European Commission Safeguards in modern MOX Fuel Fabrication Plants

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European utilities use separated Plutonium from reprocessing in nuclear reactors since more than 30 years. Starting from small facilities with mainly manual operations, technology has moved on to almost fully automatically operated plants, thus reducing necessary human intervention and the related dose uptake to a minimum. Modern MOX plants are operated in general remotely with a high degree of state-of-the-art technologies in place.

The major, modern MOX Fuel Fabrication Plants in Europe are in operation at the Marcoule site in France and at Sellafield in the United Kingdom. The Melox plant, which is in operation since 1995 has increased its throughput from initially 100 tonnes of Heavy Metal (HM) to 145 tonnes in 2003, and recently further up to 195 tonnes. Construction of the Sellafield MOX plant (SMP) was started in 1993 and is in operation since a few years.

Crucial planning and commissioning phase

For any credible and robust safeguards scheme it is essential to have experienced inspectors that have an in depth understanding of the facilities and their production processes. This can only be achieved if they are involved from early stages of the projects onwards. Nuclear operators in the European Union are obliged by Regulation 302/2005 to inform the European Commission at least 200 days before the first consignment of nuclear material is due to be received. Given the size and complexity of MOX Fuel Fabrication Plants this would not allow for any adaptation of the plant design or equipment for safeguards purposes, nor for any detailed design verification by inspectors. It is therefore common practice of nuclear operators in the European Union to inform the European Commission early in the project phase of bigger plants in order to ensure a full involvement of the safeguards authorities and a smooth integration of safeguards provisions into the plants' designs. This early involvement makes it possible for the inspectors to build up a profound plant knowledge and establish suitable safeguards concepts.

For these complex facilities it is also necessary to have inspectors regularly on-site to ensure a continuous knowledge build up and comprehensive familiarisation with the plant and its organisation. Another important element is to have regular contacts with the operator, thus inspectors must be available for any queries that might come up during installation and commissioning of the safeguards instrumentation. Later modifications or additions to the process instrumentation have proven to be difficult and costly. It is therefore crucial to have the instrumentation correctly installed during the plant construction phase to avoid late modifications. It is therefore helpful to have regular contacts with the installation and

commissioning teams to answer their queries and to ensure that the necessary contacts with HQ specialists are maintained. As both MELOX and SMP form part of sites which have other safeguarded installations, inspections were often combined with these facilities in the early stages of the projects, thus allowing inspectors to be regularly at the installation without the need for additional inspections.

During the installation and commissioning phase it is essential to collect the relevant documentation for the safeguards instrumentation but also the relevant plant processes. The presence of well informed commissioning inspectors made this is a unique period to gather relevant information and to ensure the build up of comprehensive reference documentation for later use by inspectors and technicians. In this respect it is also essential to have a certain degree of stability within the project teams to ensure continuity of knowledge on the planned Safeguards implementation for all stakeholders. Working groups, dealing with different aspects of the safeguards implementation like measurement instrumentation, containment and surveillance, safeguards concepts etc., were formed to bring the relevant people from all parties together for detailed discussions. Regular Plenary meetings ensured a co-ordinated approach amongst the working groups and a common, conceptual and practical understanding of the safeguards activities.

For the Sellafield MOX Plant the build up of a comprehensive project dossier has proven to be useful. This dossier was used as common documentation of the foreseen safeguards approach during all project phases, starting from the design verification until routine operations. All major agreements reached between the stakeholders were signed and included. It was a living document, updated and enhanced frequently and formed the basis for drafting the legal PSP document. The Particular Safeguards Provisions document is used within the framework of the Euratom Regulation 302/2005 to define specific reporting and administrative arrangements between the Safeguards inspectorate and the operator.

Data management and evaluation

The documentation and follow up of safeguards activities and findings are essential elements for any credible inspection scheme. Database based applications are used onsite to record all inspection activities, related findings and agreements reached with the operators. These data are taken back to the Luxembourg Headquarters after each inspection, thus ensuring immediate information of the whole team of inspectors and the management on return from an inspection. However, these data are also helpful as a basis for the inspection reports and related follow up activities.

