IAEA
International Atomic Energy Agency

Nuclear Material Accounting Handbook

Vienna, May 2008

Services Series 15

IAEA Services Series No. 15

Nuclear Material Accounting Handbook

IAEA
International Atomic Energy Agency

May 2008

The originating Section of this publication in the IAEA was:

External Courses Unit
International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna, Austria

NUCLEAR MATERIAL ACCOUNTING HANDBOOK
IAEA, VIENNA, 2008
IAEA-SVS-15

© IAEA, 2008

Printed by the IAEA in Austria
May 2008

FOREWORD

The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) provides the legal basis for the negotiation of safeguards agreements between the International Atomic Energy Agency (IAEA) and States for the implementation of safeguards. Under these safeguards agreements, each State is required to establish and maintain a State system of accounting for and control of nuclear material (SSAC) subject to safeguards under the agreement. A cornerstone of both safeguards and the SSAC is nuclear material accountancy of which nuclear material accounting is a key component and includes the corresponding reports that are required to be submitted to the IAEA.

In recent years, not only has additional emphasis been placed on nuclear material safeguards; increased attention has been paid to physical protection, export controls and combating the illicit trafficking of nuclear material. With regard to IAEA safeguards and in the context of the IAEA programme for nuclear security, this handbook has been prepared by the IAEA for use by States and their organizations in their application of nuclear material accounting.

The handbook documents existing best practices and methods used to account for nuclear material and to prepare the required nuclear material accounting reports for submission to the IAEA. It provides a description of the processes and steps necessary for the establishment, implementation and maintenance of nuclear material accounting and control at the material balance area, facility and State levels, and defines the relevant terms.

This handbook serves the needs of State personnel at various levels, including State authorities, facility operators and participants in training programmes. It can assist in developing and maintaining accounting systems which will support a State’s ability to account for its nuclear material such that the IAEA can verify State declarations, and — at the same time — support the State’s ability to ensure its nuclear security. In addition, the handbook is useful for IAEA staff who are closely involved with nuclear material accounting.

Valuable support in the preparation of this handbook was provided by J. Maritz, the former long term head of the South African SSAC who, based on his excellent expertise and experience in the areas of nuclear material accountancy and through a Special Service Contract, prepared the first draft of the handbook, incorporated comments and proposals from the “Meeting of International Experts Consultative Group” and greatly assisted IAEA officials with its completion.

All experts participating in the “Meeting of International Experts Consultative Group” were very active in discussing the draft document and submitted a number of comments and advice on possible improvements of its content, structure and text. Their expertise and willingness to facilitate an open discussion on all areas of nuclear material accountancy, to be covered in the handbook, highly contributed to the creation of this well balanced publication.

The Agency is indebted to those who contributed to the process of creating this handbook.

EDITORIAL NOTE

The use of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the IAEA.

CONTENTS

1. INTRODUCTION

Accounting aspects of safeguards application by the IAEA in States

The IAEA safeguards system is viewed as a key instrument of international non-proliferation policy and implementation thereof is regulated by the IAEA Statute [1] and the accompanying safeguards activities based on IAEA safeguards agreements. The objective of the agreements is to verify that nuclear material subject to safeguards is not used for the manufacture of nuclear weapons or other nuclear explosive devices [2, paragraph 2] or for purposes unknown. These agreements focus on nuclear material, so the important element of implementation of safeguards is nuclear material accountancy.

In principle in IAEA safeguards, the use of nuclear material accountancy is the fundamental safeguards measure, with containment and surveillance as important complementary measures.

Purpose of the Handbook

The purpose of this handbook is to provide States with a document to assist them in developing and maintaining accounting systems which will support a State's ability to account for its nuclear material such that the IAEA can exercise its right and meet its obligation to verify a State's declarations.

This book describes the procedures, methods, measures and techniques which could be referred to as best practices when used in the State in establishing and maintaining the State system of accounting for and control of nuclear material (SSAC).

The intended audience is staff directly involved in and responsible for nuclear material accounting. However, it could also be beneficial to those who should be aware of needs for nuclear material accounting.

A nuclear material accounting system is one that keeps track of nuclear material in the possession of an organization. Accounting means to determine categories and quantities of nuclear material and to declare it to the IAEA or to the relevant authority.

When a comprehensive safeguards agreement is concluded between the IAEA and a State, as per (see Section 1, 1.1.2) IAEA document INFCIRC/153 (Corrected) [2], various requirements are stated: inter alia, that the State shall establish an SSAC and that safeguards be applied such that they enable the IAEA to verify that the nuclear material is not used for the manufacture of nuclear explosive devices.

The Statute of the IAEA defines nuclear material [1, Article XX,] as:

— special fissionable material: plutonium-239 or uranium enriched in the isotopes uranium-233 or uranium-235;

— source material: natural uranium or depleted uranium or thorium.

For further clarification:

— ‘safeguards’ refers to all measures established in a State to prevent the diversion of nuclear material from peaceful uses and to enable the timely detection of diversion of any material to the production of nuclear explosive devices;

— as to accounting and control of nuclear material, the emphasis in this book is on the accounting aspect. However, a certain measure of control always accompanies accounting, but only so far as it means administrative and management control relating to the possession, use and transfer of nuclear material as well as control over the organization, functions and performance of nuclear material accounting systems in the State [3, paragraph 1.3];

— the objective for safeguards and the system for accounting and control is the same: namely, verification to provide assurance that there has been no diversion of nuclear material from peaceful uses to nuclear weapons or other nuclear explosive devices or for purposes unknown;

— the State is and remains responsible for its system of accounting and control up to the point where verification is performed and a statement is made that no diversion of nuclear material has occurred. Therefore, emphasis will also be on provision of information on nuclear material for verification.

Nuclear material accountancy can be compared to established financial accounting and inventory control practices. Although an understanding of financial practices could be to the advantage of the user in establishing systems for nuclear material accountancy, there are vast differences between nuclear material accountancy and financial accounting. The difference between nuclear material accountancy and nuclear material accounting is explained in Section 1. In Section 2, a parallel is drawn between the two systems.

The user of the handbook will notice that there are occasions where it is indicated whether a matter is a requirement or just a recommendation.

There are various documents available at the IAEA to assist the States in setting up their SSACs. The most important are listed under ‘References’ at the end of this handbook. Though information contained in these documents appears in and forms part of the handbook, the handbook does not intend to add to, subtract from or amend in any way the objectives, requirements or guidelines described in the reference documents. The purpose of the handbook remains to assist States in developing, improving and maintaining accounting systems which will ultimately support the implementation of national and international objectives.

Scope

The handbook includes the steps and procedures a State needs to set up and maintain to provide assurance that it can account for its nuclear material and submit the prescribed nuclear material accounting reports defined in Section 1 and described in Sections 3 and 4 in terms of the relevant agreement(s), thereby enabling the IAEA to discharge its verification function as defined in Section 1 and described in Sections 3 and 4.

The contents of the handbook are based on the model safeguards agreement [2] and, where applicable, there will also be reference to the model additional protocol [3]. As a State using this handbook has a safeguards agreement based on the model safeguards agreement, references in this book are based on the above-mentioned models. The focus throughout will be on nuclear material and the related accounting.

The handbook consists of five sections.

In Section 1, definitions or descriptions of terms used are provided in relation to where the IAEA applies safeguards or, for that matter, accounting for and control of nuclear material in a State. The IAEA's approach in applying safeguards in a State is also defined and briefly described, with special emphasis on verification.

In Section 2, the obligations of the State immediately following the entry into force of its safeguards agreement, including some other possible obligations, are described. This section is intended to sensitize the officials involved in establishing nuclear accounting systems, reporting to the IAEA and facilitating inspections to attend to such matters. Part 2.1 relates to obligations of the State regarding INFCIRC/153-type agreements. Part 2.2 refers to accounting and reporting of source material in a State relating to a safeguards agreement and additional protocol. Part 2.3 presents other State obligations relating to accounting and reporting under bilateral agreements with another State(s). Part 2.4 describes resulting actions in a State necessary for establishing the SSAC in a State. This part also compares nuclear material accountancy with financial accountancy and other control measures.

Section 3 describes the activities related to nuclear material accounting implementation at State level. The aspects that feature in the section include:

— authority and responsibility relating to accounting of nuclear material in the State;
— laws, regulations and other measures necessary to account for nuclear material;
— the information system needed for an accounting system;
— establishment of requirements for nuclear material accounting and control;
— ensuring compliance and the inspection regime;
— technical support and training.

Section 4 focuses on the development of accounting and reporting aspects at facility level. To achieve the required objective, the aspects described are:

— organization and management of nuclear material accounting at the facility level;
— establishing a measurement system and measurement control programme at the facility;
— establishing a record and report system at the facility;
— establishing a system for physical inventory taking at the facility;
— establishing a system of material balance closing at the facility;
— the system of physical verification at the facility.

Section 5 attends to various topics relating to quality management. The IAEA, in applying safeguards in a State, expects to receive high quality data (e.g. correct, complete, accurate, consistent, formatted, timely and transmitted through appropriate channels). Proposals on systems to ensure this are discussed.

Finally, the various appendices are included, such as pro forma forms, examples and diagrams, and the lists of references and abbreviations that will be of value to users of the handbook.

2. IAEA NUCLEAR MATERIAL ACCOUNTING AND ITS IMPLEMENTATION IN STATES

This section describes nuclear material accounting from the standpoint of IAEA safeguards, how accounting is applied in States and features and significance of the IAEA cooperation with State systems of accounting for and control of nuclear material (SSACs) regarding nuclear material accounting. The basic concepts of nuclear material accounting are defined and the way these apply to States with INFCIRC/153-type safeguards agreements is described [2].

2.1. Nuclear Material Accounting and Accountancy

Nuclear material accounting refers to "activities carried out to establish the quantities of nuclear material present within defined areas and the changes in those quantities within defined periods" [4, paragraph 6.2]. Nuclear material accountancy is defined as "the practice of nuclear material accounting as implemented by the facility operator and the SSAC, inter alia, to satisfy the requirements in the safeguards agreement between the IAEA and the State (or group of States); and as implemented by the IAEA, inter alia, to independently verify the correctness of the nuclear material accounting information in the facility records and the reports provided by the SSAC to the IAEA" [4, paragraph 6.1].

In this book, the emphasis is placed on establishing and maintaining an accounting system which enables the State not only to account for the nuclear material, but also to submit the necessary accounting reports to the IAEA.

2.2. Legal Basis for Provision of Nuclear Material Accounting Data by States

With the ratification of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) [5, Art III (1)], States are required to negotiate a safeguards agreement with the IAEA using guidelines published by the IAEA as INFCIRC/153 [2]. This model safeguards agreement specifies various types of information that must be reported to the IAEA. In addition to accounting reports (paragraphs 62–67), information on material before or at the starting point of safeguards (paragraph 34); nuclear material customarily used outside facilities (paragraph 49); exports and imports of nuclear material (paragraphs 92–95); requests for termination, exemption or de-exemption (paragraphs 35–38); and special reports, if needed (paragraphs 68 and 97), must also be reported. The State is also obliged to submit information regarding safeguards relevant features of facilities (paragraph 8) to the IAEA.

When the safeguards agreement has been adopted, subsidiary arrangements are prepared to define procedures for implementing the provisions specified in the safeguards agreement. These subsidiary arrangements consist of a General Part applicable to all common nuclear activities of the State concerned, and a facility attachment, prepared for each facility in the State. The General Part is divided into subparts, called codes. Code 10 specifies the format (fixed or labeled) and content of accounting reports to be submitted to the IAEA by the State and provides the detailed procedures to be followed for reporting to the IAEA. There are two versions of Code 10 that have different formats but both provide for the necessary data elements for implementing safeguards. The format to be used is to be agreed on with the IAEA.

Safeguards agreements and subsidiary arrangements apply to an entire State. Details that are specific to individual facilities are specified in facility attachments that are negotiated between the State and the IAEA. These facility attachments describe the individual facilities and the manner in which safeguards are to be applied; they also specify how Code 10 will be applied in producing records and preparing reports for the facility (e.g. which specific reporting codes are to be used under certain circumstances). Models of facility attachments for various facility types have been developed by the IAEA for use as a basis for these negotiations.

The safeguards agreement and subsidiary arrangements specify the safeguards procedures to be applied to provide assurance that nuclear material accountancy can be performed on the basis of the State's nuclear material accounting system.

2.3. Nuclear Material Accountancy

Because nuclear material accounting is always a subset of accountancy, wherever the latter is discussed, accounting comes to the fore. Since the descriptions and definitions that follow might involve accountancy, they would always include nuclear material accounting:

2.3.1. State System of accounting for and control of nuclear material

INFCIRC/153 specifies that the safeguards agreement to be concluded with States should provide that the State establish and maintain a system of accounting for and control of all nuclear material subject to safeguards under the agreement. The SSAC corresponds to legal, technical and organizational arrangements that may have a national and an international objective:

— a national objective to account for and control nuclear material in the State and to contribute to the detection of possible losses or unauthorized use or removal of nuclear material; and
— an international objective to provide the essential basis for the application of IAEA safeguards pursuant to the provisions of an agreement between the State and the IAEA.

To achieve the above objectives, the SSAC should function at the State authority level as well as at the facility level.

While the functional separation between the State authority and facility levels may vary from State to State, in general the State authority level establishes the requirements for the SSAC and, in many cases delegates responsibility to the facility operator to implement the system in compliance with authority requirements.

The requirements of the SSAC will, to a great extent, depend on the types of nuclear activity and on the form and quantity of nuclear material present in the State.

The SSAC shall be based on a structure of material balance areas (MBAs) and shall provide for the establishment of a measurement system, a records and reports system, procedures for taking a physical inventory and provisions to ensure that accounting procedures and arrangements are correctly operated.

2.3.2. Facility and locations outside facilities

The IAEA makes the distinction between facilities and locations in States and other locations.

— Facility means "(a) a reactor, a critical facility, a conversion plant, a fabrication plant, a reprocessing plant, an isotope separation plant or a separate storage installation; or (b) any location where nuclear material in amounts greater than one effective kilogram is customarily used" [2, paragraph 106].

— Other locations, generally called locations outside facilities (LOFs), are "any installation which is not a facility, where nuclear material is customarily used in amounts of one effective kilogram or less" [4, paragraph 5.25].

2.3.3. Material balance area(s): single and multiple MBA facilities

MBA is an area in or outside of a facility such that:

— the quantity of nuclear material in each transfer into or out of each MBA can be determined; and

— the physical inventory of nuclear material in each MBA can be determined when necessary, in accordance with specified procedures in order that the material balance for IAEA safeguards purposes can be established [2].

The MBA is the nuclear material accounting area for reports made to the IAEA. Material crossing the boundary of an MBA must be reported to the IAEA as an inventory change and material within the boundary must be reported as part of the physical inventory. Movements of nuclear material within an MBA are not to be reported to the IAEA. However, as noted later, certain changes to nuclear material in an MBA (e.g. nuclear transformations, category changes and changes of batch structure) are to be reported to the IAEA.

Most facilities comprise only a single MBA; thus, for accounting purposes, the MBA and facility are identical. However, large, complicated facilities (e.g. manufacturing and reprocessing plants) frequently require additional internal controls that a single MBA structure cannot support. In such cases, an arrangement with a single facility comprising two or more MBAs may be agreed upon with the IAEA. In a State, it is possible to combine a number of LOFs under a single MBA.

2.3.4. Key measurement points

A key measurement point (KMP) is a location where nuclear material appears in such a form that it may be measured to determine material flow or inventory. KMPs thus includes, but are not limited to, the inputs and outputs and storage areas in MBAs. The facility attachment for a facility clearly specifies the flow and inventory KMPs agreed between the IAEA and the State.

2.3.5. Records system

The facility operator must maintain a system of accounting and operating records for each MBA [2]. The accounting and operating records system should reflect:

— all inventory changes, so as to permit a determination of the book inventory at any time;

— all measurement results that are used for determination of the physical inventory (including laboratory analyses and source documents); and

— all adjustments and corrections that have been made in respect of inventory changes, book inventories and physical inventories [2, paragraph 98].

