector equipment, the development of the safeguards approach, and for IAEA resource planning, both human and financial. This cooperation needs to continue during construction, commissioning and into operations, and eventual decommissioning. The introduction of safeguards features into the design of a facility will lead to enhanced ‘safeguardability’, resulting in lower costs and less effort needed for the introduction of enhanced effectiveness in the implementation of a safeguards approach.

References

[i] Thomas Shea et al., “Safeguarding Reprocessing Plants: Principles, Past Experience, Current Practice and Future Trends,” *Journal of the Institute of Nuclear Materials Management,* Vol. 21, Issue 4, 1993.

[ii] Hastings Smith, Jr., and Phyllis A. Russo, “Densitometry”, in *Passive Nondestructive Assay of Nuclear Materials,* Edited by Doug Reilly, Norbert Ensslin, Hastings Smith, Jr., and Sarah Kreiner, pp 273-312, NUREG/CR-5550, US Nuclear Regulatory Commission, Washington, DC, 1991.

[iii] H. Ottmar and H. Eberle, “The Hybrid K-Edge / K-XRF Densitometer: Principles - Design - Performance”, *Kernforschungszentrum Karlsruhe report KFK 4590,* PWA 01/91, 1991.

[iv] S. Johnson and A. Islam, “Current IAEA Approach to Implementation of Safeguards in Reprocessing Plants”, *Fourth International Conference on Facility Operations—Safeguards Interface*, October 1991.

[v] Shirley Johnson, Thomas Shea, and Anton Ratchev, “A Safeguards Improvement Plan for Reprocessing Plants”, *Proceedings of the Symposium on International Safeguards*, Vienna, Austria, October 1997.

[vi] S. J. Johnson, R. Abedin-Zadeh, C. Pearsall, et al, “Development of the Safeguards Approach for the Rokkasho Reprocessing Plant,” *IAEA Symposium on International Safeguards*, Vienna, Austria, 1997

[vii] S.J. Johnson, B. Chesnay, C. Pearsall, “Meeting the Safeguards Challenges of a Commercial Reprocessing Plant”, *7th International Conference on Facility Operations-Safeguards Interface,* Charleston, SC, 2004.

[viii] International Atomic Energy Agency, “Report of the LASCAR Forum: Large Scale Reprocessing Plant Safeguards”, IAEA, STI/PUB/922, Vienna, Austria, 1992.

[ix] B. Chesnay, C. Creusot, S. Johnson, et al, “Innovative Approaches to DIE/DIV Activities at the RRP”, *7th International Conference on Facility Operations-Safeguards Interface*, Charleston, SC, 2004.

[x] V. Sequeira, et al. (European Joint Research Center (JRC)-Ispra): “3D Site Modeling and Verification of Plant Design for Nuclear Security Applications,” *Proceedings of the 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR’05)*, San Diego, CA, June 20-25, 2005; V. Sequeira, et al. (JRC-Ispra, JNFL and the IAEA): “3D Laser Range Finder for Design Information Verification in the Rokkasho Reprocessing Plant,” *Poster, IAEA Safeguards Symposium*, October 2006.

[xi] J. Wuester, B. Chesnay, G. Gerrein, et al, “Automating the Operator Interface – Operator Declarations at RRP”, *7th International Conference on Facility Operations-Safeguards Interface*, Charleston, SC, 2004.

[xii] M. Ehinger, B. Chesnay, C. Creusot, J. Damico, et al, “Solution Monitoring Applications for the Rokkasho Reprocessing Plant”, *7th International Conference on Facility Operations-Safeguards Interface,* Charleston, SC, 2004.

[xiii] K. Tolk, M. Aparo, C. Liquari, A. Capel, “Design of Safeguards Systems for Authentication”, *Symposium on International Safeguards – Addressing Verification Changes*, Vienna, Austria, October 16-20, 2006; Keith Tolk and Peter Merkle, “The impact of Safeguards Authentication measures on the Facility Operator”, *8th International Conference on Facility Operations – Safeguards Interface*, Portland, OR, march 30 – April 4, 2008.

[xiv] C. Creusot, G. Duhamel, K. Tolk, et al, “Control and Tracking of the Unattended Sample Taking for Safeguards Purposes at the RRP”, *7th International Conference on Facility Operations-Safeguards Interface,* Charleston, SC, 2004.

[xv] G. Duhamel, et.al., “Establishing the Joint IAEA/JSGO/NMCC Safeguards On-Site Laboratory for the Rokkasho Reprocessing Plant: A Major Challenge for Managing the Interfaces”, *7th International Conference on Facility Operations-Safeguards Interface*, Charleston, SC, 2004.