HANDBOOK OF INTERNATIONAL NUCLEAR SAFEGUARDS

Integrated Support Center for Nuclear Nonproliferation and Nuclear Security

Japan Atomic Energy Agency

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DISCLAIMER:

This Handbook was prepared by staff of Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN) of the Japan Atomic Energy Agency (JAEA) with the support of experts both internal and external to JAEA, including experts affiliated with the US Department of Energy. The Handbook's objective is to serve as a training aid at national, regional and international safeguards training courses of ISCN/JAEA. It should be used as reference material for training purposes only for ISCN/JAEA training courses and related activities. ISCN/JAEA does not necessarily endorse any of the statements, information or opinions presented in this Handbook. The International Atomic Energy Agency does not endorse the contents of this Handbook. Readers are advised to refer to official IAEA documents[1] for authoritative guidance while using this Handbook.

[1] Several useful official IAEA publications can be found in page 94, "References and Bibliography".

FOREWORD

There is abundant literature on International Atomic Energy Agency (IAEA) safeguards, which deal with detailed and thorough features of safeguards. Information is, however, scattered in a number of publications such as books on the history of the IAEA, detailed authoritative Guidelines on safeguards implementation (published as "Services Series" by the IAEA), handbooks on nuclear material accounting, and specialized manuals on Non Destructive Assay. There are also short brochures and fact sheets with summary information on the IAEA and safeguards. There are few, if any, mid-size reference handbooks where information from authoritative sources is compiled in a succinct yet comprehensive manner.

This Handbook[2] is meant to fulfill this need by summarizing, in one single document, information from several publications and sources. The Handbook is illustrated with a number of photographs and diagrams that facilitate the understanding of safeguards principles and technology. It will be provided to participants attending National, Regional and International SSAC Training courses sponsored by the Integrated Support Center for Nuclear Nonproliferation and Nuclear Security, ISCN.

[2] A list of the most important safeguards publications consulted can be found at the end of this Handbook, under "References and Bibliography".

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1. PURPOSE, SCOPE AND STRUCTURE OF THE HANDBOOK

1.1 PURPOSE

This handbook is a contribution of the Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN)[3] targeted to participants of national, regional and international SSAC Training courses organized or sponsored by ISCN. It has the purpose of facilitating the understanding of IAEA safeguards to State authorities responsible for safeguards implementation and operators responsible for operating and maintaining State Systems of Accounting for and Control of Nuclear Material (SSAC) by providing broad information on basic safeguards principles and practices in a single, concise document.

1.2 SCOPE

This handbook is, by nature, neither authoritative nor comprehensive, however it includes a number of cross-references, links and bibliography that address a variety of safeguards topics published by safeguards authorities and institutions across the globe. For the sake of correctness and accuracy, several parts of the handbook include text reproduced textually from official sources[4].

1.3 STRUCTURE

The handbook has been structured in sections that start defining and explaining the IAEA safeguards system as it was created from its outset, then it describes the basic undertakings for the application of safeguards (why are safeguards implemented) and continue with a section describing the areas of cooperation of the State with the IAEA (who is supposed to do what). Then, the handbook concentrates on the IAEA verification activities resulting from the application of the safeguards agreement and of its additional protocol (what is done and when). Finally, some information on the IAEA's efforts towards the optimization of the system is provided. References, bibliography and the most used abbreviations are included at the end of the handbook.

[3] ISCN was established under the Japan Atomic Energy Agency (JAEA) to contribute to the strengthening of nuclear non-proliferation and security in Asian countries and other regions.

[4] Such material is reproduced with permission, as acknowledged.

2. THE IAEA SAFEGUARDS SYSTEM

The safeguards system of the International Atomic Energy Agency (IAEA) has a key responsibility in promoting peace and security in the world. The purpose of safeguards is to provide credible assurances to the international community that nuclear material and other specified items are not diverted from peaceful nuclear uses. The objective of IAEA safeguards is to deter the spread of nuclear weapons by early detection of misuse of nuclear material or technology, thereby providing credible assurances that States are honoring their legal obligations. The IAEA has therefore an indispensable function in the global nuclear non-proliferation regime.

The IAEA, or simply "the Agency", was established in 1957. The origin of the IAEA was the "Atoms for Peace" speech[5] presented by US President Eisenhower to the United Nations General Assembly on 8 December 1953 where he proposed the creation of an "international atomic energy agency" to promote the peaceful uses of nuclear energy and to seek to ensure that nuclear energy would not serve any military purpose. President Eisenhower's proposed that governments would make joint contributions from their stockpiles of fissile materials and natural uranium and allocate those materials "to serve the peaceful purposes of mankind". Eisenhower's speech was received with appreciation by the delegations at the UN but it took several years until the world's major nuclear powers were able to agree on the actual functions that this organization would be responsible for, functions that did not fully followed the intentions expressed in Eisenhower's speech.

US President D. Eisenhower addressing the UN General Assembly, 8 December 1953

Photo credit: IAEA imagebank

After lengthy and difficult negotiations, the IAEA's objectives and functions were incorporated into the Agency's Statute[6], a multilateral treaty, which came into force on 29 July 1956 and that resulted in the creation of the IAEA. The dual aim of the Agency is to "seek to accelerate and enlarge the contribution of atomic energy to peace, health

[5] The full version of Eisenhower's speech can be found at: https://www.iaea.org/about/history/atoms-for-peace-speech

[6] The IAEA's Statute can be found at: http://www.iaea.org/About/statute.html

and prosperity throughout the world. It shall ensure that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose". The functions assigned to the Agency are broad and can be summarized as follows:

- Promote research on, development of and practical applications of nuclear energy for peaceful purposes (IAEA Statute, Article III.A.1).
- Provide materials, services, equipment and facilities for such research and development (IAEA Statute, Article III.A.2).
- Establish and apply nuclear safeguards to ensure that any nuclear assistance or supplies with which the IAEA was associated should not be used to further any military purposes – *and apply such safeguards if so requested, to any bilateral or multilateral arrangement* (IAEA Statute, Article III.A.5).

Tokai-1 gas-cooled reactor, now permanently shut down.

Photo source: JAEA

The Agency started functioning in 1957; however it was only in 1959 that the first safeguards were applied to the Japanese JRR-3 research reactor in Tokai- mura, Ibaraki Prefecture. Safeguards were applied as a result of a request to the IAEA by the Japanese government to procure Uranium for its reactor. Canada provided 3 tons of natural uranium in metal form to Japan under a supply project with the IAEA.

The first significant inspections took place when Japan and the IAEA signed an agreement placing under safeguards all nuclear plants and fuel of US origin in Japan. Two large reactors and 11 smaller research reactors and critical facilities were included in the agreement that was signed on September 1963. In the same month, Japan and the United Kingdom informed the IAEA that the Tokai-1, a 587 MW(th) gas-cooled power reactor that started operation in 1965 with fuel of British origin will be put under safeguards. Other states soon followed suit and also concluded item specific agreements with the Agency.

Following the experience gained in implementing safeguards under item-specific agreements and the changes in world politics, a new treaty was negotiated and agreed upon: The Treaty on the Non-Proliferation of Nuclear Weapons (NPT)[7] that entered into force on 5 March 1970. The treaty was —and remains— the first global nuclear non-proliferation treaty. It has the objective of preventing the spread of nuclear weapons and weapons technology. It also fosters the peaceful uses of nuclear energy and furthers the goal of disarmament. In line with the functions stipulated in Article III.A.5 of its Statute, the Agency[8] accepted the responsibilities assigned in the NPT. The treaty assigns to the IAEA the obligation of verifying, at the global level and through it safeguards system, that non-nuclear weapon states fulfill their obligations not to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices.

As of December 2015, there were 191 states that are party to the NPT, making it one of the most subscribed international treaties in history. As a result of the NPT, the Agency received "a tremendous boost, making it the keystone of the non-proliferation regime and catapulting it from the periphery to the center of the international political system"[9].

Following the entry into force of the NPT, the IAEA Board of Governors (BoG) established a Safeguards Committee, "Committee 22". This Committee developed a document entitled "The Structure and Content of Agreements between the Agency and States required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons"[10]. Based on this document, the IAEA applied, since 1970, "comprehensive safeguards" to States that are signatories of a Safeguards Agreement. The scope of this agreement is to cover all nuclear material in a State, rather than selected facilities chosen to submit to be placed under safeguards by a State. Therefore, they are called comprehensive safeguards agreements (CSA). Under such an agreement, the State undertakes to accept Agency safeguards on all source or special fissionable material in all peaceful nuclear activities within the territory of the State, under its jurisdiction, or carried out under its control anywhere. For its part, Agency has a corresponding right and obligation to ensure that safeguards are so applied on all such material, for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices. CSAs are focused on

7 Published by the IAEA as Information Circular 140 or "INFCIRC/140" see: https://www.iaea.org/sites/default/files/publications/documents/infcircs/1970/infcirc140.pdf

8 See text *in italics* on page 10

9 From "The International Atomic Energy Agency and World Order, by L. Scheinman

10 Published by the IAEA as INFCIRC/153 (Corrected)

the verification that declared nuclear materials are not diverted to proscribed uses.

The discovery in Iraq, after the 1991 Gulf War, of a clandestine nuclear weapons programme led to a substantial strengthening of the system to provide assurance not only that declared material is not diverted but also that undeclared nuclear activities are not taking place. In 1993, the BoG requested the IAEA secretariat to submit concrete proposals for the strengthening of the effectiveness and efficiency of Agency safeguards. The Secretariat established "Programme 93+2", which identified several measures that could be implemented within the existing authority of the Agency and those measures that required complementary legal authority. Based on these findings, the BoG established Committee 24 that negotiated the text of a "Model Protocol Additional to the Agreements between States and the International Atomic Energy Agency for the Application of Safeguards"[11]. In 1997, the BoG approved the text negotiated by the Committee and States started to conclude additional protocols (AP) with the IAEA and to enter them into force. The measures included in the AP equip the IAEA with important additional verification authority that provide for broader access to information about the State's nuclear programme, increased physical access by the IAEA and improved administrative arrangements. As of December 2015, additional protocols were in force in 127 states.

Inspectors assess the ruins of a facility used to produce HEU during an IAEA inspection in Iraq.

