The European experience in safeguarding nuclear fuel recycle processes and Pu stores

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Abstract

Civil nuclear programs in the European Union member states have from their onset included fuel recycling as an option. Uranium and Plutonium separated in reprocessing plants is either stored or recycled in LEU and MOX fuel fabrication plants. In more recent years the option of long term storage and final disposal of irradiated fuel elements in underground repositories was also pioneered by certain EU member States.

The Euratom Treaty gives to the European Commission the obligation to apply safeguards controls to all civil Nuclear Material in the European Union, and to facilitate the implementation of IAEA safeguards. The European Commission (EURATOM) has thus gained years of experience in safeguarding reprocessing plants, Pu storages, and MOX fuel fabrication plants and is currently participating in the development of approaches and measures for safeguarding long term repositories.

The aim of this paper is to present the regulator's views and experience on safeguarding nuclear fuel recycle processes and Pu stores, which is based on the following principles:

- Early involvement of the control organizations in the design of the safeguards measures to be developed for a plant (currently referred to as Safeguards by Design)
- Early definition of a safeguards strategy including key measurement points
- The design and development of plant specific Safeguards equipment, including an on site laboratory for sample analysis
- The development by the operator of an appropriate Nuclear Material accountancy system to facilitate meeting their declaration obligations.
- The introduction of an inspection regime allowing comprehensive controls under the restrictions imposed by financial and Human Resources limitations
- Optimization of the inspection effort by using unattended measuring stations, containment and surveillance systems and secure remote transmission of data to the regulator's headquarters
1. Introduction

Reprocessing as a back end option was already introduced during the early conception of the nuclear fuel cycle of many EU Member States. As a result, a number of Member States embarked on the development of reprocessing technologies, the construction of demonstration and pilot plants, and eventually in the setting up of commercial operations. The plants in Sellafield (Magnox and Thorp) and in La Hague (UP2 and UP3) are in commercial operations since a number of decades, and represent more than half the world wide installed reprocessing capacity.

The reprocessing plants product (Uranium and Plutonium) is then recycled in fuel fabrication plants or is stored for later use. EU member states have again pioneered the fabrication of MOX fuel elements and their use in Light Water Reactors. The plants in Cadarache, Marcoule, Hanau, Dessel and Sellafield were brought into commercial operation many decades ago, and some continue to operate successfully.

On the other hand, the capacity of the MOX fabrication plants sized to the requirements of MOX element use in reactors, does not allow the reduction of the Pu stockpile produced by reprocessing plants. The development of large safe and secure Pu stores has thus responded to the above need.

Recycling plants are characterised not only by their complexity and difficult access in many areas due to high radiation levels, but also by their continuous mode of operation requiring a high degree of automation and the presence of significant amounts of direct use material both as throughput and inventory. Security considerations play also a significant role in limiting direct inspector presence for verification purposes.

As a consequence of the above characteristics of recycling plants, safeguards approaches based on the installation of unattended equipment operating in continuous mode, maximum use of containment and surveillance systems and most important, transfer of the signals/information collected either to a dedicated technical room or preferably to the Inspectors' office on site were conceived already in the 70s and 80s [1,2].

The existence of such central data collection configurations was further exploited at a more recent stage, with the remote transmission of some of the data collected towards the Euratom Headquarters in Luxembourg, and was complemented by the electronic transfer of some of the operators operating data to Luxembourg, making thus the comparison between operating records, inspectors' measurement observations and results, feasible at HQ.

This paper will attempt to describe the experience that Euratom has gained in Safeguarding Pu Recycle facilities, the current state as far as installed equipment and remote data transmission of safeguards related data from Recycle plants and Pu stores to the Euratom HQ is concerned, and their possible use at headquarters combining Remote Safeguards Activities with results of on site inspections in order to reach safeguards conclusions, increasing thus the efficiency and effectiveness of the safeguards system.
2. Current Safeguards Approaches in Recycling Plants

Safeguards approaches in Recycling Plants are developed after careful examination of their basic technical characteristics, taking into account that after the active start up of the installation some activities (e.g. the accountancy tank calibration or the verification of absence of undeclared circuits) could not be realised without undue irradiation burden on both the operator and the inspectorate. An early start of the discussions between the operator and Euratom and the inclusion of some Euratom safeguards requirements in the design of the plants, is essential. Such an early involvement would increase the safeguardability of the plant and would decrease the cost of installing safeguards related equipment.

The first step in designing the safeguards approach is the division of the plant in Material Balance Areas and the Introduction of Key Measurement Points, in such a way that the control of the flow of material and its inventory becomes feasible by the operator's accountancy system and can be controlled by the inspectorate.

A typical structure for a reprocessing plant would include separate MBAs for the different phases of the process (i.e. Wet storage of irradiated fuel elements, Shearing and dissolution of elements, Separation and conditioning of Pu, U and fission products, Pu and U product storage, Waste treatment facility).

