

French centralized nuclear material accounting: a tool at the heart of national security and safeguards implementation

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Abstract:

In the context of a revision of the national regulations for the protection and control of nuclear materials, the French authorities have reexamined their expectations in terms of the security of nuclear materials and the links with the implementation of safeguards. The existence of a nuclear material accounting has been reaffirmed as a pillar of security and safeguards.

The principles of nuclear material accounting in France are presented, on the one hand at the local level of nuclear material holders, and on the other hand at the national level within a so-called centralized accounting system.

The organization of centralized accounting is also detailed: the actors of this accounting system as well as all its interlocutors and stakeholders.

The contributions of centralized accounting for security purposes and for the implementation of agreements and texts relating to safeguards on nuclear materials are explained, including some of the contributions of accounting for certain national needs that go beyond security and safeguards issues alone.

A reflection is also proposed on the fundamental elements of nuclear material accountancy (e.g., time step or granularity of the follow-up) and on the constraints induced on this accountancy according to the objectives assigned to it, in particular with regard to security objectives or in terms of safeguards.

Keywords: Centralized accountancy, France, NMAC, Security, Safeguards

1. Introduction

The French authorities have recently launched a process to review the national regulatory framework for the protection and control of nuclear materials. This has resulted in a new decree applicable since January 1st, 2023. The publication of the various implementing orders is ongoing, some of which have already been published, while others are expected to be published quite quickly, leading to a transition period extending to December 31st, 2024.

Nevertheless, there have been no major changes in the concepts and requirements, but the desire to explicitly introduce the notion of internal threat, as well as to give meaning to the obligations and to be able to explain the objectives to those subject to the law. This has led to a reflection on the role of nuclear materials accountancy in the security of nuclear materials on French territory and in the implementation of Safeguards.

2. Nuclear material accountancy in France

In terms of the responsibility of actors involved in the field of nuclear materials, it falls under the responsibility of operators under the Defense Code (Article L1333-4) to protect materials and to be able to detect any theft or diversion, as well as to be able to verify any allegation of this nature. The public authorities, for their part, are responsible for ensuring that operators respect their obligations (Articles L1333-5 and 8).

Similarly, at the regional and international levels, it is up to France and French operators to demonstrate compliance with the objectives subscribed to by France: in particular that nuclear materials on national territory are not diverted from the intended uses declared by the operators (EURATOM treaty) and that the obligations for peaceful use and other bilateral or international obligations concerning the materials are met (safeguards agreement between France, EURATOM and the IAEA, EURATOM/third country agreements, bilateral agreements between France and third countries).

Integrating these requirements, the French system is based on a three-tiered organization: local accounting at the level of the nuclear material holder, accounting at the national level for nuclear safety purposes, and "international" accounting, largely based on national accounting, to meet the requirements of international safeguards and controls of materials. These two levels constitute the so-called "centralized" accounting of nuclear materials.

3. The fundamentals of a nuclear materials accountancy system

The main objective of a nuclear materials accountancy system is to guarantee that the protection of materials is ensured and that their location is known at any moment. This requires knowing the quality, quantity and location of nuclear materials at all times.

The definition of such a system must be based on the following elements:

- Identification of the perimeter of the accountancy system, i.e. identification of the materials concerned because of its sensitivity (U, Pu and Th, other materials like tritium or lithium enriched in Li_6 followed by the French system, or any other materials, ...);
- Definition of thresholds (if any) below which the monitoring could be lightened;
- Temporal step with which we wish to be able to analyze the gathered data (day, month, year);
- Spatial granulometry with which one wishes to be able to follow the materials at the accounting level (fine monitoring at the level of a room, a facility, a plant, a company, the country, ...);
- Perimeter of nuclear materials targeted and level of detail or aggregation targeted in the tracking of materials (desire or not to differentiate materials in accounting according to enrichment or enrichment ranges, isotopic composition, physicochemical composition, irradiation, nature of containers, etc.).

The accountancy system shall define at any time the stocks of materials expressed in units of mass and broken down according to the characteristics chose for accounting purposes.

These identified characteristics, which allow the tracking of materials in an aggregated manner, are to be defined according to the tracking objectives, i.e. according to national requirements for the detection of theft or diversion as well as supranational requirements (bilateral, regional, international).

However, knowledge of stocks alone is insufficient for cross-checking the consistency of stocks between sender and receiver during movements of materials. To this end, material movements and, more generally, inventory changes must also be tracked in the accountancy system.