Photo Credit: Petr Pavlicek, IAEA Imagebank

2.1 The IAEA now

The International Atomic Energy Agency is an intergovernmental organization with headquarters in Vienna, Austria. It is an independent organization *related* to the United Nations (UN) by a special agreement. Two policy-making organs compose the IAEA: the Board of Governors (BoG) and the General Conference (GC). The BoG consists of representatives of 35 Member States. They represent the most advanced

[11] Published by the IAEA as INFCIRC/540 (Corrected)

states in nuclear technology from eight regions: North America, Latin America, Western Europe, Eastern Europe, Africa, Middle East and South Asia, South East Asia and the Pacific, and the Far East. The BoG meets generally five times per year: in March and June, twice in September (before and after the General Conference) and in December. The BoG examines and makes recommendations to the General Conference on the IAEA accounts, Programme and Budget, and applications for membership. It also approves safeguards agreements and has the responsibility for appointing the Director General of the IAEA with the approval of the GC. In case of a country's noncompliance with its safeguards agreements, the Board decides upon further steps ranging from a call to clarification to a referral to the United Nations Security Council.

The General Conference is the top policy-making body of the IAEA. It is composed of representatives of all member states and meets annually, usually in September, to consider and approve the Agency's programme and budget and to decide on matters brought before it by the BoG, the IAEA Director General and Member States.

The IAEA reports annually to the UN General Assembly and when appropriate to the UN Security Council, regarding non-compliance by States with their safeguards obligations.

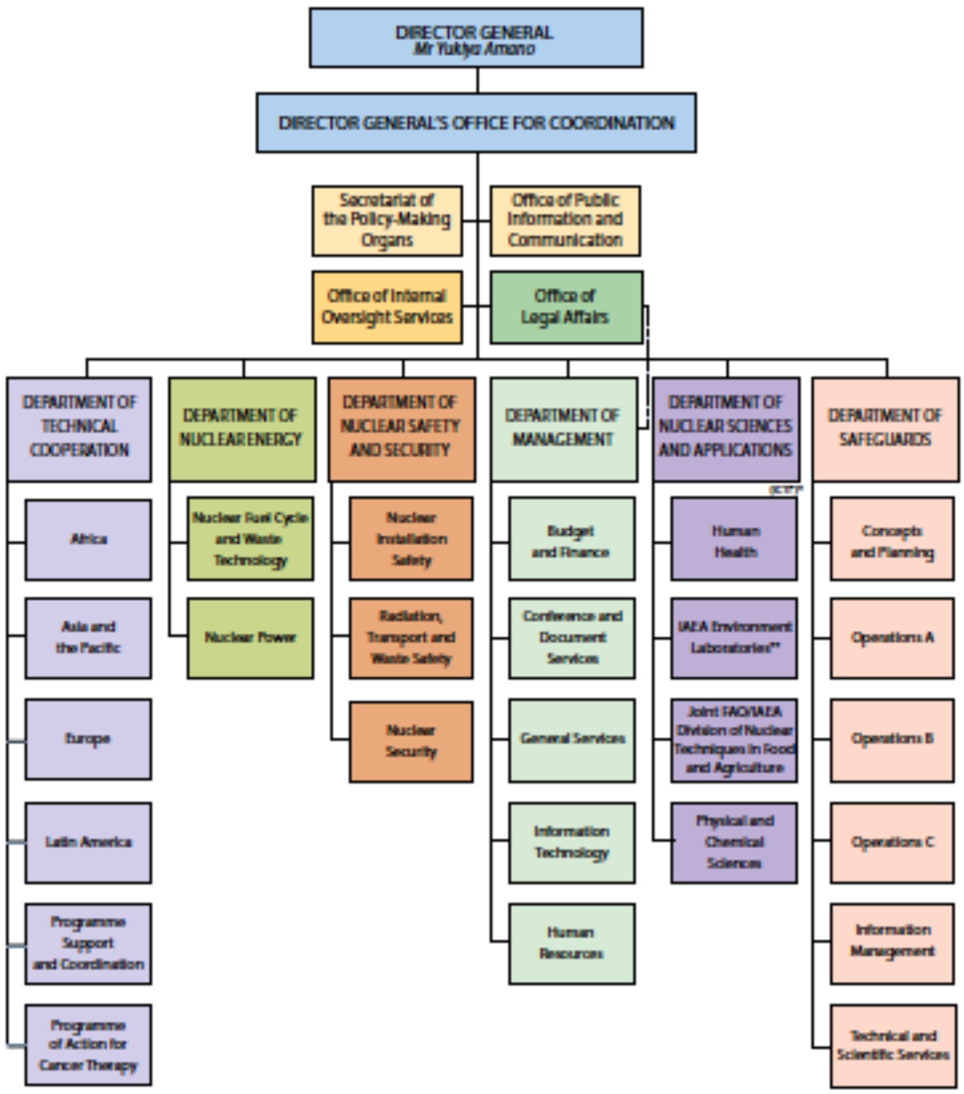
Headquarters of the IAEA, Vienna, Austria.

Photo credit: IAEA imagebank

A Director General, currently Mr. Yukiya Amano of Japan, who is serving his second mandate in office, heads the IAEA Secretariat. The Secretariat is composed of about 2500 professional and support staff from over 125 countries. Most of the IAEA professional staff has scientific and technical backgrounds, typically in sciences and engineering disciplines associated with the nuclear field. The IAEA is organized into six major departments: Management, Nuclear Sciences and Applications, Nuclear Energy, Nuclear Safety and Security, Technical Cooperation and Safeguards.

ORGANIZATIONAL CHART

(as of 31 December 2015)



* The Abdus Salam International Centre for Theoretical Physics (ICTP), legally referred to as the "International Centre for Theoretical Physics", is operated as a joint programme by UNESCO and the Agency. Administration is carried out by UNESCO on behalf of both organizations.

** With the participation of UNEP and IOC.

The IAEA has a budget of 352.1 million US dollars supplemented by extra-budgetary expenditures of around 85.8 million US dollars (as of 2015).

The Department of Safeguards, as the verification arm of the IAEA, has the primary role to deter the proliferation of nuclear weapons by detecting early the misuse of nuclear material or technology, and by providing credible assurances that States are honoring their safeguards obligations. The Department also contributes to nuclear arms control and disarmament, by responding to requests for verification and other technical assistance associated with related agreements and arrangements. The Department consists of six Divisions: one that is responsible for concepts and planning, one that covers information management, another that provides technical and scientific services and three for operations; There are also three Offices reporting to the Deputy Director General for Safeguards: One for verification in Iran, one for Safeguards Analytical Services and one for Information and Communication Systems. Each of the three Operations Divisions is responsible for the implementation of safeguards in a different geographical area. Division of Operations A is responsible for inspections in Australasia and East Asia; Division of Operations B is responsible for the Middle East, South Asia, Africa, some non-European Union states, and the Americas; Division of Operations C is responsible for Europe, the Russian Federation and Central Asia and there is an office dedicated to verification in Iran. The Operations Divisions and the office for verification in Iran play a major role in verifying that, for States with safeguards agreements in force, there is no diversion of declared nuclear material from peaceful nuclear activities and no indications of undeclared nuclear material or activities in the State as a whole.

To this end, IAEA inspectors implement nuclear material (NM) accountancy measures in the field including, among others, NM accounting audits, non-destructive assay, sampling and chemical analysis of nuclear materials, and environmental sampling. Containment and surveillance techniques (e.g. the application of seals and the use of cameras and detectors installed at the facility) may be deployed to prevent undetected access to nuclear material or undeclared operation of the facility. In order to verify that the facility has been used as declared, environmental samples may be taken for analysis. The IAEA also makes use of unattended and remote monitoring data (surveillance, seals and non-destructive assay) of declared facilities through use of the transmission of encrypted data. These are supported by announced or unannounced random inspections. Additionally, inspectors verify the Design Information provided by States and perform complementary accesses to all parts of a State's nuclear fuel cycle to provide assurances as to the absence of undeclared nuclear material and activities in a State.

Each Operations Division conducts an evaluation of the consistency of the State's declared nuclear programme against the results of the Agency's verification activities under the relevant safeguards agreement, additional protocol (where applicable) and with all other safeguards-relevant information available to the Agency. In particular, a comprehensive State evaluation, based on all information available to the Agency about the State's nuclear and nuclear-related activities, is conducted[12].

3. Basic undertakings for the application of Safeguards

3.1 Comprehensive Safeguards Agreements (CSA)

The vast majority of safeguards implemented in the world results from article III of the Treaty on the Non-Proliferation of Nuclear Weapons:

"Each Non-nuclear-weapon State Party to the Treaty undertakes to accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency in accordance with the Statute of the International Atomic Energy Agency and the Agency's safeguards system, for the exclusive purpose of verification of the fulfillment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices. Procedures for the safeguards required by this Article shall be followed with respect to source or special fissionable material whether it is being produced, processed or used in any principal nuclear facility or is outside any such facility. The safeguards required by this Article shall be applied on all source or special fissionable material in all peaceful nuclear activities within the territory of such State, under its jurisdiction, or carried out under its control anywhere".

Dukovany Nuclear Power Plant in the Czech Republic (4 reactors in operation).

Photo credit: IAEA imagebank

The NPT makes it mandatory for all non-nuclear-weapon States (NNWS) parties to conclude comprehensive safeguards agreements (CSA) with the IAEA and therefore authorizes the application of safeguards to all of their source or special fissionable material. They are called "comprehensive" because they cover all nuclear material in the State.[13]

[12] Source: IAEA web page, Safeguards: https://www.iaea.org/about/organizational-structure/department-of-safeguards

[13] In February 1992 the IAEA's BoG affirmed that the scope of CSAs was not limited to material actually declared by the State, but included any material that is required to be

The basis of CSAs is available in an IAEA document adopted by the Board of Governors in 1972, INFCIRC/153 (corrected), "The Structure and Content of Agreements between the Agency and States required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons"[14]. As of the end of 2015, there were 173 States with comprehensive safeguards agreements in force.

INFCIRC/153 has two parts: Part I specifies the *fundamental rights and obligations* of the parties while Part II specifies the *technical principles and procedures to be applied.* Both the State authority responsible for safeguards implementation (SRA) and facility operators (the officers at a facility in charge of the implementation of safeguards) are advised to examine thoroughly the CSA in force for their State[15].

The main provisions of INFCIRC/153 are summarized below:

3.1.1 PART I OF INFCIRC/153[16]

Basic undertaking: The State agrees to accept IAEA safeguards on all source or special fissionable material in all peaceful nuclear activities within the State's territory or under its jurisdiction or control anywhere. This undertaking ensures compliance with the NPT and other regional non-proliferation Treaties.