2.3.6. Batch

The batch is the basic unit of nuclear material accounting in reports sent to the IAEA. All inventories and inventory changes are reported in terms of batches. It is a portion of nuclear material handled as a unit for accounting purposes at a KMP (see paragraph 2.3.4) and for which the composition and quantity are defined by a single set of specifications or measurements. The nuclear material may be in bulk form or contained in a number of separate items [2, paragraph 100]. Code 10 of the General Part of the subsidiary arrangements specifies the codes to be used to report the material's physical form, chemical form, irradiation status and containment. All items in a batch should be described with a single set of codes; otherwise it represents two or more batches. A batch might also be one item. On the basis of negotiations and consultations between operator, State authority and the IAEA, typical batches are defined in the facility attachment.

2.3.7. Initial report

The initial report is defined in INFCIRC/153 [2] as indicating all nuclear material subject to safeguards in a State. It has to be dispatched to the IAEA within 30 days of the last day of the month in which the agreement enters into force.

2.3.8. Reporting system

The operator prepares accounting reports based on MBA accounting records and submits these reports via the State (or relevant responsible authority of a group of States) to the IAEA.

2.3.9. Inventory change

Inventory change means an increase or decrease, in terms of batches, of nuclear material in an MBA [2, paragraph 107].

2.3.10. Physical inventory

The physical inventory is the sum of all the measured or derived estimates of batch quantities of nuclear material physically present at a given time within an MBA, obtained by facility operator in accordance with procedures specified [2, paragraph 113] by the operator(s) and described in facility attachment(s). It is determined by the facility operator as a result of a physical inventory taking (PIT) and is reported to the IAEA in a physical inventory listing (PIL).

2.3.11. Material balance

Establishing a material balance is the process of comparing a book inventory with the corresponding physical inventory for each type of nuclear material. This is done as of the date of physical inventory taking and any difference in the result of the comparison is known as material unaccounted for (MUF).

2.4. Accounting concepts

Using the definitions given above, the following are some specific examples of the major concepts used in IAEA nuclear material accounting.

2.4.1. Physical inventory listing

Each MBA contains an inventory of nuclear material that must be reported to the IAEA; the timing of inventory taking is normally specified in the facility attachment. This inventory is reported as a PIL, indicating the batches that are present at each inventory KMP. The listing typically provides one entry for each batch of nuclear material present in the MBA as of midnight on the date of the PIT or on an agreed date (usually the last day) of a PIT that takes several days. If there is no inventory on the date of the PIT, a 'null' PIL (a PIL with no batches) must be submitted indicating that there is no inventory. If there is nuclear material at the MBA at the time that the MBA comes under safeguards, an initial PIL is submitted listing all of the nuclear material batches. If there is no inventory of nuclear material when the MBA comes under safeguards, a dummy initial PIL is not required.

There are situations, due to rounding, when the physical inventory does not exactly match the information reported on the PIL, one reason being that MBAs have the option of reporting rounded figures on their reports to the IAEA. For reporting purposes the weights of individual items in the batch shall be added together before rounding to the nearest unit. In such cases, the sum of the rounded figures reported in the PIL might differ from the sum of the unrounded figures. This situation must also be taken into consideration when submitting other reports to the IAEA, as described in 1.1.4.9.

2.4.2. Inventory change report

Over time, the inventory of nuclear material at an MBA may change due to shipments, receipts, nuclear transformations (e.g. production of plutonium and consumption of uranium), transfers to waste, process losses, accidental gains or losses of material. Most inventory changes involve the movement of material across the MBA border; however, there are several inventory changes (e.g. nuclear transformations, uranium category changes and blending) that occur within the MBA boundaries. These inventory changes must be reported to the IAEA in an inventory change report (ICR), indicating the flow KMP involved in the change. If there is no inventory at an MBA when it comes under safeguards, an ICR reporting the receipt of material will be the first accounting report normally received by the IAEA. Inventory changes that occur on the same date as a PIT are deemed to occur before the PIT is established.

2.4.3. Shipper/receiver difference

Code 10 of the General Part of the subsidiary arrangements specifies that nuclear material received at an MBA shall be reported on the basis of the shipper's data. Therefore, receipts shall be reported using the shipper's weights. If the receiving MBA subsequently determines a weight of nuclear material different from that specified by the shipper, it must then report a shipper/receiver difference in an ICR which adjusts the receiver's values at the IAEA to match those that the receiver maintains on its books. The adjustment is accounted for as the day of the determination, and not as of the original receipt date.

A shipper/receiver difference (SRD) is viewed as an adjustment, but is reported as an inventory change in an ICR. It is defined as the difference between the quantity of nuclear material in a batch, as stated by the shipping MBA, and that measured at the receiving MBA [2, paragraph 114]. It is, thus, a component part of determining the book inventory defined in paragraph 1.1.4.4.

2.4.4. Book inventory

The book inventory for an MBA for each nuclear material category is the algebraic sum of the previous physical inventory (as determined at a PIT) and any subsequent inventory changes (as reflected in the ICRs). Thus,

Book inventory	=	Previous physical inventory + Increases to inventory – Decreases in inventory

The book inventory is a statement of what nuclear material should be present in the MBA.

2.4.5. Rounding adjustment

A rounding adjustment (RA) is used to account for differences between summarized MBR values and the sum of amounts in the corresponding ICR or PIL values.

It is reported only in MBRs and is added to the MBR value so that the MBR amount agrees with the consolidated sum of the relevant ICR or PIL entries.

Rounding adjustments could be minimized by a State keeping all facility records and State reports to the same level of decimal significance, while still maintaining the minimum reporting level of units as required by Code 10 of the General Part of the subsidiary arrangements.

2.4.6. Material balance period

The material balance period (MBP) is the period between two consecutive PITs. From the IAEA's accounting perspective, an MBP starts at 00.00 on the day after a PIT and ends at 24.00 on the date of the subsequent PIT.

2.4.7. Material balance

Establishing a nuclear material balance for an accountable element or isotope in an MBA is the process described by:

— Taking a physical inventory.

— Identifying and summarizing all inventory changes since the previous physical inventory taking.

— Determining the amount of material that should be in the MBA by accounting for all increases and decreases since the previous physical inventory taking.

— Adjusting for rounding and shipper/receiver differences.

— Comparing the amount that should be in the MBA to that which is physically present.

2.4.8. Material unaccounted for

When the physical inventory is determined at the subsequent PIT (in preparation for submission of the PIL) and the material balance is closed, it may be determined that this physical inventory differs from the book inventory calculated on the basis of the previous physical inventory and subsequent inventory changes. The difference between the book inventory and the physical inventory is defined as material unaccounted for (MUF).

$$\text{MUF} = \text{Book inventory (as of date of the PIT)} - \text{Current physical inventory}$$

Thus, MUF is the difference between the weight of material that should be in the MBA based on the accounts and the weight that is actually there. MUF can be negative (if more inventory is found than calculated), positive (if less inventory is found than calculated) or zero. For item facilities, normally zero MUF is expected. For bulk handling MBAs a non-zero MUF is expected because of measurement uncertainties and the nature of the process. MUF is not in itself an indication that diversion has occurred, but does constitute an estimate of the quantity that might have been available for diversion. One aspect of nuclear material accountancy performed by the IAEA is to evaluate the significance of MUF. This is clarified in Section 4.

2.4.9. Material balance report

A material balance report (MBR) is defined as an accounting report submitted by the State to the IAEA showing the material balance based on a physical inventory of nuclear material actually present in the MBA.

The MBR entries are:

— Beginning physical inventory;

— Increases, summarized for each inventory change type;

— Decreases, summarized for each inventory change type;

— Shipper/receiver differences;

— Rounding adjustments;

— Book inventory;

— Ending physical inventory;

— MUF.

2.5. Reporting to the IAEA

The following reports and associated information should be submitted to the IAEA in the formats specified in the subsidiary arrangements.

2.5.1. Initial report

An initial report, preferably in the format of a PIL, must be submitted if the MBA contains nuclear material when it becomes subject to safeguards. If there is no material in the MBA, a ‘null’ inventory report could be submitted; in such a case, the subsequent report will be an ICR reporting receipt of nuclear material. Note that the first material balance period starts one day after the initial report date or on the date of the first ICR transaction.

2.5.2. Inventory change report

The ICR is an accounting report provided by the State to the IAEA “showing changes in the inventory of nuclear material”. Using the set of codes specified in Code 10 of the General Part of the subsidiary arrangements, each inventory change (including nuclear material category changes) in an MBA must be reported to the IAEA.

2.5.3. Material balance report and physical inventory listing

At the end of the material balance period, the MBA submits an MBR summarizing the status over the MBP for each material category. The PIL submitted with the MBR provides a basis for calculating the ending physical inventory figure on the MBR. The MBR ending physical inventory (PE) provides the beginning physical inventory (PB) for the subsequent MBP.

2.5.4. Concise notes and textual reports

Each MBA, report or entry in a report may be referred to by concise notes to explain or elaborate on the information provided in the report. A concise note is frequently used to provide the recipient’s name for a shipment, the effective burn up for a report of nuclear production/loss, explanation of accidental gain/loss, exemption, re-application and termination, or the reason for a correction. One of two possible formats in Code 10 of the General Part of the subsidiary arrangements also provides for stand-alone textual reports in addition to concise notes.

2.5.5. Special reports

The safeguards agreement specifies that special reports shall be provided to the IAEA if unusual circumstances occur. There is currently no standard form for such reports.

2.5.6. Timeliness requirements

Nuclear material accounting reports are to be submitted to the IAEA as soon as possible after the corresponding event, but at least within a specified time period. INFCIRC/153 specifies that an ICR must be submitted within 30 days after the last day of the month in which inventory changes occurred or were established and that an MBR with its accompanying PIL must be submitted within 30 days of the PIT.

2.5.7. Corrections to reports

It may be necessary to correct information provided to the IAEA in previous accounting reports and those corrections are the responsibility of the State. These corrections must be included in subsequent reports of the same type (i.e. ICR, MBR or PIL), either as a report consisting only of corrections or mixed with new original entries. Under exceptional circumstances and only for certain data elements, the IAEA may be contacted with a request in writing to perform the correction on behalf of the State. An audit trail of all changes made to accounting data is retained in the IAEA information system.

3. STATE OBLIGATIONS AND RESULTING ACTIONS

States with nuclear fuel cycle activities may accede to the NPT at various stages of the life cycles of their facilities and conclude safeguards agreements with the IAEA. This section describes the State obligations immediately after a safeguards agreement with the IAEA has entered into force.

3.1. Obligations under safeguards agreement relating to accounting and reporting

3.1.1. State system of accounting for and control of nuclear material

A Government that enacts a safeguards agreement with the IAEA has to establish and maintain an SSAC indicating clearly that on the State level, organizational arrangements are established such that the national and international objectives of the SSAC are met.

The SSAC should be independent from any operators or promoters of nuclear energy or related activities dedicated to nuclear material accountancy and safeguards matters. As such it should be a central coordinating body with the basic functions, as stated in parts 2.3 and 2.4.

3.1.2. Initial report

The safeguards agreement requires that an initial report be provided to the IAEA. This initial report shall include all nuclear material [2] inventories in facilities and LOFs which are subject to safeguards under the agreement. This report shall be dispatched by the State concerned to the IAEA within 30 days of the last day of the month in which the agreement enters into force and shall reflect the status of the State's inventories as of the last day of that month. The following should be considered when preparing the initial report:

— Nuclear material in non-nuclear use should also be declared and form part of the initial report. Thereafter, requests for exemption thereof could be arranged with the IAEA, as provided for in the safeguards agreement;

— Nuclear material in retained waste should also be included in the initial report [4];

— The initial report could be merely a summarized statement for each facility (MBA), but it is preferred that a PIL format is used.

3.1.3. Provision of design information

Apart from the nuclear material mentioned in the previous paragraph, information regarding features of facilities and LOFs where the nuclear material is present should be submitted using a design information questionnaire (DIQ). According to the safeguards agreement, the IAEA should be provided with such information to the extent relevant for the implementation of IAEA safeguards.

3.1.4. Negotiating subsidiary arrangements

Negotiating subsidiary arrangements is one of the first steps in implementing the safeguards agreement. This will greatly support the State in establishing a nuclear material accounting system and defining safeguards starting point, exemptions, terminations etc. The discussions between the IAEA and the State regarding the above aspects should start as soon as possible following signing of a safeguards agreement in connection with the NPT.

3.1.5. Reports regarding changes to inventories and physical inventory taking

Submitting reports on changes to nuclear material inventories to the IAEA is one of the main obligations of the State under the safeguards agreement. The changes occurring on the first day following the date of the initial report and onwards should be reported in an inventory change report (ICR), and consequences of the changes occurring on or before the date of the initial report should be reflected in the initial report. Therefore, material shipped on or before the date of the initial report should not be included in it.

Reporting on PITs is an obligation on the State after signing an agreement with the IAEA. The timing thereof should be communicated to the IAEA so as to allow for the physical inventory verification during, or in reasonable time after, the PIT. The interval for inventory taking should be specified in the facility attachment.

3.1.6. Keeping prescribed records

The State should establish a system for keeping the prescribed records for each MBA that enables it to substantiate the amounts reported as well as to provide data with regard to the complete inventory of nuclear material in the State.

3.1.7. Facilitating IAEA inspection activities

IAEA inspectors have the task of verifying State declarations through regular verification activities. The obligation is on the State to facilitate such inspection activities. This also implies providing the necessary correct and complete information in a timely manner.

3.2. Accounting for and reporting source material in State

3.2.1. Introduction

The NPT states clearly in Article III (2) that States party to the NPT should not provide source material to non-nuclear-weapon States for peaceful purposes unless such source material is subject to safeguards [5]. Source material is defined as “uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound, or concentrate; any other material containing one or more of the foregoing in such concentrations as the Board of Governors shall from time to time determine; and such other material as the Board of Governors from time to time determines” [1]. What is further important is that the term ‘source material’ shall not be applied to material in mining or processing activities [2].

The importance of each of the components mentioned above is that:

— natural uranium as it occurs in nature can be enriched and in so doing provides special fissionable material;

— in the case of uranium depleted in the isotope 235, the abundant isotope 238, could be utilized for the production of plutonium, which is special fissionable material;

— in the case of thorium, it could, through transmutation in a nuclear plant, become the uranium isotope 233 which is defined as special fissionable material.

The starting point of all safeguards procedures for nuclear material, as defined in paragraph 34(c) of INFCIRC/153, differentiates between uranium or thorium of a composition and purity suitable for fuel manufacturing or for isotopic enrichment [2] and uranium or thorium which is not. Ore and ore residue should not be viewed as source material. From the above it is also clear that there are two classes of source material, namely material "suitable for fuel fabrication or for isotopic enrichment" and material not yet satisfying these criteria [2]. The first class will be accounted for and reported to the IAEA according to all safeguards procedures. For the second class of source material, the facility attachment will specify at what stage it will be subject to all safeguards procedures.

For nuclear material that has not yet reached that stage, nuclear material accounting does not apply but some safeguards provisions are relevant and records need to be kept about this material, especially viewing the corresponding requirements in the additional protocol. Information specifying the location, operational status and the estimated annual production capacity of uranium mines and concentration plants and thorium concentration plants, and the current annual production of such mines and concentration plants is to be provided upon the provision of Article 2.a.(iv) of the additional protocol. This information does not require detailed nuclear material accountancy.

3.2.2. Reporting requirements under safeguards agreement and additional protocol for source material which is not suitable for fuel fabrication or for isotopic enrichment

The State should have a system, as foreseen in section 2.2.3, to enable it to perform its obligations regarding exports and imports for nuclear purposes relating to source material under paragraph 34 of safeguards agreements [2]:

— When any material containing uranium or thorium which has not reached the stage in the nuclear fuel cycle where it has a composition and purity suitable for fuel fabrication or isotopic enrichment, or has directly or indirectly been exported to a non-nuclear-weapon State, the IAEA should be notified regarding the quantity, composition and destination.