4. The principles of nuclear material accounting in France

The system implemented for nuclear material accounting in France is essentially the result of requirements relating to national, European and international levels

The national level

These requirements are those of the Defense Code, which imposes constraints on holders of nuclear materials.

At the national level, it is the responsibility of the holder, regardless of the quantity of materials held, to know at all times the location and use of the materials and to detect the nature and quantities of any missing materials (Defense Code). This requirement is part of an ad hoc regulation (Protection and Control of Nuclear Materials, their Installations and Transport), under which the holder is obliged to implement a local accounting system for his nuclear materials (local accountancy).

When the materials held exceed certain thresholds defined in the French law, the holder is required to obtain an authorization from the ministry in charge of nuclear security (Ministry

of Energy Transition in the civilian sector and Ministry in charge of Defense in the military sector).

Material holders must have a physical and accounting follow-up of the materials in real time, which are subject to national inspections in the same way as the physical protection. Local accounting is reported daily at the national level (except in the case of very small quantities of materials, which are only reported annually) to the centralized accounting system maintained by IRSN, the technical support of the French authorities. This accounting system tracks uranium, plutonium, and thorium, but also tritium and lithium enriched in lithium 6. The holders have 24 hours to report any operation on their nuclear materials, which allows a day-to-day follow-up. This accounting is part of the national security system and aims in particular to protect against theft, diversion and malicious acts. It is based on a different accountancy language from the EURATOM accounting system.

The European level

At the same time, holders make monthly declarations of inventory changes under the EURATOM Regulation. Transmission is made via IRSN on behalf of the French authorities. The latter are represented by the EURATOM Technical Committee (CTE), which is a department of the Prime Minister in charge of implementing the safeguards agreement, the additional protocol, the EURATOM Treaty and Regulation, the secondary legislation of all these texts, and the bilateral agreements signed by France.

The experience feedback since the beginning of EURATOM control shows the efficiency of this approach: it guarantees a good level of quality of French declarations within a satisfactory timeframe from the point of view of the Regulation, thanks to the action carried out by the CTE and its technical support, IRSN, to follow up declarations and to contact the declarants when necessary.

The international level

Under the French Safeguards Agreement, the Commission is responsible for the transcoding of the accounting declarations in EURATOM format into Code 10 and the transmission of these declarations to the IAEA for the relevant facilities.

5. The benefits of a centralized accounting

National level

Accountancy allows a common and homogeneous language to be established between the different holders and the different facilities.

Accounting is the only tool that can be used to identify the repeated diversion of very small quantities of materials that would result from the exploitation of internal collusion, knowledge of the detection thresholds of physical protection devices, etc. The effectiveness of accounting for this purpose is therefore based on a requirement in the French system: the need of a real separation between local accounting of materials and physical monitoring.

Thus, it is fundamental that:

- Persons with responsibilities or missions in local accounting or physical protection are not allowed to make movements or operations on nuclear materials;
- Persons with responsibilities in physical monitoring are not authorized to intervene in accounting or physical protection;
- Equipment and procedures for physical monitoring, physical protection and accounting are separated.

Accounting is also essential for crisis inventories to verify the consistency between the assumed and actual inventory of a facility faced with an abnormal or unusual situation suggesting a loss, theft, diversion or dispersal of materials. These situations are not limited to the security domain. Safety can also benefit from accountancy information. Indeed, knowledge of the exact quantity of materials involved in a crisis situation can be an important added value for the assessment of the radiological consequences of an incident or accident, and the existence of an effective communication channel between the entity in charge of accounting and the one in charge of the crisis would appear to be highly beneficial in this respect. The presence of these two units within IRSN (French TSO common to both fields), is an obvious factor of efficiency and fluidity.

The sole accountancy locally implemented by nuclear materials holders is not sufficient to meet the expectations at the State level. Several reasons therefore can be mentioned. First of all, the separation between physical tracking, accounting tracking and physical protection is not sufficient to protect against internal malicious acts, in particular because of the possibility of collusion between several malicious parties, but also because the action of a malicious party may be based on a pre-existing weakness in the system set up by the holder. The answer to this weakness is the existence of a centralized accounting system independent of the holders of nuclear materials, which allows for an external and independent control. This makes it impossible, for example, to make any a posteriori correction of an accounting declaration in order to cover an unjustified discrepancy (whether malicious or not) in the physical tracking. It also authorizes control of material movements between holders by cross-checking the consistency of their local accounts.

The centralized accounting system also allows a pre-analysis of the accounting information relating to a holder in preparation for an inspection carried out by the French Authorities at the said holder's premises.