Application of safeguards: provides the Agency the right and obligation to apply safeguards under the safeguards agreement *"for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices".*

Co-operation between the Agency and the State: compels the government to cooperate fully with the IAEA in implementing safeguards. To implement this clause, the government must make binding arrangements for all public and private institutions to support the verification activities conducted by the IAEA.

National system of accounting for and control of nuclear material: requires the establishment and maintenance of a State's system of accounting for and control of all nuclear material (SSAC) subject to safeguards that would enable the Agency to verify that there has been no diversion of nuclear material from peaceful uses. The SSAC should include as necessary: a measurement system, a system for the evaluation of

declared.

14 https://www.iaea.org/Publications/Documents/Infcircs/Others/infcirc153.pdf

15 A list with the latest status and number of safeguards agreements with States can be found at: https://www.iaea.org/sites/default/files/16/07/sg_agreements_comprehensive_status_list.pdf

16 Source: Based on "Handbook on Nuclear Law", IAEA 2003, with permission. op. cit.

instrument precision and accuracy, procedures for reviewing measurement uncertainties, procedures for carrying out physical inventories, a system for the evaluation of accumulations of unmeasured inventories, records and reports systems for all material balance areas, and a system for reporting to the Agency. In the past, the term SSAC has been used by the international safeguards community to denote – frequently interchangeably – both the administrative entity through which the State discharges its responsibilities for implementing safeguards, and the entire system of regulations, procedures and measures established and implemented within the State to meet the requirements of the safeguards agreement. The SSAC is actually a system comprised of all the elements necessary for a State to control and report its nuclear material inventory including laws and regulations, nuclear material (NM) accounting systems at facilities and the resulting reporting system. The authority overseeing the implementation of IAEA safeguards in the State is the "State authority responsible for safeguards implementation" or SRA[17]. In practice, the SRA is also the contact point between the State and the Agency for operational issues such as the conduct of announced or unannounced inspections, complementary accesses etc. Due to the evolution of the IAEA safeguards system, the responsibilities of SRAs have been expanded beyond nuclear material accountancy and the reporting of imports and exports of nuclear material: the SRAs are also responsible for a wide variety of activities associated with the implementation of additional protocols[18] and in some cases also responsible for nuclear safety, radiation protection and export/import controls. Another important players in the implementation of safeguards are the implementation officers in charge of safeguards at a facility and the facility operators who ultimately are responsible for nuclear material accountancy and control at the facility level.

Provision of information to the Agency: requires the timely provision of all necessary information by all institutions and operators to the IAEA in order to ensure the effective implementation of safeguards.

Agency inspectors: requires co-operation with IAEA inspectors so that they may effectively perform their functions.

Privileges and immunities: confirms that the IAEA (including its property, funds and assets), its inspectors and officials will be afforded the privileges and immunities set out

17 SRA also stands for "State or Regional Authority" to take account of regional authorities such as EURATOM in the EU and ABACC in Argentina and Brazil.

18 For the actual responsibilities arising from the application of the Additional Protocol see point 3.2.

in IAEA document INFCIRC/9/Rev.2[19].

Transfer of nuclear material out of the State: requires notification to the IAEA of transfers. If the transfer exceeds specified quantities, the notification must be made in advance of the transfer.

Non-nuclear activities: records the need for previous agreement with the Agency to exempt nuclear material from safeguards, or to terminate safeguards on it, for non-nuclear uses.

Non-application of safeguards to NM to be used in non-peaceful activities: prescribes the procedures to be applied in the case that a State exercises its option to use safeguarded material for non-explosive, non-peaceful nuclear activities, including notification to the agency, provision of an assurance that the activity does not conflict with the State's peaceful use commitments, provision of an assurance that no nuclear explosive device(s) will be made and provision of information related the activity, provision of information on the quantity and composition of the material. This could be the clause that allows a State to use NM in a nuclear-propelled submarine, for example.

Finance: indicates that the Agency and the State shall bear the expenses that each one incurs in implementing safeguards, unless in the case of extraordinary expenses as agreed in advance.

Interpretation and application of the Agreement and settlement of disputes: requires consultations on questions of the interpretation or application of the safeguards agreement. The State has the right to request that the BoG considers any question regarding the interpretation of the agreement except conclusions of the Board on the diversion of safeguarded nuclear material by the State.

Amendment of the Agreement: requires consultations between the IAEA and the State, at the request of either of them, regarding proposed amendments to the safeguards agreement.

3.1.2 Part II of INFCIRC/153

Objective of Safeguards: the objective of safeguards is *"the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes*

[19] INFCIRC/9 Rev 2 can be found at: https://www.iaea.org/publications/documents/infcircs/agreement-privileges-and-immunities-agency

unknown, and deterrence of such diversion by the risk of early detection". The agreement provides that (nuclear) material accountancy is a safeguards measure of fundamental importance, with containment and surveillance as important complementary measures. The agreement stipulates that the technical conclusion of the Agency should be a statement in respect of each Material Balance Area (MBA)[20].

Starting point of safeguards; Stipulates that safeguards do not apply to material in mining or ore processing activities[21]. It requires the State to notify the Agency about exports or imports of uranium and thorium. This applies to NM that does not have a composition or purity suitable for fuel fabrication or for being isotopically enriched.

Glass with uranium oxide (Under terminated safeguards)

Credit: Z. Vesoulis - Own work.

Termination: allows the State to request the Agency to terminate safeguards on nuclear material upon determination that the material is practically irrecoverable. This could be the case of uranium used in the fabrication of "uranium glass"

Exemptions from safeguards: allows the State to request the IAEA to exempt nuclear material from safeguards for specified uses or within specific quantity limitations.

Subsidiary arrangements: provides that the State and the Agency negotiate and agree on Subsidiary Arrangements where the measures necessary for the IAEA and the State to fulfill its responsibilities are described in detail[22].

Design information: requires the State to provide information on the design of nuclear facilities to the IAEA as early as possible before nuclear material is introduced in a new facility[23].

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20 MBA is described in Section 4.3 of this Handbook

21 As it will be explained later in this Handbook, the additional protocol to CSA requires States to provide information about uranium mines and concentration plants and allows for complementary access to these places by IAEA inspectors.

22 A model Subsidiary Agreement can be found at: https://www.iaea.org/safeguards/documents/Online_Version_SG-FM-1170_--_Model_Subsidiary_Arrangement_Code_1-9.pdf

23 The State should provide the design information on new facilities and on changes in existing facilities as soon as the State authorities decide to construct, authorize

Information on Nuclear material outside facilities: requires the State to provide the IAEA with information (and details of any changes in the information) on nuclear material outside facilities[24], including its location, the user's name, and the procedures for accountancy and control.

Records system: requires the State to establish and maintain nuclear material accounting and operating records system in respect of each MBA[25]. The accounting records should include, among others, all inventory changes to permit the determination of the book inventory at any time and the measurement results that are used for the determination of the physical inventory.

Reports System[26]: requires the State through its State safeguards authority (SRA) to provide reports to the IAEA as foreseen in the safeguards agreement, including: inventory change reports; material balance reports (showing the material balance based on a physical inventory actually present in the MBA); and special reports, in the event of any unusual incident leading to a loss of safeguarded nuclear material.

IAEA Inspections[27]: stipulates the Agency's right to perform inspections and describes the purposes, scope, access, frequency, and notice of inspections. The designation of inspectors to specific States follows a consultation with the State; there are provisions for the prompt issuance of visas for inspectors and for facilitating the performance of inspectors' tasks and provides for the rendering of services needed by inspectors.

Statements on Agency's verification activities: The Agency is obliged to inform the State regarding the results of inspections and on the conclusions it has drawn from its verification activities.

Transfers out of and into the State: requires the State to provide notice to the IAEA of transfers out of the State and to confirm completed transfers into the State. There is also a requirement to notify the Agency before the nuclear material is prepared for shipping or the expected arrival of NM.

3.2 Protocol Additional to Safeguards Agreements

construction or modify a facility. The IAEA has the continuing right to verify the design information over the facility's lifecycle, including decommissioning.

[24] Any installation or location which is not a facility but that uses customarily nuclear material is defined as a LOF, "location outside facilities".

[25] MBA is defined in paragraph 110 of INFCIRC/153.

[26] The reports to be provided to the Agency are discussed in more detail in point 4.4

[27] Inspection activities are described in more detail under Section 5, IAEA Verification Activities.

Since the end of the Cold War, a series of events has changed the requirements of the safeguards system. This events are the discovery of a clandestine nuclear weapons programme in Iraq in 1991 (despite an existing comprehensive safeguards agreement between Iraq and the IAEA), the inability to verify the initial report of the Democratic People's Republic of Korea (DPRK)[28] upon entry into force of their safeguards agreement, and the decision of the Government of South Africa to give up its nuclear weapons programme and join the Treaty on the Non-Proliferation of Nuclear Weapons. These events have played a role in a determined effort by International Atomic Energy Agency Member States and the Secretariat to strengthen the safeguards system as all these events demonstrated that an effective verification regime must also focus on possible undeclared material and activities. A number of measures to strengthen the safeguards system started to be applied within the framework of existing comprehensive safeguards agreements. For others, the IAEA required additional legal authority. A major milestone in this effort was reached in May 1997 when the IAEA Board of Governors approved a Model Protocol Additional to Safeguards Agreements. The model additional protocol was negotiated by an open-ended committee ("Committee 24") of the Board involving some 70 Member States and two regional safeguards authorities.

INFCIRC/153 and INFCIRC/540.

Photo credit: IAEA imagebank

The Model Protocol Additional to the Safeguards Agreement (reproduced in INFCIRC/540(Corr.)) contains a number of provisions giving the Agency the legal authority to implement further strengthening measures. The additional protocol is integral to the strengthened system. Its principal objective is to equip the system with better tools to provide assurance about both declared and possible undeclared activities. Under the additional protocol, States are required to provide the Agency with an expanded declaration that contains information covering all aspects of their nuclear and nuclear fuel cycle activities. The States must also provide the Agency broader rights of access and enable it to use advanced technologies.

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[28] The DPRK became a party of the NPT on 12 December 1992 and has a Safeguards Agreement in force since 10 April 1992. After being declared by the BoG in "non-compliance", DPRK announced its withdrawal from NPT two times. The last time withdrawal was effected was on 11 January 2003.

