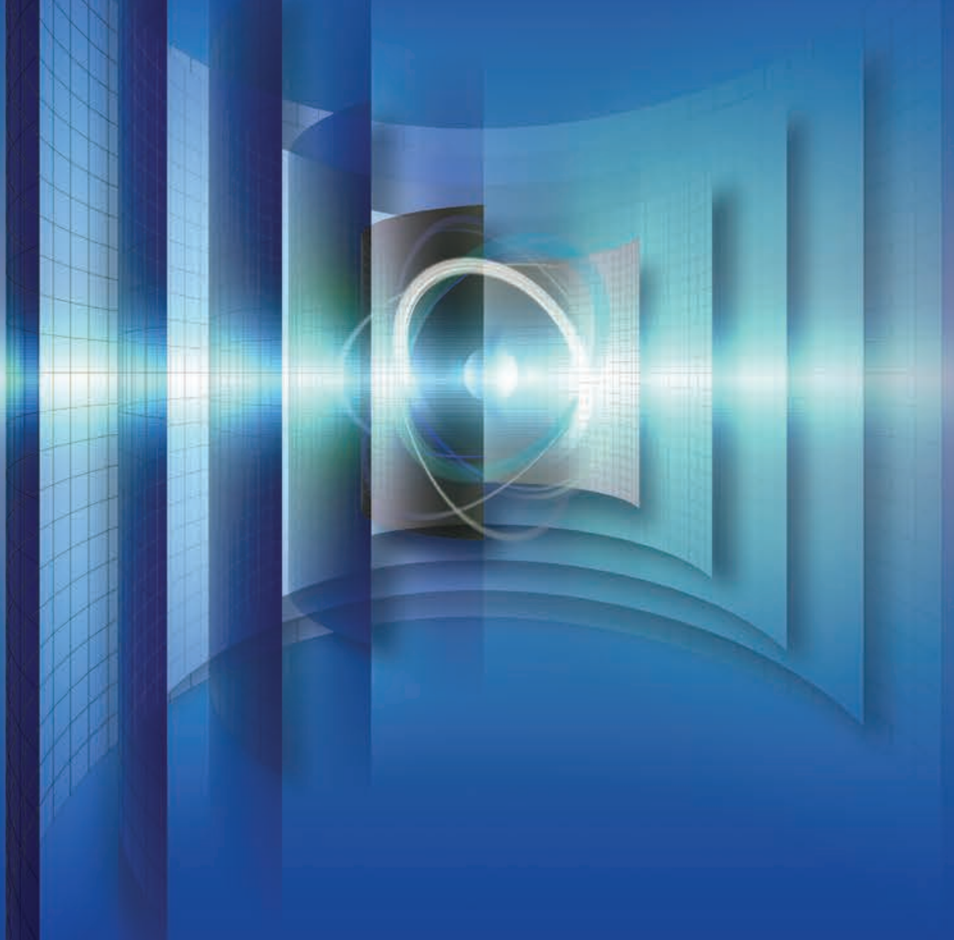
IAEA Nuclear Security Series No. 25-G

Implementing Guide

Use of Nuclear Material Accounting and Control for Nuclear Security Purposes at Facilities



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IAEA NUCLEAR SECURITY SERIES

Nuclear security issues relating to the prevention and detection of, and response to, criminal or intentional unauthorized acts involving, or directed at, nuclear material, other radioactive material, associated facilities or associated activities are addressed in the **IAEA Nuclear Security Series**. These publications are consistent with, and complement, international nuclear security instruments, such as the Convention on the Physical Protection of Nuclear Material and its Amendment, the International Convention for the Suppression of Acts of Nuclear Terrorism, United Nations Security Council resolutions 1373 and 1540, and the Code of Conduct on the Safety and Security of Radioactive Sources.

CATEGORIES IN THE IAEA NUCLEAR SECURITY SERIES

Publications in the IAEA Nuclear Security Series are issued in the following categories:

- **Nuclear Security Fundamentals** specify the objective of a State's nuclear security regime and the essential elements of such a regime. They provide the basis for the Nuclear Security Recommendations.
- **Nuclear Security Recommendations** set out measures that States should take to achieve and maintain an effective national nuclear security regime consistent with the Nuclear Security Fundamentals.
- **Implementing Guides** provide guidance on the means by which States could implement the measures set out in the Nuclear Security Recommendations. As such, they focus on how to meet the recommendations relating to broad areas of nuclear security.
- **Technical Guidance** provides guidance on specific technical subjects to supplement the guidance set out in the Implementing Guides. They focus on details of how to implement the necessary measures.

DRAFTING AND REVIEW

The preparation and review of Nuclear Security Series publications involves the IAEA Secretariat, experts from Member States (who assist the Secretariat in drafting the publications) and the Nuclear Security Guidance Committee (NSGC), which reviews and approves draft publications. Where appropriate, open-ended technical meetings are also held during drafting to provide an opportunity for specialists from Member States and relevant international organizations to review and discuss the draft text. In addition, to ensure a high level of international review and consensus, the Secretariat submits the draft texts to all Member States for a period of 120 days for formal review.

For each publication, the Secretariat prepares the following, which the NSGC approves at successive stages in the preparation and review process:

- An outline and work plan describing the intended new or revised publication, its intended purpose, scope and content;
- A draft publication for submission to Member States for comment during the 120 day consultation period;
- A final draft publication taking account of Member States' comments.

The process for drafting and reviewing publications in the IAEA Nuclear Security Series takes account of confidentiality considerations and recognizes that nuclear security is inseparably linked with general and specific national security concerns.

An underlying consideration is that related IAEA safety standards and safeguards activities should be taken into account in the technical content of the publications. In particular, Nuclear Security Series publications addressing areas in which there are interfaces with safety — known as interface documents — are reviewed at each of the stages set out above by relevant Safety Standards Committees as well as by the NSGC.

USE OF NUCLEAR MATERIAL ACCOUNTING AND CONTROL FOR NUCLEAR SECURITY PURPOSES AT FACILITIES

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

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IMPLEMENTING GUIDE

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FOREWORD

by Yukiya Amano
Director General

The IAEA's principal objective under its Statute is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world." Our work involves both preventing the spread of nuclear weapons and ensuring that nuclear technology is made available for peaceful purposes in areas such as health and agriculture. It is essential that all nuclear and other radioactive materials, and the facilities at which they are held, are managed in a safe manner and properly protected against criminal or intentional unauthorized acts.

Nuclear security is the responsibility of each individual State, but international cooperation is vital to support States in establishing and maintaining effective nuclear security regimes. The central role of the IAEA in facilitating such cooperation and providing assistance to States is well recognized. The IAEA's role reflects its broad membership, its mandate, its unique expertise and its long experience of providing technical assistance and specialist, practical guidance to States.

Since 2006, the IAEA has issued Nuclear Security Series publications to help States to establish effective national nuclear security regimes. These publications complement international legal instruments on nuclear security, such as the Convention on the Physical Protection of Nuclear Material and its Amendment, the International Convention for the Suppression of Acts of Nuclear Terrorism, United Nations Security Council resolutions 1373 and 1540, and the Code of Conduct on the Safety and Security of Radioactive Sources.

Guidance is developed with the active involvement of experts from IAEA Member States, which ensures that it reflects a consensus on good practices in nuclear security. The IAEA Nuclear Security Guidance Committee, established in March 2012 and made up of Member States' representatives, reviews and approves draft publications in the Nuclear Security Series as they are developed.

The IAEA will continue to work with its Member States to ensure that the benefits of peaceful nuclear technology are made available to improve the health, well-being and prosperity of people worldwide.

EDITORIAL NOTE

Guidance issued in the IAEA Nuclear Security Series is not binding on States, but States may use the guidance to assist them in meeting their obligations under international legal instruments and in discharging their responsibility for nuclear security within the State. Guidance expressed as 'should' statements is intended to present international good practices and to indicate an international consensus that it is necessary for States to take the measures recommended or equivalent alternative measures.

Security related terms are to be understood as defined in the publication in which they appear, or in the higher level guidance that the publication supports. Otherwise, words are used with their commonly understood meanings.

An appendix is considered to form an integral part of the publication. Material in an appendix has the same status as the body text. Annexes are used to provide practical examples or additional information or explanation. Annexes are not integral parts of the main text.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. This publication provides guidance that a State may voluntarily use to enhance nuclear security at the nuclear facility level through use of its nuclear material accounting and control (NMAC) system. (The term ‘accounting’ in this publication is used synonymously with the term ‘accountancy’ in other NSS publications.) A number of nuclear security related publications describe the need for using such a system to support nuclear security and outline the requirements and recommendations for the contribution of NMAC to nuclear security at nuclear facilities. In 2004, the United Nations Security Council passed Resolution 1540 [1]. This resolution, regarding the non-proliferation of weapons of mass destruction, was adopted unanimously on 28 April 2004. It establishes obligations under Chapter VII of the United Nations Charter for all United Nations Member States to, inter alia, “(a) Develop and maintain appropriate effective measures to account for and secure [nuclear material] in production, use, storage or transport; (b) Develop and maintain appropriate effective physical protection measures”. The Convention on the Physical Protection of Nuclear Material (CPPNM) of 1980 [2] is the only international legally binding instrument in the area of physical protection of nuclear material, including protection during international transport, that establishes measures related to the prevention, detection and punishment of offences relating to nuclear material. In addition, the Amendment to the CPPNM of 2005 extends the scope of the CPPNM to also cover nuclear facilities and nuclear material in domestic use, storage and transport used for peaceful purposes, as well as sabotage. Nuclear Security Recommendations on the Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5) [3], published in 2011 in the IAEA Nuclear Security Series, defines the role and recommended contribution of NMAC to nuclear security at nuclear facilities (in paras 3.17, 3.19, 3.26, 3.28, 3.36, 3.47, 4.10, 4.11, 4.57, 4.58 and 5.19, and in ‘Definitions’). (The term ‘nuclear facility’ as used in this publication is specifically defined in Ref. [3]. The term ‘facility level’ is often shortened to ‘facility’ for readability and is intended to differentiate from the ‘State level’.)

1.2. The guidance provided in this publication is not legally binding and is not intended to add to, subtract from, amend or derogate from, in any way, the rights and obligations of the IAEA and its Member States set forth in relevant safeguards agreements or legally binding international instruments in the area of nuclear security. In using the guidance provided in this publication, Member

States should ensure that its implementation will not result in contradiction or interference with the fulfilment of their obligations under relevant IAEA safeguards agreements.

1.3. This publication focuses on measures to prevent and mitigate the risk posed by insider threats. It describes elements of a programme that can be implemented at a nuclear facility in coordination with other systems existing at the facility level, such as physical protection, radiation and radioactive contamination monitoring and operational systems, for the purpose of deterring and detecting unauthorized removal of nuclear material. In many sections of this publication, the functionalities or enhancements that are particularly important to mitigating insider threats are highlighted in the subsections entitled ‘Aspects of particular relevance to nuclear security’.

1.4. Nuclear security measures are designed to protect nuclear facilities and nuclear material from adversaries such as non-State actors both inside and outside the nuclear facility. (Historically, the term physical protection has been used to describe what is now known as the nuclear security of nuclear material and nuclear facilities [3].) The Implementing Guide: Preventive and Protective Measures against Insider Threats [4] describes an adversary as any individual performing or attempting to perform a malicious act. A malicious insider is an adversary with authorized access to a nuclear facility or nuclear material in transport and knowledge of operations or sensitive information, with time to perform a malicious act. An insider might be a facility manager or an employee of another organization, employed in areas within the nuclear facility, such as NMAC, physical protection, administration, maintenance or operations, or a contractor or a temporary employee.

1.5. At the nuclear facility level, an NMAC system helps to deter and detect unauthorized removal of nuclear material by maintaining an inventory of all nuclear material, including information related to its location. The system should provide information on the isotopic composition, quantity, type, location, use and movement. It should have the capability to register an alarm and to initiate a response if the system indicates that nuclear material may have been removed without authorization or used in an unauthorized manner. An effective NMAC system can detect malicious insider activities involving nuclear material, and supports the correct assessment of an irregularity involving nuclear material. In case of the unauthorized removal of nuclear material from the nuclear facility, the NMAC system provides the ability to identify the quantity and characteristics of the nuclear material that has been removed.

1.6. It is important to nuclear security that physical protection systems and NMAC systems function in a coordinated and complementary manner. The recommendation in Ref. [3] is to arrange the physical protection and NMAC systems to provide defence in depth and improve detection of unauthorized removal of nuclear material. The operator is ultimately responsible for the protection of the nuclear material [3].

OBJECTIVE

1.7. The objective of this publication is to describe how to use an NMAC system at a nuclear facility to enhance nuclear security by detecting in a timely manner any unauthorized removal of nuclear material and providing deterrence against such possible actions. The primary objective of an NMAC system is to maintain and report accurate, timely, complete and reliable information on all activities and operations (including movements) involving nuclear material. This information should include the locations, quantities and characteristics of nuclear material at the nuclear facility. The goal is to maintain control over the nuclear material to ensure continuity of knowledge, and thereby to enhance the ability to deter and detect unauthorized removal of nuclear material.