— When any material containing uranium or thorium which has not reached the stage in the nuclear fuel cycle where it has a composition and purity suitable for fuel fabrication or isotopic enrichment is imported into a State, the IAEA shall be notified regarding the quantity and composition.

Additional protocol Articles 2.a. (v) and (vi) spell out what the State's obligations are relating to source material:

— Article 2.a. (v) requires information specifying the location, operational status and estimated annual production capacity of uranium mines and concentration plants and thorium concentration plants and the current annual production of such mines and concentration plants in the State as a whole. The State shall provide, upon request by the IAEA, the current annual production of any individual mine or concentration plant [3];

— Article 2.a. (vi) requires information on use, intended use and export or import for non-nuclear purposes regarding source material which has not reached the composition and purity suitable for fuel fabrication or for isotopic enrichment [3], as follows:

- The quantities, chemical composition, use or intended use thereof, whether in *nuclear or non-nuclear use* for each location in the State at which material is present in quantities exceeding ten metric tons of uranium or twenty metric tons of thorium and for other locations with quantities of more than one metric ton, the aggregate for the State as a whole if the aggregate exceeds ten metric tons of uranium or twenty tons of thorium.

- The quantities, chemical composition and destination of each export out of the State of material for *non-nuclear purposes* where quantities exceed ten metric tons of uranium or for successive exports from the State of less then ten metric tons, but exceeding a total of ten metric tons per year. Also, for twenty metric tons of thorium, or for successive exports from the State of less then twenty metric tons, but exceeding a total of twenty metric tons per year.

- The quantities, chemical composition, current location and use or intended use of each import into the State of material for *non-nuclear purposes* where quantities exceed ten metric tons of uranium or for successive exports from the State of less then ten metric tons, but exceeding a total of ten metric tons per year. Also, for twenty metric tons of thorium, or for successive exports from the State of less then twenty metric tons, but exceeding a total of twenty metric tons per year.

The provision of information for Articles 2.a. (v) and (vi) does not require detailed nuclear material accounting. It is further understood that there is no requirement to provide information on such material intended for non-nuclear use once it is in its non-nuclear end-use form. General guidance on preparing and submitting such information is available [6].

3.2.3. State accounting system for production, imports/exports and stocks

Production: This is one part of the information required from the State by the IAEA in terms of the additional protocol (See 2.2.2). It will therefore be necessary for the State to maintain records regarding production of mills or concentration plants relating to uranium and thorium. This will allow for preparation of whatever reports are necessary. The State should request the submission of such information from producers of uranium/thorium.

Imports and Exports: As for the above information, that concerning imports and exports should also be submitted at least semi-annually (preferably monthly or quarterly), allowing the State authority also to report information relating to paragraphs 34(a) and 34(b) of INFCIRC/153.

Stocks: Producers should submit reports concerning stocks at least annually (preferably quarterly) to allow the State authority to reconcile production, imports and exports with the current stocks and to report in terms of the additional protocol as required.

Material	INFCIRC/153 Type Agreement	Additional Protocol in Force
Import (nuclear use)	Paragraph 34(b)	N/A
Import (non-nuclear use)	N/A	Article 2.a.(vi)(c)
Export (nuclear use)	Paragraph 34(a) (only to NNWS)	N/A
Export (non-nuclear use)	N/A	Article 2.a.(vi)(b)
Stocks (nuclear use)	N/A	Article 2.a.(vi)(a)
Stocks (non-nuclear use)	N/A	Article 2.a.(vi)(a)
Stocks (use not known)	N/A	Article 2.a.(vi)(a)

FIG. 1. NNWS Reporting Modalities of Source Material.

3.3. Other State obligations relating to accounting and reporting

A State may also have an obligation to comply with a bilateral agreement with another State that requires, for example, separate accounting for nuclear material supplied by that State. The obligations for a State may be a series, or network, of such agreements. Supplier States might only be willing to provide nuclear material or equipment under such a bilateral safeguards agreement. The agreement will impose obligations on the receiving State to control the material and equipment in various ways, including requiring the receiving State to keep track of the items and material to which those obligations are attached. A report of all items carrying an obligation to a supplier is made to the relevant bilateral partner. Bilateral obligations typically impose commitments on receiving countries such as notification of receipts and shipments, regular reports to the supplier and alternative safeguards measures to be implemented if the existing safeguards regime ceases.

National objectives can differ widely in scope from State to State. Many will include some requirement for physical protection oversight. This goes beyond what is required under IAEA safeguards agreements (but not beyond what might be required by bilateral agreements). Others may include requirements for radiation protection and control of nuclear material transport or emergency planning. There are a number of States requiring the accounting for and control of nuclear material before the starting point of IAEA safeguards, such as for uranium ore concentrate (yellowcake) or, conceivably, after the termination of IAEA safeguards. The reasons and extent to which the national authority carries out completely independent accountancy of nuclear material, similar to that carried out by the IAEA, varies from country to country.

3.4. Resulting actions in State

3.4.1. Laws and regulations

Legislation is needed in a State to ensure that it meets both its national and international obligations. One of the main objectives should be to enact requirements relating to what is expected in terms of the safeguards agreement. Detailed description of necessary legislation is provided for in the *Handbook on Nuclear Law* [7]. The necessary laws and regulations will allow the State to enforce the implementation and application of safeguards on the national level. In various countries, nuclear energy is regulated by a nuclear energy act and accompanying regulations which prescribe exactly, how safeguards will be implemented, and provides for the establishment of a State authority.

3.4.2. Assigning State authority

Below is a description of a possible structure for appropriate authorization, coordination, control and supervision of the SSAC:

— Government department where the power to regulate nuclear fuel cycle activities is vested;

— State level SSAC body, independent from nuclear energy promoter, to whom the authority to provide assurance that IAEA safeguards and any additional protocols are implemented and applied is delegated and which then, on behalf of the State, is the designated State authority;

— Facility level SSAC to which implementation of safeguards related to the facility is delegated and, as such, forms an integral part of the SSAC in the State.

This will, however, depend on the State.

Government responsibilities could include the issuance of a licence to site, construct and operate a nuclear facility and the necessary authority for possession acquiring, use or disposal of nuclear material and further to import, export, process, enrich or reprocess nuclear material. The Government, however, is free also to delegate some of these responsibilities to the State authority.

3.4.3. SSAC at the State level: State authority

The State authority has been delegated authority and responsibilities and will be functioning under a leader such as a manager, senior manager and director, or as appropriate. For practical reasons, especially for States with significant nuclear fuel cycle, it is advisable to divide the group into two sections:

— The first section will be responsible for the collection of reported data, the processing thereof and submission of reports to the IAEA and other stakeholders and eventually the establishment and maintenance of a filing system. This is the safeguards information systems section. It is clear that the main responsibility of the section is that of nuclear material accounting and reporting at State level and will consist of a number of officials to be able to perform such responsibilities and also responsibilities relating to the information system, networking facility and general administrative functions;

— The second section is the safeguards inspection section. It consists of a number of officials mainly responsible for nuclear material control. The number of inspectors in State inspections would vary depending on the number and type of nuclear facilities as well as the nuclear material programmes. However, it is possible that each inspector could be responsible for a number of facilities, depending on other responsibilities to be performed in the *State authority* as such.

To meet national objectives, the *State* authority may place additional requirements on facility operators, e.g., a requirement for the separation of the nuclear material accounting and control function from operations and, in the process, provide organizational checks and balances.

Various sources indicate that the State level component of the SSAC could be addressed by the functional elements mentioned below:

— Authority and Responsibility (including Independence);
— Laws, Regulations and other Measures;
— SSAC Information System;
— Establishment of Requirements for Nuclear Material Accounting and Control;
— Additional Protocol Implementation;
— Export/Import Controls;
— Ensuring Compliance (Inspection/Verification Activities);
— Technical Support and Training.

The above elements are discussed in Section 3.

3.4.4. Accountancy system versus financial system

To understand the central position that accountancy holds in the responsible handling of nuclear material, it is useful to draw an analogy with a financial system. However, it must be emphasized that, though there are some similarities, there are vast differences between nuclear material and financial accounting, especially when it comes to determining the amounts in question.

In most countries it is not necessary to be issued with a licence or permit to hold money. It is, however, necessary to hold a licence to operate a bank, where large quantities of money are handled.

Banks make ample use of physical protection to prevent the money they hold from being taken by thieves. But physical protection is only one part of the story, because all it does is provide a disincentive to people from outside the bank from trying to rob it. The bank also needs to assure itself that its own employees, or others who may have found a way of stealing that bypasses the physical protection system, have not removed money.

Accountancy provides this assurance, in that it allows one to verify that all the money that should be there is there, by providing for proper recording and approved movements into and out of the bank.

If one assumes that the accountancy system itself has not been tampered with, then it will show all losses of money, regardless of who stole it and how they did so. It does not ask how the money was lost, but only whether we have all the money we calculate that we should have. That is the great strength of accountancy, and explains why it is so widely used for valuable and dangerous material.

Seen in this light, physical protection and accountancy are complementary. Physical protection has its effect before the theft, and thus has the power to prevent it. But it is not effective against all theft mechanisms.

Accountancy, on the other hand, acts mainly after the loss or theft, and thus is powerless to prevent them (except by deterrence due to the thieves' foreknowledge that the loss will be detected), but it should, in principle, detect loss or theft by every possible route.

In addition, we might observe that we can rely very heavily on physical protection, and comparatively little on accountancy when the money or material is not being used, but is contained in a safe or vault which is never opened. As we move from that situation towards one where the money or material is frequently used and where many people have access to it, physical protection has less and less of a part to play, and accountancy becomes more and more important.

We can extend the analogy between a bank's accounting system and nuclear material accountancy further. A bank's accounts are likely to be verified by auditors to provide assurance that the bank management is not itself removing, for its own personal use, money which is rightly the property of the bank's shareholders or investors, or perhaps the State. It is quite likely that a large bank will hold internal audits, carried out by the bank's own staff, and external audits carried out by auditors quite independent of the bank. We can see that the internal audit is analogous to certain activities carried out by the national safeguards system, and that the external audit is analogous to the IAEA's verification activities.

However, there is an important difference between accounting for money and accounting for nuclear material, which applies where the nuclear material is in loose, or bulk, form. This is that money conveniently has its value, which is almost invariably a whole number of currency units, stamped or written on it. As a result, there is no uncertainty associated with its value, which is known exactly. On the other hand, if one considers a drum containing say, uranium oxide, we can never determine its nuclear material content exactly. We can only estimate the contents by making measurements, which are always associated with known uncertainties. In addition, to be able to identify the origin of the nuclear material in question, accounting for it requires implementation of a procedure for nuclear material batch follow-up. This is not applicable in accounting for money.

3.4.5. Control measures

The above paragraph indicates that there are various control measures. The first measure that comes to mind when one thinks of a State keeping nuclear material under control is the introduction of some kind of licensing system, or a system of permits. Under such a system, it may be that only specific individuals or organizations are permitted, or licensed, to hold nuclear material, and then only for well-defined purposes, and subject to defined conditions. In short, there will be legislation governing the use and handling of nuclear material, the details of which can vary considerably from country to country.

The above is indicative of a means of discharging the safeguards function, which becomes the measures a State would establish to prevent the diversion of nuclear material from peaceful uses and the timely detection of diversion of any nuclear material to the production of nuclear explosive devices.

To elaborate further on a State's obligations regarding nuclear material accounting implementation at State level, the State level components of the SSAC are addressed in Section 3.

3.4.6. Nuclear material accounting at facility level

Nuclear material accounting at the facility level will then be conducted by facility officials who do not perform line functions. An official could be appointed as safeguards implementation officer responsible for implementation and application of safeguards at assigned facilities. Also, nuclear material accountants could be appointed, each responsible for the nuclear material accounting and reporting at as many facilities he/she can handle. Each safeguards implementation officer with the nuclear material accountants will then form the nuclear material control group. The principal point is that the safeguards implementation officer is the point of contact through which the State authority communicates with the facility and through whom safeguards is applied at a facility.

To elaborate further on a State's obligations regarding nuclear material accounting implementation at facility level, the facility level components of the SSAC are addressed in Section 4.

4. NUCLEAR MATERIAL ACCOUNTING IMPLEMENTATION AT STATE LEVEL (STATE INVENTORY)

4.1. Introduction

Once nuclear activities begin in a State, that State has to establish its regulatory role in a number of different areas. Some examples of such areas where the State needs to exert control primarily for its own benefit and to protect its citizens might include:

— protection of workers and the general populations against radiation;

— use and transportation of radioactive material;

— radioactive waste management;

— engineered nuclear safety and licensing of installations;

— export/import control;

— physical protection of nuclear installations;

— accounting for and physical protection of nuclear material to ensure that it is not stolen and no diversion occurred;

— environmental monitoring.

The State exerts control in these areas primarily to meet its national needs and objectives. There are, however, areas where a State has to exercise control in order to fulfil its international obligations, i.e. to meet international objectives.

One of the areas is the nuclear material accountancy and control required to meet the obligations incurred when the State joined the IAEA safeguards regime. But the State could also have other resulting activities in its territory, as we have seen in Section 2. And it may have other nuclear obligations not related to IAEA safeguards (e.g. where the State has a responsibility to notify another State regarding its nuclear material in that State).

The functions of an SSAC are carried out at two principal levels, namely the State level and the facility level. In this handbook, it is assumed that the person or group of persons that carries out the functions of the SSAC at the State level is known as the State authority, as was envisaged in Section 2.

Many of the functions of the State authority involve establishing standards of performance to be maintained by persons and organizations in possession of nuclear material, i.e. the nuclear facility operators. Facility or LOF operators are said to carry out the functions of the SSAC at the facility level. The State authority also has the responsibility of confirming that the standards it prescribes are, in fact, maintained. Therefore:

— responsibility for establishing, implementing and maintaining all nuclear regulatory systems in a State, including designation of the SSAC, rests with the government of that State (or, if a number of States establish this task collectively, with all their governments); and

— a State will normally designate a State authority to implement and maintain the system. This authority will need to have certain legal powers to fulfil its functions, so it will have to be backed up by legislation.

4.2. Authority and responsibility relating to accounting of nuclear material

To establish an SSAC, the government should take the following steps.

4.2.1. Defining objectives

The State's international objective may just be to meet its safeguards commitments under INFCIRC/153 and agreements, including additional protocols. However, it may also have an objective of complying with a bilateral (or regional) agreement with other State(s), as is described in Section 2.

As far as the national objective is concerned, Section 2 provides a description of the scope and resources committed to achieve it, while the introductory paragraph to this section also provides further information relating to this matter.

4.2.2. Designating nuclear material accounting and control authority

The designated responsibilities of the State authority include:

— Establishing, or assisting with establishing, provisions governing the possession, acquisition, disposal or use of nuclear material, taking into account the State's obligations under IAEA safeguards agreements and bilateral agreements, such as reporting, keeping records, and giving advance notification. Regarding this responsibility:

  – the State authority should set up a system requiring those involved to apply for and obtain the necessary licences or permits for possession, acquisition, disposal or use of nuclear material;

– the State authority should act in accordance with national legislation and what it allows them to do so as to fulfil the State’s national and international obligations;

– the necessary channels of communication should be established in a State to complement the State’s information system described in 3.4. If there are multiple levels in the SSAC at State level, further communication channels should be established.

— Ensuring that the State’s nuclear material accounting and control objectives are met as mentioned in the State legislation. Therefore:

– in the case of acquiring or transferring nuclear material, the State authority should set up a system to ensure timely advance notification in terms of relevant agreements;

– similarly, the State authority should set up a system to ensure that the operators of facilities provide the necessary reports for submission to the stakeholders and that the accounting records are kept at State authority offices;

– a system should be established that is able to handle not only documents from the operator but also documents received from the IAEA. The system must be such that it can trace both incoming and outgoing documents and retrieve them from the filing system. The system must also provide all necessary features to be in compliance with relevant information security and retention requirements.