Under CSAs alone, routine access is limited to specific "strategic points" in declared facilities. An additional protocol requires a State to provide access to any place on a nuclear site and to other locations where nuclear material is, or may be, present.

The State is required to provide access to all locations that are, or could be, engaged in activities related to the nuclear fuel cycle and, in cases where such access may not be possible, to make every reasonable effort to satisfy Agency requirements without delay through other means. The additional protocol also provides for certain improved administrative procedures including streamlined procedures for designating inspectors and providing them with long-term visas and improved means by which inspectors may communicate with Agency Headquarters.

The strengthened system is based on a political commitment to support the verification system - one where qualitative assessment takes place alongside quantitative accounting measures. States have recognized and committed themselves to a common, objective; bound themselves to certain material obligations; and granted an impartial inspectorate the necessary authority to verify compliance with the States' commitments"[29].

As of the December 2015, there were 174 states with CSA in force of which 127 States have both a comprehensive safeguards agreement and an additional protocol in force. This means that as of December 2015 there were still 47 States with comprehensive safeguards agreements in force, but without additional protocols in force[30].

3.2.1 Provisions of the Model Additional Protocol

The text of the Model Additional Protocol (AP)[31] consists of a preamble, eighteen articles, and two annexes. The language of the Preamble reflects the backbone of the negotiations: the need for a balance to be struck between, on the one hand, the desire to strengthen the effectiveness and improve the efficiency of the Agency's safeguards system and, on the other hand, the obligation to keep the frequency and intensity of activities to a minimum consistent with this objective.

The relationship between the Model Additional Protocol and the Safeguards Agreement

[29] From "Non-proliferation of Nuclear Weapons and Nuclear Security, IAEA Safeguards Agreements and Additional Protocols", a free publication of the IAEA, May 2005

[30] The BoG of the IAEA has stated that that it is the sovereign decision of any State to conclude an additional protocol, however, the BoG has also encouraged all States which have not yet done so to conclude and to bring into force additional protocols as soon as possible

[31] The complete text of the additional protocol can be found at: http://www.iaea.org/Publications/Documents/Infcircs/1997/infcirc540c.pdf

is specified in Article 1: the safeguards agreement and the additional protocol are to be read as a single document with, in cases of conflict, the provisions of the additional protocol prevailing.

Articles 2 and 3 of the Model Additional Protocol relate to the *"Provision of Information"*[32].

Article 2 is divided into three parts, a, b and c:

a. Information required to be provided to the Agency by the State. These elements include information about the following:

(i) Nuclear fuel cycle-related research and development activities not involving nuclear material carried out anywhere that are funded, specifically authorized or controlled by, or carried out on behalf of, the State. The significance of this language is that it requires the State to declare such activities regardless of whether they are carried out within the State or on the territory of another State;

(ii) Operational activities of safeguards relevance at facilities and locations outside facilities where nuclear material is customarily used (LOFs);

(iii) Description of each building on each site of every facility and LOF in the State;

(iv) Description of the scale of activities listed in Annex I of the Model Additional Protocol. These include activities which, while not necessarily involving the use of nuclear material, are crucial to nuclear-fuel cycle programs;

(v) Location, status and status of uranium mines and concentration plants and thorium concentration plants;

(vi) Inventories, exports and imports of nuclear material that is not currently required to be declared to the IAEA under INFCIRC/153 alone (pre-34(c) material);

(vii) Information on nuclear material that has been exempted from safeguards (for example, nuclear material exempted for use in a non-nuclear activity);

(viii) Information on intermediate or high-level waste containing plutonium, high enriched uranium or ^{233}U on which safeguards have been terminated;

(ix) Information on specified equipment and non-nuclear material listed in Annex II of the Additional Protocol;

(x) General plans for the succeeding ten-year period relevant to the development of the nuclear fuel cycle;

b. Information that the State is required to make every reasonable effort to provide to the Agency:

[32] Details on the information to be provided pursuant to Articles 2 and 3 can be found in Section 4.7 later in this Handbook.

(i) Description of nuclear fuel cycle-related research and development activities not involving nuclear material which are specifically related to enrichment, reprocessing of nuclear fuel or the processing of intermediate or high-level waste containing plutonium, high enriched uranium or ^{233}U that are carried out anywhere in the State, but which are not funded, specifically authorized or controlled by, or carried out on behalf of, the State;

(ii) Description of activities and the identity of the person or entity carrying out such activities, at locations identified by the Agency outside a site which the Agency considers might be functionally related to the activities of the site; and

c. Amplifications or clarifications of information provided under Article 2 of the Model Additional Protocol, which States are required to provide upon request by the Agency.

The IAEA Board of Governors approved in 1997 a Model Additional Protocol to be concluded with States having a CSA with the Agency.
Photo Credit: IAEA Imagebank

Article 3 sets out the time limits for the provision of the information required under Article 2, including a requirement for an initial declaration of the information called for under Articles 2.a.(i), (iii)-(v), (vi)(a) and (x) and Article 2.b.(i), and annual updates of such information; annual declarations on exports and imports of pre-safeguards nuclear material; quarterly reports on exports of the specified equipment and non-nuclear material identified in Annex II of the Model Additional Protocol; declarations of changes in locations of intermediate and high-level waste and advance reporting of plans to further process such waste.

Articles 4 through 10 contain the provisions concerning *"Complementary Access"*, the other cornerstone of the strengthening safeguards measures. Article 4 describes the why and when of complementary access: access may be requested to assure the absence of undeclared nuclear material and activities and to resolve questions relating to the correctness and completeness of the information provided pursuant to Article 2 or to resolve an inconsistency relating to that information. Complementary access may also be requested to the extent necessary for the IAEA to confirm the decommissioned status of a facility or LOF. Advance notice of at least 24 hours is required for complementary access, except for access to any place on a site that is sought in connection with design information verification visits or ad hoc or routine inspections on that site, which may be two hours or, in exceptional circumstances, less than two hours. Article 4 also provides for the State to have an opportunity to clarify and facilitate the resolution of a question or inconsistency before a request for access is granted, unless the Agency considers that delay in access would prejudice the purpose for which the access is sought.

Article 5 obliges a State to provide access to the Agency to any place on a site of a nuclear facility or a LOF, to any location where the State has declared nuclear material to be present (Article 2.a.(v)-(viii)), and to any decommissioned facility or LOF. With regard to other locations identified by the State under Article 2.a or 2.b, if the State is unable to provide access to the Agency, the State is required to “make every reasonable effort to satisfy Agency requirements, without delay, through other means”. Article 5 also authorizes the Agency to carry out location-specific environmental sampling at any other location in the State specified by the Agency, provided that if the State is unable to provide such access, the State must make “every reasonable effort to satisfy Agency requirements, without delay, at adjacent locations or through other means”.

Article 6 identifies the activities that the Agency is authorized to carry out at the various categories of locations as set forth in Article 5. They include visual observation; collection of environmental samples; utilization of radiation detection and measurement devices; examination of records, including production and shipping records; the use of seals and other identifying and tamper indicating devices; and, in consultation with the State, other objective measures which are demonstrated to be technically feasible and the use of which has been agreed by the Board of Governors.

Article 7 provides for managed access under the Model Additional Protocol in order to prevent the dissemination of proliferation sensitive information, to meet safety or physical protection requirements, or to protect proprietary or commercially sensitive information, a concept borrowed from the Convention on the Prohibition of Chemical Weapons[33]. However, as also provided for in Article 7, such arrangements are not to preclude the Agency from conducting activities necessary for the exercise of its rights and obligations.

Article 8 contemplates the possibility of a State offering the Agency access to other locations in the State. It also provides that if a State requests the Agency to conduct verification activities at any other location in the State, the Agency shall, without delay, make every reasonable effort to act upon that request.

Article 9 provides for the use by the Agency of wide-area environmental sampling within

[33] Managed Access is an inspection procedure used also by Chemical Weapons inspectors when an inspected party wishes to protect sensitive installations and prevent disclosure of confidential or proprietary information.

the State at such time as the Board of Governors has approved the use of such sampling and the procedural arrangements for its use. As with other new technologies, the implementation of wide-area environmental sampling would require consultations between the Agency and the State. Wide-area environmental sampling has not been yet considered by the BoG.

Article 10 of the Model Additional Protocol requires the Agency to provide the State with statements on the results and conclusions of complementary access, and sets out the time frames within which the Agency is required to do so.

Articles 11 and 12 establish simplified procedures for the designation of Agency inspectors to the State and provision of visas, and require the State, within one month of the receipt of a request therefore, to provide a designated inspector with appropriate multiple entry/exit and/or transit visas, where required. If the State requires a visa, the visa must be valid for at least one year and must be renewed, as required, to cover the duration of the inspector's designation to the State.

Article 13 provides for the conclusion of *"Subsidiary Arrangements"*, but does not suspend the implementation of the Protocol pending their conclusion.

Article 14 reflects the need to modernize communications and data transmission systems, acknowledging the Agency's right to protected free communication, including attended and unattended transmission of information. It establishes the right of the Agency to make use of internationally established systems of direct communications, including satellite systems and other forms of telecommunications that are not available for use in the State.

The obligation of the IAEA for the "*protection of confidential information"* is underscored in Article 15, which requires Board approval and periodic review of a regime to ensure the effective protection of disclosure of commercial, technological and industrial secrets and other confidential information coming to the Agency's knowledge in the implementation of the Protocol.

Article 16 sets out the procedures for amendment of the technical "*annexes"* to the Model Additional Protocol. Any such amendment will take effect four months after adoption by the Board of Governors acting upon the advice of an open-ended working group of experts. Such amendments would thus require no formal revision of the Protocol to become effective.

Article 17 permits the State to elect "*entry into force"* of its additional protocol upon signature or upon written notification that its statutory and/or constitutional requirements for entry into force have been met. In accordance with the Vienna

Convention on the Law of Treaties, the Model Protocol also contemplates the provisional application of an additional protocol by a State after its signature pending its entry into force.

Article 18 contains the *"definitions"* of terms used in the Model Protocol. Annex 1 contains the list of activities referred to in Article 2.a(iv) of the Protocol and Annex 2 includes the list of specified equipment and non-nuclear material for the reporting of exports and imports according to Article 2.a(ix).