SCOPE

1.8. This publication provides guidance on evaluating and enhancing, where necessary, NMAC systems to meet a State's nuclear security objectives at the nuclear facility level [3]. The guidance is intended for use within States by the competent authority [3] and operators of any type of nuclear facility. The scope of this publication is limited to nuclear material, although the general principles apply to the security of radioactive material other than nuclear material. Implementing measures may differ according to the potential consequences associated with unauthorized removal of these materials.

1.9. This publication does not cover the safety of nuclear facilities or nuclear material. Requirements for radiation protection and safety in nuclear facilities and related activities, and recommendations on meeting the requirements, are established in IAEA safety standards, which are issued in the IAEA Safety Standards Series.

1.10. Not all sections of this publication are relevant to all nuclear facilities.

1.11. To fully address nuclear security objectives, the State or facility operator may need to enhance existing NMAC system capabilities. Guidance on these enhancements is provided in this publication. The entire NMAC system should be subject to State oversight.

STRUCTURE

1.12. Following this Introduction, Sections 2–4 describe the general principles of NMAC and their application to nuclear security at the nuclear facility level. Section 2 addresses the relationship between the regulatory framework and the use of the NMAC system for nuclear security purposes, including guidance on licensing, oversight and enforcement. Section 3 addresses optimization of the NMAC system at the facility level, including evaluation of the NMAC contribution to the overall effectiveness of nuclear security, and the coordination of NMAC with other systems at the facility level, such as the physical protection system, to deter and detect unauthorized removal of nuclear material. Section 4 describes contributions of the NMAC system elements and practices (including a description of terms regarding movements of nuclear material within the facility or from a facility) to meeting nuclear security objectives, in the following areas:

- Management structure;
- Records and reports;
- Physical inventory taking of nuclear material;
- Measurements and their quality control;
- Nuclear material control;
- Nuclear material movements;
- Detection, investigation and resolution of irregularities;
- Quality management.

1.13. Terms are defined in the section entitled ‘Definitions’. In cases where the definitions are derived from a publication, the reference is provided. It should be noted that in a few cases these terms may be identical to, or similar to, terms which have different definitions in other contexts; where this occurs, it is identified in the text at the first occurrence.

2. REGULATORY FRAMEWORK FOR THE NMAC SYSTEM

2.1. The NMAC system at the facility level is established within the context of a national regulatory framework and is controlled by the State's competent authority. IAEA guidance on nuclear law and implementing legislation, including aspects for nuclear security, is provided in the Handbook on Nuclear Law [5] and the Handbook on Nuclear Law: Implementing Legislation [6].

SPECIFIC CONSIDERATIONS REGARDING NMAC IN THE STATE'S REGULATORY FRAMEWORK

2.2. The State's regulatory framework should set forth requirements for the design and performance of NMAC systems at the nuclear facility level, including those related to nuclear security. Nuclear security requirements should be consistent with a graded approach similar to that applied to physical protection [3] regarding the stringency of measures to be taken based on the quantities and attractiveness of the nuclear material at facilities. The State may incorporate elements of this guidance, as appropriate, into the regulatory framework.

AUTHORIZATION AND LICENSING

2.3. An operator that wishes to carry out activities involving nuclear material should obtain authorization (e.g. a licence) from the State's competent authority for each nuclear facility before it begins operation or receives nuclear material. Before receiving a licence to possess nuclear material, an operator should demonstrate, inter alia, that it has developed an effective NMAC system based upon:

— Legislation regulating the production, processing, use, handling and storage or disposal of nuclear material;
— Regulations, rules and orders;
— Guidance documents suggesting possible approaches to implementation.

2.4. The State or the State's competent authority should include in its licensing considerations a requirement for submitting an evaluation of the NMAC system at the facility level. There are several approaches that can be used by the State's authority and the operators to perform such activities. The facility should document evaluations of the NMAC system and demonstrate its capability to deter and detect unauthorized removal of nuclear material. The operator has responsibility for the implementation of the NMAC system throughout the lifetime of the nuclear facility.

2.5. Both the State competent authority and the operator need to recognize the importance of using NMAC for nuclear security purposes. NMAC should be promoted within the nuclear security culture as an important contributor to nuclear security.

REGULATORY OVERSIGHT OF THE FACILITIES BY THE COMPETENT AUTHORITY

2.6. Facility NMAC systems should be subject to oversight by the State's competent authority. Oversight should include periodic inspections and evaluations of the facility's NMAC system's contribution to meeting the nuclear security objectives of the facility.

2.7. Oversight of nuclear facilities by the competent authority should not be limited to inspections. In addition to inspections, and depending on the regulatory framework existing in the State, the competent authority may also base its oversight on information submitted to it by operators of nuclear facilities. This information should include accounting reports, material balance reports, inventory change reports, incident notifications, licence requests and other relevant documents. Observation of routine operations or facility self-assessments may also provide useful information to the competent authority. Such information can be useful in evaluating the compliance of the facility NMAC system with regulatory requirements, and may be necessary to organize, prepare and conduct inspections.

2.8. Any failure by a nuclear facility's operator to operate securely and to accurately account for and effectively control nuclear material should be subject to regulatory actions commensurate with the severity of the violation of the State's regulatory requirements.

3. TAILORING NMAC SYSTEMS FOR NUCLEAR SECURITY

3.1. This section describes the general principles and objectives of NMAC systems at the facility level, the implementation of which strengthens nuclear security. The individual system elements and their related implementing measures are described in Section 4.

OBJECTIVES OF AN NMAC SYSTEM

3.2. The primary objectives of an NMAC system are to:

- Maintain and report accurate, timely, complete and reliable information on the locations, quantities and characteristics of nuclear material present at the facility;
- Maintain control over the nuclear material to ensure continuity of knowledge, thereby enhancing the ability to deter and detect unauthorized removal;
- Provide the basis for investigation and resolution without delay of any irregularity indicating a possible loss of nuclear material, assistance in determining whether unauthorized removal has actually occurred and performance of an emergency inventory, if needed;
- Provide information helpful to the recovery of missing nuclear material.

3.3. To achieve timely detection of unauthorized removal of nuclear material, an effective NMAC system should also:

- Provide the capability to assist in detecting misuse of the facility’s processing or handling equipment, which may provide opportunities for unauthorized removal of nuclear material;
- Act as a deterrent by providing the capability to detect insider activities related to nuclear material, if they occur.

COMPLEMENTARY USE OF NMAC, PHYSICAL PROTECTION AND OTHER FACILITY SYSTEMS IN DETERRING AND DETECTING UNAUTHORIZED REMOVAL OF NUCLEAR MATERIAL

3.4. The contribution of NMAC systems to nuclear security mainly derives from their ability to maintain precise knowledge of the types, quantities and locations of nuclear material at the facility, to conduct efficient physical inventory of the nuclear material and, in some cases, to ensure that the activities performed in connection with the nuclear material have been properly authorized. NMAC related information should be subject to regulatory or facility specific requirements for information security (e.g. a facility specific information security plan).

3.5. As noted in paras 3.2 and 3.3 and in Ref. [3], one objective of nuclear security at a nuclear facility is to detect in a timely manner any unauthorized removal of nuclear material and deter, by this capability, malicious actions by an insider adversary. The NMAC system and the physical protection system are two distinct systems that should complement one another in achieving the nuclear security objective of deterrence and timely detection of unauthorized removal of nuclear material. Each system has its own set of requirements and objectives, and both are important to nuclear security.

3.6. Responsibilities for nuclear security and the functions of each of the systems at a facility should be clearly identified and documented to ensure that there is no overlap of responsibilities and, more importantly, that there are no omissions. For effective nuclear security consistent with the recommendations in Ref. [3], the NMAC system and the physical protection system should coordinate activities when appropriate, e.g. during the investigation of an irregularity that may be an indication of unauthorized removal of nuclear material. However, the separation of NMAC and physical protection functions and responsibilities is a good practice. The possibility that a malicious insider might be a member of the staff with responsibilities for NMAC or physical protection should not be ignored. NMAC personnel should not be allowed access to physical protection devices and systems without authorization from the physical protection department. Information concerning nuclear material inventories and locations is necessary for the design and the implementation of the physical protection system, but physical protection personnel should not be allowed access to NMAC records and systems without authorization from the NMAC department. Access to detailed information about nuclear material quantities and locations of NMAC and physical protection systems, and in particular, information about vulnerabilities and design of such systems, should be limited to those with approved authorization and a 'need to know' approval.

3.7. NMAC and physical protection should be coordinated with other facility systems that could contribute to deterring and detecting unauthorized removal of nuclear material (e.g. operations, radiation protection, criticality safety, environmental protection, personnel health and safety and waste management).

Examples of equipment used for operations or other purposes that might also contribute to the detection of unauthorized removal of nuclear material are:

- — Flowmeters;
- — Mass spectrometers;
- — Tank level indicators;
- — Non-destructive assay equipment;
- — Scales designed to monitor nuclear material quantities and concentrations;
- — Video surveillance equipment;
- — Radiation monitoring and contamination control equipment.

3.8. Operational or safety equipment may also be used to detect unauthorized removal of nuclear material by triggering an alarm when nuclear material is moved or containment has been breached, provided that there will be an appropriate response to the alarm. Measures should be taken to provide assurance that equipment used for the detection of unauthorized removal of nuclear material is not tampered with or manipulated.

DEFINING NUCLEAR SECURITY CRITERIA FOR ASSESSMENT OF THE FACILITY NMAC SYSTEM

3.9. The facility NMAC system should be designed to meet all legal obligations associated with a safeguards agreement, as well as the nuclear security objectives described in paras 3.2–3.3. It should take into account requirements established by the State authority, the threat as defined by the State authority and the recommendations in Ref. [3]. It should also take account of the quantities of the nuclear materials held at the facility and their attractiveness based on isotopic composition, chemical composition, physical form and fissile element concentration. The NMAC system should be designed to be effective during routine operations at the facility, under emergency conditions and during nuclear security events.

3.10. A graded approach [3] should be taken in designing the NMAC system for application to nuclear security to ensure that the selected measures are proportionate to the potential consequences of unauthorized removal of nuclear material.

3.11. The criteria and performance requirements for an NMAC system are established in the overall context of nuclear security and are especially useful to assess the nuclear security system against an insider threat. The criteria should address the different types of nuclear material and the timeframes for detection of unauthorized removal of nuclear material.

3.12. An objective of nuclear security measures at a nuclear facility is to deter and detect an unauthorized removal of nuclear material, even a single item. (For NMAC purposes, an item is a discrete quantity, container or piece of nuclear material that has a unique identity, is separate and individually distinct, and whose presence and integrity can be visually verified.)

3.13. The competent authority should establish criteria, including definitions of amounts of nuclear material that, if removed in an unauthorized manner, should be detected within a defined time. Amounts and timeframes for detection of unauthorized removal of nuclear material should take into consideration different types of nuclear material and possible consequences of its unauthorized use.

3.14. In determining the amount of nuclear material that could be removed through unauthorized means, the competent authority could consider the values used in the Categorization of Nuclear Material table for physical protection in Ref. [3]. In practice, the amount that is defined as detectable by the NMAC system should also be influenced by factors such as the State's threat assessment, and specific factors such as the types and quantities of nuclear material present (e.g. isotopic compositions, chemical compounds, physical forms, concentrations and matrix types), and the scope of nuclear activities at the facility.

3.15. The performance of the nuclear facility NMAC system should address both situations where nuclear material is acquired in a single event (abrupt theft) and situations where nuclear material is acquired in small amounts during several events (protracted theft).

3.16. Adversary scenarios should be evaluated to determine whether the NMAC system meets the required nuclear security objectives to detect insider activities and to allow a response which prevents the unauthorized removal of nuclear material.

THE ROLE OF THE COMPETENT AUTHORITY

3.17. Nuclear security measures should be maintained in a condition capable of meeting the State's regulations and effectively responding to the State's requirement for timely detection of the unauthorized removal of nuclear material. To ensure this, the competent authority should require that operators of nuclear facilities conduct evaluations based on performance testing. Such evaluations should be reviewed by the competent authority. The competent authority's review should assess whether or not the adversary scenarios considered are comprehensive, the methodology used is appropriate and the conclusions of the evaluation are correct, including the effectiveness provided through multiple detection elements.

3.18. When a need for increased effectiveness of the NMAC, the physical protection systems or all of these is identified, the competent authority may require additional measures to be taken by the operator, as suggested above.

4. ELEMENTS OF AN NMAC SYSTEM AT THE FACILITY LEVEL

4.1. This section presents elements that are essential for the effective functioning of an NMAC system and are important for enhancement of nuclear security at a facility. NMAC system objectives are achieved through the functioning and interaction of NMAC elements, and individual elements, such as a records system, should be redundant, so that failure of a single element can be compensated for through the use of other elements and does not result in failure of the NMAC system. The NMAC measures used at item facilities (e.g. reactors) may differ from those used at bulk facilities (e.g. conversion or fuel fabrication plants).

4.2. An NMAC system consists of a variety of elements, some of which are clearly for control, some of which are clearly for accounting, and some of which are for both. The overall effectiveness of the NMAC system depends on the effectiveness of the individual elements (which are addressed in this section) and their interaction.