— Serving as the point of contact in implementing relevant agreements concluded with the IAEA and bilateral agreements, including, where appropriate, the State’s additional protocol. Regarding this responsibility:

– the State authority is, in fact, the centre around which the various activities relating to safeguards implementation revolve. So the ability of the State authority to handle these activities, especially nuclear accounting activities, is really crucial for the successful application of safeguards in the State;

– in the case of the additional protocol, the provision of information could involve more than that provided by nuclear facilities, and might involve, for example, private laboratories or universities. This needs a national communication network to be established by the State authority with detailed definition of roles to be performed by all involved entities.

— Developing, approving and implementing nuclear material accounting and control procedures necessary to enable the State to discharge its obligations under IAEA safeguards agreements. In more detail:

– these procedures relate, for example, to the preparation and keeping of prescribed records, submission of reports, measurement systems and control programmes. The procedures are accompanied by instructions for the above and for physical inventory taking (PIT) and reporting thereof and for material balance closing, which follows the PIT. These activities are carried out with the full cooperation of all parties involved;

- the requirements for nuclear material accounting and control are fully described in part 3.5;
- the various procedures and instructions will be updated regularly and the latest versions will be available to those concerned after approval by the State authority and then be implemented as of a certain date.

— Where appropriate, developing procedures for:

- collecting a complete and accurate set of information meeting the requirements of Article 2 of the additional protocol;
- forwarding required information to the State authority;
- updating that information in a comprehensive and accurate way as required by Article 3.

It is not obligatory but *recommended* that all the foregoing responsibilities should be discharged by a single body. All the above five main items relate to meeting the international objective. When one adds possible further responsibilities directed at meeting the national objective, it is likely that they will be shared or may even reside elsewhere.

4.2.3. Establishing appropriate arrangements for prompt notification of responsible government authorities

In the event that evaluation of accounting and control information suggests loss, unauthorized use or removal of nuclear material, it should be investigated and reported. The following apply:

— These arrangements may imply a special report or other form of notification to the IAEA, but the system must be such that it prompts the State authority to act decisively and act quickly so as to inform the various stakeholders regarding a sudden change in inventories in a State.

— The arrangements may include responsibility for the detection and response to instances of illicit trafficking of nuclear material.

— If the State is a party to the IAEA’s illicit trafficking database, the IAEA should be informed. There should be arrangements for the State authority to obtain such information regarding nuclear material. There should be excellent cooperation between the State authority (as the point of contact), police, custom officials, intelligence agencies and facility operators in identifying such material.

4.3. Laws, regulations and other measures necessary to account for nuclear material

As was indicated in Section 2, the State authority must be seen to be a body separate from the promoter of nuclear industry, especially by the IAEA, which will take into account the perceived effectiveness and functional independence of the State authority when determining the actual intensity, duration, timing and mode of routine safeguards inspections.

The form of the State authority's legislation and, more particularly, the regulations introduced under it, varies from country to country, especially in the extent to which they seek to lay down detailed prescriptive rules for every facet of national system operation. Legislation could vary from very modest to very complex; however, the objective should be to regulate nuclear material accounting and control in the State. Licences issued to facility operators would, in some cases, be very prescriptive, establishing in advance and in considerable detail how each aspect of nuclear material accountancy is to be implemented. Others, on the other hand, may contain only general requirements. Facility operators, when making applications for licences, would define the manner in which they propose to fulfil the requirements.

Although there may be different views about which of these two systems is preferable, there is really no evidence to show that either is inherently superior to the other. Whatever the form of the requirements — whether they are written into legislation, regulations or licence conditions — they should cover nuclear material, facilities and international transfers as described in the following paragraphs. Where appropriate, there should also be legal requirements to ensure that the State is able to meet its commitments under the additional protocol.

4.3.1. Nuclear material

The legislation should establish conditions for possession of nuclear material, including possession thereof outside facilities, for transfer, including imports, exports and domestic transfer, and for use.

The legislation should empower the State authority to administer domestic safeguards. Persons or organizations who possess, use, store and transport nuclear material should be authorized to perform such functions;

The same applies to relevant imports into or exports out of the State.

Regarding nuclear material accounting and control, conditions will generally be specified in detail by the State authority, whether by way of regulations, or licence or permit conditions, and are discussed in more detail in part 3.5. However, the legislation may well impose broad requirements, such as conforming to international safeguards obligations.

The national legislation should give the State authority the power to implement its requirements and control the implementation thereof.

4.3.2. Facilities

The legislation should empower the State authority to:

— require the reporting and updating of design information according to the safeguards agreement;

— approve or be notified of the organizational arrangements for nuclear material accounting and control made by facilities;

— require the granting of appropriate access for inspection by the State authority and the IAEA during construction, operation and decommissioning of facilities;

— call for, where appropriate, the site description required under the additional protocol, for review and subsequent submission to the IAEA.

If appropriate, the provisions may also include the submission and review, during construction, of relevant information bearing on facility design and construction to ensure that adequate accounting and control measures are defined, incorporated and approved before the receipt of nuclear material.

4.3.3. Implementation of additional protocol

The State needs the legal power to ensure that the information identified in Article 2 of the additional protocol is made available to the State authority for the timely transmission to the IAEA, as set out in Article 3 of the additional protocol.

The State needs the legal power to ensure that the State's inspection provisions include the right of the IAEA inspectors to have access as needed (including access to decommissioned facilities).

4.4. SSAC information system

4.4.1. Purpose

The State authority should establish and maintain an information system for the main purposes [3, paragraph 2.3] of:

— recording and processing information on nuclear material accounting and control, provided by operators and reported to the State authority;

— collecting, processing and recording the information gathered by the State authority, and preparing reports for evaluation internally and for submission to designated bodies (e.g. but perhaps not exclusively, the IAEA). These reports include declarations required by the additional protocol;

— maintaining a record of IAEA activities in the State, including inspections and complementary access;

— ensuring the quality of information and archiving of records.

4.4.2. Basic elements

The State authority's information system should, to the extent relevant to the nuclear activities within the State, contain:

— a listing of all current facilities and locations outside facilities (LOFs), with information on material accounting and control procedures, including any containment and surveillance required by the State. This should include design information on facilities and LOFs that exist or have been approved for construction. This information should be at least sufficient to meet the requirements of the IAEA's design information questionnaire and site descriptions as required by the additional protocol. The early reporting of design information or of any changes to design information previously declared to the IAEA is an important function of the SSAC;

— a record of data on nuclear material inventories possessed at each facility and location in sufficient detail to permit categorization of the material for accounting and control purposes (and the follow-up of any IAEA requests in that regard) and for planning State authority inspection activities, as appropriate;

— data on all domestic and international transfers;

— a record of State authority inspection data and all operational information required for the evaluation and review of loss mechanisms, shipper/receiver differences, MUF and measurement uncertainties associated with MUF, as appropriate;

— information on installations, part of the State's overall nuclear fuel cycle, that — prior to safeguards — process or handle nuclear material, as defined in paragraph 34(c) of INFCIRC/153;

— where appropriate, information — additional to that identified above — needed to compile complete and accurate declarations as required by the additional protocol;

— as much information as possible on past nuclear activities, predating the entry into force of the safeguards agreement:

  – existing and available historical accounting and operating records;

  – description, purpose and scope of prior operations and the current status and use of decommissioned facilities, and of other locations previously containing nuclear material that have (or had) hot cells or where activities related to conversion, enrichment, reprocessing or fuel fabrication have taken place.

This applies to:

— carrying out inspections;

— receiving information from facility operators; and

— where appropriate, receiving information from partners in bilateral agreements.

State authorities collect a great deal of information on nuclear material inventories and movements thereof. It is recommended that to manage those data, a database should be developed using relevant computer hardware and software.

4.4.3. SSAC information system as central point for receiving nuclear material accounting information

The State authority should use SSAC information to:

— maintain a record of all nuclear material (indicating types, amounts and locations) and of responsible individuals;

— generate reports to the IAEA or for other safeguards obligations;

— process and evaluate information acquired during State authority inspections, and information submitted by the facility operators;

— audit and evaluate facility records and reports, as appropriate;

— review loss mechanisms, shipper/receiver differences, MUF and measurement uncertainties associated with MUF, as appropriate;

— where appropriate, track material subject to the State's network of bilateral agreements worldwide, and produce notifications and reports required by the various bilateral agreements; and

— manage and plan the State authority's inspection activities.

4.5. Requirements for nuclear material accounting and control

The following relates to the above activities regarding accounting and control by the State. Individual facilities will have their own points where their responsibility for accounting and control begins and ends, usually when nuclear material enters and leaves the facility. The State authority should address the following requirements and ensure that they are met.

4.5.1. Starting point of safeguards

This is the point in the nuclear fuel cycle at which it is going to begin to require the full application of nuclear material accountancy and control. Naturally, that should be consistent with the requirements of the safeguards agreement and agreed upon in consultation with the IAEA during negotiations on subsidiary arrangements;

Full accounting and control should start at or before the starting point of safeguards as defined in paragraph 34(c) of INFCIRC/153, an example being uranium ore concentrates in a conversion facility. However, where material not conforming to paragraph 34(c) is imported or exported, the State authority should be aware that the IAEA must be notified regarding certain aspects of the import/export and where it is for a nuclear purpose [2];

States may have different criteria for determining the starting point as required by domestic regulations, but the level as defined is the safeguards agreement must at least be met.

4.5.2. Termination of safeguards

This is the point in the nuclear fuel cycle at which the full application of nuclear material accountancy and control can be terminated. To be consistent with INFCIRC/153, this cannot be before the termination of safeguards is permitted by the IAEA. A State must request termination approval from the IAEA, as provided for in the relevant provision of subsidiary arrangements.

Termination of accounting and control is not allowed until it is determined (and granted by the IAEA) that the material has been consumed or has been diluted in such a way that it is no longer usable for any nuclear activity, or has become, for all practical purposes, practicably irrecoverable. It also applies to material transferred to another State which has assumed responsibility therefore [4, paragraph 2.12].

Once granted, termination should then be reported in an inventory change report (ICR) as a termination use (TU). In the event that previously terminated material, for some reason, needs to be placed under safeguards, there is no corresponding inventory change code for returning that terminated material to MBA accounts. The approach should be to report an accidental gain accompanied by a concise note explaining the circumstances.

Where applicable, the additional protocol imposes some reporting requirements on nuclear material upon which safeguards have been terminated, under certain circumstances [3, paragraph 2.a.(viii)].

4.5.3. Exemption from safeguards

The conditions for exemption from accounting and control should be specified, consistent with the State's international obligations and domestic requirements:

— The State authority should make the facility operator aware that exemption could be obtained (granted by the IAEA) either by reason of quantity [2, paragraph 37] or of use [2, paragraph 36] of the material;

— A State must request relevant exemption approval from the IAEA, as provided for in the relevant provision of subsidiary arrangements;

— Once granted, the material should be exempted for nuclear purposes in the former case and for non-nuclear use in the latter case. The exemptions should then be reported in an inventory change reports (ICRs) as an exemption of quantity (EQ) and/or an exemption of use (EU);

— The additional protocol, Article 2.a.(vii), contains requirements for continuing reporting on nuclear material exempted from safeguards under the safeguards agreement [2, paragraph 37]. State authorities with an additional protocol in force will need mechanisms in place to allow them to acquire and maintain the necessary information;

— When safeguarded material is stored with exempted material, the exempted material should be de-exempted or stored separately;

— The operator and SSAC should keep a record of all exempted material;

— The operator and SSAC should be aware that for every category of nuclear material exempted there are stated limits which may not be exceeded [2, paragraph 37].

4.5.4. Retained waste

Retained waste refers to "nuclear material generated from processing or from an operational accident, which is deemed to be unrecoverable for the time being but which is stored" [2, paragraph 107]. Such material is stored at an MBA and continues to be subject to IAEA safeguards, but is not included in the inventory of the MBA. Therefore, procedures should be established and maintained for handling and accounting for retained waste. As far as nuclear material accounting is concerned:

— nuclear material transferred to retained waste will decrease the inventory of the MBA and material retransfer from retained waste will increase the inventory;

— material in retained waste based on nuclear accounting reports can be determined by subtracting the total material returned from retained waste from the total transferred to retained waste;

— when a batch of waste is returned from retained waste, the amounts used in reporting the return should be based on the factors used when determining the original transfer to retained waste.

— records of retained waste should be maintained.

4.5.5. Terminated waste

Under the additional protocol, a State is required to provide the IAEA with "information regarding the location or further processing of intermediate or high-level waste containing plutonium, high-enriched uranium or uranium-233 on which safeguards have been terminated" [3, paragraph 2.a.(viii)]. Therefore, a procedure is required for the operator to:

— keep track of terminated waste;

— provide the State authority with the necessary information for initial declaration or to provide the information regarding further processing 180 days before processing is carried out;

— provide the State authority with the necessary information on changes in location of terminated waste for the period covering the previous calendar year by the end of April of each year.

4.5.6. Categorization of nuclear material

From an accounting point of view, the material subject to safeguards should be categorized in the order:

— plutonium

— enriched uranium

— natural uranium

— depleted uranium

— thorium.

Within the facility records the operator has to stratify the material and list by location, type (the element contained and, for uranium, the enrichment) and composition; depending on IAEA requirements, there may be the need for additional stratification:

— plutonium contained in irradiated fuel

— separated plutonium

— high enriched uranium

— low enriched uranium

— natural uranium

— depleted uranium

— thorium.

For some facility types, IAEA safeguards may be applied using a single ‘unified’ account for all uranium categories combined. The use of a unified uranium account is a subject of negotiation between the State and IAEA, and should be recorded in the relevant facility attachment.

In addition to the above, there might be other State requirements relating to national obligations.

The licence of a facility or LOF prescribes categories and quantity limits that could be present at a facility. The SSAC obtains these quantities of categories from the accounting reports submitted, so records can be established. Control by the State authority then is possible insofar as the quantities do not exceed the stated limits.

4.5.7. Material balance areas

The State authority, on the basis of proposals of operators, should define the factors to be taken into account and the criteria to be met when specifying material balance areas (MBAs). The main consideration here is that it must be possible to define inventory and flow key measurement points (KMPs) such that it is possible to measure the complete inventory of the MBA, and all flows into it and out of it. Other key factors include:

— whether key measurement points have already been agreed on with the IAEA and, if so, their location;

— containment and surveillance possibilities, as appropriate to the State authority’s remit;

— the required accuracy of the measurement system with error limits;

— the type of accounting, i.e. item or bulk accounting.

Furthermore, it must be kept in mind that:

— the nuclear material is declared per MBA and that all reporting relates to the relevant MBA;

— for practical purposes, LOFs are typically included within one or several MBAs;

— it is important that the batch names be defined for every MBA so that it is clear which batch names could appear in facility reports.

The State authority should approve a structure of State MBAs as usually proposed by operators in consultation with the State authority. On the basis of operators’ permits or licences, nuclear material will be accounted for in State MBAs (which might be different from the IAEA MBAs) for single or for several operators.

INFCIRC/153 states that States should, as far as possible, use for their own purposes a system of MBAs compatible with the system agreed on in the subsidiary arrangements between the IAEA and the State. That generally means that the MBAs specified for safeguards can be subdivided for the State's own purposes so that:

— the inventory KMPs remain the same, with all the inventory KMPs from the IAEA-agreed MBA falling in one or other of the smaller, State-defined KMPs;

— the flow KMPs from the IAEA-agreed MBA will remain the same; and

— one or more additional State-flow KMPs will be needed on the boundaries between the other, smaller, State-defined KMPs.

The IAEA, on the basis of its experience, might recommend a suitable MBA structure. For a bulk handling facility such as a fuel fabrication plant, a triple-MBA structure consisting of a feed storage MBA, a process MBA and product storage MBA might be a suitable choice. The main reasons are:

— to separate quantities involved in shipper/receiver differences from quantities of MUF;

— to make the process MUF evaluation a more sensitive measurement error indicator by removing the effect of a large feed and product storage inventories, the latter being item controlled.