In a MOX fabrication plant separate MBAs would normally be proposed for the powder receipt area, the mixed oxide production area, the MOX element assembly area and the waste treatment area.

Large Pu stores are normally treated as separate MBAs, or as a group of MBAs in case physically separate stores are part of the same PU storage facility.

Within each MBA the safeguards approach comprises the following elements:

- Verification of the flux of nuclear material
- Annual Physical Inventory Verification
- Evaluation of the MUF (in the bulk handling MBAs)
- Evaluation of the C/S measures for Continuity of Knowledge purposes

Depending on the MBA type and the state of the Nuclear Material the following verification activities are performed in order to implement the safeguards approaches:

- Item Identification
- Weighing
- Volume and density measurements of tanks
- Continuous monitoring of the liquid level in the tanks
- DA sample taking and analysis (concentration, assay, isotopic composition)
- NDA measurements (neutron and gamma)
- Neutron Portal monitoring
- Video surveillance and electronic sealing
- Use of Copper Brass metal seals
With the exception of the item identification and the DA sampling, all other verification activities are based on continuously monitoring systems connected to a local acquisition system. Raw data are transferred to the inspectors' office on site, are analysed and compiled to the 'events database'. The latter is then compared with the operating records as declared by the operator.

Most bigger Recycling plants have developed a site wide system of operating records, which apart from serving operational needs, also constitutes the basis of the operating records submitted to the Regulator in fulfilment of the operator's obligations under the Regulation. Considering the big number of 'events' that have to be reported to the regulator, operating records are often produced an transferred electronically.

As it will be explained in the next point, on some occasions the 'events database' is transferred electronically to the Euratom Headquarters in Luxembourg, where it is compared with the operator's operating records and reports, also transferred to Luxembourg by electronic means (USB stick).

Current Euratom inspector presence in Recycling Plants (number of inspectors and frequency of inspections) is rather related to the bulk of the information provided, the time needed to process it and the requirements of the operator to access part of the installation for maintenance of equipment than any nuclear material timeliness criteria.

3. The development of purpose safeguards equipment including remote data transmission

As discussed above, a big amount of raw data are recorded by the various measurement and monitoring systems installed at Recycling Plants, and are analysed and compiled into the events database to be compared with the operator's operating records and reports. Appropriate equipment interfaces and analysis software have been developed, allowing the unattended collection, transfer and analysis of data.

Examples of such software packages developed by Euratom include:

- The RADAR (Remote Acquisition of Data and Review (3)) software package aiming at the unattended acquisition of data from a variety of instruments, which combined with the data evaluation package CRISP (Central Radar Inspection Software Package) provides for the unattended creation of the events database and its comparison with the Operator's declarations.

- The DAI (Data Analysis and Interpretation (4)) monitoring software tool, capturing a vast amount of signals from different types of instruments and analysing them in a way that nuclear material flow through a recycling plant can be tracked and compared to the Operator's declarations.

The same packages are used to capture the large amount of state of health information that is available. The transfer of all above data via commercially available transmission lines from the nuclear installation to the Regulator's Headquarters, is understood under the term Remote Data transmission (RDT).

Data candidate for RDT could be clustered into the following categories:
- Euratom equipment state of health
- Euratom equipment measurement data
- Branching of Operator's equipment
- Euratom video surveillance data
- Euratom electronic seals data
- Operator's operating records
- Operator's operating reports
- Operator's supporting documents
- Inspector's inspection working documents

All above data are considered as sensitive and carry a confidentiality classification at a level that might vary from one Member State to another. It is thus important that for each category of data, Euratom, the State Authorities and the Operator involved, come to an agreement on exactly which data and in which way it will be transmitted so that the security requirements are met. Particular precautions have to be taken when data already classified are put or transferred together (e.g. data pertaining to nuclear material weights, location and time).

So far, for Recycling Plants in the EU, Euratom has obtained the agreement of the competent authorities for the remote transmission of some C/S and Euratom equipment data from Sellafield [5], while Operator's records and supporting documents are transferred using USB sticks from both Sellafield and La Hague.

Details of the technical and security arrangements agreed have been presented on earlier occasions [6]. In order to avoid issues related to the volume of the data transmitted and the synchronisation of the data bases in Luxembourg and on site, the preferred option would be to store all data on dedicated servers on site and access them via remote secure protocols from Luxembourg. The same servers would serve as the depository of the operator's data currently scanned and transferred via USB to Luxembourg.