4.3. All elements of an NMAC system contribute to nuclear security. However, the functionalities or enhancements that are particularly important to mitigating insider threats are highlighted in the following text, in the subsections entitled 'Aspects of particular relevance to nuclear security'. These aspects will enhance the continued capability of the nuclear facility operator to detect unauthorized removal of nuclear material from the facility.

4.4 This element includes structure, documentation and procedures, functions and responsibilities, control over changes, and staffing and training. Effective organization and management will provide greater assurance of the capability of the NMAC system to detect unauthorized removal of nuclear material at the facility, thereby enhancing nuclear security. The NMAC system should be subject to a sustainability programme to ensure that it is effective in the long term.

Organizational structure

4.5. The operator should appoint an NMAC manager and assign to that person the responsibility for accounting and control of all nuclear material at the facility.[1] The NMAC manager should have the authority to communicate directly with the general manager of the facility, who has ultimate responsibility for the protection and control of nuclear material. To avoid potential influence on decisions regarding NMAC, the NMAC manager should also be independent from organizations that handle, process or store nuclear material at the facility. An organization chart should be developed that clearly defines the relation between NMAC and other facility organizational units.

4.6. The roles and responsibilities of the NMAC manager and NMAC personnel should be clearly defined and documented. Sufficient resources should be provided to ensure an effective NMAC system. All facility personnel involved with nuclear material should be aware that their actions contribute to the effectiveness of accounting and control. The NMAC manager should be aware of and provide oversight, as appropriate, of activities involving nuclear material and related information, including those conducted by other departments and contractors who are not employees of the facility.

Aspects of particular relevance to nuclear security

4.7. The role of the NMAC manager is one of the most important for the facility. The person selected for this position should have the appropriate level of education and training to meet the requirements of the job. The NMAC manager should also be trained on insider threats and be fully aware of NMAC's contributions

[1] The Nuclear Material Accounting Handbook [7] refers to the NMAC unit at a facility as a 'Nuclear Material Control Unit'. The NMAC manager and the NMAC unit manager are two terms which both describe the person or function responsible for NMAC at a facility. In small facilities, this person may also have other responsibilities.

to nuclear security. The NMAC manager should be independent from the managers of other facility departments to avoid potential inappropriate influence from another manager that might compromise the effectiveness of the nuclear security programme.

Functions and responsibilities of the NMAC manager and staff

4.8. The NMAC manager and staff have responsibility for maintaining the records system used by the facility to document and track all nuclear material at the facility, including inventory and movements. NMAC personnel should develop facility specific procedures that convey the NMAC requirements to operations personnel. NMAC staff should provide appropriate NMAC training to all facility personnel to assure the quality and status of implementation of NMAC requirements. A strong working relationship should be developed and maintained between the NMAC department and other departments such as physical protection, operations, radiation safety, and the analytical laboratory or other measurement groups.

Aspects of particular relevance to nuclear security

4.9. Facility management should promote and ensure a strong working relationship between NMAC and the other departments involved in activities related to nuclear material. All facility personnel should have a clear understanding of the importance of NMAC to nuclear security. The NMAC staff should be aware of the importance of accuracy and of the timeliness requirements of the NMAC records system. All NMAC requirements should be clearly described and implemented through facility specific procedures.

4.10. The assignment of NMAC functions should be such that the activities of one person or department serve as a control over and a check of the activities of other persons or departments. Facility personnel, other than NMAC staff (including contractors), may be involved in handling and movement of the nuclear material, but responsibility for the control and accounting of nuclear material should remain with the NMAC department.

4.11. Separation of functions and responsibilities for nuclear material should be implemented, where possible, and separation of duties should be sufficient to deter and detect malicious acts by an insider and misuse of nuclear material. Separation of duties is an approach in which a process that involves nuclear material and related information is divided into steps which are performed by different persons acting independently. For example, one person could calibrate a scale and make a weight measurement of a container of nuclear material. Another person, acting independently from the first person, would enter the results of the measurement into a record. Separation of duties and multiple checks of data and operations serve as additional measures to deter and detect malicious insider activities.

Material balance areas

4.12. Effective design and implementation of an NMAC system requires establishment at the nuclear facility of specific areas (zones) for accounting and control purposes, which are referred to as material balance areas (MBAs). An MBA is an area in a nuclear facility designated such that: (a) the quantity of nuclear material in each movement into or out of each MBA can be determined; and (b) 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 can be established. MBAs form the basis for NMAC for all nuclear material in the facility. An MBA may be one or more related rooms, one or more related buildings, an operating unit such as a laboratory or production shop, or an entire nuclear facility.

4.13. Facility requirements, as well as State and international requirements, are considered in determining the appropriate MBA structure. For facilities under IAEA safeguards, MBAs are agreed between the IAEA and the State and specified in facility attachments, together with the inventory and flow key measurement points. Accounting and control measures should be designed for each MBA. MBAs that are defined for nuclear security purposes are often smaller and more process specific then those defined for IAEA safeguards.

4.14. MBAs are designed to enable the quantification of the inventory and to confine any differences between the physical inventory and the book inventory (the inventory as stated in the accounting records) to a specific area. To meet nuclear security objectives, the MBA should be small enough, depending on available measurement points, for it to be possible to determine where a loss or a difference occurred.

4.15. Regardless of the number and size of MBAs used for nuclear security purposes, the structure should be properly documented and clearly described, including boundaries for each MBA and categories of nuclear material in each MBA. Specific responsibility for the nuclear material in the MBA should be assigned, preferably to one person. Each item or batch at the facility should be assigned to an MBA and not to more than one MBA. When material is moved from one MBA to another, custody of the material and responsibility for its movement should be transferred from one person to another.

Aspects of particular relevance to nuclear security

4.16. The MBA is the basic unit for an NMAC system and may be also used to assign custodial responsibility for nuclear material. The approach taken to establish MBAs should also take into consideration nuclear material control boundaries (administrative or physical). Controls for nuclear material, including accounting requirements, should be established at the MBA level.

4.17. For increased capability in general, smaller MBAs make control of nuclear material easier and reduce the size of the area to which an unauthorized removal or loss can be attributed.

Sustainability programme

4.18. A sustainability programme, as described in Ref. [3], should be established. This programme should ensure sustainability of elements of the NMAC programme including:

- — NMAC documentation and procedures (paras 4.20–4.26);
- — Configuration management (paras 4.27–4.28);
- — Staffing and training (paras 4.29–4.32);
- — Quality control (paras 4.82–4.107 and 4.169–4.180);
- — Performance testing (paras 4.169–4.180).

Aspects of particular relevance to nuclear security

4.19. To enhance the continued capability of the nuclear facility operator to detect unauthorized removal of nuclear material, the sustainability programme should ensure that facility NMAC systems are sustained and effective in the long term. Sustainability of NMAC systems is essential to ensuring their continued contribution to nuclear security.

NMAC documentation and procedures

4.20. A nuclear facility operator should develop written policies and procedures to ensure the continuity of knowledge of and control over nuclear material. Policies and procedures should be part of the facility's sustainability programme for NMAC. Consideration should be given to requiring a formal facility NMAC plan that documents all of the NMAC practices and requirements. If such a plan is required, it should be subject to approval by the NMAC manager and the facility's general management, as well as by the competent authority, if required. Use of procedures provides a method of conducting activities that reduces reliance on memory and eliminates the need for quick, and potentially erroneous, judgement. Procedures should address the conduct of activities at the MBA level to reflect specific requirements and features of individual MBAs.

4.21. Procedures should, as a minimum, adequately address the following topics, regardless of which facility organizational group is responsible for the particular topic:

- Generation, maintenance and retention of records and reports;
- Control of items;
- Authorization for access to nuclear material and prior authorization of all activities involving nuclear material (a topic which commonly falls within the NMAC domain);
- Control of access to nuclear material, sensitive areas (a topic which commonly falls within the physical protection domain) and information;
- Physical inventory taking, including reconciliation of the physical inventory with the book inventory and closure of the material balance;
- Measurements, including accounting measurements (accurate measurements used for inventory and inventory changes) and confirmatory measurements (measurements used to confirm nuclear material quantities);
- Measurement quality control;
- Maintenance and operation of facility containment, surveillance, material control devices and procedures;
- Investigation and resolution of irregularities;
- Characterization and accounting for nuclear material recovered during cleanup;
- Gaseous, solid and liquid waste streams.

4.22. For facilities that process nuclear material, procedures should address as a minimum the following additional topics:

- Sampling techniques, analysis capabilities and measurement methods for accounting measurements, including estimating measurement uncertainty;
- Controlling, monitoring and evaluating nuclear material during processing;
- Preparing nuclear material for physical inventory taking (i.e. placing material into containers and stratifying the inventory to support sampling and measurements);

— Monitoring and evaluating nuclear material operating losses (measured discards or discards estimated on the basis of previous measurements) and other losses;
— Monitoring and evaluating accumulations in hold-up;
— Material balance evaluation, including calculation and evaluation of material unaccounted for (MUF), its uncertainty σ_{MUF}, and cumulative MUF, as described in paras 4.75–4.81.

4.23. The level of detail of the instructions in the procedures depends on the type of work performed and the type, form and quantity of nuclear material possessed. For example, facilities which process nuclear material should have more detailed procedures than item handling facilities.

4.24. Within the framework of an appropriate quality management system (as described in paras 4.169–4.180), provision should be made for the review, approval and use of procedures. Management should issue an instruction requiring that the procedures be followed and should periodically audit use of the procedures. Essential procedures, i.e. those procedures which, if not performed correctly, could result in a failure to achieve one or more of the objectives of the NMAC system, should be evaluated.

Aspects of particular relevance to nuclear security

4.25. The NMAC procedures, outlined in section 4.22–4.24 above, form the basis for implementation of NMAC requirements at the facility level. An NMAC plan can serve as a means of documenting the agreement between the facility and the State's competent authority for implementation of NMAC policies and procedures. Well written and effectively implemented facility level procedures which cover all elements of the NMAC system help to ensure the security of the facility's nuclear material.

4.26. Special attention should be given to procedures related to control of access to nuclear material, equipment and records that could assist a malicious insider.

Configuration management

4.27. The purpose of configuration management is to ensure that any change to any part of the NMAC system or any other relevant facility system will not degrade the performance of the NMAC system or overall nuclear security. Changes should be properly documented, assessed, approved, issued, implemented and incorporated in the facility documentation [3]. The operator should control all changes and ensure reporting to the competent authority. Control over changes to the NMAC system helps to ensure that the NMAC system's performance remains consistent with its requirements and design throughout its life. As with other elements of the NMAC system, a graded approach is recommended for the configuration management programme.

Aspects of particular relevance to nuclear security

4.28. To ensure that the capability of the facility to detect unauthorized removal of nuclear material is maintained, it is important to have a configuration management programme that controls all activities that have the potential to degrade the NMAC system in any way. All changes to any element of the NMAC system should be properly documented, assessed, approved, issued, implemented and incorporated in the facility documentation. For example, a radiation monitor installed in one room to monitor nuclear material movement could be intentionally affected by a malicious insider through the relocation of radioactive material in an adjacent room. Proper configuration management and change review should prevent such an occurrence. Facility management should ensure that the NMAC system's performance remains consistent with its requirements and design throughout its life.

Staffing and training

4.29. The operator should provide the NMAC manager with sufficient staff. NMAC staff should understand the NMAC and operational processes and should have the appropriate competences to be able to detect unusual occurrences, which could indicate unauthorized removal of nuclear material. NMAC staff members and other facility personnel performing NMAC activities should receive training and should be evaluated to ensure that they are qualified to perform their specific role in the organization before they begin their assignments.

Aspects of particular relevance to nuclear security

4.30. Appropriate staffing of the NMAC department is critical to the success of the NMAC system. NMAC personnel should be qualified with the appropriate educational attainment and should be trained in NMAC procedures. All personnel performing NMAC activities should be evaluated to ensure that they are qualified to perform their specific role before they begin their assignments.

4.31. All facility personnel should be made aware, through training, of the importance of NMAC to nuclear security. All facility personnel should know the potential consequences of loss of control over nuclear material, the sensitivity of information related to NMAC, the rules to be applied for protecting information, the potential consequences of failure of nuclear security at the facility, and the appropriate response to possible irregularities.

4.32. The operator should give due priority to a nuclear security culture to enhance the protection and control of nuclear material and ensure that all workers understand their individual responsibilities and contributions to nuclear security, which are described in Ref. [8].

RECORDS

4.33. The records system is a primary component of an NMAC system. The overall records management system should conform to the recommendations of recognized international standards. Measures should be taken to ensure accuracy of records.

4.34. Nuclear facility NMAC records and reports should be complete, accurate and timely, and provide sufficient information to resolve irregularities. Records and reports are used for many different purposes, e.g. nuclear security, compliance with safeguards agreements and control of customer owned material. The collection of additional information in NMAC records for nuclear security should not contradict or interfere with the collection of information required for reporting under the relevant safeguards agreement between the State and the IAEA, nor with State regulations.

