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United States of America Nuclear Regulatory Commission's Approach to Inspections and Quality Control of Data

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Abstract. In recent years, the International Atomic Energy Agency (IAEA) has benefited greatly from an increased number of data sources along with enhanced capabilities to assist safeguards inspectors who analyze this new data. However, the quality and reliability of State declared information used by the IAEA to draw safeguards conclusions remains critically important. Each State or Regional Authority has the responsibility to ensure reports provided to the IAEA are accurate and complete. This paper describes the United States Nuclear Regulatory Commission's (US NRC) approach to quality control of safeguards declarations provided to the IAEA and how this process supports fulfillment of the United States' international obligations. The US NRC's audit-based approach to domestic inspections will be reviewed along with the advantages and challenges of such an approach to the quality control of information. Furthermore, examples of quality control of safeguards-relevant information at facilities, the national nuclear materials database, and the NRC will be cited and used to show how each step helps build confidence in the final declaration provided to the IAEA.

Introduction

At the end of World War II and beginning of the world's awareness of atomic weapons, the United States of America (U.S.) Congress established a system intended to protect the world from uncontrolled use of atomic energy for peaceful or non-peaceful uses. Congress passed the Atomic Energy Act of 1946 which resulted in creation of an Atomic Energy Commission (AEC) and the transfer of ownership and responsibility of special nuclear material (SNM) in the U.S. from the Manhattan Project to the AEC. The Act authorized the AEC to produce nuclear materials and nuclear weapons, but only to the extent authorized by the U.S. President. It also authorized research and development activities, but only at AEC facilities or facilities under an AEC contract. As a direct result, nuclear material controls were first conceived and introduced by the Special and Fissionable Material Accountability Branch of the AEC in 1947[1 2].

Slow progress was made between 1946 and 1954 in developing reliable accountancy measures for SNM because of the limited understanding of what was needed in this area and lack of appropriate verification technology. It became clear by 1954 that large scale peaceful uses of nuclear energy were possible, but could not be developed commercially under the strict rules of the original Atomic Energy Act of 1946. The U.S. Congress passed a completely revised Act in 1954 that included the ability for private individuals to possess (but not own) SNM for peaceful purposes. In addition, the AEC was authorized to issue licenses to qualified applicants requesting the possession/use of materials and performed accounting inspections at all facilities working with special nuclear material. The philosophy of why there should be nuclear material control

and accounting (MC&A) changed markedly during the late 1950's. The former Special and Fissionable Accountability Branch was renamed the Division of Nuclear Materials Management at the AEC, eliminating a perceived stigma that accountability was a synonym for bookkeeping. By 1964, the U.S. Congress passed the Private Ownership Act which authorized individuals or corporations to own SNM requiring the AEC to grow its material control and accounting program to meet the new challenge.

Evolving Safeguards in the United States

Nuclear material safeguards objectives and principles were introduced in the Atoms for Peace speech given in 1953 by U.S. President Dwight D. Eisenhower to the United Nations General Assembly, ending an era based solely on nuclear material management and beginning an era of international safeguards. A strong safeguards article was introduced into the newly established International Atomic Energy Agency charter in 1957. Some changes were made in the AEC beginning in 1963, which included its material control and accounting system employing an increased emphasis on safeguards. The U.S. offered to share much of its non-weapons nuclear materials and equipment with other nations that would agree to bilateral U.S. safeguards, including inspections, to ensure continued peaceful use of the materials furnished. Later, the Private Ownership Act of 1964 determined that the AEC had the ability to safeguard nuclear material as a function of who had physical possession, rather than who had legal title to the material.

In 1967 and 1968 the AEC began to focus its efforts more on nuclear material safeguards instead of financially motivated nuclear material management. Where, in the case of precious metals monetary value was more important than strategic value of a material that might be used in an atomic bomb. Of particular importance was the addition of a series of license conditions designed to ensure SNM was safeguarded by its licensees. The AEC's inspection responsibility of U.S. licensed nuclear facilities was moved into the Division of Nuclear Materials Safeguards under the Director of Regulation. Routine inspections were performed by the AEC at these facilities to ensure compliance with Federal Regulations.