The advantages of RDT would then be used to their full extend. Such advantages are:

- Increased data security through appropriate secure transmission
- Better possibilities of organising, exploring and archiving the data
- Data consolidation and stratification through early agreement on which data need to be provided
- Better possibilities to develop programs for data analysis and evaluation, based on the agreed format and context of data transmitted
- Increased efficiency through harmonisation and streamlining between facilities of the same kind
- Improved conservation and transfer of inspection know-how and the cross-fertilisation between teams of inspectors
4. Optimising the inspection regime

As already mentioned, Recycling plants are characterised by high quantities of Nuclear material throughput and inventory, and a big amount of data (operating records and measurement or C/S data) available to the Regulator often remotely. Thus, the question of their use towards improving the efficiency and the effectiveness of safeguards verification activities becomes evident.

Recent developments of Euratom's inspection regime in recycling plants point towards a combination of inspection verification on site and inspection activities performed remotely at Headquarters.

Activities that could be performed at Headquarters to support or to prepare inspection activities include the following:

As far as equipment is concerned:

- Follow up of the state of health of equipment and planning of interventions
- Planning of alternative safeguards measures in case of equipment failure or loss of containment
- Remote update of system parameters (mainly software)
- Checking of completion of maintenance or upgrade actions requested by the inspectors (e.g. transducers calibration, or testing of proximity switches)

As a result of the above, the operator would have higher flexibility in planning and performing maintenance operations, and could have enhanced access for maintenance of his/her equipment installed in controlled areas (currently limited during inspector presence). Reduction of dose uptake for the inspectors but also for the operator via better planning, is obvious.

As far as information is concerned:

- Review of surveillance records and reconciliation with events as declared by the operator
- Review of electronic seal events and reconciliation with events as declared by the operator
- Evaluation of continuous measurements (e.g. accountancy tank volume and density, or neutron and gamma measurements) and comparison with operating records.
- Evaluation of unattended NDA measurements of discrete items against the operator's declarations
- Comparison of operating records and reports with accountancy declarations received in Luxembourg

As a result of the above, possible discrepancies will be detected and analysed before the arrival of the inspector to the installation, giving adequate response time to the operator.

The question now arises whether the activities at Headquarters described above could replace the physical presence of inspectors at facilities, and could thus be considered as a safeguards inspection executed remotely.
The answer to this question could be different, depending on the type and characteristics of an installation:

For example, in static stores with effective C/S (e.g. a multilayer containment and ideally a robust, reliable and failsafe outer containment layer (door switch), a number of physical inspections could be substituted by Remote activities without either jeopardising the possibility of the operator to access the store for equipment maintenance, or increasing the probability of follow up measures due to C/S failures.

On the other hand, in bulk handling facilities, the physical presence of inspectors would have to be continued at a fairly high level, but the emphasis on their work on site would be shifted to activities like BTC re-verification, examination of supporting documents, audits of the operator's NMAC system, and resolution of anomalies. It should also be noted that physical presence of inspectors familiarises them with the installation and the processes, and is of utmost importance when introducing new inspectors to a new facility. Direct contact with the personnel of the installation should also not be underestimated as a positive factor for problem solving. Inspector presence serves also as a deterrent for potential diversion and promotes application of good operational practice.

Another factor to be considered is related to the optimisation of the inspector's time, both at Headquarters and during inspections. It can be argued that Remote Inspection Activities could lead to a more efficient use and a homogenisation of the inspector's work pattern at Headquarters, and an increase of their efficiency during inspections (through better planning and reduction of unforeseen difficulties).

For the operators, Remote Inspection Activities could only lead to advantages, related to the flexibility in planning their equipment maintenance interventions and the predictability of the inspectorates' requirements during inspections. Possible reduction of physical presence of inspectors would also reduce the need for the provision of escorts and operational staff for manipulating nuclear material, and would thus have an indirect positive effect.

An issue that will need to be addressed, is the integration of the verification and comparison activities performed at Headquarters to the overall safeguards conclusions reached as a result of an inspection. A procedure replacing the current "opening meeting" i.e. the clarification of the scope of the verifications, the transmission of operating data and the discussion of any current issues potentially influencing the verifications, should be introduced. The format can however be more mechanistic and consist of a functional mailbox and standardised checklists per type of verification. The same applies for the 'final inspection meeting' during which the preliminary results of an inspection are presented to the operator. The latter will have to be substituted by a different means of communication (e.g. videoconference) which will allow the Inspectorate to inform the operator of the preliminary results of the integrated verification activities at Headquarters and on site.

5. Conclusions

The need to include safeguards requirements already in the design phase is complied with by at least the more recent Recycling plants and nuclear material stores. Due to the big number of operating records and measurement data produced, unattended collection and electronic transmission of data has been developed.
Remote data transmission offers a number of advantages related not only to the better organisation and the security of data transmitted, but also to a better and timely preparation of inspections – reducing thus unforeseen problems.

Introduction of remote inspection activities could be advantageous to all involved. Under such a scheme, the range of inspector's activities at Headquarters and during inspections will have to be revisited so that an optimisation of the efficiency and the effectiveness of the system are achieved without any undue extra pressure on the operator.

6. References