4.35. The records system can be used to resolve indications of unauthorized removal and aid in the investigation and recovery of missing material. The system should provide accurate and complete information about the identity, quantity, type and location of all nuclear material in the facility. An effective records system is updated each time an item of nuclear material is received, transferred, relocated, processed, produced, shipped or discarded. Records should be updated in a timely manner, using a computerized system if possible. Every nuclear material transaction needs to be recorded in the records system.

4.36. The records system should be capable of generating reports in a timely manner.

4.37. Records should include accounting records, operating records and any other records that are important to NMAC. Traceability of all records should be maintained. The nuclear facility should retain records for a minimum period as required by the competent authority.

Aspects of particular relevance to nuclear security

4.38. The NMAC records system forms the basis for the facility's nuclear material inventory. Accuracy and timeliness of recording nuclear material information is essential for an effective records system.

4.39. In order to identify whether unauthorized removal of nuclear material has occurred following an irregularity, an effective records system should be capable of quickly creating a list of the current inventory, which can be used for locating items and quantifying nuclear material in process. Inadequate or inaccurate records might be an indication of falsification of information concerning nuclear material for the purpose of unauthorized removal.

4.40. For nuclear security, the records system should provide the information needed to assist in identifying and quantifying in a timely manner the amount of any nuclear material missing or stolen, based on:

— The capability to create an accurate list of the current book inventory at any time;
— An accurate history of all nuclear material activities;
— The capability to detect falsification or attempted falsification;
— Support for item control.

Accounting records

4.41. All activities involving nuclear material should be recorded, including movements (shipments, receipts, transfers and relocations), physical inventory takings, measurements and associated uncertainties, adjustments to records, transfers to a waste account, measured discards, etc. Results of item monitoring and control activities should also be documented, including corrections to information about the location of individual items (as discussed in more detail in paras 4.138–4.139). All original signed documents of nuclear material transactions should be retained, as required by the competent authority's regulations or the relevant safeguards agreement between the State and the IAEA.

4.42. Records of an activity should include at least the following information:

— Unique item or batch identification;
— Item or batch history;
— MBA(s) in which the activity occurred;
— Location (original location and new location, when an item is moved);
— Type of nuclear material;
— Material description (chemical and physical form, such as oxide in solution) and container type (e.g. vial, transport cask, sealed item);
— Nuclear material quantities (gross, tare and net weights; element assay, element weight and isotopic composition);
— Measurement methods and uncertainties;
— Type of transaction (e.g. receipt, shipment, enrichment, blending);
— Date of transaction and date recorded;
— Signatures (manual or electronic) of individuals performing the activity (e.g. receipt, relocation);
— Identifier of tamper indicating device (if applied).

4.43. The location designations should be specific enough to provide for the retrieval of the items in a prompt manner. The quantities and locations of all items listed in the accounting records should be correct and verifiable (with the possible exception of items that have been moved or consumed during the most recent shift of processing).

4.44. The accounting system should be capable of producing at any time an itemized list of the current holdings of nuclear material in any MBA at the facility. This itemized list is prepared by starting with an itemized list of holdings at the beginning of the material balance period (based on a physical inventory of nuclear material items) and by updating the list based on all changes to the inventory, such as receipts, inputs to process, production of items, shipments, transfers, etc. This itemized list should include batch or item identification, location of the batch or item, and accounting information for each item. At the end of a material balance period, another physical inventory is taken and an itemized list of actual holdings at the end of the material balance period is prepared. This actual list should be compared with the records prepared from the original itemized list and changes to it during the period, and any differences should be explained. The accounting system should also allow adjustments to be made based on the evaluation of the differences between the records and the results of the second itemized list. (Physical inventory taking is covered in more detail in paras 4.60–4.81.)

4.45. Every entry in the records should be traceable through a numbering or reference system to the original source documents, operating records, or both. Records should be substantiated by supporting documents that are correct and complete.

Aspects of particular relevance to nuclear security

4.46. For nuclear security purposes, the use of computerized accounting records is encouraged because computers provide easy access to data and the capability for timely updates. Sufficient protection and backup of the records should be provided so that an act of record alteration or destruction, whether intentional or unintentional, authorized or unauthorized, would not eliminate the capability to provide a complete and correct set of NMAC information. In addition, specific attention should be given to the consistency of records. Measures should be developed for reconciling records and for ensuring that supporting documents exist, as applicable, before the associated accounting records are generated.

4.47. The NMAC records system should provide information needed to assess a situation that might involve unauthorized removal of nuclear material. Designated personnel should be authorized to gain access to the accounting records, and access should be limited to only the required information. A process should be developed and implemented to provide checks to ensure the accuracy and completeness of the records (data quality check).

Operating records

4.48. Operating records are any records maintained by the operator that are related to use or handling of nuclear material. These records should be available for use in and support of the NMAC system. Such operating records may include:

- Data obtained from any operation that results in a change of quantity or composition of nuclear material;
- Data obtained from calibration and maintenance of scales, tanks and other measurement equipment;
- Data from evaluations of sampling and measurement systems;
- Operating records to justify the quantity of nuclear material based on an analytical procedure, a nuclear material disposal procedure or a measurement control procedure.

Aspects of particular relevance to nuclear security

4.49. The evaluation of effectiveness may conclude that certain additional operating records are necessary for, or relevant to, the proper implementation of nuclear security. Operating records may contain information that could aid the NMAC department in its evaluation of activities involving nuclear material to detect possible unauthorized removal of nuclear material.

Other supporting documentation

4.50. Any documentation that may be used to support NMAC records should be available for use in the NMAC system as necessary for its proper implementation or verification. Such documentation may include shipping documents, batch records, weight measurement records, laboratory records and tamper indicating device records. The documentation may also include safety records, such as records of radiation and criticality alarms, and physical protection records, such as logs showing personnel access to controlled areas and maintenance logs for containment and surveillance devices.

Aspects of particular relevance to nuclear security

4.51. Records that may be necessary in case of an emergency involving nuclear material should be identified. Some of these records may overlap with accounting or operating records and may not be needed for routine activities, but all of these records should be made available to the NMAC department in the event of a nuclear security event or an emergency, or for specific verifications.

Record update

4.52. Accounting records should be updated as soon as practicable when any movement or inventory change occurs or becomes known. The data update process should include a procedure for validation of data. This validation should include data quality control whereby a second person or a computer system confirms the initial entry.

Aspects of particular relevance to nuclear security

4.53. Timeliness requirements for input of different types of new records and updating of the facility record system should be identified. Regardless of the approach to record keeping, i.e. whether the system is manual or computerized, actions required for updating records should be treated as top priority so that the records reflect near real time knowledge of nuclear material. Validation of the data is important for ensuring the effectiveness of the nuclear facility's records.

Record keeping approach

4.54. Based on the quantity and type of nuclear material at the facility, records used for NMAC purposes may be manual or computerized. A manual process may be sufficient for a facility that possesses small quantities of nuclear material or a small number of items. A computerized approach may be the better option for a facility with a large quantity of nuclear material or a large number of items. Use of a computer allows for much faster and more extensive data analysis, which can be useful in identifying errors or discrepancies that could be an indication of unauthorized activities. Computers provide more timely information for the resolution of irregularities.

4.55. If a computerized system is used, measures should be taken to ensure that the identity of the person performing the activity is authenticated and recorded. The accounting records should be protected from unauthorized changes or falsification of information. For activities involving handling of items which could contain nuclear material, both the physical activities and the records of the activities should be verified by at least two persons. Use of bar-code readers, electronic scales and other electronic equipment connected directly to the computerized system can improve the reliability of the entire system, reduce errors inherent in manual input, and reduce the work needed for data input and verification.

Aspects of particular relevance to nuclear security

4.56. Controls should be implemented to ensure that NMAC records users have access to only the data required to complete their jobs and that they can perform only authorized transactions in their assigned MBAs, whether the record system is manual or computerized. Sufficient checks and balances should be incorporated to detect falsification of data and reports that could conceal unauthorized removal of nuclear material. Checks should be programmed into the electronic system to detect mistakes or falsifications. Paragraph 4.123 discusses data control in more detail.

4.57. In all cases, security of NMAC records should be assured. If a computerized system is used, a facility specific computer security plan should be developed in close consultation with physical protection, safety, operations and information technology specialists. The computer security plan should as a minimum address:

— Organization and responsibilities;
— Asset management;
— Risk, vulnerability and assessment of compliance;
— System security design and configuration management.

The plan should also address operational security procedures such as:

— Access control;
— Data security;
— Communication security;
— Computer system and software security and system monitoring;
— Computer security maintenance;
— Incident handling;
— Personnel management.

The plan should cover routine backup and should also ensure the integrity of the accounting system.

4.58. An information security plan should be developed to ensure the confidentiality, integrity and availability of the data collected in a computerized system, as well as the original records. Provisions to ensure proper information security should be applied.

4.59. The information security plan should include provisions for reconstructing lost or destroyed records. Protection and redundancy of the records system should be considered so that any act of record alteration or destruction will not eliminate the ability to provide a complete and correct set of NMAC information. The plan should include measures to protect against malicious acts by the information system administrator or manager.

PHYSICAL INVENTORY TAKING OF NUCLEAR MATERIAL

4.60. Any nuclear facility operator should conduct periodic physical inventory taking of all nuclear material in every MBA. The frequency of the physical inventory taking should depend on the quantities and category of the nuclear material. The State should establish the minimum frequency of physical inventory taking. The results of the physical inventory taking should be reported to the competent authority, as required.

4.61. The methods of taking a physical inventory will vary depending on the material to be inventoried and the type of operations conducted at the facility. In general, all nuclear material should be measured using an approved measurement system at the time of physical inventory taking, or should have a prior measurement whose integrity is assured by a tamper indicating device. For nuclear material in item form, performing a physical inventory usually consists of checking the unique identification of each nuclear material item by visual observation, the identity and integrity of its tamper indicating device (if one has been applied to the item), and its location. If no measures (such as use of tamper indicating devices) have been taken to ensure the continuity of knowledge of the item contents, the item should be verified by appropriate means. When determining the extent of verification, including measurements and their accuracy, due attention should be paid to the attractiveness of the nuclear material in question. The book inventory should be adjusted following the periodic physical inventory taking to resolve differences and establish agreement between the book inventory and the physical inventory.

Aspects of particular relevance to nuclear security

4.62. The physical inventory taking process is important to nuclear security because, if conducted correctly, it confirms the presence of nuclear material and the accuracy of the book inventory, and provides evidence that the facility NMAC system has been effective. A physical inventory taking may reveal unauthorized removal of nuclear material that was not detected previously by other aspects of nuclear security. However, because physical inventory taking may not always ensure the timely detection of the unauthorized removal of nuclear material, the NMAC measures discussed in this document are needed.

Physical inventory taking

4.63. Section 5.4 of Ref. [7] provides detailed guidance regarding procedures and activities to be carried out when conducting a physical inventory taking. A programme for taking physical inventory should include, but should not be limited to, the following measures:

- Clear assignment of duties and responsibilities for physical inventory taking, under the oversight of the NMAC department;

- Measures to ensure that the physical inventory taking is conducted by knowledgeable personnel that are independent of the persons responsible for the nuclear material and does not rely on a single individual;
- Measures to ensure that all items are included in the physical inventory listing and that no item is listed more than once, e.g. the use of colour coded inventory stickers to identify items that have been inventoried during the inventory period;
- Measures to ensure homogenization, sampling and analysis of bulk material (depending on the type of material);
- Measures to ensure that calibration of all equipment used to measure material in the inventory is up to date and in accordance with procedures;
- Measures to ensure that other material at the facilities which could be substituted for nuclear material is controlled, accounted for and inventoried;
- Measures to ensure that no nuclear material is located in an unauthorized location, e.g. nuclear material in containers identified as empty;
- Measures to ensure that movements of nuclear material are prohibited during the physical inventory taking so that all quantities in an area are inventoried and none are inventoried in more than one area;
- The capability to calculate measurement uncertainties, MUF, and MUF uncertainty (σ_{MUF}) to aid in material balance evaluation following a physical inventory taking.

4.64. The following activities should be performed following the physical inventory taking:

- Reconcile the physical inventory listing with the book inventory records, item by item;
- Investigate and resolve discrepancies between the physical and book inventory records;
- Make accounting entries to adjust the book inventory records to match the results of the physical inventory taking.

4.65. For facilities that process nuclear material, the physical inventory taking should include, but not be limited to, the following additional elements:

- Ensure that the quantity of nuclear material associated with each item is a measured value;
- Measure all quantities of nuclear material in the physical inventory that were not previously measured;

— Specify the extent to which each internal control area and process is to be shut down, cleaned out or is to remain static during conduct of the physical inventory.

4.66. Tamper indicating devices, when used as part of an effective material control programme, can reduce the effort needed to conduct a physical inventory by reducing the number of measurements. (Tamper indicating devices are discussed in more detail in paras 4.130–4.133.) To avoid observing and re-measuring items during the physical inventory taking, some containers can be measured prior to the physical inventory taking and sealed with a tamper indicating device. Tamper indicating devices can also be used when storage characteristics preclude verifying each individual item. In such cases, physical inventory taking consists of verifying the identity and integrity of the tamper indicating device and container. Confirmatory measurements may be used during physical inventory taking as an additional measure to ensure that the containment and surveillance measures have been effective.