The centralized accounting system thus allows for the monitoring of the implementation of the regulatory obligations by the material holders.

Completely independent of the monitoring of nuclear materials, the French security regulatory framework includes a system for authorizing and monitoring in real time the transports of nuclear materials. This monitoring is also carried out within IRSN.

This allows verification of consistency between accounting movements and the physical movements corresponding to the shipments monitored in this context. This also constitutes an additional control tool that takes advantage of the existence of centralized accounting and of the role of IRSN as the TSO for all fields relating to radiological and nuclear risks.

Similar synergies are also used to reconcile accounting data with data relating to the inventory of radioactive sources, also carried out at the Institute. This type of reconciliation has proven useful for example for monitoring gamma radiography equipment, which has

not only a radioactive source, but also radiological shielding made of depleted uranium that is monitored as a nuclear material.

In addition, the existence of a centralized accounting system that is independent of the operators makes it possible to have redundant accountancy in the event of a cyber-attack on an operator's information systems.

Finally, the definition of the appropriate physical protection means for a facility depends on the inventory of nuclear materials. The existence of a centralized accounting system gives the security authorities the possibility of verifying, independently of the information transmitted by the operator, the adequacy between the flows and stocks during the life of an installation and the associated physical protection means.

These different arguments show that centralized accountancy is part of the principle of defence in depth, a concept that is common in the context of nuclear safety, but which is also fully justified in the field of security, by aiming to systematically exploit several barriers, whether physical or organizational, intended to ensure security, even in the event that a security element is compromised or fails.

The existence of a centralized accountancy system is therefore a crucial element for meeting the objectives of the public authorities in terms of security. Thus, French regulations specify that *"The Nuclear Défense Expertise Directorate of the Institute for Radiation Protection and Nuclear Safety [IRSN] is responsible for keeping a centralized accountancy of nuclear materials and for defining the technical procedures to be applied by the licensee to enable it to fulfil this mission."*

In addition, the effectiveness of this centralized accountancy system requires, on the one hand, that not only inventories but also movements be monitored, and, on the other hand, that movements be monitored for facilities with a certain sensitivity with the same granularity as in the framework of "local" accounting (one declaration per movement and not declarations aggregating several movements). Similarly, real efficiency in a crisis situation requires that stocks be monitored in real time: daily reporting is therefore necessary and the current requirement to report movements to the centralized accountancy system within 24 hours seems to be the most appropriate. The lesser sensitivity of holders of very small quantities of materials may in some cases allow these constraints to be relaxed, particularly in terms of the frequency of declarations.

International level – TNP and EURATOM Treaty

At the international level, the first argument for requiring a nuclear material accountancy is purely legal.

Thus, the existence of a "national" accountancy is underpinned by the requirements of the Non-Proliferation Treaty (NPT). In this regard, the comprehensive safeguards agreements provide for the obligation of states to establish and maintain a "national nuclear materials accountancy and control system" (NMAC). The Agency's document INFCIRC/153 describes the structure and content of these agreements, and also sets out the basic requirements for NMAC systems.

IAEA also issued a Services Series document in 2015 entitled "Safeguards Implementation Practices Guide on Establishing and Maintaining State Safeguards Infrastructure" (Services Series No. 31), which emphasizes the importance of national nuclear material accountancy in the Agency's safeguards system.

It should also be noted that in 2015, IAEA issued a document in the "implementing guide" series relating to the principles to be implemented in terms of nuclear material accounting from a security perspective: "Use of Nuclear Material Accounting and Control for Nuclear Security Purposes at Facilities" (Nuclear Security Series n° 25-G). This document specifies the role of the State in evaluating the NMAC system of operators, the importance of transmitting accounting reports to the authority, and the need for State inspections of these aspects¹. It is also to be underlined that the need for the national authority to analyse the materials unaccounted for (MUF) and the cumulated MUF (CUMUF) obtained during the inventories by the operators is explicitly mentioned. This places at the heart of the nuclear material security system the analysis of accountancy and inventories. This is largely confirmed in INFCIRC/225 Rev.5 on "Nuclear Security Recommendations on the Physical Protection of Nuclear Material and Nuclear Facilities", which indicates the complementarity and indispensability of physical protection and of an NMAC system. This IAEA document also states the need for the national competent authority to have access to information from this accounting and control system.

The requirements with respect to EURATOM are quite different. Thus, as a member of the EU, France is fully subject to the obligations of the EURATOM Treaty and its implementing regulation n° 302/2005. The resulting requirements apply mainly to operators (and not to the State, as is the case with IAEA control), particularly regarding the need to implement an NMAC system.