4.5.8. Record and report system

The State authority should specify the requirements (for material both in item form and in bulk form) for accounting and operating records and accounting reports for each MBA. The record and report system should provide relevant data on nuclear material transactions and operations affecting nuclear material accounting:

— that are complete, so that the data give the State authority a clear picture of the nuclear material inventory;

— using a system of unique batch names/identification in a State to be able to account for each batch;

— presented in such a manner as to allow the State authority to easily construct its own reports for onward transmission.

By this mechanism, operators submit information about routine activities on a regular basis and, for special events, as they arise. It is particularly important that this is done within specified time frames where the information is required for the State authority to provide the information to either the IAEA or other parties in order to meet commitments.

In practice, the State authority's responsibilities may be such that it is not sufficient to report only the nuclear material inventory and completed transactions to it. The State authority may find that it needs facility operators to draw attention also to:

— applications for approvals, i.e. in respect of certain matters that must be approved by the State authority before action can be undertaken by the operator;

— notifications, i.e. where an event is planned or has occurred and about which the State authority must be informed; and

— records and reports, i.e. routine reporting of information supported by certain records such as inventory information required by the State authority to prepare reports for the IAEA, and also special reports.

The information required to be provided, and the form in which it should be submitted, might be specified in the safeguards permit or licence or instruction. Examples might include:

Applications for approval

Approval should be required for each new:

- construction of new facility;
- change in DIQ;
- exemption of nuclear material from safeguards;
- transfer of nuclear material to waste;
- export or import of nuclear material or associated items;
- project where nuclear material will be consumed, or will be diluted in such a way that it is no longer useable for any nuclear activity relevant from the point of view of safeguards, or will become practicably irrecoverable;
- project involving disposal of nuclear material;
- proposed location for storage of nuclear material;
- project where nuclear material will be put to non-nuclear use;
- project where fission products will be separated from irradiated nuclear material;
- project where material will be blended to an enrichment of 20% or more uranium-235;
- project where the isotope uranium-233 will be produced.

Notifications

Notifications should be required for:

- advance notification of export or import of nuclear material;
- confirmation that an import has been received or that an export has been made;
- incidents involving loss of control or accidental gain/loss of material;
- planned dates of PITs;
- changes to nuclear material accounting system measures;
- transfer of nuclear material within the State;
- incidents affecting access to nuclear material or the ability to carry out safeguards procedures;
- any changes to design information for nuclear fuel cycle operations, facilities and locations where nuclear material is produced, used, consumed or stored;

— annual outline of planned facility activities involving nuclear material for the coming year.

Records and reports

The following records and reports might be required:

— Nuclear material inventory change report (ICR);

— Material balance report (MBR);

— Physical inventory listing (PIL);

— Listing of inventory items as required for inspections;

— Incident investigation report: special reports on gain/loss of nuclear material or change in containment;

— Regular general ledger covering all changes to the inventories and the resulting balances for each material category;

— Country of obligation report for nuclear material under bilateral agreements.

Some of the foregoing information might be provided to the State authority for its internal use. Other information might be used in reports by the State authority to the government, the IAEA, or to partner States in a bilateral agreement.

4.5.9. Measurement system and programme to control measurement

The measurement system is viewed as an important requirement of the SSAC. It entails the determination of quantities of nuclear material, which is a basic characteristic of nuclear material accounting.

The State authority should, therefore, specify requirements for a measurement system and measurement uncertainties, including provisions for the determination of:

— quantities of nuclear material received, produced, shipped, lost or otherwise removed from inventory;

— inventory quantities based on sampling for destructive analysis or non-destructive assay (NDA), as appropriate.

At item facilities (those with discrete items of nuclear material), such as most reactors, it may be that only very basic measurements, such as counting and item identification (and for some of them nuclear material transformation calculations and perhaps qualitative NDA), are required.

More complex facilities may require dedicated in-plant equipment and laboratories for measurements which has to be prescribed by the State authority.

The State authority should require the setting up of a programme of measurement control with the objectives of ensuring that:

— for preparation of accounting records, the most current international standards measurement system is used;

— adequacy of routine operation of the measurement system is confirmed;

— measurement systems are recalibrated at appropriate intervals;

— random and systematic errors are properly estimated for propagation so that the limits of measurement uncertainties associated with MUF can be established; and

— clerical errors are, so far as practicable, detected and corrected.

While this is plainly very important at facilities handling nuclear material in bulk form, these issues should not arise at item facilities, with the exception of clerical errors.

4.5.10. Nuclear material flow

The State authority should specify requirements, when relevant, for the accounting and control of the flows of nuclear material, taking into account the degree of assurance to be obtained from any State-applied containment and surveillance measures. Requirements for measuring, including corresponding uncertainties, and for identifying receipts, shipments, and transfers at a facility should be defined in such a way as to facilitate the regular establishment of material balances. Personnel from the nuclear material control unit at the facility should be informed when there is material flow and thus ensure continuity of knowledge for the State authority at the facility level. See Appendices 1–4 for examples.

The State authority should approve procedures proposed by facilities for calculating nuclear loss (burn up) of uranium and production of plutonium in power reactors.

4.5.11. Physical inventory taking

The State authority should specify the requirements for the physical inventories to be taken by the facility operators, because quantities of nuclear material present within each MBA (facility) should periodically be determined [4, paragraph 6.1(d)]. This should include the completeness and frequency of inventory taking.

Provisions should be included for the State authority to notify the IAEA in advance of dates when physical inventories will be taken, so as to allow for planning the IAEA PIV which normally follows the PIT at a facility.

Procedures should be established at State and facility levels to ensure the success and timely availability of the results of a PIT at a facility.

The procedures should specify the accounting documentation associated with the PIT.

4.5.12. Shipper/receiver differences

Most reactor fuel is accounted for by using the shipper's values as the basis, so shipper/receiver differences do not normally arise at power reactors.

In bulk-handling facilities, shipper/receiver differences will occur. Where significant shipper/receiver differences do occur, the cause should be investigated and in extreme cases of significant differences, apart from investigating the cause, the IAEA must be informed and a special report prepared and submitted. Also, other stakeholders should be informed, not only from a safeguards point of view but also for possible financial reasons.

The State authority should:

— define when and where shipper/receiver differences are allowed to be declared (depending on the quality of measurement systems);

— define the requirements for identifying, reviewing, resolving and evaluating differences in all shipper/receiver measurements and for deriving the limits of measurement uncertainty of transfers between MBAs within its control; and

— describe the procedures to be followed when shipper/receiver measurement limits exceed specified values.

4.5.13. Material balance closing

The information which a closed material balance can provide in relation to unrecognized losses and gains becomes available only when a PIT has been performed. Closing a material balance includes such activities as tabulating and totalling results and evaluating it against set criteria.

The State authority should require that MUF be kept to the lowest practicable level. In real terms, the resulting MUF should be small enough to be within the uncertainty of the eventual material balance established for each facility.

The State authority should not only specify limits for MUF, but also the measurement uncertainties associated with MUF, conforming substantially with the latest international standards and with the procedures to be followed to routinely monitor compliance with these standards.

The State authority should prescribe procedures to be followed when MUF or the measurement uncertainties associated with MUF exceed the appropriate specified level.

As a rule, MUF is not expected at item facilities.

Accounting reports associated with material balance closing and the timeliness thereof should also be specified.

The State authority should therefore establish requirements for:

— establishing a material balance at each facility;

— calculating MUF together with its limits of measurement uncertainty;

— determining the components of the material balance through the use of measurements or derived estimates based upon measurements; and

— evaluating accumulations of unmeasured inventory and unmeasured losses and their limits.

4.5.14. International transfers of nuclear material

The State authority should specify requirements for international transfers of nuclear material. INFCIRC/153 requires that the IAEA be given advance notification of such transfers, and the other party to the transfer will, clearly, also require advance notification. If the transfer is taking place between one State and another having a bilateral safeguards agreement established, the requirements for advance notification have to be agreed in advance.

In the more general case, as a minimum, the State authority acting on its behalf should:

— be in close contact with other State authorities responsible for gaining approvals for international transfers. This helps the two State authorities to agree on the way the transfer is to be undertaken, the advance notification required, and the information to be included in the advance notification;

— determine, in agreement with those authorities and with other States involved in the transfer, the points at which the transfer of authority and responsibility for nuclear material accounting and control should take place;

— ensure the continuity of the material identity, which is important from an international safeguards point of view. It is, therefore, preferable that the batch identity reported by the shipping State is also used for reporting purposes by the receiving State.

4.5.15. Inspections

The State authority should specify requirements to be observed by operators during State authority and IAEA inspections to ensure that they can be carried out in an efficient and effective way. For IAEA inspections, the obligations under the safeguards agreement should be kept in mind. The following are important aspects [2, paragraph 9]:

— Arrangements should be made so that IAEA inspectors can discharge their functions effectively;

— The scheduling of IAEA inspections should be arranged such that it would reduce any possible inconvenience or disturbance to the State;

— IAEA inspectors would ensure protection of industrial secrets and confidential information entrusted to them during inspections;

— The necessary procedures should be established to ensure the orderly execution of any inspection by either the IAEA inspectors or the State authority.

4.6. Ensuring compliance and inspection regime

4.6.1. General

The obligation is on the State authority to ensure operator compliance with the requirements of the system of accounting and control established by it. The assessment of its effectiveness can be achieved by means of a comprehensive inspection programme. It all amounts to the operator performing at such a level and being capable of recording and reporting changes to its inventories correctly, completely and in a timely way and of submitting correct and complete data for inspections. The inspection programme should focus on ensuring that:

— accounting for and control of nuclear material satisfies the requirements of the agreement with the IAEA; and

— the accounting and control measures implemented by the facility operator are effective and, in conjunction with other measures, enable the IAEA to conclude that there has been no unauthorized removal or use of nuclear material, and that there is no undeclared nuclear material or facility within the State.

The above should contribute to the determination by the IAEA, through its independent verification activities, of whether there has been any diversion of significant quantities of nuclear material. The State authority should establish criteria against which the operator's capability and performance, and the results of State authority inspections and evaluations, can be assessed.

4.6.2. Inspection programme

The inspection activities of the State authority should be aimed at meeting the requirements stated above through:

— examining the design information presented in the licence application or by any other agreed means and the proposed operating practices in order to determine the capability of the applicant to perform the required accounting and control functions. Periodic verification of design information for operating and closed-down facilities/LOFs is needed to ensure its continuing correctness.

— conducting inspections during construction and start-up of a facility, to determine whether the arrangements for nuclear material accounting and control it has approved have been satisfactorily implemented.

— conducting periodic inspections at facilities and LOFs after receiving nuclear material to determine whether the performance of nuclear material accounting and control reaches the standard set by the State authority. For this purpose it is necessary to:

  – examine records, e.g. follow entries in records to their source and from the source to the record. Include laboratory and operating records of measurement quality, of calibration data, of data on unmeasured inventories and losses, and of measured discards;

  – observe PIT and operators' measurements;

  – perform independent measurements to assess the quality of operators' measurements.

— evaluating data presented in accounting and operating reports for trends in book inventory, MUF, cumulative MUF, shipper/receiver differences, measured discards, losses, calibration data and the corresponding limits of measurement uncertainties by ensuring that:

  – State-prescribed requirements for the detection of losses of nuclear material are met;

  – the estimates of measurement uncertainties are correctly stated;

  - all significant contributions to the measurement uncertainties associated with MUF and shipper/receiver differences are identified;

  - the figures for measured discards, accidental losses, transfers to waste and accumulated unmeasured inventory are credible and do not exceed pre-established limits; and

  - the figures for MUF and shipper/receiver differences have been correctly calculated and explained in a satisfactory manner.

— evaluating feedback from the IAEA, especially with regard to:

  - accounting reports;

  - routine and other inspections conducted in a State and providing IAEA statements on the results of inspections;

  - physical inventory verifications (PIVs) subsequent to a PIT conducted in a State and providing IAEA statements on conclusions and a declaration regarding design information verification. Special attention should be paid to remarks regarding MUF and cumulative MUF;

  - semi-annual book inventory and transit matching statements.

Information on the above should be disseminated to the facility operators with the conclusions of the State authority and with requests for improvement of the relative accounting and control aspect at the facility, because the facility should strive for continual improvement of its system(s).

The independent inspection activities by the State authority would, in no respect, limit the IAEA's right to conduct its own independent verification in a State. However, the conduct of such activities when the results are made available to the IAEA — particularly, if that is done in a time frame that realistically makes them subject to independent IAEA verification — could contribute to improving the effectiveness and efficiency of the IAEA verification process.

4.7. Technical support and training

4.7.1. Staff training

Training of personnel responsible for accounting and control of nuclear material at State and facility levels is critical for the successful operation of an SSAC.

The first line of training should be the staff of the State authority itself. IAEA training courses, workshops, fellowships and scientific visits are available. It is suggested that the IAEA be contacted for the necessary training resources available, including an IAEA SSAC advisory service. Once the training of State authority staff is completed, the facility personnel can also make use of the training offered by the IAEA at their headquarters, at international courses or in specific States. Such training should be a continuing activity.

4.7.2. Technical assistance to operators

The State should facilitate the provision of adequate technical assistance from external sources, if necessary, to the facility operators in nuclear material accounting and control in order to enable the operator to fulfil requirements relating to the State. This could include help in establishing adequate record and measurement systems which may incorporate data processing and analysis procedures. Assistance should also be given toward meeting international standards and establishing containment and surveillance measures.

In bulk-handling facilities, for instance, considerable technical assistance to the operator may be necessary to establish complex measurement systems and programmes to control measurement that could ensure the success of the SSAC. Also, the evaluation of such SSAC programme results could be complex.

The State authority is advised to seek the assistance, guidance and recommendations of the IAEA in any case where the need arises and in the process of ensuring that effective nuclear material accounting systems are developed, implemented and applied at the State and facility level.

5. NUCLEAR MATERIAL ACCOUNTING IMPLEMENTATION AT FACILITY LEVEL

This section describes the development of the accounting and reporting elements necessary for nuclear material accounting at the facility level, which forms the structure to effectively meet the State authority requirements discussed in the previous section.

The facility or MBA is the area where data relating to nuclear material originate. Data of safeguards relevance should be controlled in such a way that the information flowing from the facility is timely, correct and complete.

During operations in a facility or in LOFs, various documents are generated, e.g. documents associated with shipping/receiving nuclear material. Although it will differ from State to State, there could, for example, be an accompanying form or proforma invoice that is partly completed by the shipper and the remainder by the receiver during the weighing process. Both parties receive a copy of the completed document. During receipt of nuclear material, the material is weighed (or the shippers weight accepted) and an internal document completed showing the weight. It could be either a manually completed document or a computer printout. These quantities are used to compute and evaluate the shipper/receiver difference.

Such information should be made available to those responsible for meeting the obligations of the agreement. It could be to:

— one or more person at the facility;

— a group of persons, i.e. the nuclear material control (NMC) unit at the facility.

Whatever the case may be, the necessary information should be provided to those who have to perform the task at hand, whether it is preparing a report for submission to the IAEA (either directly or through the State authority) or updating the relevant general ledger and listing inventory items for State authority or IAEA inspections.

The above activities and documentation will be discussed in detail in this section.

To further meet the requirements and criteria discussed for the State authority in the previous section, the various key elements necessary to implement nuclear material accounting for the SSAC at the facility level are presented in this section:

— organization and management;

— nuclear material measurement and measurement quality;

— records and reports;

— physical inventory taking;

— material balance closing;

— nuclear material verification.

It should also be stated that the legal basis for the operator to perform tasks required by the State's international obligations, is supplied by:

— the safeguards agreement;

— subsidiary arrangements, consisting of the general part and facility attachments including Code 10 relating to reporting;

— the additional protocol, if applicable;

— bilateral and/or regional agreements;

— State legislation.

5.1. Organization and management of nuclear material accounting

In Section 2, relating to the organization structure at the facility level, it is suggested that a system be adopted where nuclear material accounting and control could be the responsibility of a nuclear material control (NMC) unit, consisting of a safeguards implementation officer and one or more nuclear material accountants. It is further suggested that these functions be separated from operational and overall facility management. As the name suggests, the safeguards implementation officer will be responsible for the overall implementation of safeguards and will be the person with whom the State authority communicates at the facility level. It is important that responsibilities of the NMC unit be clearly defined, especially keeping in mind the legal basis, as is stated above, which will determine the information to be provided to the unit.