4.67. Use of technologies such as bar-codes to identify individual containers or items, locations and tamper indicating devices can also improve the efficiency of physical inventory taking. A physical inventory should be taken in accordance with written inventory procedures. All nuclear material in an MBA should be included in the inventory. A clear cut-off should be established between material balance periods. To distinguish between periods, physical inventory taking is generally conducted when operations are static or shut down and movement of material has ceased. All processing equipment should be cleaned out to the extent possible in preparation for a routine physical inventory taking. If not all nuclear material can be removed from the processing equipment, an attempt should be made to measure the nuclear material held up in the process, which is generally referred to as process hold-up. Measuring process hold-up may be difficult and the uncertainty of the measurement may be large. Specially designed and tested equipment is often required to improve the accuracy of the measurement of process hold-up.

4.68. Sometimes it is necessary for a facility to perform a physical inventory while processing operations are underway (which is referred to as an in-process physical inventory taking [7]).

4.69. The accounting records should be adjusted to reflect the nuclear material quantities in the physical inventory. If there are discrepancies between the physical and book inventory records, they should be investigated, reported as necessary to the competent authority, and resolved.

4.70. Occasionally, an unscheduled physical inventory taking may be needed, e.g. in the case of a change in the responsibility for nuclear material, and in the event of a change to an operation in the facility. The facility should have procedures in place for taking an unscheduled physical inventory in every MBA at the facility. One type of unscheduled inventory taking is an emergency inventory, which may be needed in the event of activation of an alarm system, such as an intrusion detection alarm, or a credible claim that nuclear material has been removed from the facility. An emergency inventory taking is a means of assisting in resolving the question of unauthorized removal. The facility should prepare a plan for an emergency physical inventory taking before the need for one occurs. An emergency physical inventory taking should be able to detect whether or not an item has been removed from the location assigned to it in the facility records or that material has been removed from its container. Emergency inventory takings should be designed to address the specific irregularity, e.g. if the locking device to one room is broken, the emergency inventory taking may only include items in that room and not the whole MBA. Priority should be given to verifying that the most attractive material is still present. Regardless of the situation, emergency inventory takings should be conducted quickly, because they are designed to determine whether unauthorized removal of nuclear material has occurred.

Aspects of particular relevance to nuclear security

4.71. Formal procedures should be developed and implemented to provide clear and complete instructions for physical inventory taking. All items should be measured at the time of physical inventory taking or should have a tamper indicating device applied and should have been subject to an effective material surveillance programme at all times.

4.72. Because of production activities at some facilities, parts of the facility and equipment are accessible only during inventory taking. A shutdown due to inventory taking provides an opportunity for checking and calibrating process control equipment used for nuclear security purposes. It is also an opportunity for maintaining and verifying facility containment and surveillance systems that are normally inaccessible. When conducting a physical inventory, attention should be paid to identifying unintentional errors, intentional changes made by a malicious insider (e.g. changes to bar-codes, container cards, tamper indicating devices, weights), and the existence of items produced through unauthorized activities.

4.73. Because an employee participating in the physical inventory taking could be a malicious insider who would try to adversely influence the results of the physical inventory, special attention should be given to mitigation of this possibility. Procedures should include steps to detect actions to remove nuclear material in an unauthorized manner. Steps should be taken to ensure that an employee does not perform physical inventory taking alone. Complete and accurate reconciliation of the physical inventory results with the facility's book inventory should be performed.

4.74. The facility should have procedures in place to fully describe the process to be followed in the event that an unscheduled inventory taking is needed to determine whether unauthorized removal of nuclear material has occurred.

Calculation and evaluation of MUF

4.75. Following each physical inventory taking, the total quantity of nuclear material calculated based on the physical inventory should be compared to the total quantity of nuclear material as indicated by the book inventory, and the MUF (sometimes referred to as the inventory difference) should be calculated as part of closing the material balance for that MBA. Calculation of MUF is explained in more detail in section 5.5 of Ref. [7].

4.76. For a facility with nuclear material in item form only (such as nuclear fuel assemblies to be used in a power reactor or an item storage facility that maintains nuclear material items in the same form in which they were received), the MUF should be zero, and a non-zero MUF indicates a serious problem: either an item has been lost, stolen or misplaced, or the record keeping procedures are inadequate. (A plutonium storage facility might appear to be an exception to the zero MUF rule because of loss from decay, but this loss can be accounted for and the MUF adjusted to zero. The same is true for nuclear production and loss at a power reactor: nuclear production, nuclear loss and radioactive decay can be accounted for and do not contribute to MUF.)

4.77. For a facility where nuclear material is processed (i.e. chemically or physically altered, manufactured, reprocessed or enriched), a non-zero MUF is to be expected due to uncertainty in measurements and in calculated (non-measured) components of the material balance. Such components as unmeasured hold-up and unmeasured losses could be estimated on the basis of previous engineering studies, but should not be assumed to equal the difference between book and physical inventory, i.e. they should not be obtained from the current balance. MUF evaluation, which involves comparison with its uncertainty, is necessary for physical inventory taking to detect unauthorized removal of nuclear material or degraded performance of the NMAC system. Criteria for evaluating MUF and cumulative MUF and limits for MUF should be established by the competent authority.

4.78. A fundamental requirement of MUF evaluation is that all material in the material balance equation is measured or calculated in accordance with established procedures based on previous engineering studies. MUF evaluation assumes that the volume or mass of each produced item is measured and the nuclear material content determined by chemical assay or non-destructive assay. Hold-up of nuclear material in processing equipment should be minimized to reduce its impact on MUF.

4.79. The size of the MUF depends not only on the measurement uncertainties for all measured values in the material balance equation, but also on other contributors such as record keeping errors, measurement mistakes, unexpected changes in the quantity of unmeasured equipment hold-up, and unmeasured losses. Although MUF may include errors unrelated to measurement, the above factors are not always included in σ_{MUF} estimation and MUF evaluation.

Aspects of particular relevance to nuclear security

4.80. It is important to recognize that excessive MUF, σ_{MUF} or both may be an indication that unauthorized removal of nuclear material could have occurred, or of other activities of a malicious insider, such as actions leading to degradation of the performance of the NMAC system. If the MUF value is statistically significant, an investigation should be conducted to find out whether it is a result of unauthorized activities carried out during the material balance period, including during physical inventory taking. Cumulative MUF information could also be used to detect and evaluate possible unauthorized activities occurring over several material balance periods.

4.81. Credible adversary scenarios in which MUF or σ_{MUF} values are manipulated to cover up unauthorized activities should be considered. Measures should be taken in response to the scenarios considered, including limiting the amount of material with large measurement uncertainty in existence at the time of the physical inventory taking.

4.82. A facility operator should establish a measurement programme for determining the quantities of nuclear material, including nuclear material in its possession and nuclear material received, produced, shipped or otherwise removed from the inventory. Measurement equipment should be appropriate for the items being measured, e.g. scales should be of an appropriate size. A measurement quality control programme should be used to ensure the accuracy and precision of measurements.

4.83. The combination of established measurement points, measurement methods, measurement and calculation procedures, sampling procedures, calibration methods and procedures, use of standards or reference material, and measurement quality control is usually referred to as the measurement system. The NMAC system should enable the operator to ensure that no nuclear material is shipped, received, transferred or produced without being properly measured. If measurements are not possible, controls should be implemented until such measurements are made.

Aspects of particular relevance to nuclear security

4.84. Knowledge of nuclear material quantities helps to deter and detect unauthorized removal. Accurate and precise measurements are important to nuclear security because they reduce measurement uncertainties, which could conceal unauthorized removal. Additional measures in support of nuclear security may be necessary, such as improved measurements that would not normally be required by the accounting system or for operational purposes. For example, if nuclear material were stolen from an item (e.g. container) that was not accurately measured, the unauthorized removal would probably not be detected by confirmatory measurement, and the quantity removed could not be determined. Re-measurement of a previously measured container could reveal if nuclear material were missing. Confirmatory measurements and some in-process measurements should be available for the NMAC systems if such measurements can help in detecting unauthorized removal.

Objectives of measurements

4.85. Nuclear material quantities used in accounting records should be based on measurements. The type of measurement should be selected based on requirements established by the competent authority, the purpose of the measurement and the type of facility and process. Characteristics that should be measured for accounting purposes include weight or volume, nuclear material element concentration and isotopic composition.

4.86. Technically justified calculations of nuclear material quantities may be permissible instead of measurements in certain situations, such as calculation of burnup in fuel after discharge from a reactor core. Technically justified estimates of nuclear material quantities may also be assigned temporarily, such as during equipment outages where measurements cannot be completed.

4.87. Confirmatory measurements may be used to physically confirm the presence of nuclear material if an effective tamper indicating device programme has been implemented.

4.88. Measurements may be made during processing to control the flow or inventory of nuclear material inside a process area. They should also be described in the measurement programme documentation. Following measurement of nuclear material, the continuity of knowledge of the measured nuclear material should be ensured. The data should be entered promptly into records and the container should be closed and a tamper indicating device applied.

Aspects of particular relevance to nuclear security

4.89. Effective nuclear security depends on accurate, timely and complete information regarding the facility's nuclear material inventory. Measurements should be appropriate for the type and quantity of nuclear material to be measured.

4.90. Measurement procedures should include additional measures to prevent substitution of nuclear material with other material during measurement or manipulation of standards, measurement equipment and data (calibration and measurement).

Measurement methods

4.91. Measurement methods should be selected for measuring the nuclear material at each KMP (key measurement point). The methods selected should be appropriate for the material being measured. Measurement methods should conform to national and international standards or be equivalent in quality. Procedures should be developed that describe each measurement method and how the measuring equipment is to be used. Procedures may be supplemented by use of equipment manuals (e.g. a scale manual) in cases where the accuracy of the equipment (e.g. scale) is known and certified. The measurement system should as a minimum provide for:

- Specifications for the measurement equipment and its limitations;
- Instructions for use of the measurement equipment;
- Qualification and calibration of measurement equipment, including pipettes, flowmeters, tanks, scales, etc.;
- Maintenance of measurement equipment;
- Training and qualification of measurement system users;
- Calculations used to determine measurement results.

Aspects of particular relevance to nuclear security

4.92. For nuclear security purposes, measurement methods appropriate for the type and quantity of nuclear material are necessary. These measurement methods should meet or be equivalent to national and international standards. Formal procedures should be developed and implemented that provide instructions on each method and the proper use of the required equipment.

4.93. Measurement methods may be chosen within the overall context of nuclear security and the accuracy requirements of material balance evaluation.

Measurement accuracy and precision

4.94. Provisions should be made for estimating the uncertainties (accuracy and precision) of every measurement method and determining their effect on the total uncertainty associated with the material balance evaluation. The MUF uncertainty should be controlled in accordance with State regulations and facility requirements. The use of measurement methods that meet or exceed the measurement accuracies in the report International Target Values 2010 for Measurement Uncertainties in Safeguarding Nuclear Materials [9] and other international standards publications is recommended. When operators of nuclear facilities use measurements made outside the facility, at another facility or by a contractor, they should perform quality control checks to ensure the validity of the measurements.

4.95. To minimize rounding adjustments, facility operators should keep all records to the same decimal significance. The IAEA requires that quantities of natural uranium, depleted uranium and thorium be reported in kilograms, and those of plutonium and enriched uranium be reported in grams. The IAEA and the State agree on the number of significant figures to be used, and the measurement system at facilities under safeguards must, as a minimum, satisfy that level of precision.

4.96. Measurement standards should be measured for calibration purposes and for control purposes. They should be measured frequently so that inaccuracy is detected in a timely manner. They should have State or international certification or should be traceable to certified standards. They should be re-certified periodically. They should be measured under the same conditions, or as close as possible to the same, as the conditions under which the nuclear material is being measured. All nuclear material standards should be stored and used under conditions that preserve their integrity. Warning and out of control limits and appropriate actions should be established and used for both control standards and accountability measurements.

Aspects of particular relevance to nuclear security

4.97. Estimating the uncertainties of every measurement method is important to nuclear security because lack of the proper information might lead to a facility not being able to detect unauthorized removal of nuclear material.

4.98. It is important to recognize the possibility that measurement standards might be substituted to conceal unauthorized removal of nuclear material. Operators of nuclear facilities should maintain control over measurement standards.

4.99. A good practice to improve the reliability of chemical analysis of nuclear material samples is to distribute sub-samples to multiple analytical laboratories for the purpose of comparing results and identifying opportunities for improved performance. This practice might also eliminate the possibility of manipulation of chemical analysis results.

Sampling

4.100. Sample collecting methods should be clearly described in procedures, including measures to prevent tampering and substitution actions. Studies should be performed to demonstrate that the samples collected are representative of the nuclear material from which they were taken and to estimate the sampling uncertainty. Studies should be repeated periodically to provide assurance that the sampling system has not changed. Measures should be taken to ensure that failures of automated sampling systems are detected. To avoid substitution and to avoid attributing results to the wrong samples (and to the wrong containers of nuclear material), it is important to maintain continuity of knowledge of samples from the time they are taken until they are analysed and the measurement results are reported. Retaining an archive sample is a good practice.