3.3 Small Quantities Protocol (SQP)

There is another protocol, which is also supplementary to CSAs, the Small Quantities Protocol also known as SQP. The purpose of a SQP is to minimize the burden of safeguards activities on States with little or no nuclear activities, while ensuring that the IAEA's safeguards conclusions for SQP States are soundly based. Under an SQP based on the original text of 1974 (GOV/INF/276/Annex B), the implementation of most of the procedures in Part II of a CSA is held in abeyance for as long as specified criteria are met. Procedures that are not held in abeyance include, for example, those relating to the reporting of exports and imports of nuclear material and any material containing uranium or thorium that has not reached the composition and purity suitable for fuel fabrication or for being isotopically enriched. The original SQP text contains a number of weaknesses, such as the inability of the IAEA to perform verification activities in order to confirm that the State meets the eligibility criteria, and the fact that the State is not required to provide the IAEA with an initial report on all nuclear material subject to safeguards.

In 2005, the Board of Governors recognized that the SQP in its original form constituted a weakness in the IAEA safeguards system and that there should be modifications to the eligibility criteria and in the substantive requirements of such protocols. Accordingly, the Board decided to make an SQP unavailable to a State with an existing or planned facility, and reduced the procedures in Part II of a CSA that are held in abeyance. Under an SQP based on the modified standardized text approved by the Board of Governors in 2005, the States are required to submit to the IAEA an initial report on all nuclear material subject to safeguards, submit reports of imports and exports of nuclear material, permit inspection activities and inform the IAEA once a decision has been made to build a nuclear facility. The modified SQP (ModSQP) is published in

GOV/INF/276/Mod.1 and Corr.1[34].

In addition to other criteria, to remain eligible to have an SQP (whether based on the original or modified text), a State's nuclear material inventory may not exceed the quantities specified in paragraph 37 of INFCIRC/153 (Corr.). As a State prepares its initial report on nuclear material, the State can determine its inventory of each of the four specified categories of nuclear material (bulleted below).

Nuclear material in the State may not exceed:

- 1 kilogram in total of special fissionable material, which may consist of one or more of the following:

(i) Plutonium;

(ii) Uranium with an enrichment of 0.2 (20%) and above, taken account of by multiplying its weight by its enrichment; and

(iii) Uranium with an enrichment below 0.2 (20%) and above that of natural uranium, taken account of by multiplying its weight by five times the square of its enrichment;

- 10 metric tons in total of natural uranium and depleted uranium with an enrichment above 0.005 (0.5%);
- 20 metric tons of depleted uranium with an enrichment of 0.005 (0.5%) or below; and
- 20 metric tons of thorium;

By July 2015, 45 States had operative small quantities protocols that had yet to be amended. Fifty-seven States had small quantities protocols based on the revised standard model.

4. Areas of cooperation of the State with the IAEA

The cooperation between the State and the Agency is mandated in Article 3 of the CSA where it is stipulated "the Agency and the State *shall* co-operate to facilitate the implementation of the safeguards provided for therein". From this and other articles of the safeguards agreement one can see that there are three areas of cooperation with the IAEA:

a. Establishment of laws, regulations and a system of accounting and control of nuclear material at the State and facility level that ensures that the provisions of the CSA and any applicable protocol are fully adhered to. To be

[34] See Annex B, "Safeguards Implementation Guide for States with SQP at http://www-pub.iaea.org/books/IAEABooks/10493/Safeguards-Implementation-Guide-for-States-with-Small-Quantities-Protocols

able to cooperate fully, States need to establish the necessary safeguards legal infrastructure that will regulate the possession, handling, use, import and export of nuclear material. Due to the significant scope of information and access in States with additional protocols in force, the State's oversight and control functions should include other activities in the State such as nuclear fuel cycle-related research not involving nuclear material or industrial activities involved in the production or commercialization of equipment listed in Annex II of the additional protocol.

b. Provision of accurate and complete reports and declarations to the IAEA according to the agreed timing. Infrastructure must be established to generate the required reports in respect of each MBA or site. Quality control/assurance measures should be implemented to assure that such reports are prepared in a correct and complete manner, provided in the required formats and at the required time. There are reports that result from the application of the CSA and its subsidiary arrangement and reports resulting from the application of the additional protocol[35].

c. Arrangements for the timely access of IAEA inspectors to nuclear facilities and sites. Ensuring access to inspectors is an essential element of the State's infrastructure. Inspectors' access may be carried out with advance notification to the State regarding the location and timing for the verification activity, and some routine inspections may be unannounced. To effectively support IAEA activities, SRAs, safeguards implementation officers and facility operators must be notified, make records and reports available, and facilitate the activities of inspectors during their access. In cases where routine inspections are unannounced, the IAEA and the SRA discuss in advance the arrangements for their implementation. Based on those arrangements, the SRA, the safeguards implementation officer and/or the facility operator must be prepared to accommodate an inspection without advance notice, while still facilitating the tasks of inspectors so that the objectives of the inspection can be met. States have the right to accompany IAEA inspectors during inspections, but in doing so, they must not impose delays or impede IAEA activities. Under an AP, the IAEA may request complementary access to locations in the State[36].

[35] See point 4.1 for more details on such reports.
[36] Credit: "International Atomic Energy Agency, Guidance for States Implementing

4.1 PROVISION OF INFORMATION TO THE IAEA

"The IAEA evaluates a State's entire nuclear programme and fuel cycle – from mining and milling to final disposition. Some information is provided under CSAs, and other information is provided under APs. The timely provision of correct, complete and up-to-date information facilitates the verification process, and enables realization of effective and efficient safeguards which are based on the evaluation of all available information about the State. Highly effective nuclear material accountancy systems which produce up-to-date information regarding nuclear material flows and inventories facilitate the use of measures such as unattended remote monitoring systems and unannounced inspections. Transparency in nuclear activities in a State increases the IAEA's understanding of the nuclear programme, facilitates analysis of its coherence and consistency, and ultimately increases confidence in the conclusions drawn by the IAEA for that State. Taken together, all information provided by the State, and information collected by the IAEA, is evaluated, analyzed and used to design a State-specific safeguards approach.

The State's system should provide all information needed to meet the IAEA reporting requirements. The SRA should ensure the quality of facility/LOF operator information before submitting it to the IAEA. In other words, the SRA must receive information from the facilities and LOFs, evaluate its correctness and completeness, and assure it is in the agreed IAEA reporting format, before submitting it on time to the IAEA. In cases where the SSAC has established an inspectorate, the conclusions of its inspections may be included in the State's reported findings.

Reports must be based on a system of records, with which nuclear-related activities and nuclear material transactions and inventories are tracked and reported. Records include both accounting records, which keep track of nuclear material, and operating records, which document the operational status and parameters at the facility/LOF that are important for determining the quantity and composition of the nuclear material inventory. Records must be kept for each MBA"[37].

4.2 DESIGN INFORMATION QUESTIONNAIRE (DIQ)

Comprehensive Safeguards Agreements and Additional Protocols", IAEA Services Series 21, IAEA, Vienna (2012), reproduced with permission, op. cit.

[37] Credit: "International Atomic Energy Agency, Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols", IAEA Services Series 21, IAEA, Vienna (2014), reproduced with permission, op. cit.

States must submit information to the IAEA about locations in the State, which are relevant to the State's nuclear programme.

Upon entry into force of its CSA, a State submits design information on existing facilities during the discussions of the Subsidiary Arrangements, typically within 90 days of entry into force of the CSA. Facility design information is submitted in the form of a design information questionnaire (DIQ). The IAEA examines and verifies the design information to support a number of safeguards activities. The IAEA verifies that facilities are operating in accordance with their stated designs. The IAEA also evaluates the facility, including its function, layout and processes, in order to design an effective safeguards approach to achieve the safeguards objectives. The IAEA determines the specific safeguards measures, and installs and tests safeguards equipment, as required.

For planned facilities, the early provision of design information provides adequate lead-time for the IAEA and the SRA to cooperate in preparing for safeguards implementation. All States — those with CSAs, original SQPs and modified SQPs — must notify the IAEA as early as possible regarding plans for a new facility. When a State anticipates building a facility, the preliminary information about the planned facility may be provided to the IAEA in a DIQ or as free text in a letter. The early notification may include only very basic information, such as "two light water reactors, approximately 700 MW each." As decisions are made about the specific design, additional information should be provided to the IAEA, including the physical location, preliminary design drawings, plant process layouts, etc. The dialog between the IAEA and the State should begin very early in the process of planning to build a nuclear facility. This cooperation allows for features to be incorporated into the facility design that support safeguards implementation, which in turn may save resources over the lifetime of the facility operation.

The early provision of preliminary design information, required to all States with CSAs, was proposed by the IAEA Secretariat in in a document of 1992 "Strengthening of Agency Safeguards – the Provision and Use of Design Information" and endorsed by the Board of Governors in its Chairman's summary of February of 1992.

Code 3.1 of the model Subsidiary Arrangements (General Part) was subsequently modified to incorporate the Board's decision, requiring the early provision of design information for new facilities beginning in the project definition stage, with additional information provided on an iterative basis as the project progresses. States must notify the IAEA as soon as the decision to construct or to authorize construction, whichever is earlier, has been taken. The completed DIQ for a new facility must be submitted to the

IAEA, based on preliminary construction plans, as early as possible, but not later than 180 days prior to the start of construction.

The IAEA's right to examine and verify design information extends throughout the lifecycle of the facility — from before construction through to final decommissioning. In the early stages of the project, the IAEA works with the SRA to identify and schedule actions that need to be taken jointly by the State, the facility operator and the IAEA, such as discussing the IAEA's safeguards approach, installing safeguards equipment and conducting design information examination and verification visits during construction. The IAEA also must perform the necessary budgetary and programme planning. Collaborative planning among the IAEA, the SRA and the operator can lead to significant improvement of the effectiveness and efficiency of safeguards, as well as reductions in the impact on facility operations, especially when new nuclear technologies and new facility types are involved.

DIQ templates for various facility types are available[38] for use by SSACs in submitting preliminary design information. A link to a LOF information template is provided in the References. A DIQ should be updated as soon as more detailed information is available regarding the facility. Subsidiary Arrangements provide additional information regarding the type of information to provide at each stage in the design and development process. As a DIQ is refined, the IAEA and the State will begin to negotiate the Facility Attachment (FA), which is based on the DIQ. The FA sets out specific details regarding safeguards implementation at the facility"[39]. Below, the first page of the template for preparing the DIQ for a research (or a power reactor) is reproduced.