To enable the unit to plan ahead, a system of advance notifications should exist. It should also be possible to control the flow of information from the points of origin to where it is needed, irrespective of the system used, whether manual or computerized.

Another important function of the NMC unit is MUF control. This is based on a safeguards technique known as the closed material balance. It essentially utilizes a near-real-time accounting system which allows for inventory taking and for updating the book inventory at planned intervals. To be effective, the safeguards system must be based on well developed control systems required by the State authority and established for the nuclear material accounting at facility level by the NMC unit in collaboration with the facility/plant operator. Such systems are typically supported with adequate information systems.

5.2. Establishing measurement system and programme to control measurements

The need for a measurement system is stated in the previous section. There are, in essence, two reasons for this requirement, namely:

- for determining quantities of nuclear material received, produced, shipped, lost or otherwise removed from inventory;
- for determining inventory quantities.

The above activities require (as applicable):

- approved measurement equipment for establishing weights (calibration, standards);
- a sampling system;
- analytical laboratories and analysts able to perform the analyses and evaluate the results;
- operators who introduce the analysis results into the operating system.

The requirements for a measurement system as envisaged by the State authority are described in section 3.5.9. It is thus important to note that personnel, procedures and instruments used for accounting measurements all form part of a measurement system.

Where it is necessary to perform quantitative measurements as new intermediate products are generated, there could be a reluctance to measure every item, for example due to the cost of analysis. There should be a balance between cost considerations and the need to know the exact quantity of nuclear material.

A measurement system further requires a programme to control measurement as was envisaged in section 3.5.9. Together it would allow the State authority to meet its obligations relating to the agreement with the IAEA.

Operators of the various facilities should select a measurement system appropriate to perform quality measurements and, in so doing, provide quality data which allow for timely, correct and valid results.

To be able to specify the measurement results desired, the following should be defined and quantified: accuracy, precision, calibration, error resolution, standards, measuring and test equipment and uncertainty measurement. Where possible, deviation limits should be set.

An important aspect related to measurement quality which needs to be addressed is that of accounting units and significant digits. It is required, in the case of natural and depleted uranium and thorium, that quantities be expressed in kilograms and, in the case of plutonium, enriched uranium and uranium isotopes, in grams. For the purpose of minimizing rounding adjustments, it is recommended to keep all facility records to the same level of decimal significance. Further, the SSAC and the State nuclear material accounting reports should reflect the same level of decimal significance maintained in the facility records. The maximum level of accuracy implemented for the IAEA is to the milligram. In some special cases (such as a cylinder containing UF_6 weighing many tons), it is reasonable to express the quantity to the nearest accounting unit, i.e. as whole kilograms or grams.

The State authority should take a clear position on this and make sure that all records reflect the same significant number of digits for the relevant types of nuclear material. This will then set the required sensitivity or capability of the measurement system. Any combination of measurement techniques (weighing, sampling or analysing) which results in a final measured quantity, that meets the special criteria, should be sufficient. The IAEA also will provide their requirements for decimal significance, as necessary.

5.2.1. General remarks relating to a measurement system and control programme

The objective of a measurement system and measurement control programme is to ensure that the measurement methods selected for use are capable (as related to random and systematic errors) of measuring the material in question to the desired levels of precision and accuracy.

The measurement control programme should generate data on the performance of measuring processes, including values for bias corrections and their uncertainties, random error variances, limits for systematic error and other parameters needed to establish the uncertainty of measurements used to determine the quantities of nuclear material.

5.2.2. Responsibilities relevant to the measurement system

The State authority should be responsible for liaison with the IAEA in respect of measuring methods and systems used for determination of quantities of material and also for acceptance of procedures for measurement systems and the measurement control programme.

The State authority would be responsible for verification of measuring methods and systems, verification of calibration validity of equipment/systems used, evaluation of analysis results and preparation of inter-laboratory comparison and trend analysis.

The NMC unit at the facility level would take responsibility for establishing and maintaining a measurement system and implementing a programme to control measurements to determine the accuracy of measurements and calibrations and correctness of recorded source and batch data, preparing a sample taking instruction for sampling, for taking duplicate samples during IAEA inspections and providing the analysis results of such samples to the State inspector, providing for sampling and recording systems and auditing the measurement system, programme to control measurements and MUF control.

5.2.3. Measurement system

For each KMP, the safeguards implementation officer should establish the appropriate test and measurement equipment or method (chemical analysis or NDA) to be used for determination of nuclear material received, produced, shipped, lost or otherwise removed from inventory and for the determination of inventory quantities (See sections 3.5.9–10).

Procedures should be prepared for each MBA indicating the KMPs within the MBA (based on DIQ) defining the:

— type of material present at the KMP;

— type of containers used for storage/processing of the material;

— tare weight(s);

— type of measurement to be used to determine the quantity of material, i.e. mass measurement, volume measurement, sampling system, analytical measurement, NDA measurement or other methods used for this purpose;

— equipment used to determine the quantity of material, i.e. type, make and serial number;

— method of measuring or calculating the uranium content of the material;

— range, accuracy and measurement uncertainties of the measurement or method;

— burn up calculation (determination of consumed uranium);

— plutonium production (determination of produced plutonium);

— batch data (name, weight, material description code as defined in Code 10);

— calibration requirements.

The measurement methods and techniques must be selected in such a way as to ensure that the measurement accuracy conforms to requirements defined by the State authority and is based on international accepted values, procedures and standards.

5.2.4. Programme to control measurements

Each nuclear facility must establish and maintain documented procedures to control, calibrate and maintain measuring and test equipment and methods to ensure the credibility of the facility material balance statements (See section 3.5.9).

All calibrations must be performed, where practical and possible, using standards calibrated by the State national accreditation services or approved/accepted test or calibration laboratories to provide traceability to national or international standards. If no nationally recognized standards exist, the basis for calibration should be documented.

Measuring and test equipment measurement and methods should be used in accordance with approved procedures to ensure that the measurement uncertainty is known and is consistent with the required measurement capability.

Calibrations must be performed in an environment controlled to the extent necessary to ensure valid measurements. Temperature and humidity must be monitored continually and recorded and, when necessary, be corrected accordingly. Calculations for the corrections should be made on the calibration notes. A statement should be included on the calibration report that the values have been corrected.

Calibration of measurement and test equipment must be performed in accordance with documented requirements specifying:

— equipment type;

— unique identification and location;

— frequency of calibration;

— calibration method;

— acceptance criteria;

— actions in case of non-conformity.

Equipment must be identified with a suitable indicator or approved record to show the calibration status.

5.2.5. Reviews

The safeguards implementation officer should perform independent reviews at intervals in keeping with international standards to determine the adequacy of the measurement system and measurement control programme, to assess the applicability of current procedures for planning audits and to verify conformity with all aspects of the measurement programme. Results of these reviews should be documented and maintained as valuable records reflecting measurement quality.

5.2.6. Sampling

Procedures for sampling should be prepared describing the methods/procedures for:

— homogenizing material to ensure that the sample is representative of the batch;

— taking the sample;

— maintaining sample integrity;

— shipping the samples to the IAEA.

5.2.7. Training

Procedures identifying training needs for personnel performing measurements to determine the quantities of nuclear material should be prepared. The relevant staff should be qualified on the basis of appropriate education, training and experience, as required. Appropriate records of training should be maintained.

It should be stated that the best techniques, method or equipment cannot ensure a quality result; however, a trained and experienced person performing the measurement could do so.

5.2.8. Interlaboratory comparison

As a good practice, the facility safeguards implementation officer should ensure that, for each sample taken by the IAEA, a duplicate sample is taken, analysed and the results forwarded to the safeguards inspector.

If necessary, the safeguards inspector should evaluate and compare the inter-laboratory analysis results for all IAEA samples taken and analysed.

The safeguards inspector should review the analysis results for trends. These observed trends should be discussed in depth with the IAEA and, if needed, plans should be devised as to rectify the source of deviations in results.

5.2.9. Uncertainties associated with material unaccounted for

The methods and techniques described above should also be used to propagate uncertainties associated with inventory changes and physical inventories. This could then be utilized deriving at measurement uncertainties associated with MUF.

5.3. Establishing a record and report system

The State authority requirements describe records and reports that are necessary (section 3.5.8) to fulfil its international obligations. To put the relationship of records and reports into perspective: a report is always based on a record which originated in the nuclear material operating activities of the facility, and a report, in turn, leads to verification and evaluation by the State authority and/or the IAEA.

5.3.1. Accounting records

Accounting records consist of the set of documents kept at a facility which show the quantity of each type of nuclear material present at the facility, the distribution in the facility and all corresponding changes. The records should meet the requirements of showing the nuclear material inventory and all inventory changes affecting it, and accurate enough to facilitate verification. Accounting records consisting of the following components can meet these requirements:

— ledgers summarizing inventory changes and providing the book inventory for a specified period;

— inventory change journals, inventory change documents and internal transfer forms used for the original entry from various supporting documents.

Supporting documents include those primary documents used for capturing data at the operating points where the data originate, i.e. containing source data. These are data recorded as a result of measurement activities or during calibration, or derived from empirical relationships. They may include mass measurements, conversion factors to determine the mass of an element, element concentration, isotopic ratios, or nuclear material handling protocols reflecting all activities relevant to nuclear material accounting or control.

Where the means exist, data could be made available in electronic form. This requires a suitable database and the necessary software to allow the users of the system to generate records/reports as needed which again could be provided either in electronic form or as hard copy.

5.3.1.1. Ledgers

A ledger has a starting point: at the beginning of the material balance period (MBP), an entry is made equal to the physical inventory at the end of the previous MBP. Entries following represent all known inventory changes, such as receipts and shipments. Thus, at any point in time the ledger shows the book inventory, i.e. the quantity of nuclear material that should be present at the facility. Every entry should be traceable through some numbering or reference system to either, a journal account, inventory change document, or source records underlying the ledger. Separate ledgers should be kept for different nuclear material categories — natural, depleted and enriched uranium, thorium and plutonium. For the purposes of the IAEA inspections, low and high enriched uranium should be provided on separate ledgers.

5.3.1.2. Inventory journals

Inventory journals are chronological records indicating various types of inventory changes that have occurred at a facility. Periodical entries are made from this document to the ledger, such as a cylinder containing UF_6 (item = batch) or a batch of drums containing UO_2 (one entry consisting of 20 items), for example. Journals are, as a rule, used in bulk handling facilities where one has a large number of entries, especially where entry is done manually. In the case of computerized accounting systems, journals might be unnecessary. Item facilities would enter data directly from the source (inventory change) documents into ledgers and in such a case, records would not be necessary. Journals in turn are supported by source documents originating where nuclear material is received, shipped, discarded, etc. The utilization of journals is a decision for the facility operator. It all depends on the number of entries and the nuclear accounting system (manual or computerized) established at the facility.

5.3.1.3. Supporting documents

A requirement of an accurate, effective and verifiable accounting system is that the data for each inventory change be recorded at the time of the change and at its source. Facilities should develop forms and systems designed to record data according to their needs and appropriate for the inventory change. Another requirement, however, is that supporting documents should provide an audit trail between data in the ledgers and the original data, namely those originating due to measurements, calibration, or other operating activity in the facility. The forms mentioned above should be numbered such that they are clearly associated with receipts, shipments or as appropriate.

Although facility operators could develop systems suitable to their needs, it is recommended to develop an accounting system using IAEA terminology, because eventually facility data must be collected and reported in IAEA terms and format. Code 10 of the General Part of the subsidiary arrangements identifies and defines types of inventory changes and the relevant IAEA codes for each.

It is important that all necessary data are recorded in supporting documents. Data that have to be recorded are:

— the *inventory change identity,* which refers to an identity code allocated to nuclear material received for use in a facility, creating a means to distinguish it from the next inventory change and allows for the audit trail in the facility. A series of alpha-numeric characters could normally be used.

— the *date of change,* which refers to the actual date the inventory change occurred.

— the *type of change*, indicated by the inventory change code, e.g. RF (foreign receipt), SF (foreign shipment), RD (domestic receipt), SD (domestic shipment). The codes are to be found in Code 10 of the General Part of the subsidiary arrangements, and should become common terminology in a facility.

— the *material description code* provides data on the type of nuclear material, the physical and chemical form, and the containment and radiation status. Four characters describe the material completely that is to be reported to the IAEA and thus it is advantageous if it is available in the source documentation, and is the same as used in Code 10.

— information on *material movement* between MBAs and other nuclear material accounting areas, an important element because it provides data on the shipping and receiving MBAs which should be reported to the IAEA so as to allocate the nuclear material to the relevant MBA.

— *batch identity,* identifying any batch by a unique batch name. For 'batch' refer to 1.1.3.6. Each MBA should establish its own set of internal batch names which can be used when an inventory change occurs.

— the *number of items* in a batch, which are reported to the IAEA and should therefore be recorded.

— *batch data,* referring to the total weight of each element of nuclear material accompanied by isotopic composition, where applicable.

— the *batch data basis,* which provides data forming the basis from which the batch data entries were derived. This will help the facility operator to know where the relevant data originates, namely from a measurement in an MBA of the facility or whether it is shipper's data determined by another operator.

— *source of* weight, and whether the weight was re-determined since last reported.

5.3.2. Operating records

With regard to nuclear material accounting, operating records consist of the results of the facility systems and procedures. These systems and procedures refer to the measurement system, measurement control programme and PIT, and include [4]:

— Operating data used to establish changes in the quantities, locations and composition of nuclear material. This refers to data recorded at the location where the measurement or determination was made. For example, at a reactor facility these are the records that provide the necessary data to calculate nuclear loss and nuclear production. It is supported by fuel element histories, experiment logs, nuclear power logs, flux maps and fuel position maps.

— Data obtained from calibration of tanks and instruments and from sampling analysis, the procedures employed to control the quality of measurements and the derived estimates of random and systematic error. This is also necessary for evaluation of results of determinations such as shipper/receiver differences and evaluation of MUF. It is also needed by IAEA inspectors in their verification and evaluation of facility nuclear material accounting.

— A description of the sequence of the actions undertaken in preparing for and taking a physical inventory to ensure it is accurate and complete. The PIT includes the use of written physical inventory procedures and the documentation of physical inventory results, namely the physical inventory item lists. The lists provide source data for the physical inventory summary and reconciliation, which can be considered the supporting document for entering a MUF adjustment, if any, into the records.

— A description of the action taken to ascertain the magnitude and cause of any accidental or unexpected loss or gain. Such records refer to actions that would be non-routine, only occurring when an accidental loss, unexpected loss or an accidental gain occurs. Action taken will depend on the seriousness of the event and also on nuclear material accounting. The primary concern would be to determine the quantity of nuclear material. Documenting the actions undertaken and procedures followed in determining the loss will permit the eventual evaluation of the incident in terms of the quantity statement and cause of the loss.

5.3.3. Accounting reports

The various accounting reports are normally based on source documents and their purpose is mentioned in 1.1.4 and 1.1.5. The submission of the reports is described in 1.1.5. The various safeguards agreements require basically three types of reports to be submitted to the IAEA:

— inventory change report (ICR);

— material balance report (MBR); and

— physical inventory listing (PIL).

5.3.4. Data handling

— *Source data and operating records*: The operator should prepare reports that are submitted to the IAEA via a State authority. It is, however, recommended that the operator provides the relevant data to the State authority, which then finalizes and submits the report(s) to the IAEA. It has been recognized as a good practice to process and transfer all nuclear material accounting data electronically. Whatever the case may be, the source of data is at the operating level of the facility. The quantity data are generated by the operation of the nuclear material measurement system. Quantity uncertainty data are generated by the operation of the program to control measurements. Inventory information is generated by the use of the PIT procedures. Various methods could be used to record the data where and when it is generated, e.g. a weigh station with a manual log or a print weight scale or process measurement points where in-line NDA devices may be directly connected to an information system. These data are recorded and used by the nuclear accounting system as and where applicable. As is clear from the above, the means of recording source data in the operating records will vary. Whatever the case may be, it is important that the data are identifiable as related to certain items and batches of material and this identity can be recorded and referenced in the accounting records: inventory change documents (ICDs); inventory change journals; and the general ledger (GL), so that data can be traced to its origin. See Appendices 5 and 6 for examples.