As part of the Atoms for Peace program, bilateral agreements for cooperation were concluded with a few Non-nuclear Weapons States. Assurances were given by the recipient governments that U.S. assistance would be used only for peaceful purposes. The State also agreed to maintain adequate records, submit periodic reports to the U.S., and allow U.S. inspections for safeguards purposes. Additionally, the U.S. began discussions with the IAEA on the potential for the U.S. to accept IAEA safeguards on US-supplied nuclear materials and facilities, while retaining a right to resume bilateral safeguards and inspections in the event of IAEA inability to carry out its safeguards responsibilities on US-origin SNM and facilities. It was a first step in providing safeguards declarations of nuclear material inventories to an autonomous international organization.

The IAEA worked on safeguards approaches for facilities beginning in 1961, publishing IAEA information circular (INFCIRC) 26 which outlined a safeguard system for research reactors. To demonstrate a willingness to be safeguarded and to provide a proving ground for new concepts, the U.S. offered to place four research reactors under IAEA safeguards. INFCIRC/26 was extended in 1964 to include power reactors. INFCIRC/26 was then replaced by INFCIRC/66 in

1965 which allowed for safeguards on specific principle nuclear facilities, nuclear material, and nonnuclear material to be safeguarded and prohibited their use for military purposes. A model comprehensive safeguards agreement was then described in INFCIRC/153 and in 1977 the U.S. signed the *Agreement between the U.S. and the IAEA for the Application of Safeguards in the U.S. (and Initial Protocol thereto) (INFCIRC/288).* The United States brought its US-IAEA Safeguards Agreement into force in 1980.

The Energy Reorganization Act of 1974 divided the AEC into two distinct organizations. The Nuclear Regulatory Commission (NRC) to license and regulate civilian uses of nuclear materials and facilities, along with the Energy Research and Development Administration (Department of Energy (DOE) precursor) to direct development and production of nuclear weapons, promotion of nuclear power and other energy-related work, and regulation of defense nuclear facilities. Acting as the U.S. National Regulatory Authority (NRA) for its commercial nuclear industry, the NRC was charged with providing oversight for implementation of procedures and practices necessary to facilitate information gathering, timely reporting, and in-field verification of all commercial nuclear activities.

Components of the NRC designed to prevent proliferation of nuclear weapons or make them available to terrorists were exercised by the newly formed agency. By far the leading supplier of nuclear fuel and other materials for the production of nuclear power abroad, the U.S. had a responsibility to ensure exports did not encourage proliferation. Global increase in terrorist activities, transfers of reprocessing and enrichment technologies, as well as India's nuclear explosion, which occurred during the decade of the 1970's triggered U.S. policy makers to reevaluate domestic and international safeguards. The U.S. Congress passed legislation during that period, called the Export Reorganization Act of 1975, which gave the NRC responsibility for determining whether an importing State's imposed safeguards were "at least substantially comparable" to those required by the United States. Determining suitability of safeguards, including material accountability, in these States was an enormous task. The NRC lacked the resources and expertise to make these broad foreign policy assessments. It was ultimately determined that implementation of IAEA safeguards under a comprehensive safeguards agreement in those States fulfilled this obligation.[3].

In 1980, under the US-IAEA Safeguards Agreement (INFCIRC/288), "Voluntary Offer," the U.S. allowed the IAEA to begin applying international safeguards on all special nuclear material (SNM) within the U.S., <u>*only*</u> excluding facilities associated with direct national security significance activities, with a view to enabling the IAEA to verify that such material is not withdrawn, except as provided for in the Agreement, from activities in facilities while such material is being safeguarded. The U.S. continues to periodically provide the IAEA with a list of facilities eligible for the application of safeguards; adding or removing facilities from that list as necessary. Revisions to this eligible facilities list (EFL) by the NRC and DOE are submitted for a 60-day Congressional review before they are submitted to the IAEA. As a result, the U.S. submits a completed IAEA Design Information Questionnaire (DIQ) and negotiates a Subsidiary Arrangement for those facilities formally selected by the IAEA from this list under the US-IAEA Safeguards Agreement or its Initial Protocol.