Aspects of particular relevance to nuclear security

4.101. Operators of nuclear facilities should take actions in response to failures of sampling systems to ensure that the failures are not intended to conceal unauthorized removal of nuclear material. Attention should be paid to possible substitution of samples before they are measured. It is important to ensure that the procedure for collection of samples is followed and that more material is not removed through the sampling process than is needed.

Documentation of measurement results

4.102. All measurement results should be properly recorded in approved forms. The forms should include provisions for at least the following information:

— Identity of sample;
— Identity of person taking sample;
— Identity of item or batch from which sample was taken;
— Type of nuclear material;
— Date, time and place sample was taken;
— Date and time of measurement;
— Identity of measurement equipment used;
— Measurement procedures used;
— Calibration standards used and results of calibration;
— Control standards, control charts, and results of control data, including out of control data;
— Sampling procedure (if applicable);
— Measurement result and its uncertainty;
— Signatures of persons performing or reviewing the measurements.

Aspects of particular relevance to nuclear security

4.103. Complete and accurate records of measurement results are necessary for effective nuclear security. Automation of measuring equipment and electronic input of measurement results generally increases the measurement data reliability, thereby contributing to nuclear security.

Measurement quality control

4.104. The scope of the measurement quality control programme depends on the complexity of the measurements. The measurement quality control programme should include at least the following:

— Assurance that personnel are qualified to perform measurements;
— Maintenance and recertification of measurement equipment;
— Control of standards;
— Maintenance and re-certification of standards;
— Calibration of equipment (frequency and method);
— Equipment recalibration and recertification;
— Verification of measurement equipment performance;
— Actions to be taken in case of equipment failure;
— Measures to ensure that the measurement equipment, standards and methods used are appropriate for the material being measured;
— Complete documentation of all measurement results, including the results of measurements of standards;
— Control charts used to monitor measurement of standards;
— Measures to be taken when a measurement system appears to be out of control.

4.105. If a measurement system does not meet the conditions identified above, it should not be used for NMAC purposes. A minimum response and corrective actions should be defined for any control measurement that exceeds an out of control limit, including re-measurement, recalibration and review of the validity of previous measurements.

4.106. Oversight of the measurement quality control programme should be provided by the NMAC department and should be independent of operations.

Aspects of particular relevance to nuclear security

4.107. To provide assurance that the facility operator is capable of detecting unauthorized removal of nuclear material, it is especially important that nuclear material measurements are subject to a fully implemented measurement quality control programme. The quality control programme should address qualification of measurement personnel, control and maintenance of measurement equipment and standards, determination of appropriate measurements and complete documentation of all measurement results.

NUCLEAR MATERIAL CONTROL

4.108. The purpose of nuclear material control is to preclude unauthorized use of nuclear material. A nuclear material control system should be established for authorizing activities for handling, processing or storing nuclear material. The system should provide tracking and continuity of knowledge of nuclear material in MBAs, whether in process, in storage or during movement, both before and after the nuclear material has been measured. Other elements of a nuclear material control system may include: coordination with the physical protection system for control of access to nuclear material, equipment and data; material containment; material surveillance; radiation monitoring; and item control. Additional elements (e.g. statistical item control, including confirmatory measurements, and statistical monitoring of material during processing) that may enhance the effectiveness of the nuclear material control programme should also be considered. Effective control measures should be redundant and diverse to eliminate the consequences of a single point failure. The number of redundant measures used should be established based on the identified threat and the type, form and quantity of the nuclear material at the facility, and in accordance with national regulations.

4.109. In establishing the nuclear material control system, all credible scenarios of removing material from gloveboxes, storage areas or buildings and all possible ways of diverting material within MBAs should be considered to provide effective material control. Scenarios should take into account the amount, type, residence time and physical form of material.

Aspects of particular relevance to nuclear security

4.110. Appropriate points or locations where nuclear material control measures are to be applied should be established, taking into account nuclear material movement and presence within the facility. All nuclear material control measures described in this section are essential for nuclear security at a facility. The main objectives of nuclear material control measures are to maintain knowledge of the location of nuclear material and detect any unauthorized handling or movement of nuclear material. The control system should include all nuclear material at the facility, as well as NMAC and operations equipment which might be used by a malicious insider for concealment of nuclear material. Consideration should be given to small quantities of nuclear material, such as samples, which may be accumulated for unauthorized removal, and to waste streams, which may be used for unauthorized removal.

4.111. Because a malicious insider may have authorized access, access control might not be entirely effective in preventing unauthorized removal of nuclear material by a malicious insider. For nuclear material control to be effective in detecting and deterring unauthorized removal by a malicious insider, NMAC personnel should work in conjunction and in cooperation with the operations, safety and physical protection departments.

4.112. Multiple control measures are needed to ensure continuous control because loss of control, even for a short period of time, increases vulnerability to the possibility of unauthorized removal. This is especially true when accurate measurements are not possible and when changes in locations and quantities are not immediately recorded (e.g. if the loss of control occurred before measurement, substitution could be facilitated).

4.113. Additional material control measures should be considered for locations where nuclear material is particularly vulnerable to malicious insider activities, such as points where nuclear material is handled, e.g. where samples are taken or at openings in gloveboxes. All exits from a nuclear material area (e.g. emergency exits, ventilation ducts, windows and drains) should be considered as possible pathways for the unauthorized removal of nuclear material by a malicious insider. Additional controls and monitoring of these exits may be considered (consistent with the graded approach) such as:

— Radiation portal monitors for entrances and exits;
— Metal detectors for entrances and exits;
— Additional inspections to detect or deter anything that could provide shielding to mask the presence of nuclear material;
— Monitoring of ventilation ducts and drains;
— Installation of fine metal mesh in addition to grates on windows and ventilation ducts;
— Measurement, monitoring, and control of all liquid, solid and gaseous waste streams leaving an MBA.

4.114. Procedures should be established to prevent accidental or intentional unauthorized removal of nuclear material by means of a waste stream. Equipment, tool boxes, samples, empty containers, etc. leaving an MBA should also be monitored and controlled. Controls should be established to prevent unauthorized access to waste monitoring instruments, cabling and calibration standards. The controls that need to be established are highly dependent on the type of material and the processes occurring in the area. For example, when a spent fuel pool is undergoing cleaning or decommissioning, all waste is highly radioactive (albeit mostly owing to short lived radionuclides), so installed radiation monitoring devices may fail to identify spent fuel assemblies or rods. For this reason, when the pool is being cleaned, it is important that the activity be monitored by a qualified person who can recognize pieces of spent fuel such as rods and pellets.

Authorization of personnel and operations related to nuclear material

4.115. At each facility, there should be a process for authorizing access to and handling of nuclear material and the authorization of personnel who can perform those activities, including the determination of trustworthiness. Instructions should be developed and approved for the authorization process, including the identification of a limited number of management personnel who are allowed to issue authorizations.

4.116. Authorizations may be general when they involve the qualification of personnel to perform activities related to nuclear material based on their job assignments, their assigned organizational unit and their role in nuclear material control. There may be situations where specific authorization is required, e.g. for a single special activity involving nuclear material. Routine situations are usually covered by general authorizations; however, they may require specific authorization if different items or types of nuclear material are involved.

4.117. The authorization process should include the identification of which nuclear material items are permitted to be handled. An authorization should be issued prior to movement of an item. Operations involving nuclear material should be authorized prior to beginning the activities.

Aspects of particular relevance to nuclear security

4.118. All activities in an MBA should require authorization, and personnel should be informed of exactly which activities are permitted. Before being authorized, attention should be paid to the fact that certain activities could lead to changes of nuclear material properties and may be used by a malicious insider for unauthorized removal of nuclear material, e.g. the change in item identification or the addition of non-nuclear material to uranium or plutonium powder to change the gross weight of the item, which would lead to incorrect information related to the item.

4.119. To provide assurance that the facility operator is capable of detecting unauthorized removal of nuclear material, it is important that an authorization programme be fully implemented. Specific instructions may be required to ensure that NMAC procedures are followed to avoid the possibility of unauthorized removal of nuclear material. Some examples include:

— Personnel requiring access to nuclear material and related information should have appropriate security clearance.
— Access to nuclear material should be strictly limited to authorized personnel whose duties require access.
— Personnel whose job functions involve the maintenance or repair of software or equipment involved with processing, measurement or protection of nuclear material should not have unescorted access to areas containing nuclear material, unless they have proper authorization and clearance.

Control of access to nuclear material, equipment and data

4.120. In most nuclear facilities, control of access to areas of the facility is performed by physical protection staff; however, after accessing a controlled area, handling of nuclear material may require further access that may not be controlled by physical protection staff. Access to nuclear material should be controlled by the operations or NMAC departments. When handling nuclear material, the operations or NMAC department should also ensure that only the material that is authorized for handling or moving was handled or moved and that it was handled or moved according to the authorization based on the specific work assignment. Maintaining records of the assignment of nuclear material handling activities by operations and NMAC staff is a good practice.

Aspects of particular relevance to nuclear security

4.121. The goal of a nuclear security system in controlling access is to prevent unauthorized persons from having access to nuclear material or to the equipment that monitors or processes nuclear material (primarily the responsibility of physical protection) and to prevent unauthorized activities (primarily the responsibility of NMAC and operations). Plans should be developed by the operator and maintained to control access of personnel to nuclear material and equipment. These plans should address routine operations, planned evacuations and emergency situations that may result in unplanned evacuations.

4.122. Because of differences in the size and complexity of facilities, implementation of an NMAC access control programme may differ from one facility to another and may be administered by different departments within the facility. The operator of the nuclear facility should select the appropriate NMAC access control measures based on a graded approach and the results of evaluations of NMAC and physical protection systems. The facility operator should develop and document the approach to be taken to identify compensatory measures if an element for nuclear security fails.

4.123. The NMAC, operation staff or both should be informed when access is provided to the most sensitive nuclear material or equipment. The NMAC access control measures should reflect the following:

- Detection of unauthorized actions could be achieved by constant surveillance (e.g. the two person rule).
- Personnel should be prevented from bringing any unauthorized objects or equipment into an area where they could be used for nuclear material removal (e.g. bringing in shielding materials).
- Limitations should be placed on access to equipment used for NMAC or for processing of nuclear material, e.g. equipment for data collection, process control, tamper indicating, measurement, calibration or safety monitoring, as well as on equipment or data used in a computerized material accounting system.
- No changes to nuclear material data should be allowed without creating an unalterable log of the changes.
- The staff controlling access to nuclear material may be able to detect unauthorized activities, which is especially important during emergency or other unusual conditions, e.g. control of personnel following a planned or unplanned evacuation until appropriate monitoring of personnel can be completed.
- Nuclear material not actually undergoing processing or use should be placed in secure storage.
- Any conflicts discovered between safety requirements and security requirements (e.g. between requirements for access control) should be resolved.

Material containment

4.124. There are numerous levels of material containment, e.g. cans, gloveboxes, storage cabinets, rooms and vaults. A large portion of the nuclear material inventory at most nuclear facilities consists of items in storage arrangements using various material containment methods. All credible pathways for nuclear material or equipment to be removed from an MBA should be monitored in a manner consistent with a graded approach.

Aspects of particular relevance to nuclear security

4.125. Measures to maintain continuity of knowledge of nuclear material can enhance the system's ability to detect unauthorized activities in a timely manner. For example, a facility operator could apply tamper indicating devices to containers to ensure continuity of knowledge of the nuclear material in the containers and periodically check the integrity of a sample of containers. Depending on the results of the evaluation of NMAC and physical protection systems, alternative methods to enhance the system's performance may warrant consideration, e.g. the use of active tamper indicating devices or other near real time surveillance measures. The evaluation of the material containment programme and its implementation should consider containment methods and controls for normal and emergency conditions.

4.126. When nuclear material is not being used, it should be stored in a vault or other room that can be locked and, if necessary, alarmed. Keeping the majority of the nuclear material in a secure location can reduce the time required to determine whether any material is missing. To reduce the risk of unauthorized removal, the minimum amount of material needed for production or use should be removed from locked storage at any given time. Measures should be taken to control material between process steps. When material cannot be moved to a secure storage location during non-working hours, additional physical protection, material surveillance measures or both should be implemented.

4.127. At item facilities, it is possible to establish an NMAC system where all nuclear material items can be accounted for and under control. If items are under control at all times, loss of an item could be detected in a timely manner. At bulk facilities, where control of all nuclear material might not be possible, timely detection of unauthorized removal of nuclear material can be established by reducing the amount of nuclear material that might be available at any time. If nuclear material is not available for removal without detection, then more events will be needed for a malicious insider to accumulate nuclear material that could be removed without authorization.

4.128. Sometimes it might be difficult to see whether the containment has been compromised, and special measures could be considered for verifying the integrity of the containment. All types of nuclear material containment should be labelled, and a good practice is to use automated labelling systems (such as bar-codes or electronic radio frequency devices).

4.129. The material containment programme should specify methods of strictly segregating and controlling different types of nuclear material located in the same area (e.g. low enriched and high enriched uranium) to deter or detect substitution, including the use of different colours or forms of containers or labels. The material containment programme should also specify material types, forms and amounts authorized to be used, brought into or removed from the area. Empty containers and sample vials should be controlled to prevent use of these items as a means of removing material.