— *Data flow*: The KMP is the place in a facility where data are generated for items and batches moving through or stored there. Each item or batch must be identifiable by some type of attached tag or label. A common method is by using data tags carrying forward data regarding the batch or item. Each item or container must be numbered for identification, either by etching the number onto it or even writing it onto the container, where applicable. Data recorded on the label or tag could, apart from a batch number, contain the type of material, quantities and composition. The label could also contain information relating to quality and is the link with source data and the final accounting reports. In the case of transfers into and out of MBAs and for all inventory changes and adjustments within an MBA, an ICD is prepared. Completion of the ICD is dependent on source data in the operating records, inventory change code, date of the change, shipper and receiver identity, etc. It is important to note that the completed documents should be distributed to the relevant user of the data and this should normally be indicated on the corresponding copy. For consistency, it is good practice to send all documentation to the offices of the NMC unit or to the records office, which they then distribute to the all involved. Inventory changes are entered into inventory change journals or directly into the ledger accounts. Procedures for data handling and flow would help to complete the correct records and distribute them to the relevant parties.

5.4. Establishing a physical inventory taking system

The requirements relevant for this activity, as envisaged by a State authority, are summarized in Section 3 (section 3.5.11). This paragraph further describes how the operator should go about establishing the various procedures and instructions for inventory taking in the facility. PIT is a nuclear material accounting activity which could quite rightly be described as the bench mark of nuclear material accounting and control. Various means of control (Introduction), accountancy (section 1.1.1) and containment and surveillance (not covered in this handbook) can be used to account for and control nuclear material.

Material balances based on a PIT that provides conclusive evidence of the physical presence of the nuclear material is the only means for the facility operator to ensure that no significant losses or discrepancies have gone undetected. The other components of the material balance, namely receipts, shipments, discards, etc., must be correctly measured or determined for the balance to be meaningful.

Procedures and instructions for different facilities will vary. Depending upon the facility type and then particularly on the types, forms and quantities of nuclear material. The mode of facility operation as well as the accuracy and effectiveness of flow control and containment/surveillance applications also play a role.

The NMC unit has to establish at least two documents containing the appropriate procedures and instructions, namely a PIT plan answering the 'what should be done' and 'how should it be done' questions relating to a PIT. The second document is the PIT instruction, answering the 'who should do it', 'when should it be done' and 'where should it be done' questions. The former will be a generic type document that:

— establishes a procedure for moving nuclear material in a location to assembly positions facilitating measurement and inventory taking. Packing should be such that all items are accessible for verification;

— describes the system whereby items will be stratified, meaning "grouping of items/batches having similar physical and chemical characteristics made for the purpose of facilitating statistical sampling." [4, paragraph 6.37]. Examples are reactor fuel elements or UF_6 cylinders listed together in the listing of inventory items (LII). See Appendices 7 and 8 for examples;

— establishes measures to prevent duplication of items in listings, an identification procedure ensuring that an item is only measured once. This is normally done by the inventorying team attaching a label of different colour showing that it was inventoried;

— sets out procedures for measurement indicating measurement techniques to be used and measurement performance desired. Reference should be made to the measurement system and measurement control programme to achieve desired results. This should include calibration standards to be used and maintenance provisions;

— establishes procedures for accepting measured values, e.g. in cases where items have previously been measured and sealed either by the State authority or the IAEA;

— provides procedures for the type of PIT. There are three types of plant clean-outs and combinations thereof. There could be a complete clean-out, a partial clean-out or even no clean-out with no down time, namely an in-process PIT. In all instances, the basis for the determination of the degree of completeness of the clean-out (where applicable) should be stated and the down time required for the clean-out and PIT. In the case of an in-process PIT, requirements for measuring in-process material inventory should be clearly stated;

— establishes procedures for handling losses and measured discards and accumulation of nuclear material;

— establishes a procedure for calculation of MUF and the measurement uncertainties associated with it;

— establishes a procedure for instances of the unforeseeable event, for instance when a large MUF is observed or a measured loss or operating accident.

The IAEA and the State authority should agree on the annual PIV schedule in a State. When received from the IAEA, the State authority would circulate the schedule to all facilities along with State information relative to the PIV. With this information available, the facilities could arrange for their individual PITs and for the subsequent IAEA PIV which coincides with the PIT at a facility. On receiving the schedule from the State authority, the NMC unit, in collaboration with the facility operator would establish the second document mentioned above, namely the PIT instruction. The instruction will involve people (who), place (location) and dates/time (when). The instruction should highlight:

— date(s) and times of the PIT;

— areas involved;

— persons responsible and supporting staff;

— dates when items could be moved in locations according to the PIT plan;

— for a complete or partial clean-out, the time when material movement stops and starting date(s) for clean-out. Enough time must be allocated to complete the analysis of samples and having all results available. In case of an in-process PIT, careful planning and coordination are needed to perform a meaningful PIT within the time limits set and the expectations stated in the Plan;

— date(s) for preparing item listings and checking it keeping in mind the stratification thereof. The same persons preparing the listings should not check it;

— the type of containers to be used in every KMP. Emphasize the use of labelling by the operator and the inventory team;

— composition of the inventory teams, dates and areas to be covered;

— dates for finalizing inventory listings and PIT summaries for the preparation of reports (ICR) for the period from the beginning of the month to the PIT date.

— plan for the opening of stores, vaults, etc. so as to have the responsible persons available on schedule, as well as access authorizations;

— special instruction for handling radioactive sources during measurement (if applicable);

— dates for preparation and finalization of the required reports (MBR, PIL);

— documentation (GL, LII and ICR) to be prepared for the PIV following the day after the PIT at a facility, time when it should be available for submission to the IAEA.

A PIT, planned and organized and carried out according to written procedures as stated above, can be conducted with better assurance of being complete and accurate.

5.5. Establishing a material balance closing system

The PIT provides evidence of the physical presence of the nuclear material at a facility. The following documents are to be established or updated:

— General ledger (GL), which should be closed by entering the book ending inventory (BE) followed by the MUF and then added up to be equal to the physical ending inventory (PE), which then forms the physical beginning (PB) for the following material balance period (MBP).

— List of inventory items (LII), completed and finalized during the PIT.

— ICR for the period from the beginning of the month to the PIT date indicating all the inventory changes that occurred during that period as reflected in the GL.

The material balance based on the physical inventory permits the determination of whether significant losses or discrepancies have occurred. Data not only from the physical inventory but also from all components of the material balance must be based on measurements of known uncertainties so that the material balance and MUF resulting from the data can be determined and evaluated and meaningful conclusions reached.

The equation relevant to determining MUF is:

$$MUF = PB + X - Y - PE$$

Where MUF = material unaccounted for

PB = beginning physical inventory

X = increases

Y = decreases

PE = ending physical inventory

The BE is calculated by PB + X – Y and should take any book adjustments into consideration, such as shipper receiver difference and in so doing reflect the amounts of material based on accounting information. The PE on the other hand reflects the physical amounts of material present. Therefore, MUF is an expression that indicates what nuclear material should be in an MBA as compared to what is actually present.

At item facilities (e.g. research reactors or nuclear power reactors, where material is in a discrete item form), MUF is expected to be zero. In bulk handling facilities (e.g. fuel fabrication), however, where there are multiple measurements, MUF is expected to exist. It follows that the operators observe MUF as a measure of possible diversion, as stated earlier. The operator's ability to detect loss is considered to be limited by the measurement uncertainty of MUF.

The IAEA's objective is to accept the operator's data, but only after verification of the items composing the operator's material balance. Here again, the IAEA's sensitivity of detection includes the operator's measurement uncertainty. The operator's ability to detect loss can be limited by this.

The data to be submitted would include the operator's estimated measurement errors for individual items and for the overall material balance. Error data in individual items are necessary for evaluation of operator/inspector differences on individual items. Information on shipper/receiver differences would also be important since this information can substantiate operator measurements. It could also provide data on measurement errors.

It is apparent that the procedures directing MUF evaluation must be in place and also address any accumulation of unexpected losses or inventory.

Reports are to be prepared on the basis of facility records.

5.5.1. Material balance report

This report is based on the information contained in the ledgers (paragraph 4.3.1.1). It consists of the entries as indicated in Section 1 (paragraph 1.1.4.7). Taking the book adjustments into consideration will supply the adjusted book inventory from which the physical inventory is subtracted to supply the MUF, which could be positive or negative.

This accounts for bulk-handling facilities. Under normal circumstances, MUF should not exist for item facilities.

5.5.2. Physical inventory listing

This listing uses the data provided in the LII (part 4.4).

It is important to note that an MBR submitted to the IAEA is always accompanied by a PIL (with the exception of the initial PIL which does not require an MBR). Further, where an ICR is submitted to the IAEA within 30 days of the end of the month in which the inventory change occurred, the MBR and PIL are submitted within 30 days of the PIT at a facility. All inventory changes occurring on the PIT date should be reflected in the corresponding PIL and MBR.

The above reports could be supported by concise notes or textual reports to explain any entry contained in the reports.

An MBR for each MBA should be prepared in terms of the facility attachments. The purpose of an MBR is described in paragraph 1.1.5.3 and further in paragraph 3.5.13.

5.6. Physical inventory verification system

On the basis of communication with facility operators, the IAEA and State authority agree on the annual PIV schedule in a State and procedures to be applied at relevant facilities. When the schedule is received from the IAEA, the State authority would circulate it to all facilities along with State information relative to the PIV. With this information available, the facilities could arrange for their individual PITs and for the subsequent IAEA PIV which corresponds with the PIT at a facility. On receiving the schedule from the State authority, the NMC unit would plan the PIV in collaboration with the facility operator.

On the day following the last day of the PIT, the IAEA inspectors could start verifying the State's declaration regarding the outcome of the PIT, but this will depend on the arrangement with the State. The Agency is provided with the itemized list of inventory items (LII) along with a summary of the inventory in every location and the total inventory for the MBA. Also, the general ledger (GL) for that material is provided. Normally, the records mentioned are put at the disposal of the State at due time on the day preceding the PIV at the MBA for submission to the IAEA so as to enable preparation for the PIV at the facility. This, however is not a requirement, but merely a recommendation.

The same procedures applicable to the PIT are applicable to the PIV, except that the IAEA inspectors perform the verification activities and the NMC unit and facility operator perform a supporting role. State inspectors will accompany the IAEA inspectors. The various events form an extended part of the PIT and are executed as such.

One important aspect of nuclear material accountancy performed by IAEA inspectors during PIV is evaluating the significance of MUF, discussed in the previous paragraph.

The PIV is viewed as settled once all relevant matters have been resolved. One such matter could be the significance of MUF, the evaluation of which should be included in PIT procedures.

6. QUALITY MANAGEMENT SYSTEM FOR SSAC

The purpose of this section is to describe how a formalized quality management system can be used to help meet the requirements placed on States (and facilities) by the IAEA under the terms of relevant safeguards agreements.

It first describes in general terms what is meant by a quality management system before describing the potential benefits that can be gained by using such a system. Following this, as an example, a description of the requirements of a quality management system based on ISO9001:2000 is presented. Finally, specific suggestions are made for processes and activities that could be included within a quality management system designed to meet the requirements placed on the State (facility) by the IAEA.

6.1. Quality management system

Quality management systems are often considered as being solely part of the commercial environment, however they can also contribute significantly to help understand and meet regulatory requirements.

A management system is an organization's structure for managing its processes and activities into a product or service to meets its objectives. When used in conjunction with the term "quality" it means the organization's management system for achieving the objective of meeting customer requirements and achieving customer satisfaction.

Whilst the relationship between a State and the IAEA is not a traditional customer-supplier relationship, the need for a State to meet the requirements placed upon it by implementation of a safeguards agreement with the IAEA can be thought of as a supplier (the State) meeting the needs of the customer (the IAEA).

It must be recognized that the quality management system should be designed to meet the specific requirements placed on the State. Whilst these will be similar for all safeguards agreements, the quality management system should be designed to meet the needs of a particular situation that will take into account such issues as:

— the requirements of the specific safeguards agreement;

— the size and complexity of nuclear fuel cycle activities in the State;

— how the nuclear industry is organized in that State;

— the organizational arrangements of the State authority;

— any existing requirements placed on the State from, for example, national or regional systems and agreements.

Therefore, these guidelines must be read with this in mind to ensure that the quality management system is designed such that it will effectively meet a State's specific needs.

The development of a quality management system with the objectives of a State meeting the requirements placed upon it by the IAEA will ensure that the necessary processes and systems are planned, implemented and monitored to ensure that, on an ongoing basis, the State is able to meet its obligations under the terms of its safeguards agreements.

The benefits from implementing a quality management system to assist the State in meeting its obligations can include:

— a clearer understanding of the requirements placed on the State and/or facilities by the safeguards agreement and increased ability to effectively and efficiently meet those requirements.

— improved communication between all stakeholders in the process — for example, facility operators, State authorities, IAEA.

— clear responsibilities defined for performance of different activities.

— the ability to understand any changes to the requirements and manage those changes effectively. For example, a State having recently ratified the additional protocol will be able to clearly define what changes are required and how these interact with the processes already in existence.

6.2. Requirements of a quality management system

One example of the requirements for a quality management system is defined in the international standard ISO 9001:2000 Quality Management Systems — Requirements. The standard is based on eight quality management principles that can be used to lead an organization towards improved performance.

The eight management principles on which the ISO 9001:2000 standard is based are:

— *Customer focus*. The State authority provides products and services to the IAEA and, therefore, should understand current and future IAEA needs in order to meet IAEA requirements and strive to meet or exceed the expectations. Cooperation between the facility operators and the State authority is very important as this affects the quality of products and services to the IAEA.

— *Leadership*. Leaders establish unity of purpose and direction of the organization. They also create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.

— *Involvement of people*. People at all levels are the essence of an organization and their full involvement enables their abilities to be utilized to the organization's benefit.

— *Process approach.* A desired result is achieved more efficiently when activities and related resources are managed as a process.

— *Systematic approach to management*. Identifying, understanding and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving objectives.

— *Continual improvement*. Overall performance improvement should be a permanent objective of the organization.

— *Factual approach to decision making.* Effective decisions should be based on the analysis of data and information.

— *Mutually beneficial supplier relationships*. An organization and its suppliers should be interdependent and mutually beneficial relationships should enhance the ability of both to create value.

From the above, it is clear that the international standard focuses on customer satisfaction, continual improvement, the demonstration of commitment and the prevention of non-conformity. It emphasizes top management's commitment, measurability of objectives, customer needs and expectations and requires greater commitment to meeting requirements and to continual improvement.

The underpinning basis of a quality management system is a Plan-Do-Check-Act (PDCA) approach. The essence of the PDCA approach is: Plan what you will do; Do what you planned; Check that you have actually accomplished it; Act on any perceived gaps between what was planned and accomplished and then restart the cycle at the 'Plan' phase. The PDCA approach is intrinsic to the ISO 9001:2000 standard.

In order to implement a quality management system in accordance with ISO 9001:2000, certain steps are required:

- Processes needed for the quality management system must be identified;
- The sequence and interaction of these processes must be determined;
- Criteria and methods required to ensure the effective operation and control of these processes must be determined;
- Information and resources necessary to support the operation and monitoring of these processes must be made available;
- Processes must be monitored, measured and analyzed;
- Actions necessary to achieve planned results and continual improvement of these processes must be implemented.

If these steps are taken, confidence will be created in the capability of processes, quality of the service and products, providing a basis for continual improvement, thus leading to increased satisfaction of customers and other interested parties.