The US-IAEA Safeguards Agreement and its associated EFL stems from discussions held between Nuclear Weapon States (NWS)[1] and major industrial Non-Nuclear Weapon States (NNWS), who were concerned that acceptance of safeguards under the NPT would place them at a commercial and industrial disadvantage in developing nuclear energy for peaceful uses. Interferences of IAEA safeguards inspections could affect the efficient operation of their commercial activities and possibly compromise their industrial secrets through IAEA personnel's access to their facilities and records. In recognition of this concern, President Lyndon B. Johnson stated on December 2, 1967 that the United States would not ask any country to accept safeguards that the U.S. was unwilling to accept for its own nuclear activities—excluding those with direct national security significance[4].

The Initial Protocol to the US-IAEA Safeguards Agreement was brought into force at the same time as the Agreement in 1980. The Initial Protocol allows for a secondary type of selection of facilities on the US EFL that only submit design information, permit IAEA inspectors to verify such information in the facility, maintain accounting records, and provide accounting reports to the IAEA without inspections. The technical provisions in the protocol follow closely the comparable provisions in the Agreement itself. Providing an initial protocol to the US-IAEA Safeguards Agreement creates a succinct distinction between facilities selected for full safeguards and those required to only submit information and perform maintenance of records.

In order to minimize costs to the IAEA, it was decided that safeguards would only be applied to a select number of facilities in the U.S., based on advanced designs or sensitivity in terms of international competition. Historically, the IAEA implemented and subsequently withdrew traditional safeguards at several NRC and DOE facilities under the US-IAEA Safeguards Agreement. The list of NRC licensed facilities inspected by the IAEA intermittently between 1980 and 2005 includes: 6 commercial power reactors, 5 LEU fuel fabrication facilities, and two HEU down-blending projects.

Nuclear Material Control and Accounting (MC&A)

Safeguarding licensed facilities, for domestic safeguards purposes, by the NRC continued to evolve from the routine inspections established by the AEC in the late 1940s and throughout the 1950s, becoming more comprehensive over time. Inspector practices were further enhanced in the 1960s-1970s by the need to meet domestic legislative requirements. As in the early years, nuclear material accountancy was always the key element of ensuring that no diversion of SNM was taking place and the prevention of diversion by threat of early detection.

In the commercial nuclear industry, quantitative control of SNM began as a philosophy that was first aimed at balancing cost of the nuclear material with effectiveness of its use to produce energy. However, in theory, as control and accounting of SNM became commensurate with the U.S. dollar, SNM worth also became proportional to its strategic value for possible weapons production. The outdated philosophy for safeguarding purposes in the commercial industry was corrected by 1968, when the concept of a material balance area (MBA) and its importance to material control was introduced as a safeguards license condition by the AEC. Periodic physical

[1] Article IX.3 of the NPT defines a nuclear-weapon State as one which manufactured and exploded a nuclear weapon or other nuclear explosive device prior to January 1, 1967. Those States are: China, France, the Russian Federation, the United Kingdom, and the United States of America.

inventories and adjustment of records accordingly helped to force licensees to prepare closed material balances at the end of each material balance period. Rules for how licensees were to construct, operate, decommission and report were codified in Title 10 of the Code of Federal Regulations (10CFR).

After 1974, nuclear material control and accounting procedures once performed under the AEC were improved by the U.S. Government through cooperation and financing of both the NRC and DOE. In time, a centralized national database for tracking and accounting for source and SNM in the U.S. was established using a computerized system under a DOE contract. The Nuclear Materials Management and Safeguards System (NMMSS) database now supports all the U.S. Government source and SNM accountancy programs. All facility identifier codes, nuclear material transactions, material balances and inventories are documented by NMMSS and used as a centralized reporting system that provides information to the IAEA under the US-IAEA Safeguards Agreement. Additionally, some facilities use a facility-specific NMMSS software program called Safeguards Management Software (SAMS) which enables the user to resolve problems and make corrections prior to sending data to NMMSS. Quality assurance is incorporated into the software as described in DOE Order O 413.1b.