Tamper indicating devices

4.130. The use of a tamper indicating device (or seal) with unique identification features provides a level of confidence that the item protected by the tamper indicating device has not been opened. The objective of a tamper indicating device is to ensure that no undetected tampering or entry occurred while it was on the item. If a properly applied tamper indicating device has not been tampered with, the contents of the container to which it was applied are most likely still intact. If a tamper indicating device has been tampered with, the container to which it was applied may have been opened, meaning that assurance that the contents are intact is lost, although nuclear material may or may not be missing. (Note: The terms 'tamper indicating devices' and 'seals' are used in this publication to describe devices applied and used by the nuclear facility as a part of its material control programme and are to be distinguished from seals used by the IAEA for safeguards purposes. Nuclear material under IAEA safeguards may have seals applied by both the IAEA and the facility.)

4.131. Tamper indicating devices are available in many different physical forms, e.g. cable locks, electronic radio frequency devices (which allow continuous monitoring and near real time alarm) and paper seals. An effective tamper indicating device programme should include: controls on acquisition, procurement, storage, issuance, removal and destruction, information on types and unique identification and procedures for training on use and application, storage, issuance and verification. Devices that can be easily copied (e.g. lead or wax seals) or defeated are not appropriate for use as tamper indicating devices in an NMAC system. Tamper indicating devices can be used on containers or storage vaults to ensure the integrity of nuclear material either when it is in transit or being stored.

4.132. The degree of confidence in the performance of a tamper indicating device will vary depending on its unique characteristics and intended use.

Selection of the type of tamper indicating device to be used should be based on the nature of its application. If the competent authority has specific requirements for tamper indicating devices or container design specifications, these should be taken into account.

Aspects of particular relevance to nuclear security

4.133. Use of tamper indicating devices in conjunction with other material control measures, e.g. surveillance to prevent or detect unauthorized access to the tamper indicating devices, can provide additional assurance that unauthorized removal of nuclear material has not occurred. A programme to control and manage the procurement, use, application, removal and destruction of tamper indicating devices is recommended for all facilities that use tamper indicating devices as part of their nuclear material control programme.

Material surveillance and monitoring

4.134. Surveillance and monitoring may be used by the facility operator to prevent or detect unauthorized movement of nuclear material or other items, to detect interference with equipment and to provide continuous information about the status of equipment and nuclear material.

Aspects of particular relevance to nuclear security

4.135. Facility surveillance and monitoring systems should be established and implemented to ensure that nuclear material items are in authorized locations and to allow for detection of unauthorized activities. The use of surveillance may provide the information necessary to evaluate indications of breach of containment. It can be useful for assessing alarms, identifying the location of unauthorized removal and estimating the quantity and form of potentially stolen nuclear material. Periodic checks should be conducted by the operator to confirm that material control measures are applied according to the established procedures and that equipment is used correctly, e.g. that checks of the surveillance cameras and of locks and tamper indicating devices on doors and containers do not reveal irregularities. The choice of components of a material surveillance system and the frequency of reviews should be based on the results of evaluations of NMAC and physical protection systems within the overall context of nuclear security.

4.136. Material surveillance measures include video surveillance, weight sensors, heat sensors, laser monitors, radiation monitors, radio frequency tags, motion detectors, etc. The surveillance programme should ensure at least that:

— Only authorized and knowledgeable personnel who are capable of detecting incorrect or unauthorized actions are assigned responsibility for surveillance of nuclear material.
— Equipment which could be tampered with to prevent detection of unauthorized removal of nuclear material or other unauthorized activities by the malicious insider is monitored.
— When the two person rule is the surveillance method, the two authorized persons are physically located where they have an unobstructed view of each other or the nuclear material, and each person is trained and capable of detecting unauthorized activities or incorrect procedures.
— Weaknesses of individual components of surveillance and monitoring systems cannot be used by the malicious insider, e.g. shielding of radiation monitors, manipulation of seals and electronics, manipulation of nuclear material items or equipment which cannot be easily identified by surveillance.
— Nuclear material in use, process or storage is under proper surveillance, alarm or equivalent protection.

4.137. Appropriate locations should be selected for radiation monitors (e.g. portal monitors) used for detection of unauthorized introduction or removal of nuclear material. Careful attention should be given to their design, installation, operation and calibration and to prevention of unauthorized access to instrumentation, cabling and calibration standards. Metal detectors should be used in conjunction with radiation monitors at entrances and exits to detect shielded containers.

Item monitoring

4.138. A programme of periodic item monitoring may be established to increase the likelihood of detecting unauthorized removal of nuclear material between physical inventory takings. Item monitoring might include confirmation of the identity and the integrity of randomly selected items, any tamper indicating devices applied to the items and the item locations. Item monitoring is a performance test for NMAC in that it verifies the accuracy of the records. The scope and frequency of the item monitoring programme should be based on the results of the evaluation of NMAC and physical protection systems. Verifying other items in the vicinity of the selected items increases the effectiveness of the test and further ensures the accuracy of location information. Any incidents involving potentially missing or compromised items, or falsified item records, should be investigated and resolved.

Aspects of particular relevance to nuclear security

4.139. To assist in identifying what item(s) may be missing, each item of nuclear material should be uniquely identified. Special attention should be paid to accurate and prompt recording of item transactions, identifications and locations. This is especially important when a large number of nuclear material items are located together in one place and when containers are reused. Empty containers should also be controlled.

Monitoring nuclear material during processing

4.140. Monitoring of material during processing can be accomplished using statistical control techniques if a process is stable and under control. The difference between the quantity of material put into the process (input) and the quantity of material taken out of the process (output) can be compared with the average input–output difference and its standard deviation to detect irregularities which may indicate unauthorized removal. Process monitoring is most effective when applied to process units where input and output can be measured. Process units could be divided into smaller units for material control tests to meet the desired loss detection sensitivity and reduce false alarm rates. Any indication of an out of control process should be investigated by NMAC personnel in cooperation with the operations department as a possible indication of an attempt to divert, produce, use or remove nuclear material. Data provided by instrumentation used for operations and other material control measures, such as flowmeters, tank level indicators and video surveillance, may be used to assist in the investigation.

4.141. An analysis should be performed of the process to establish what kind of operations data are of relevance for NMAC and should therefore be made available to NMAC personnel. This analysis is best performed during the design of the process. Operations equipment can provide information useful to NMAC. For example, a flowmeter installed in the process line to provide the production organization with process control data can also provide the NMAC departments with an early indication of unauthorized removal.

Aspects of particular relevance to nuclear security

4.142. In a facility that processes nuclear material, a programme should be established to provide timely detection of unauthorized removal of material that is undergoing processing. It is important to monitor process differences to ensure that these differences do not fluctuate significantly, because fluctuation may be indicative of activities undertaken by a malicious insider to accomplish unauthorized removal of nuclear material.

4.143. For example, large processing differences may be the result of large quantities of poorly measured scrap. Large MUF and σ_{MUF} caused by scrap in the inventory can be reduced by more frequent scrap processing or the use of a more accurate measurement technique. If this is not possible, additional mitigating measures that could be taken might include:

— Making the process units as small as possible and segregating scrap by process unit, operational shift, batch, etc.;
— Measuring scrap promptly (e.g. by non-destructive assay and weighing);
— Monitoring and evaluating the quantities of nuclear material introduced to the process unit, product removed from the process unit, and nuclear material held up in the processing equipment;
— Conducting checks daily or on every shift to provide assurance that the quantity of scrap removed from the process unit is consistent with the expected quantity.

4.144. These measures could significantly reduce the number of successful malicious insider scenarios and could assist in detection of unauthorized removal of nuclear material. They could mitigate some abrupt theft scenarios, reduce possible nuclear material quantities involved in the event of protracted theft, and therefore increase the completion time for some scenarios.

4.145. A similar approach could be used in other nuclear material processing areas, units or equipment, where implementation of more accurate measurements might be desirable for nuclear security purposes but is technically difficult. Some scenarios of unauthorized removal by a malicious insider could be eliminated by use of monitoring and frequent evaluation of nuclear material losses. Increasing the time needed to complete an unauthorized removal could eliminate the scenario as a possibility.

NUCLEAR MATERIAL MOVEMENTS

4.146. In this publication, the term ‘shipment’ refers to an outgoing movement of nuclear material from one facility to another facility. The term ‘receipt’ refers to an incoming movement of nuclear material from one facility to another facility.

The term ‘transfer’ refers to nuclear material movement within a facility between MBAs. The term ‘relocation’ refers to movement within an MBA. The general term ‘movement’ refers to all terms described in this paragraph and used in this publication. (Note that these terms may differ from those normally used in a State or in IAEA safeguards activities.)

4.147. All movements (shipments, receipts, transfers and relocations) should be recorded in the accounting system and documented. Documentation should include item identification, tamper indicating device identification, the location from which the nuclear material was moved and the location to which it was moved. The documentation should also include the signatures of the personnel making and verifying the movement.

Aspects of particular relevance to nuclear security

4.148. Shipment off-site and preparation for shipment, and to a lesser degree transfers between MBAs on-site, are sensitive operations that may present specific opportunities for unauthorized removal. To deter and detect unauthorized removal of nuclear material, NMAC should be included as part of the shipping and transfer processes. Because of the potential vulnerabilities during shipments and transfers of nuclear material, specific measures should be taken to identify and prevent intentional malicious acts or unintentional errors involving such shipments and transfers. Responsibility for the nuclear material during shipment and transit should be clearly defined by the shipper and receiver prior to the shipment. Other nuclear security measures for protecting nuclear material in the shipment, transfer and transport process are covered in Ref. [3].

Shipments of nuclear material

4.149. The NMAC system may address the following for nuclear material during preparation for shipment, packaging and transport:

— Responsibilities for control of nuclear material;
— Preparation of the shipment;
— Packaging and shipping records;
— Unique identification of items shipped;
— Application and verification of the identity and integrity of tamper indicating devices;
— Visual examination of items shipped;
— Measurement data for the items shipped, including measurement uncertainty;
— Methods used to measure nuclear material content.

4.150. The element and isotope content of nuclear material to be shipped should have been measured in accordance with the measurement programme, as described in paras 4.82–4.107, and continuity of knowledge should have been maintained following the measurement. To preclude the possibility that nuclear material might be shipped in error (whether accidental or malicious), packaging of any material (whether nuclear or non-nuclear) for shipment within an area where nuclear material is stored or processed, should be observed by individuals knowledgeable about NMAC and the physical characteristics of nuclear material. An example of good practice is the use of two individuals for data review and verification of tamper indicating devices.

Aspects of particular relevance to nuclear security

4.151. Facility operators should establish measures for shipping nuclear material to provide assurance that unauthorized removal will be detected. Procedures should be developed to verify prior to shipment that containers labelled as empty are actually empty and that items removed from a nuclear material area that are identified as non-nuclear are actually non-nuclear. Detailed information about the transport of nuclear material should be treated as sensitive information until the movement is complete; however, this should not conflict with notification requirements such as those contained in safeguards agreements. All shipping activities should be subject to oversight by NMAC and physical protection personnel who are knowledgeable about NMAC requirements and are capable of recognizing unauthorized activities.

Receipts of nuclear material

4.152. Checks to be performed by the receiving nuclear facility should begin with verification of the integrity of the shipping (transport) container and any tamper indicating devices. Following the initial check, actions should include:

— Verification of the number of items in the shipping container;
— Verification of the item identities;
— Verification of the integrity of containers and their tamper indicating devices;
— Measurement of items, as required.

4.153. Contents should be compared to the information contained in the shipping documentation. The items should be placed in the book inventory immediately following receipt verification using the nuclear material quantities and type stated in the shipper's documentation, which may be adjusted when receiver measurements are complete. Any significant discrepancies found during the verification activities should be reported to the shipper and the competent authority, investigated and resolved. The competent authority should specify the time within which all receipt activities should be completed, including the time limit for completing receipt verification. Items under investigation should be isolated and secured, and not processed or shipped until all discrepancies are resolved.

4.154. If the nuclear material received is processed by the receiving facility, a shipper–receiver comparison should be completed as described in paras 4.158–4.160. Any statistically significant differences should be resolved before the material is released for processing. For encapsulated items such as fuel assemblies, rods and elements, shipper's values may be accepted provided the encapsulation is intact. Nuclear material which may be exempted from shipper–receiver difference comparisons should be approved as required by the competent authority and documented as agreed to by both the shipper and receiver.

Aspects of particular relevance to nuclear security

4.155. Nuclear facility operators should establish measures, including the involvement of NMAC personnel, for receipt of nuclear material to ensure that any unauthorized removal that may have occurred is detected. Special attention should be given to eliminating the possibility of using shipper–receiver differences to conceal unauthorized removal of nuclear material as described in paras 4.158–4.160. Received material should be segregated and not processed until receipt measurements have been completed.

Documentation and records of movements

4.156. Movements of nuclear material should be clearly documented and the records updated as described in paras 4.52–4.53. When nuclear material is moved, authorization should be required by facility management or other authorized personnel, and checks should be performed as appropriate.