International level – Secondary legislation and other multilateral or bilateral commitments

The range of constraints resulting from the possession of nuclear materials is even broader because EURATOM has signed agreements with third countries (United States, Canada, Australia, Japan, etc.) that require material accounting and may impose other obligations, in particular the preparation of summary accounting reports or the monitoring of restrictions on the use or transfer of these materials. The implementation of these constraints relies on the accounting tracking of materials. Similarly, France has signed (and continues to sign) bilateral cooperation agreements in the nuclear field with economic partners. These agreements generally include clauses similar to those mentioned for EURATOM/third country agreements and therefore require reliance on material accounting.

In view of all the constraints resulting from these different texts, France has from the beginning wanted to centralize the information due from operators. In this context, the CTE - Euratom Technical Committee - attached to the Prime Minister's office, and its technical support, IRSN, are responsible for transmitting to EURATOM all the accounting declarations and other documents related to the life of an installation, due from the operators.

¹ Such a system exists in France but not necessarily in all EU countries; nevertheless, EURATOM control can be considered as an NMAC system at a regional level.

This centralisation has many advantages for the French authorities. This makes it possible to ensure the homogeneity of inspections in all French installations and to defend the interests of French industrialists in the implementation and interpretation of the EURATOM treaty and regulations. By being the custodian of accounting declarations, IRSN is able to carry out real analysis and prospective thinking on behalf of the French authorities (Prime Minister Services, Ministry of Foreign Affairs, Ministry of Defense, Ministry of Industry, Ministry of Energy), which would be impossible without detailed knowledge of the accounts of all national holders.

In addition, centralized accounting allows the French State to make a certain number of declarations in order to meet the international commitments it may have made in the context of nuclear material control or multilateral or bilateral nuclear cooperation agreements. Thus, the use of data collected by the centralized accounting system (Cf. [1]) allows France to fulfil its obligations under:

- France's safeguards agreement: monthly and semi-annual declarations made by France to the IAEA and sent for transmission to EURATOM;
- INFCIRC/415: a monthly declaration by France to the IAEA and sent for transmission to EURATOM, including the quantities of mining concentrates imported by France, broken down by country of origin of the material;
- INFCIRC/549: annual declaration to the IAEA of stocks of plutonium in French installations;
- the commitment made by France concerning "transparency of highly enriched uranium": annual declaration to the IAEA of stocks of highly enriched uranium in French installations;
- the cooperation agreement between France and Japan:
 - annual declaration to the Japanese authorities of stocks of materials subject to the agreement, broken down by installation and by major category of movement
 - continuous monitoring of stocks of materials covered by the agreement as a result of their passage through equipment of Japanese origin listed in the agreement (steam generators in certain EDF plants),
- the cooperation agreement between France and Australia: annual declaration to the Australian authorities of the stocks of materials subject to the agreement, broken down by installation, by category of movement and by day.

Contribution to internal issues in France

In the context of the constraints applicable under the EURATOM regulation, centralized accounting ensures the transmission on behalf of operators of all accounting reports due under the EURATOM regulation. In addition to advising the material holders, the centralized accounting system also verifies data formats in order to improve the quality of the data transmitted to EURATOM. It allows the French authorities to remind their obligations to the holders of materials who do not comply with the regulatory deadlines of the EURATOM Regulation.

The centralized accounting also makes it possible to meet internal French obligations, in particular in the context of transparency actions in the nuclear sector.

It makes it possible to respond to specific requests for information on the history of materials, which are often part of the needs expressed by the government or ministries.

6. Conclusion

Centralized accounting is a pillar of security as well as of international safeguards and controls of nuclear materials. It is a powerful tool at the service of the French government and industry:

- For security reasons, because it is the only bulwark against theft or repeated detour of small quantities of materials, and because it constitutes one of the key elements of a global system of defense in depth;
- To meet the requirements of the IAEA under safeguards agreements;
- To meet the safety standards defined by the IAEA;
- For national use in order to prepare declarations or reports due to EURATOM or to economic partners with which France or the Community have signed agreements,
- For knowledge of stocks and flows of materials for the purpose of sizing the physical protection of installations or managing crisis situations;
- To enable the French authorities to have all the relevant information and analyses in order to defend French economic, industrial and strategic interests.

7. References

- [1] BRETON S., “ICEBERG : An Informatic Platform Processing Nuclear Material Accounting Data for French Non Proliferation Commitments”, INMM & ESARDA Joint Annual Meeting, 2023