[38] http://www.iaea.org/sites/default/files/diq_model_generic_rr.pdf

[39] Credit: "International Atomic Energy Agency, Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols", IAEA Services Series 21, IAEA, Vienna (2012), reproduced with permission, op. cit.

IAEA International Atomic Energy Agency Department of Safeguards	This online document is valid for use for 2 years from the version date.	Version Date:	03-07-2013
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THIS FORM IS TREATED AS HIGHLY CONFIDENTIAL WHEN COMPLETED AND SUBMITTED BY THE STATE TO THE IAEA AND ALL PAGES ARE SO MARKED

Example Design Information Questionnaire Template[1]

RESEARCH AND POWER REACTORS

DATE: ____________

GENERAL REACTOR DATA		
13.	FACILITY DESCRIPTION	GENERAL FLOW DIAGRAMS ATTACHED UNDER REF. Nos.
14.	RATED THERMAL OUTPUT, ELECTRICITY OUTPUT (for power reactors)	
15.	NUMBER OF UNITS (REACTORS) AND THEIR LAYOUT IN THE NUCLEAR POWER PLANT	
16.	REACTOR TYPE	
17.	TYPE OF REFUELLING (on or off load)	
18.	CORE ENRICHMENT RANGE AND Pu CONCENTRATION (at equilibrium for on-load reactors, initial and final for off-load reactors)	
19.	MODERATOR	
20.	COOLANT	
21.	BLANKET, REFLECTOR	

NUCLEAR MATERIAL DESCRIPTION		
22.	TYPES OF FRESH FUEL	
23.	FRESH FUEL ENRICHMENT (U-235) AND/OR Pu CONTENT (average enrichment per each type of assembly)	
24.	NOMINAL WEIGHT OF FUEL IN ELEMENTS/ASSEMBLIES (with design tolerances)	
25.	PHYSICAL AND CHEMICAL FORM OF FRESH FUEL (general description)	
26.	REACTOR ASSEMBLIES* (indicate for each type) • types of assemblies; • number of fuel assemblies, control and shim assemblies, experimental assemblies in the core, in blanket	DRAWINGS ATTACHED UNDER REF. Nos.

[1] An Official DIQ Template may be requested from the relevant IAEA Country Officer, or by sending a request to official.mail@iaea.org.

4.3 MATERIAL BALANCE AREAS (MBA) AND KEY MEASUREMENT POINTS (KMP)

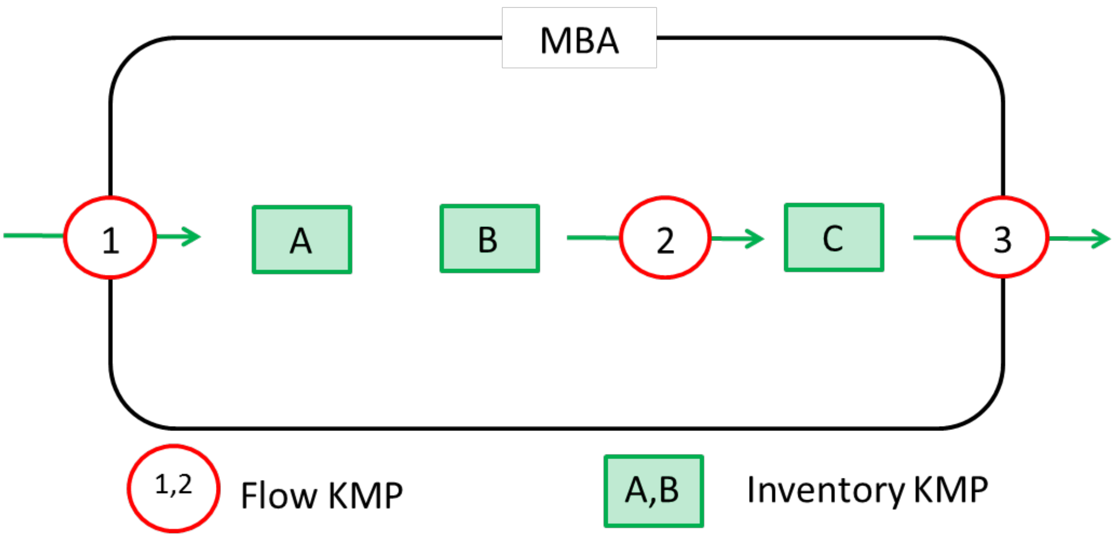
The Agency's verification activities under a CSA take place at defined areas that are part of a nuclear facility, called Material Balance Areas (MBA) and at locations where nuclear materials can be measured, called Key Measurement Points (KMP).

Material Balance Area (MBA) is defined in paragraph 110 of INFCIRC/153 as “an area in or outside of a facility such that the quantity of nuclear material in each transfer into or out of each ‘material balance area’ can be determined; and the physical inventory of nuclear material in each ‘material balance area’ can be determined when necessary, in accordance with specified procedures, in order that the material balance for Agency safeguards purposes can be established”.

Paragraph 46(b) of INFCIRC/153 stipulates that design information made available to the IAEA shall be used: “To determine material balance areas to be used for Agency accounting purposes and to select those strategic points which are key measurement points and which will be used to determine the nuclear material flows and inventories; in determining such material balance areas the Agency shall, inter alia, use the following criteria:

- The size of the material balance area should be related to the accuracy with which the material balance can be established;

Power Reactor MBA and KMP structure example



Flow Key Measurement Point		Inventory Key Measurement Point	
Code	Description	Code	Description
1	Receipt	A	Fresh Fuel Storage
2	Nuclear Product, Nuclear Loss	B	Reactor Core
3	Shipment	C	Spent Fuel Storage

- In determining the material balance area advantage should be taken of any opportunity to use containment and surveillance to help ensure the completeness of flow measurements and thereby simplify the application of safeguards and concentrate measurement efforts at key measurement points;
- A number of material balance areas in use at a facility or at distinct sites may be combined into one material balance area to be used for Agency accounting purposes when the Agency determines that this is consistent with its verification requirements; and
- If the State so requests, a special material balance area around a process step involving commercially sensitive information may be established".

Key measurement point is defined in paragraph 108 of INFCIRC/153 as "a location where nuclear material appears in such a form that it may be measured to determine material *flow* or *inventory*. "Key measurement points" thus include, but are not limited to, the inputs and outputs (including measured discards) and storages in material balance areas".

4.4 Accounting and Operating Records; Supporting Documents

The State Authority responsible for safeguards implementation should specify the requirements (for material both in item form and in bulk form) for accounting and operating records and accounting reports for each MBA within the State. The records and reports system should provide relevant data on nuclear material transactions and operations affecting nuclear material accounting: The system should be complete, so that the data give the SRA a clear picture of the nuclear material inventory; it should use a system of unique batch names/identification to be able to account for each batch and it should be presented in such a manner as to allow the SRA to easily construct its own reports for onward transmission.

The above described requirement results from comprehensive safeguards agreements that oblige states to establish a measurement system for the determination of the quantities of nuclear material received, produced, shipped, lost or otherwise removed from the inventory and for determining the quantities of the inventory. Inventory quantities could be established based on sampling for destructive analysis or non-destructive assay (NDA), weighing, volume determination or other methods, as appropriate. The above activities require (as applicable):

- Approved measurement equipment for establishing weights (calibration, standards);
- A sampling system;
- Analytical laboratories and analysts able to perform the analyses and evaluate the results;
- Operators who introduce the analysis results into the operating system.

The quantities of nuclear material determined with the help of the measurement system above should be recorded in a system of records and reports showing, for each material balance area, the inventory of nuclear material and the changes in that inventory including receipts into and transfers out of the material balance area. To put the relationship of records and reports into perspective: a report is always based on a record which originated in the nuclear material operating activities of the facility, and a report, in turn, leads to verification and evaluation by the State authority and/or the IAEA.

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

- *Ledgers* summarizing inventory changes and providing the book inventory for a specified period; typically, there is a General Ledger for the MBA and a number of Subsidiary Ledgers for each KMP and each Nuclear Material.

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

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

In the example shown here, the Inventory Change Document (ICD) includes the weights of uranium total and uranium fissile as well as the amount of plutonium present in each fuel assembly shipped outside of the facility to a foreign country.

APPENDIX V
ICD EXAMPLE

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

Example of an ICD. Credit: IAEA International Atomic Energy Agency, Nuclear Material Accounting Handbook, IAEA Services Series 15, IAEA, Vienna, 2008, reproduced with permission

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

- *Itemized list of inventory items (LII),* which is provided on the day following the last day of the Physical Inventory Taking (PIT) so that the IAEA inspectors could start verifying the State's declaration regarding the outcome of the PIT.

Supporting documents include those primary documents used for capturing data at the operating points where the data originate, i.e. containing source, identity and batch data for each accounting transaction. These are data recorded as a result of measurement activities or during calibration, or derived from empirical relationships. They may include mass measurements, conversion factors to determine the mass of an element, element concentration, isotopic ratios, or nuclear material handling protocols reflecting all activities relevant to nuclear material accounting or control. Shipping documents, weight or volume records, laboratory records, charge/discharge records and power production records are examples of supporting documents.

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

- The inventory change identity, which refers to an identity code allocated to nuclear material received for use in a facility, creating a means to distinguish it from the next inventory change and allows for the audit trail in the facility. A series of alphanumeric characters could normally be used.
- The date of change, which refers to the actual date the inventory change occurred.
- The type of change, indicated by the inventory change code, e.g. RF (foreign receipt), SF (foreign shipment), RD (domestic receipt), SD (domestic shipment). The codes are to be found in Code 10 of the General Part of the Subsidiary Arrangements, and should become common terminology in a facility.
- The material description code provides data on the physical form, the chemical form, and the containment and irradiation status. Four characters describe completely the material that is to be reported to the IAEA and thus it is advantageous if it is available in the source documentation, and is the same as used in Code 10.
- Information on material movement between MBAs and other nuclear material accounting areas, an important element because it provides data on the shipping and receiving MBAs which should be reported to the IAEA so as to allocate the nuclear material to the relevant MBA.
- Batch identity, identifying any batch by a unique batch name. Each MBA should establish its own set of internal batch names that can be used when an inventory

change occurs.

- The number of items in a batch, which are reported to the IAEA and should therefore, be recorded.
- Batch data, referring to the total weight of each element of nuclear material accompanied by isotopic composition, where applicable.
- The batch data basis, which provides data forming the basis from which the batch data entries were derived. This will help the facility operator to know where the relevant data originates, namely from a measurement in an MBA of the facility or whether it is shipper's data determined by another operator.
- Source of weight, and whether the weight was re-determined since last reported.