Licensed facility operators in the U.S. are required to prepare nuclear material inventory and material flow report(s) and send them to the NRC for review. Normally, under domestic regulations (10CFR), data is transmitted electronically in the U.S. from the facility operator to the national accounting program managed by NMMSS utilizing proper domestic codes. When selected by the IAEA for safeguards, the facility operator generally performs the same procedure with the addition of key measurement points (KMPs), IAEA material description codes and measurement basis to their reports. Once this essential data is received by NMMSS, the information is structured into the proper IAEA reporting format outlined in the Facility Attachment (or Transitional Facility Attachment) and routed to the NRC, which then finalizes and submits the report(s) to the IAEA. Impact of this additional reporting to the IAEA is primarily absorbed by selected facilities from the U.S. EFL. However, the NRC and NMMSS bear the added responsibility of ensuring all reports from facilities under IAEA safeguards are accurate and complete.

It is important to note that accurate and complete information recorded in facility records and reported to the IAEA be identifiable to inspectors and consistent with international standards. Information as it relates to certain items and batches of material should be recorded and referenced in the accounting records, inventory change documents and general ledger, so that data can be traced to its origin. Although the act of maintaining the accurate and complete information isn't an additional impact, providing feedback to inquiries from the IAEA inspector could present some amount of burden to the NRC and facility operators.

Performance-Based Domestic Safeguards

US NRC inspectors have performed routine and unannounced inspections at licensed facilities constantly since the AEC was abolished. Techniques used by the NRC inspectors at reactors, spent fuel storage and nuclear fuel cycle facilities (fuel fabrication, enrichment and conversion) during the late 1970s included several methods of verification for inventory and nuclear material

flow. Instrumentation for measuring unique items, scales for weighing, destructive analysis of bulk material and human surveillance were all part of the domestic safeguards approach.

After the 1979 Three Mile Island event, the NRC focused more resources on nuclear safety and began to utilize an oversight program that included audit-based inspections for safeguards. The current material control and accounting process by the licensee is designed to use control and monitoring measures to prevent or detect loss when it occurs or soon thereafter. Additionally, statistical and accounting measures are used to maintain knowledge of the quantities of special nuclear material present in each area of a facility. Physical inventories and material balances are used to verify the presence of licensed material or to detect the loss of such material after it occurs, in particular, through theft by an insider.[5]

Oversight of the licensee's MC&A recordkeeping system by NRC inspections ensures accountability of nuclear material and demonstrates that performance objectives and facility system capabilities are met. Facility records used to provide complete and accurate information to the IAEA can also be used to trace source material and SNM declared inventory and flow in monthly inventory change reports (ICRs), physical inventory listings (PILs) and material balance reports (MBRs). Inspectors also review facility MC&A procedures associated with the receipt and shipment of imports and exports as described in a facility import or export license. Quality control of the US Government reports to the IAEA begins with the assurance of proper MC&A recordkeeping accuracy and completeness by the facility as outlined in the 10CFR 50.9 and 70.9.

Fuel Cycle Facilities

The framework for oversight includes gathering and processing performance information from a facility, evaluating risk by using a significance determination process based on results from risk assessments that licensees prepare under 10CFR Part 70. The NRC uses licensee provided performance indicator data to complement its core inspection, allowing the NRC to reduce the scope of these inspections, thereby enhancing efficiency for both the NRC and licensees.

The fuel cycle facility oversight program employs a predictable, graded process to focus NRC oversight and is based on risk and acceptability of performance. The NRC inspection program carries out a base level oversight program for all licensed facilities, focusing on the most safety and safeguards significant plant activities being performed.

Inspections at fuel cycle facilities occur several times a year and typically cover activities such as nuclear criticality control, chemical process, emergency preparedness, fire safety, and radiation safety. The facility Fundamental Nuclear Material Control Plan is required for each fuel cycle facility and is used as the framework for MC&A inspections. Resident inspectors are assigned to operating Category I Fuel Facilities and perform daily inspections at those sites. Periodic specialized inspections are conducted using personnel from NRC headquarters in Rockville, Maryland and the Region II office in Atlanta, Georgia. The NRC Inspection Manual provides guidance for inspectors on the objectives for each type of inspection and procedures to be used.