Due to the high level of automation of the fabrication process, the nuclear material being processed in modern MOX Fuel Fabrication plants is usually not easily accessible for inspection. It is therefore essential to tailor the Safeguards approaches to the specifics and constrains of the installations. Thanks to the early start of discussions between the operators and the European Commission's Safeguards Office, it was possible to devise an efficient approach making best use of data declared by the operators and data received from branching operator's equipment and the European Commission's own automated, unattended safeguards instruments.

Thanks to the involvement of the inspectorate in early stages of the projects, most of these systems are directly integrated into the process flows and allow, together with the related data collection and evaluation tools, for on line process monitoring systems. Together with appropriate C&S measures the intrusiveness of Safeguards activities to plant operations has been minimised and allows for a continuous operation of the plant between Physical

Inventory Takings without the need to compromise production targets because of safeguards verifications.

The operators' legal reporting obligations form the basis for safeguards verifications. These reports are compared with supporting documents at the installations during inspections. However, the complexity and throughput of these installations requires additional, more frequent data than the monthly declarations to allow for a comprehensive follow up of plant operations and a robust and credible safeguards scheme. As modern plants have normally a fully computerised material tracking system, most of these operating data and supporting documents are available in an electronic format. Therefore it has been agreed with the operators to transmit data on internal nuclear material flows and the stock situation at midnight on a daily basis. This allows for an automatic treatment and comparison of these data with the statutory declarations. It has been agreed with the operators to transmit daily data on internal moves and the stock situation at midnight.

The overall consistency of these data provides another, more detailed level of assurance to the safeguards authorities that the operator is in good control of his plant and maintains a credible, robust and reliable Nuclear Material Accountancy and Control System, which is able to detect even minor deficiencies with a high probability within a short period of time. In terms of possible diversion scenarios the necessity to produce coherent declarations to the safeguards authorities and to keep the related operational data coherent with a high frequency is an important deterrent for a possible diversion together with the detection risk during the regular random verifications. To cover up a diversion by falsifying declarations and operational records becomes more difficult with increasing granularity and frequency of the data provided. Since these consistency checks are mainly done by software applications the manpower requirements are normally modest. However, the required modelling of the plant is resource demanding and makes only sense if plant operations are stable enough to allow for an automatic evaluation without too many false alarms because of manual interventions or unusual movements.

After having checked the accountancy and operational data for coherence and consistency, they are compared with the results of the safeguards instrumentation and other signals from the plant. At both plants, MELOX and SMP, the main process flows are monitored with unattended measurement stations. These measurement stations, some of them using neutron detectors and high resolution gamma systems, allow for an independent verification of the operators' declarations. These instruments together with other signals, either branched from operators' instruments or dedicated safeguards equipment like bar code readers, proximity switches, balances etc. are combined to form so called Points of Interest. Since most of the signals received are in a raw format they need to be processed, combined with other signals and translated into events to allow for a comparison with the operating data. As some of the signals, like neutron monitors or balances, consist of a data stream instead of single events like barcode readers or proximity switches, the relevant readings need to be evaluated and filtered by event detection algorithms. These event detection algorithms look up the data streams for predefined signal changes or whole patterns to detect for example the presence of a Plutonium can in a detector by the rise and fall of the neutron signal above and below a predefined threshold. The definition of these events and the related signal sequences requires a detailed understanding of the plant processes and functioning. It has proven to be essential that experienced inspectors are involved in the set up of these systems and the event definition. The combination of acquired data from different, related signal sources at the Points of Interest with related calibration data, will then allow for a direct comparison with declared events in the daily received operating data.

The plant processes are therefore mainly monitored from two sides, the very detailed plant control at the signal level and the overall consistency checks of the operating records and onsite data with monthly declarations. This results in a very detailed insight into plant operations and into the performance and robustness of the operator's Nuclear Material Accountancy and Control (NMAC) system.