Operating records consist of the results of the facility systems and procedures with regard to nuclear material accounting. These systems and procedures refer to the measurement system, measurement control programme and PIT, and include:

- Operating data used to establish changes in the quantities, locations and composition of nuclear material. This refers to data recorded at the location where the measurement or determination was made. For example, at a reactor facility these are the records that provide the necessary data to calculate nuclear loss and nuclear production. It is supported by fuel element histories, experiment logs, nuclear power logs, flux maps and fuel position maps.
- Data obtained from calibration of tanks and instruments and from sampling analysis, the procedures employed to control the quality of measurements and the derived estimates of random and systematic error. This is also necessary for evaluation of results of determinations such as shipper/receiver differences and evaluation of material unaccounted for (MUF). IAEA inspectors in their verification and evaluation of facility nuclear material accounting also need it.
- A description of the sequence of the actions undertaken in preparing for and taking a physical inventory to ensure it is accurate and complete. The PIT includes the use of written physical inventory procedures and the documentation of physical inventory results, namely the itemized physical inventory listing. The listing provide source data for the physical inventory summary and reconciliation, which can be considered the supporting document for entering a MUF adjustment, if any, into the records.
- A description of the action taken to ascertain the magnitude and cause of any accidental or unexpected loss or gain. Such records refer to actions that would be non-routine, only occurring when an accidental loss, unexpected loss or an

accidental gain occurs. Action taken will depend on the seriousness of the event and also on nuclear material accounting. The primary concern would be to determine the quantity of nuclear material. Documenting the actions undertaken and procedures followed in determining the loss will permit the eventual evaluation of the incident in terms of the quantity statement and cause of the loss. In practice only a few cases were reported as NM accidental loss and the amounts involved were usually small.

The operating records of a reactor show, for example, the integrated thermal power produced by the reactor for a given period and the associated data of the reactor operation for that period as needed to determine the nuclear production and nuclear loss, and the location of each fuel element at any time.

4.5 Reports to the IAEA: ICR, PIL, MBR, Concise Notes

The accountancy records form the basis for the preparation of reports to the IAEA, as specified in the Safeguards Agreement [40] and its subsidiary arrangement. The safeguards agreement requires basically three types of reports to be submitted to the IAEA for each Material Balance Area in the State:

Inventory change report (ICR) is an accounting report "showing changes in the inventory of nuclear material. The reports shall be dispatched as soon as possible and in any event within 30 days after the end of the month in which the inventory changes occurred or were established". Using the set of codes specified in Code 10 [41] of the General Part of the subsidiary arrangements, each inventory change in an MBA (including uranium category changes) must be reported to the IAEA.

Material balance report (MBR) and physical inventory listing (PIL). At the end of the material balance period (MBP), the State submits an MBR for each Material Balance Area summarizing the status over the MBP for each material category. The MBR includes the beginning physical inventory, the inventory changes that took place during the MBP, the ending book inventory, shipper receiver difference (SRD), if applicable, the book inventory adjusted by the SRD, the ending physical inventory; and the material unaccounted for, if any. The PIL submitted with the MBR provides a basis for calculating the ending physical inventory figure on the MBR. The MBR ending

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40 See articles 59 to 69 of INFCIRC/153

41 A model code 10 (fixed format) can be found at: https://www.iaea.org/safeguards/documents/SG-FM-1171_--_Model_Subsidiary_Arrangement_Code_10_Fixed.pdf

physical inventory (PE) provides the beginning physical inventory (PB) for the subsequent MBP.

Concise notes. Each MBA, report or entry in a report may be referred to by concise notes to explain or elaborate on the information provided in the report. A concise note is frequently used to provide the recipient's name for a shipment, the effective burn up for a report of nuclear production/loss, explanation of accidental gain/loss, exemption, re-application and termination, or the reason for a correction.

4.6 Import/Export notifications and Special Reports

The IAEA keeps track of nuclear material movements between States, which are referred to in INFCIRC/153 as 'international transfers,' and include both imports and exports. The IAEA checks that exports to a particular location in a State where the material will be subject to safeguards is actually received at that location and reported as part of the next inventory change report for the receiving MBA. States must notify the IAEA regarding planned transfers of nuclear material outside of the State.

A PWR fuel assembly ready to be shipped to a reactor.

Photo Credit: D. Calma, IAEA/Westinghouse Electric Sweden AB Fuel Fabrication Plant

The CSA has provisions regarding amount and timeliness for providing advance notifications of international transfers. The CSA stipulates that "any intended transfer out of the State of safeguarded nuclear material in an amount exceeding one effective kilogram, or by successive shipments to the same State within a period of three months each of less than one effective kilogram but exceeding in total one effective kilogram, shall be notified to the Agency after the conclusion of the contractual arrangements leading to the transfer and normally at least two weeks before the nuclear material is to be prepared for shipping".

If nuclear material is exported to a State where it will not be under safeguards (i.e. to a Nuclear Weapon State), the exporting State must make arrangements for the receiving

State to notify the IAEA of its receipt within three months. A State that imports the material has the responsibility to notify the IAEA regarding the anticipated location and date of receipt and the schedule for unpacking of the material, among other things. The transfer of responsibility for the nuclear material from the exporting State to the receiving State is referred to in paragraph 91 of INFCIRC/153. States through which nuclear material transits en route to its final destination do not have reporting responsibilities regarding the transfer.

If either the exporting or the importing State believes that there may have been a loss of nuclear material during transfer, or a significant delay, the State must notify the IAEA.

States must report unusual occurrences of relevance to safeguards, with particular focus on the possible loss of, or loss of control over, nuclear material, through 'special reports,' within 72 hours of the event. Also, the IAEA may ask the State to further explain information in other reports or declarations, by requesting 'amplifications' (requesting additional information) or 'clarifications' (requesting the resolution of questions regarding the information provided)[42].

4.7 Additional Protocol: initial declarations and updates[43]

The information required under a safeguards agreement with an additional protocol is intended to provide the Agency with a complete and clear understanding of the nuclear activities in a State and will serve three important purposes:

- Because of its scope and comprehensiveness, this information will lead to increased transparency, thus allowing the Agency to confirm with a high degree of confidence that no undeclared nuclear activities are concealed within the State's declared programme and that no elements of that programme are used for undeclared nuclear activities;
- By committing itself to an expanded declaration about its nuclear and nuclear-related activities, the State will provide considerably improved information on all aspects of its nuclear activities which can be compared with information obtained from other sources (e.g., on procurement activities or from environmental sampling) for consistency and follow-up. The more accurate and

[42] Credit: "IAEA, Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols", IAEA Services Series 21, IAEA, Vienna (2014), reproduced with permission.

[43] Credit: IAEA, Guidelines and Format for Preparation and Submission of Declarations Pursuant to Articles 2 and 3 of the Model Protocol Additional to Safeguards Agreements, IAEA Services Series 11, IAEA, Vienna, 2004, reproduced with permission.

comprehensive the information, the less frequently questions and inconsistencies should arise; and

- The requested information will provide a basis for the efficient planning and implementation of Agency activities relevant not only to the safeguarding of declared nuclear material, but also to the providing of assurance of the absence of undeclared nuclear material and nuclear activities in the State.

As discussed under point 3.2.1 earlier in this handbook, "Provisions of the Additional Protocol"[44], the information required under this legal instrument results from Article 2, clauses 2.a and 2.b. Information required under clause 2.a is mandatory while the information required under 2.b requires States to "make every reasonable effort to provide the Agency with information" as described. The timing with which the information is to be provided is specified in Article 3.

A separate declaration is required for each article and, in the case of Article 2.a.(iii), for each site and for any update of a previously provided declaration. Each declaration should show the name of the State (or Party) and the number of the declaration, with the first declaration number being "1" and continuing sequentially for each subsequent declaration.

An explanation of each clause of Article 2 of the AP is included below:

Article 2.a.(i)

"The State shall provide the Agency with a declaration containing:

(i) A general description of and information specifying the location of nuclear fuel cycle-related research and development activities not involving nuclear material carried out anywhere that are funded, specifically authorized or controlled by, or carried out on behalf of the State".

Article 18.a defines that:

"Nuclear fuel cycle-related research and development activities means those activities which are specifically related to any process or system development aspect of any of the following:

- Conversion of nuclear material,
- Enrichment of nuclear material,
- Nuclear fuel fabrication,
- Reactors,
- Critical facilities,

[44] The complete text of the additional protocol can be found at: http://www.iaea.org/Publications/Documents/Infcircs/1997/infcirc540c.pdf

- Reprocessing of nuclear fuel,
- Processing (not including repackaging or conditioning not involving the separation of elements, for storage or disposal) of intermediate or high-level waste containing plutonium, high enriched uranium or uranium-233,

but do not include activities related to theoretical or basic scientific research or to research and development on industrial radioisotope applications, medical, hydrological and agricultural applications, health and environmental effects and improved maintenance."

Article 18.e defines:

"High enriched uranium means uranium containing 20 percent or more of the isotope uranium-235."

Article 18.h defines that:

"Nuclear material means any source or any special fissionable material as defined in Article XX of the Statute. The term source material shall not be interpreted as applying to ore or ore residue. Any determination by the Board under Article XX of the Statute of the Agency after the entry into force of this Protocol which adds to the materials considered to be source material or special fissionable material shall have effect under this Protocol only upon acceptance by the State".

<u>Purpose and use of the information</u>

There are nuclear processes and associated process equipment that can be developed to an advanced level without the introduction of nuclear material. Examples include centrifuges utilized to enrich uranium in the isotope ^{235}U or the development of pulsed columns and centrifugal contactors used in the separation of plutonium. Information provided under Article 2.a.(i), Article 2.b.(i) and information on fuel cycle research and development (R&D) involving nuclear material provided under the safeguards agreement give the Agency as complete a picture as practical of the R&D activities in a State relevant to the future development of its fuel cycle.

The reporting under Article 2.a.(i) addresses the nuclear fuel cycle-related R&D activities not involving nuclear material, per Article 18.a, where the State is involved. The reporting under Article 2.b.(i) requires that the State make every reasonable effort to provide the Agency with information *regarding private sector* nuclear fuel cycle-related R&D not involving nuclear material that are specifically related to enrichment, reprocessing and the processing of intermediate or high level waste containing plutonium, high enriched uranium or uranium-233.