The Office of Nuclear Material Safety and Safeguards (NMSS) has overall responsibility for the NRC's regulation of fuel cycle facilities. NMSS personnel review all ICR, PIL and MBR reports prior to their transmission to IAEA Headquarters in Vienna, Austria. Currently there are three NRC licensed low enriched uranium (LEU) fuel fabrication facilities and one gas centrifuge

enrichment plant reporting to the IAEA under the U.S. Initial Protocol, utilizing a Transitional Facility Attachment (TFA) for guidance and a completed IAEA DIQ describing essential equipment and routine operations of the plant.

U.S. Additional Protocol

When the U.S. Additional Protocol (AP) entered into force on January 6, 2009, the U.S. Government began providing data to the IAEA that differed from previous data sets and required a new approach to quality control. In particular, the AP does not focus on accountancy reports from nuclear facilities but instead requires the U.S. to provide information on fuel cycle research and development activities not involving nuclear material, uranium recovery, site layout and building descriptions, export information, and other Article 2 activities. In order to ensure the overall quality of the U.S. declaration to the IAEA, the NRC recognized that two different approaches were required. First, the industry needed to be educated about the U.S. AP and its associated requirements to help ensure quality data is reported to the U.S. Government. Second, the NRC needed to perform continuous quality control reviews of the data that was submitted in order to catch any mistakes or negative trends.

The NRC began providing outreach on the U.S. AP and its associated requirements in 2008. It was recognized early in the process that one critical component of ensuring the quality of data provided to the IAEA was an adequate understanding of the U.S. AP by the domestic nuclear industry. Through tradeshows, conferences, and meetings, the NRC and Department of Commerce provided information to a variety of different licensees, and non-licensed advocacy groups (e.g., Nuclear Energy Institute). The focus of this outreach effort was on the various reporting requirements under the U.S. AP and the U.S. Government process and deadlines for submitting data.

Beginning with its initial declaration, the U.S. Government instituted a review process for the quality control of data. Multiple U.S. Government agencies reviewed the data to ensure it is consistent with requirements under the U.S. AP. While this was a fairly straightforward change, there is a fundamental difference between how data under the VOA and AP is treated within the U.S.

The Department of Commerce is used as the central repository for the entire U.S. Government data submitted pursuant to the AP. This means that NMMSS is not involved in the processing of data for the annual declaration, or the quarterly import/export requirements. By removing the traditional role of NMMSS, one critical quality control step is also removed from the process. Therefore, over time, the NRC adopted an internal review process that helps to augment the U.S. Government-wide process. As an example, beginning between late 2012 and early 2013, the NRC incorporated a review of AP documentation and source data into the domestic inspection program at uranium recovery facilities. Approximately once a year while on-site for an inspection, NRC inspectors will ask for the facility to produce the declared AP reports and any source data used to produce the final report. This process helps to ensure that licensees reporting under articles 2.a.v and 2.a.vi are correctly interpreting the requirements in 10 CFR Part 75, and that there are no typographical errors in what is sent to the Department of Commerce.

Summary

Accurate and complete reports provided to the International Atomic Energy Agency by the U.S. Government from selected US NRC licensed facilities is ensured by a series of measures established over nearly 70 years of experience in nuclear material control and accounting. After the U.S. Congress passed the Energy Reorganization Act of 1974 and the Export Reorganization Act of 1975, the NRC was made responsible for ensuring importing States of U.S. supplied SNM and equipment were under suitable safeguards. States with a comprehensive safeguards agreement in place fulfilled this obligation. Nuclear material accountancy has always been the key element to verify that no diversion of SNM has taken place and prevent diversion by threat of early detection. The U.S. Government utilizes a national database to track all source and SNM in the U.S., and provide reports to the IAEA. Quality control is incorporated into the nuclear material management and safeguards system software that provides reports for IAEA selected licensed facilities. The ICRs, PILs and MBRs are reviewed by the NRC prior to being sent to the IAEA. The Additional Protocol declaration review process is different than the nuclear material accountancy review process, in that it has an additional U.S. Government-wide review for initial declaration, annual updates and changes that takes place after the lead agencies review the declarations from those entities for which they are responsible.

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