The ISO 9001:2000 standard specifies 6 procedures that are required to be documented in the quality management system. These are:

- **Control of documents** — defining the procedures needed to approve, review, update and identify the changes in revisions of documents. It also ensures that legible, identifiable, controlled copies of current revisions are available at point of use;
- **Control of quality records** — to ensure that they remain legible, identifiable and retrievable to provide evidence of conformity to requirements;
- **Internal audits** — at planned intervals to determine whether the quality management system conforms to the requirements of the ISO international standard and to the requirements established by the State authority, and whether the system is effectively implemented and maintained;
- **Control of non-conforming products** — defining the controls, related responsibilities and authorities for dealing therewith;
- **Corrective action** — defining the requirements for reviewing non-conformities (including IAEA identified issues needing resolution), determining the causes thereof, evaluating the need for action to ensure that it does not recur, determining and implementing action needed, records and review of the action taken to ensure the adequacy thereof;
- **Preventive action** — defining the requirements for determining potential non-conformities, evaluating the need for action to prevent occurrences, determining and implementing action needed for prevention, records and review of action taken.

However it should be noted that ISO 9001:2000 also requires the documentation *to include documents required by the organization to ensure the effective planning, operation and* *control of its processes.* Therefore it is up to the State to decide the amount and detail of documentation required to support its quality management system. This will be dependent on a number of factors such as the experience and competence of the staff carrying out the work, the frequency and complexity of an activity and the importance of the activity to the overall process as well as the risk and consequence of an activity or process being carried out incorrectly.

This section uses ISO 9001:2000 as an example of standard defining requirements for a quality management system and a number of the requirements have been highlighted. However, the State should select the standard against which they are going to work on the basis of what meets its needs — be it ISO 9001:2000, a national standard developed within that State, or a regional standard. Benchmarking and sharing best practices with other States may also provide an opportunity to identify the requirements for its quality management system.

6.3. Meeting the requirements of the safeguards agreement — what to include in a quality management system

The purpose of this section is to help identify the types of processes and activities, specifically related to nuclear material accountancy and safeguards, which should be formalized and documented within the State's quality management system. It does not consider the ISO9001:2000 requirements for the more generic management system components and documents already identified.

Relevant areas for inclusion in the quality management system include:

— determining the objectives of the SSAC and organizational arrangements for the SSAC;

— communication between facilities, the State and the IAEA;

— definition of MBAs and KMPs;

— provision of the initial report;

— provision of design information;

— negotiation of subsidiary arrangements;

— advance notifications of import/export and other notifications as required;

— reporting inventory changes, physical inventories and material balances;

— maintenance of required records;

— facilitating IAEA inspections and other verification activities;

— measurement of nuclear material and control of measurements;

— physical inventory taking and verification;

— closing the material balance;

— feedback on results of verification activities.

The areas covered are not intended to be an exhaustive list but illustrate important areas that need to be considered and more detailed information has already been discussed in previous sections. The actual processes included in the management system will be dependent on the needs of the State and the specific requirements of its safeguards agreement.

Most of the areas identified above will have activities at both the State and facility level. It is important to design them as processes covering the whole range of activities and different stakeholders in order to allow each stakeholder to understand their role in the overall process and achievement of its objectives.

APPENDIX I
IMPORT REACTOR FUEL

ACTIVITY: IMPORT REACTOR FUEL	
OPERATOR/NUCLEAR MATERIAL CONTROL UNIT	**STATE AUTHORITY**
a. Apply for licence /permit	b. Approve or get approval
	c. Provide licence /permit to operator or NMC
d. Inform State authority	
	e. Submit advance notification to IAEA
f. Receive fuel	
– Handle source documents	
– Prepare an inventory change document (ICD)	
– Enter data into general ledger	
– Enter data into listing of inventory items (LII)	
	g. Audit facility
h. Prepare inventory change report (ICR) and submit	i. Finalize and submit ICR to IAEA within 30 days of the end of the month in which the inventory change took place

APPENDIX II
RECEIVE FEED MATERIAL

ACTIVITY: RECEIVE FEED FOR FUEL FABRICATION	
OPERATOR/NUCLEAR MATERIAL CONTROL UNIT	**STATE AUTHORITY**
a. Inform State authority	b. Submit advance notification to IAEA
c. Depending on reaction of the IAEA, transfer feed cylinder	
d. Receive cylinder	
– Weigh cylinder	
– Calculate and evaluate shipper/receiver difference	
(SRD)	
– Accept/Reject cylinder	
– Transfer to feed store or arrange for return	
e. Handle source documents	
f. Seal removal by IAEA or State authority or by operator for use of the feed material	
g. Prepare accounting records	
– Enter data into inventory change document (if in use)	
– Enter data into LII	
– Enter data into general ledger	
	h. Audit facility regarding receipt
i. Prepare inventory change report (ICR)	
– Use shipper's data	
– SRD, namely shipper's weight – receiver's weight and uranium weight based on that weight and being positive or negative	
	j. Finalize ICR and submit to IAEA within 30 days of end of month in which inventory change took place

APPENDIX III
PREPARATION FOR INSPECTION

ACTIVITY – Preparation for inspection	
OPERATOR/NUCLEAR MATERIAL CONTROL UNIT	**STATE AUTHORITY**
	a. Receive notice of inspection from the IAEA
	b. Prepare and send schedule and activities notice to facilities
c. Prepare an Inspection Plan based on Inspection Instruction indicating date of inspection and associated activities and responsibilities	
d. Prepare a LII and general ledger for every category of nuclear material and submit on day before the inspection to State authority. If working on computer, data should be provided on hard copy and on CD/diskette	
	e. Check documentation for correctness and Completeness and provide to IAEA inspector(s)
f. Pre-inspection meeting	g. State authority inspector accompanies IAEA inspector(s)

APPENDIX IV
CLOSING MATERIAL BALANCE

ACTIVITY: CLOSING THE MATERIAL BALANCE **Remark**: Material balance is closed following second of two successive physical inventory takings at facility	
OPERATOR/NUCLEAR MATERIAL CONTROL UNIT	**STATE AUTHORITY**
a. Checking that listings of inventory items (LII) are complete for every category of nuclear material	
b. Establish batches to be included in physical inventory listing (PIL)	
c. Establish summaries for every component of material balance (MB) – Increases (X) – Decreases (Y) – Shipper/receiver differences (for bulk-handling facilities only)	
d. Establish MB for facility according to definition MB = Physical beginning + X - Y at PIT date	
e. Compare MB with current physical inventory (PE) which equals material unaccounted for(MUF) Thus, MB - PE = MUF	
f. Evaluate the MUF, considering uncertainty of measurement and processing. Calculate Sigma MUF & compare with international accepted values for that type of facility Evaluate every component in the MUF equation and ensure it is within accepted limits	
g. Wait for the results of the IAEA verification and incorporate any further adjustments in original PIT results and finalize LII and PIL	
h. Provide any further explanation of existing MUF to State authority.	
i. Provide PIT information to State authority – Closed general ledger for every category of nuclear material	

ACTIVITY: CLOSING THE MATERIAL BALANCE **Remark**: Material balance is closed following second of two successive physical inventory takings at facility	
OPERATOR/NUCLEAR MATERIAL CONTROL UNIT	**STATE AUTHORITY**
– LIIs – ICR for the period beginning of the month to the PIT date – PIL – Summaries for components of MB	
	j Prepare and finalize material balance report (MBR)
	k. Evaluate results and act accordingly
	l. Submit MBR and PIL within 30 days of PIT to IAEA.
	m. Submit ICR within 30 days of end of month
	n. Above reports could be accompanied concise notes or textual reports, as appropriate
	o. Submit any explanation regarding MUF to IAEA

APPENDIX V
ICD EXAMPLE

			Uranium					Plutonium	
Line	Batch Identity	No. of Items	Inventory Change Code	Element Code	Isotope Code	Element Weight (g)	Isotope Weight (g)	Element Code	Element Weight (g)
1	IBC794	1	SF	E	G	177990	1812	P	1450
2	IBC795	1	SF	E	G	177216	1746	P	1473
3	IBC797	1	SF	E	G	178471	1876	P	1423
4	IBC798	1	SF	E	G	178222	1746	P	1461
5	IBD810	1	SF	E	G	177579	1909	P	1393
6	IBD812	1	SF	E	G	178263	1944	P	1380
7	IBD813	1	SF	E	G	177847	1785	P	1456
8	IBD816	1	SF	E	G	177807	1830	P	1436
9	IBD818	1	SF	E	G	176007	1594	P	1512
10	IBD819	1	SF	E	G	176232	1594	P	1513
11	IBD821	1	SF	E	G	177575	1820	P	1435
12	IBD824	1	SF	E	G	177770	1914	P	1390
13	IBD825	1	SF	E	G	176781	1579	P	1529
14	IBE916	1	SF	E	G	178438	2056	P	1379
15	IBE920	1	SF	E	G	178795	1988	P	1427

			Uranium					Plutonium	
Line	**Batch Identity**	**No. of Items**	**Inventory Change Code**	**Element Code**	**Isotope Code**	**Element Weight (g)**	**Isotope Weight (g)**	**Element Code**	**Element Weight (g)**
16	IBE921	1	SF	E	G	178921	1982	P	1420
17	IBE933	1	SF	E	G	178950	2050	P	1386
18	IBE938	1	SF	E	G	178222	1958	P	1428
19	IBE961	1	SF	E	G	178562	1982	P	1426
20	IBE968	1	SF	E	G	178760	1978	P	1421
21									
22									
23									
24									
25									
Subtotals:		**20**				**3558408**	**37143**		**28738**
Totals:		**70**				**12443535**	**126174**		**101586**

Doc. No.: **MT-401** Page No.: **3/3** Shipper-Receiver Difference: Date Measured:

Shipping Date: **950318** Shipper Signature: **Mr. Shipitout** Receiving Date: Receiver Signature:

APPENDIX VI
GENERAL LEDGER EXAMPLE

GENERAL LEDGER (EXAMPLE)

Facility**: Neptune 1 Power Plant** MBA: **NN-B**

Material Description: **Enriched Uranium** Element Code: **E** Isotope Code: **G** Unit: **g**

ine	Date	ICD/PIL	IC Code	No. of Items	Increases				Decreases				Inventory		No. of Items
					Receipts		Other		Shipments		Other				
					U	U-235	U	U-235	U	U-235	U	U-235	U	U-235	
1	940816	PIL											**124358164.0**	**2650947.0**	702
2	950318	MT-401	SF	70					12443535.0	126174.0			111914629.0	2524773.0	632
3	950401	MT-001	RD	100	17173193.0	520797.0							129087822.0	3045570.0	732
4	950617	MT-301	SD	34					6056242.0	63396.0			123031580.0	2982174.0	698
5	950724	MT-402	SF	70					12484496.0	136121.0			110547084.0	2846053.0	628
6	951020	NLP-101	LN	116							682078.0	375138.0	109865006.0	2470915.0	628
7	951020	PIL											**109865006.0**	**2470915.0**	628
8															
9															
10															

APPENDIX VII
LII — ITEM EXAMPLE

LIST OF INVENTORY ITEMS (EXAMPLE)
Item Facility

Material balance area **NN-B**

Physical inventory taking **1995-10-20**

Location		Identification		Material	Uranium	Uranium			Nuclear	Irradiated Fuel	
KMP	Position	Item	Batch	Description	Element (g)	Fissile (g)	Plutonium (g)	Nuclear Loss (g)	Production (g)	Burnup	Cooling
A	AB-17		IBL960	BV1F	171991	5234					
A	AB-15		IBL968	BV1F	171680	5215					
A	AC-11		IBL984	BV1F	172193	5226					
A	AC-12		IBL985	BV1F	172076	5217					
B	09-05		IBK770	BV4F	172587	5253					
B	10-05		IBK781	BV4F	172532	5250					
B	11-05		IBK782	BV4F	172438	5251					
B	12-05		IBK783	BV4F	172385	5251					
C	BA-09		IBF113	BV1G	178845	2080	1310	5374	1310	26541	0
C	AF-14		IBF118	BV1G	178264	1904	1386	5832	1386	26499	0

APPENDIX VIII
LII — BULK SAMPLE

LIST OF INVENTORY ITEMS (EXAMPLE)
Bulk Facility

Inventory Date: 1996-05-07 KMP: B

MBA: NNA2 Material description: GQJB

Item ID	Batch ID	Gross Weight (g)	Tare Weight (g)	Net Weight (g)	Percent Element	Uranium Weight (g)	Percent Enrichment	Material Category	Isotope Weight (g)	Location	Remarks
X01	1112583	25971	1503	24468	87.20	21336	2.9	E	619	1 S 10	
X02	1112583	25973	1504	24469	87.20	21337	2.9	E	619	1 S 10	
X03	1112583	25969	1500	24469	87.20	21337	2.9	E	619	1 S 10	
X04	1112583	25970	1502	24468	87.20	21336	2.9	E	619	1 S 10	
X05	1112583	25974	1505	24469	87.20	21337	2.9	E	619	1 S 10	
X06	1112583	25972	1504	24468	87.20	21336	2.9	E	619	1 S 10	
X07	1112583	25973	1503	24470	87.20	21338	2.9	E	619	1 S 10	
X08	1112583	25971	1501	24470	87.20	21338	2.9	E	619	1 S 10	
X09	1112583	25973	1503	24470	87.20	21338	2.9	E	619	1 S 10	
X10	1112583	25973	1504	24469	87.20	21337	2.9	E	619	1 S 10	
					Total U:	**213370**		**U235:**	**6190**		

REFERENCES

[1] IAEA Statute, as amended up to 23 February 1989, IAEA, Vienna (2006).

[2] The Structure and Content of Agreements between the IAEA and States required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons, INFCIRC/153 (Corrected), IAEA, Vienna (1972).

[3] Model Protocol Additional to the Agreement(s) Between State(s) and the International Atomic Energy Agency for the Application of Safeguards, INFCIRC/540 (Corrected), IAEA, Vienna (1998).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safeguards Glossary, International Nuclear Verification Series No.3, IAEA, Vienna (2003).

[5] Treaty on the Non-Proliferation of Nuclear Weapons, INFCIRC/140, IAEA, Vienna (1970)

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Guidelines and Format for Preparation and Submission of Declarations Pursuant to Articles 2 and 3 of the Model Protocol Additional to Safeguards Agreements, IAEA Services Series 11, IAEA, Vienna (2004).

[7] STOIBER, C. et al., Handbook on Nuclear Law, IAEA, Vienna (2003).

ABBREVIATIONS

BE	book ending
DIQ	design information questionnaire
GL	general ledger
ICD	inventory change document
ICR	inventory change report
ISO	International Standards Organization
KMP	key measurement point
LII	listing of inventory items
LOF	location outside facilities
MB	material balance
MBA	material balance area
MBP	material balance period
MBR	material balance report
MUF	material unaccounted for
NDA	non-destructive assay
NMC	nuclear material control
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
PB	physical beginning
PE	physical ending
PIL	physical inventory listing
PIT	physical inventory taking
PIV	physical inventory verification
QMS	quality management system
RA	rounding adjustment
SQ	significant quantity
SRD	shipper/receiver difference
SSAC	State system of accounting for and control of nuclear material

CONTRIBUTORS TO DRAFTING AND REVIEW

Cisar,V.	International Atomic Energy Agency
Doulgeris, N.	Nuclear Accountancy and Control, Australian Safeguards and Non-proliferation Office, Australia
Dahlin, G.	Office of Nuclear Non-Proliferation, Swedish Nuclear Power Inspectorate, Sweden
Jeffrey, T.	International Atomic Energy Agency
Kainulainen, E.	Radiation and Nuclear Safety Authority, Nuclear Waste and Materials Regulation, Finland
Keeffe, R.	Technical Development and Services Division, Office of International Affairs, Canadian Nuclear Safety Commission, Canada
Keselica, M.	NPP Dukovany, Czech Republic
Maritz, J.	South African State System of Accounting and Control
Marzo, M.	Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials, Brazil
Minnaar, R.	South African Nuclear Energy Corporation Limited, South Africa
Oakberg, J.	International Atomic Energy Agency
Santos Bento, J.	DG-TREN, Energy and Transport, European Commission
Szollosi, E.	Hungarian Atomic Energy Authority
Valentino, L.	Nuclear Regulatory Authority, Argentina