Aspects of particular relevance to nuclear security

4.157. The NMAC system should be designed to deter and detect unauthorized removal or substitution of nuclear material during movements and related preparations. Continuity of knowledge of the material should be maintained.

Shipper–receiver difference evaluation

4.158. A shipper–receiver difference is the difference between the quantities of nuclear material in a batch as stated by the shipping MBA and as measured at the receiving MBA. To the extent possible, receipts of nuclear material should be measured to confirm that the quantity received is consistent with the shipper's supporting documentation. The receiving facility should perform a shipper–receiver comparison using a statistical methodology. The maximum acceptable shipper–receiver difference should be established, taking into account measurement capabilities and the design basis threat, and should be appropriate for the type and form of the nuclear material measured. Cumulative shipper–receiver differences should also be calculated and evaluated as required by the competent authority. Resolution of a significant shipper–receiver difference may involve a measurement by a third party of a sample taken for this purpose. Significant differences should be reported to the shipper and the competent authority, investigated and resolved as described in paras 4.161–4.168.

Aspects of particular relevance to nuclear security

4.159. Shipper–receiver differences, especially in the case of large quantities of nuclear material or large measurement uncertainties, could be used by a malicious insider to conceal unauthorized removal of nuclear material. In the design and evaluation of the facility's nuclear security approach, consideration should be given to compensatory measures to be taken in the case of statistically significant shipper–receiver differences. Any statistically significant shipper–receiver difference should be resolved before the material in question is released for processing.

4.160. In situations where large shipper–receiver differences occur, the design and evaluation of the nuclear security approaches of both the shipping and receiving facilities should consider the possibility of malicious insider activities.

DETECTION, INVESTIGATION AND RESOLUTION OF IRREGULARITIES

4.161. An objective of NMAC is to detect, investigate and resolve irregularities, including appropriate responses and notifications. Irregularities are possible indications of unauthorized removal of nuclear material, and for each facility, criteria should be established for defining what constitutes an irregularity.

All irregularities should be investigated and resolved. Possible irregularities may include:

- — Missing item(s) or material loss;
- — Allegation of unauthorized removal;
- — Item found in the wrong location;
- — Item found unexpectedly of which there is no record;
- — Unauthorized action involving nuclear material;
- — Damaged container;
- — Damaged or broken tamper indicating device;
- — Failure of surveillance measures;
- — Damaged, incorrect or missing item identification;
- — Damage to or failure of NMAC related equipment;
- — Violation of the two person rule;
- — Discrepancy in a nuclear material record or report;
- — Significant difference between a measured and a recorded value of nuclear material;
- — Statistically significant value of MUF or cumulative MUF;
- — Shipper–receiver difference that fails to meet the acceptance criteria;
- — Unauthorized access to data, equipment or nuclear material;
- — Alarm of NMAC systems, including monitoring equipment;
- — Unauthorized operation involving nuclear material or NMAC system elements;
- — Violation of NMAC procedures;
- — Failures or incidents involving nuclear material;
- — Overstatement or understatement of shipments or receipts.

Aspects of particular relevance to nuclear security

4.162. During an investigation, the possibility should be considered that an irregularity was created intentionally to disguise unauthorized removal. Some irregularities, such as the loss of an item, call for an immediate response. Other irregularities, such as finding nuclear material or recording errors, may not appear to be serious problems, but should be carefully evaluated as they may indicate a serious problem with the NMAC system. Where possible, all items associated with a possible irregularity or discrepancy should be isolated in separate storage areas until the issue is resolved. Allegations of unauthorized removal or wrongdoing should also be investigated.

Response measures and investigation of irregularities

4.163. The actions to be taken in response to an irregularity depend on the nature of the irregularity and the nuclear material involved, e.g. the type of material, the risk of unauthorized removal, and the possible consequences. Potential problems that can arise should be identified before they occur, and a comprehensive set of possible mitigating responses should be developed. Procedures should be developed for resolving irregularities. Steps to resolve irregularities might range from re-measurement of an item to conducting a full emergency physical inventory. As discussed in paras 4.29–4.32, facility personnel should be made aware of the importance of immediate actions to be taken in response to an irregularity.

4.164. A system should be developed to analyse the alarms generated by the different elements of the NMAC system and initiate the appropriate response. The alarm resolution programme should be capable of identifying the type of system error or innocent cause that resulted in an alarm, so that remedial action can be taken. The alarm response should be timely to ensure that alarms are investigated and resolved promptly (e.g. while memories of events are still fresh, material is still available for re-measurement and material has undergone as few processing changes as possible).

Aspects of particular relevance to nuclear security

4.165. Each of the nuclear material control elements provides methods for the detection of the unauthorized production, use or removal of nuclear material. The effectiveness of these detection methods depends on the accurate and timely recognition and evaluation of the alarms generated. An irregularity may indicate that malicious insider activities have occurred. In the case of a serious irregularity involving possible unauthorized removal of nuclear material, the response should begin with immediate notification to facility management, physical protection management, NMAC management and the competent authority. NMAC actions should be coordinated with actions taken by physical protection personnel. If a security area is breached for any reason, physical protection personnel and NMAC personnel should collaborate to establish the appropriate response. Possible actions to be taken by the NMAC department may include conducting an emergency physical inventory with confirmatory measurements, if needed. In some cases, it may be appropriate to obtain external assistance to resolve the irregularity. Movements of material and personnel in the affected area should be limited during the investigation of serious irregularities.

Documenting investigations of irregularities

4.166. The NMAC system should provide formal guidance on investigation of irregularities including the nature of the investigations to perform, composition of the team conducting the investigation, alerts, deadlines and the reporting process. Investigations should be documented in formal reports providing sufficient details on the nature of the irregularity, analysis of the events that led to detection of the irregularity, description of the actions taken to characterize the irregularity and to initiate the appropriate response, and corrective actions to prevent recurrence of the irregularity.

4.167. Irregularities should be reviewed regularly and frequently to measure the effectiveness of corrective actions. The review, categorization and analysis of irregularities may identify weaknesses in the NMAC system, equipment or both. Appropriate corrective actions should be taken.

Aspects of particular relevance to nuclear security

4.168. Prompt and complete resolution of irregularities enhances a facility operator's capability to detect unauthorized removal of nuclear material. Accurate and complete documentation of investigations of all irregularities should be required by a facility operator. Documentation should be reviewed and evaluated on a frequency that is appropriate for the type and quantity of nuclear material at the facility to determine if any of the events might be related. Knowledge that there will be a response to any irregularity serves as a deterrent against malicious insider activities.

ASSESSMENT AND PERFORMANCE TESTING OF THE NMAC SYSTEM

4.169. A programme should be established for periodic evaluation and review of the NMAC system. The programme should consist of evaluations of the overall system and its elements. The testing of NMAC measures to determine whether or not they are implemented as designed, adequate for the proposed natural, industrial and threat environments, and in compliance with established performance requirements is referred to as performance testing, and should be used where appropriate.

4.170. The assessment programme should not be limited to design criteria, but should also consider the effectiveness of the overall system. The assessment programme should:

— Ensure that procedures and instructions are understood, implemented and maintained;
— Detect and alert management to any sign of inadequate performance of the NMAC system;
— Provide for proper corrective actions to prevent recurrence of problems.

4.171. The frequency of periodic evaluations should take into account the attractiveness of the nuclear material. More frequent evaluations may be necessary if problems have been identified.

4.172. The assessments and performance tests may be conducted by NMAC staff, an organization outside the NMAC department or an organization external to the facility. They should be performed by knowledgeable, technically competent individuals with appropriate authorization and free from conflicts of interest, such as having direct responsibility for performing the activities being assessed.

4.173. The assessments and performance tests should be documented. Any identified deficiencies should be brought to the attention of management so that they can be corrected. Management's response, including any corrective actions ordered by management and the expected timeframe for completing such actions, should be documented.

4.174. The results of assessments and performance tests should be made available to NMAC staff. Corrective actions to prevent recurrence of the identified deficiencies should be taken based on the use of sound analysis techniques, and should be commensurate with the severity of the problem. Corrective actions should address long term sustainability of the NMAC programme and not merely the immediate solution to the problem. Follow-up evaluations, audits and performance tests should be conducted to assess the effectiveness of the corrective actions taken.

4.175. The performance testing programme at a facility should include:

— Proper documentation and approval of methods and scope of the performance tests;

— Scheduled routine testing, such as tests of material surveillance procedures or periodic administrative checks;
— Testing for other activities, such as tests of changes made to NMAC systems;
— Coordination of performance tests with all facility organizations involved or affected by the test.

4.176. Performance testing of the NMAC system elements should be used to confirm that NMAC measures are performing as designed and that they fulfil their intended function. Proposed changes to the facility or processes that have a potential impact on the NMAC systems should be subject to evaluation as part of the initial review and approval of the proposed change. The evaluations should also take into consideration the criteria defined by the State or the competent authority.

4.177. The quality management system for the NMAC system should conform to methods presented in established standards, such as those published by the International Organization for Standardization (ISO).

Aspects of particular relevance to nuclear security

4.178. Periodic evaluations of the NMAC system should be conducted to ensure that it is capable of detecting unauthorized removal of nuclear material as designed. An effective NMAC system depends upon all elements of the system performing effectively at all times. All documentation of identified deficiencies should be protected as sensitive information, because information on deficiencies in the NMAC system could benefit potential adversaries.

4.179. One of the major difficulties encountered during conduct of an NMAC performance test is providing for a realistic test while ensuring that the nuclear material is under control during the test. Careful planning and coordination are needed to ensure material control without negatively affecting the test or compromising NMAC.

4.180. Performance testing is especially important for ensuring that goals of nuclear security are achieved.

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GLOSSARY

The following terms are used in this publication, as defined here:

adversary. Any individual performing or attempting to perform a malicious act.[1]

book inventory. The algebraic sum of the previous physical inventory (as determined at a physical inventory taking) and any subsequent inventory changes (as reflected in the inventory change reports).[2]

competent authority. Governmental organization(s) or institution(s) designated by a State to carry out one or more nuclear security functions.[3]

configuration management. The process of identifying and documenting the characteristics of a facility's physical protection system — including computer systems and software — and of ensuring that changes to these characteristics are properly developed, assessed, approved, issued, implemented, verified, recorded and incorporated into the facility documentation.

containment. Structural elements (cans, gloveboxes, storage cabinets, rooms, vaults, etc.), which are used to establish the physical integrity of an area or items and to maintain the continuity of knowledge of nuclear material.

control (of nuclear material). Activities, devices, systems and procedures that ensure that the continuity of knowledge (e.g. location, quantitative measurements) about nuclear material is maintained.

defence in depth. The combination of multiple layers of systems and measures that have to be overcome or circumvented before nuclear security is compromised.[3]

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[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Preventive and Protective Measures against Insider Threats, Implementing Guide, IAEA Nuclear Security Series No. 8, IAEA, Vienna (2008).

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graded approach. The application of nuclear security measures proportional to the potential consequences of a malicious act.[2]

insider. One or more individuals with authorized access to nuclear facilities or nuclear material in transport who could attempt unauthorized removal or sabotage, or who could aid an external adversary to do so.[2]

irregularity. An unusual observable condition which might result from unauthorized removal of nuclear material, or which restricts the ability of the facility operator to draw the conclusion that unauthorized removal has not occurred.

nuclear facility. A facility (including associated buildings and equipment) in which nuclear material is produced, processed, used, handled, stored or disposed of and for which a specific licence is required.[2]

nuclear material. Any material that is either special fissionable material or source material as defined in Article XX of the IAEA Statute[4].

"1. The term "special fissionable material" means plutonium-239; uranium-233; uranium enriched in the isotopes 235 or 233; any material containing one or more of the foregoing; and such other fissionable material as the Board of Governors shall from time to time determine; but the term "special fissionable material" does not include source material.

"2. The term "uranium enriched in the isotopes 235 or 233" means uranium containing the isotopes 235 or 233 or both in an amount such that the abundance ratio of the sum of these isotopes to the isotope 238 is greater than the ratio of the isotope 235 to the isotope 238 occurring in nature .

"3. The term "source material" means 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 concentration as the Board of Governors shall from time to time determine; and such other material as the Board of Governors shall from time to time determine."

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[4] The Statute of the IAEA (1956), with amendments (1963, 1989), IAEA, Vienna.

operator. Any person, organization or government entity licensed or authorized to undertake the operation of a nuclear facility.[3]

physical inventory. The sum of all the measured or derived estimates of batch quantities of nuclear material physically present at a given time within a material balance area, obtained by a facility operator in accordance with specified procedures.[2]

surveillance. The collection of information through devices or direct observation to detect unauthorized movements of nuclear material, tampering with containment of nuclear material or falsification of information related to location and quantities of nuclear material.

system for nuclear material accounting and control. An integrated set of measures designed to provide information on, control of and assurance of the presence of nuclear material, including those systems necessary to establish and track nuclear material inventories, control access to and detect loss or diversion of nuclear material, and ensure the integrity of those systems and measures.

two person rule. A procedure that requires at least two authorized and knowledgeable persons to be present to verify that activities involving nuclear material and nuclear facilities are authorized in order to detect access or actions that are unauthorized.

unauthorized removal. The theft or other unlawful taking of nuclear material.

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