Some of the software applications in use were written by experienced inspectors, others are professional products developed together with the inspection units. Most of these applications are facility specific and require additional inspector training and are difficult to be maintained because of their age, variety or abandoned development platform. One of the priorities at the moment is therefore to standardise the instruments and applications in use. For the safeguards instrumentation the Commission has developed the RADAR (Remote Acquisition of Data And Review) software providing a standardised interface and review facility. However, the comparison with operating data and accountancy reports requires further data consistency checks that need to be standardised in order to reduce the maintenance effort, training requirements and allow for a centralised review, storage and the possibility to evaluate statistics at Luxembourg HQ. For this purpose a new software project has been started to treat these data from different operators with a single application, using standardised algorithms and criteria, thus giving the inspectors a generic tool.

Review of European Commission's safeguards activities

At present the European Commission is reviewing their nuclear safeguards activities. The implementation of these activities is being defined in cooperation with the Member States of the European Union (EU). The aim of the review is to improve the effectiveness and efficiency of nuclear safeguards within the EU. The resulting new inspection approaches with reduced inspection frequencies as described in the IETS (Implementing Euratom Treaty Safeguards) document have implications for all facility types. From an original continuous inspection scheme at MOX plants, when inspectors were present at the facility every week, it is now foreseen to reduce to 6 to 11 inspections per year plus the PIV (Physical Inventory Verification). The detection probabilities to be achieved are to be within 60 to 95 %, depending on the confidence in the operators NMAC system. These detection probabilities can only be achieved under the reduced inspection schemes if additional data evaluation can be performed outside the scheme of onsite inspections. Sending inspectors to facilities results in an administrative and travel time overhead that could be reduced if methods were found which would allow them to carry out or continue their evaluations outside the scope of inspections, at HQ.

It is therefore essential to be able to take safeguards data offsite. This could be done preferably by remote data transmission, as already done at some facilities in the EU, or by data transfer on secured media like encrypted memory sticks or on the encrypted hard drives of inspectors' notebooks.

However, remote data transmission allowing the processing of instrument and operators' data at HQ is the preferred solution for EC safeguards. It will allow a more efficient and effective use of inspection resources, lead to standardisation and harmonization effects and allows for generic evaluation software. Routine evaluation activities can be more efficiently carried out at HQ where the full infrastructure is available including the IT and instrument support. Technical interventions can be planned and better prepared if all necessary data are available.

Existing security concerns of operators and state authorities need to be addressed. The use of accredited encryption devices in line with national security requirements is often the only way to come to acceptable arrangements for all sides concerned.

Transmitted data allow for a central archiving at HQ, thus enabling the inspectorate to ensure a better issue follow-up and statistical analysis. However, the reduced inspection frequencies require new modes of communication with the operators. In the past open issues where followed up most of the time by the next inspection team and onsite follow up mechanisms like electronic logbooks were used to keep the inspectors informed. With monthly or even longer time gaps between inspections it is essential to have agreed communication channels allowing for a timely resolution of queries coming from the data review at EC HQ. The safeguards awareness of the operation staff reduces with the lowered inspection frequencies and the memory of details of plant events that lead to safeguards queries fades away with time. Encrypted email links and postbox systems have proven to be of help; however, frequent review meetings with the operator need to be held to ensure the necessary feedback at all levels. Since the applied detection probabilities will depend on the confidence in the operators Nuclear Material Accountancy and Control (NMAC) system, there is a need for a comparison between the different plants and operators. A central data repository in HQ has to allow for a statistical analysis of data and a comparison of different material balance periods, installations, operators and Member States.

An annual review of activities and the establishment of a work program as a result of regular evaluation of inspection results and findings are essential to keep the inspection effort in balance. Performance indicators to harmonize the assessment are essential to come to comparative results with reduced subjectivity.

During the year inspection findings might lead to a review and adaptation of the inspection scope and scheme in order to address detected shortcomings and ensure a detailed follow up.

These concepts need to be seen in the overall quest to increase the efficiency of the EC safeguards system. They will also lead to the use of additional tools like auditing techniques but also require a further cooperation of operators in terms of communication, data handling and transmission.

Safeguards in MOX facilities are a continuous process requiring cooperation and flexibility from all stakeholders. Experience gained in European MOX plants could be a very useful blueprint for similar facilities worldwide.