This combined information will increase the transparency of a State's nuclear programme and will improve the basis for confirming the overall consistency of the State's nuclear programme with its nuclear-related activities, imports and exports (of specified equipment and non-nuclear materials listed in Annex II of the Model Protocol).

Declaration submission times

In accordance with Article 3.a., the initial declaration for Article 2.a.(i) should be dispatched to the Agency within 180 days of the entry into force of an additional protocol. The declaration should normally reflect the "as of" date for the status of R&D being described. This "as of" date may be any date between the entry into force of an additional protocol and 180 days after entry into force.

In accordance with Article 3.b., the annual updates of this declaration should be dispatched to the Agency by 15 May of each year. These declaration updates should be labeled in the header with the time period covered by the declaration. With the exception of the time period between the initial declaration and the first annual update, it is expected that the declaration period will be one calendar year.

Example

Format of declaration for Article 2.a.(i) (initial declaration with example entries)

Name of State (or Party):	Ruritania		
Safeguards Agreement INFCIRC:	000	Protocol Article:	2.a.(i)
Declaration number:	2	Declaration Date:	2001-10-14
Declaration period:	as of 2001-10-01		
Comment:	This is declaration number 2. Number 1 was declaration for Article 2.a.(ix)(a) for the period 30 April 2001 to 30 June 2001.		

Entry	Ref.	Fuel Cycle Stage	Location	General Description	Comments
1	3-21	Enrichment of nuclear material	Advanced Projects Agency, 23 Main Avenue, R-1384 Pointsmore, Ruritania. (APA laboratory on site AEC-NRC, building RA-18)	RAPA Isotope Separation - Phase I. Project RA-01-12. Privately funded but carried out at the APA, a government laboratory. Phase I is a study of the feasibility of adapting a molecular method of laser isotope separation for stable isotopes (developed at the University of Ruritania) to uranium enrichment. The objectives are to conduct a feasibility study of the use of two commercially available laser systems. Work is just beginning with completion scheduled for the end of 2003.	
2		Enrichment of nuclear material	Advanced Projects Agency, 23 Main Avenue, R-1384 Pointsmore, Ruritania (APA headquarters)	RAPA Isotope Separation - Phase II. Project RA-01-12. Privately funded but carried out at the APA, a government laboratory. Phase II is an engineering and economic study of adapting a molecular method of laser isotope separation for stable isotopes (developed at the University of Ruritania) to uranium enrichment. The objectives are to develop estimates of enrichment costs and prepare design of laboratory-scale test equipment. Work is scheduled for completion at the end of 2002.	
3		Reactors	Univ. of Ruritania Engineering School, McGrath Building, 401 Macron Drive, R-2257 Dembigh, Ruritania	Development of a generalized computer simulation package (GCSP) for the calculation of nuclear fuel burn-up and the accumulation of specified fission and activation products, as a function of time and position in the reactor, for several types of LWR cores. The objective is an improved reactor code that will support implementation of an advanced nuclear fuel management scheme to achieve high burn-up without loss of safety margins. This is a 3-year project set for completion 2003-06-30 being carried out in the Nuclear Engineering Department, University of Ruritania (project UR/GCSP/01). The sponsors are a consortium of private utilities and the Ruritania Ministry of Science and Industry.	

Source: Guidelines and format for preparation and submission of declarations pursuant to Articles. 2 & 3 of the AP. Services Series 11, IAEA (reproduced with permission)

Article 2.a.(ii)

"The State shall provide the Agency with a declaration containing:

(ii) Information identified by the Agency on the basis of expected gains in effectiveness or efficiency, and agreed to by the State, on operational activities of safeguards relevance at facilities and locations outside facilities where nuclear material is customarily used."

Article 18.i defines that:

"Facility means:

(i) A reactor, a critical facility, a conversion plant, a fabrication plant, a reprocessing plant, an isotope separation plant or a separate storage installation; or

(ii) Any location where nuclear material in amounts greater than one effective kilogram is customarily used."

Article 18.j defines that:

"Location outside facilities means any installation or location, which is not a facility, where nuclear material is customarily used in amounts of one effective kilogram or less."

Purpose and use of the information

Article 2.a.(ii) establishes a mechanism to provide information, agreed between the Agency and the State, that could facilitate and increase the efficiency of safeguards implementation. Each additional item of information may be identified by the Agency on the basis of expected gains in safeguards effectiveness or efficiency or both and, following consultations with, and agreement by the State, included in the State's Article 2.a.(ii) declarations for specific circumstances for specific facilities or LOFs. For example, the information could be used by the Agency to facilitate implementation of integrated safeguards approaches [45] that incorporate unannounced or short notice routine inspections, for the evaluation of remotely transmitted surveillance records or to schedule interim inspections for flow verification. These arrangements could be mutually beneficial in reducing overall Agency inspection effort and the corresponding effort by operators and by the State.

Declaration submission times

Article 3.f provides that the timing and frequency for the provision of any such information would be as agreed by the State and the Agency. The information to be provided, how it is to be provided and the frequency with which it is to be provided would be subject to the agreement of the State. This provision would become operative when and if the State and the Agency so agree.

Article 2.a.(iii)

"The State shall provide the Agency with a declaration containing:

(iii) A general description of each building on each site, including its use and, if not

[45] See point 6.1, "Integrated Safeguards"

apparent from that description, its contents. The description shall include a map of the site."

Example of a site map.

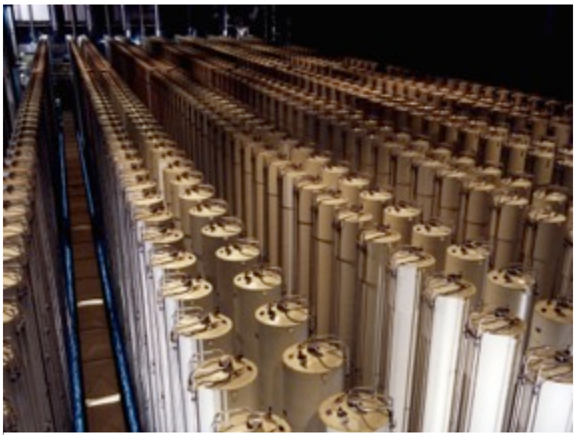
Credit: IAEA, Service Series 11, May 2004, with permission

Article 18.b ("Definitions") describes that:

"Site means that area delimited by the State in the relevant design information for a facility, including a closed-down facility, and in the relevant information on a location outside facilities where nuclear material is customarily used including a closed-down location outside facilities where nuclear material was customarily used (this is limited to locations with hot cells or where activities related to conversion, enrichment, fuel fabrication or reprocessing were carried out). It shall also include all installations, co-located with the facility or location, for the provision or use of essential services, including: hot cells for processing irradiated materials not containing nuclear material; installations for the treatment, storage and disposal of waste; and buildings associated with specified activities identified by the State under Article 2.a.(iv)."

Article 18.d defines that:

"Closed-down facility or closed-down location outside facilities means an installation or location where operations have been stopped and the nuclear material removed but which has not been decommissioned."



Cascade of gas centrifuges used to produce enriched uranium.

Source: US DOE, Public Domain

Purpose and use of the information

A primary objective of strengthened safeguards is to provide assurance that no undeclared nuclear material or activities are co-located with nuclear facilities and LOFs in order to utilize the infrastructure of manpower, technology, equipment and services that is in place to support elements of the declared programme. This article, Article 2.b.(ii) and the associated access provisions support this objective. The information in these declarations will be the basis for actions to obtain credible assurance regarding the absence of undeclared nuclear material and activities on sites. It will be used for planning complementary access to the sites of facilities and LOFs and for evaluation of consistency with the results of access activities and other information available to the Agency.

Declaration submission times

In accordance with Article 3.a, the initial declaration for Article 2.a.(iii) should be dispatched to the Agency within 180 days of the entry into force of the Protocol. The declaration period should be the "as of" date for the general descriptions provided.

This "as of" date may be any date between the entry into force of the Protocol and 180 days after entry into force.

In accordance with Article 3.b, the annual updates of this declaration should be dispatched to the Agency by 15 May of each year. These declaration updates should be labeled in the header with the time period covered by the declaration. The information provided should be valid as of the ending date of the declaration period.

With the exception of the time period between the initial declaration and the first annual update, it is expected that the declaration period will be one calendar year.

Article 2.a.(iv)

"The State shall provide the Agency with a declaration containing:

(iv) A description of the scale of operations for each location engaged in the activities specified in Annex I to this Protocol."

ANNEX I of the AP reads as follows:

LIST OF ACTIVITIES REFERRED TO IN ARTICLE 2.a.(iv) OF THE PROTOCOL

(i) The manufacture of centrifuge rotor tubes or the assembly of gas centrifuges.

Centrifuge rotor tubes mean thin-walled cylinders as described in entry[46] 5.1.1(b) of Annex II [of the AP].

Gas centrifuges means centrifuges as described in the Introductory Note to entry 5.1 of Annex II.

(ii) The manufacture of diffusion barriers.

Diffusion barriers mean thin, porous filters as described in entry 5.3.1(a) of Annex II.

(iii) The manufacture or assembly of laser-based systems.

Laser-based systems means systems incorporating those items as described in entry 5.7 of Annex II.

(iv) The manufacture or assembly of electromagnetic isotope separators.

Electromagnetic isotope separators means those items referred to in entry 5.9.1 of Annex II containing ion sources as described in 5.9.1(a) of Annex II.

(v) The manufacture or assembly of columns or extraction equipment.

Columns or extraction equipment means those items as described in entries 5.6.1, 5.6.2, 5.6.3, 5.6.5, 5.6.6, 5.6.7 and 5.6.8 of Annex II.

(vi) The manufacture of aerodynamic separation nozzles or vortex tubes.

Aerodynamic separation nozzles or vortex tubes means separation nozzles and vortex tubes as described respectively in entries 5.5.1 and 5.5.2 of Annex II.

(vii) The manufacture or assembly of uranium plasma generation systems.

Uranium plasma generation systems means systems for the generation of uranium plasma as described in entry 5.8.3 of Annex II.

(viii) The manufacture of zirconium tubes.

Zirconium tubes means tubes as described in entry 1.6 of Annex II.

(ix) The manufacture or upgrading of heavy water or deuterium.

Heavy water or deuterium means deuterium, heavy water (deuterium oxide) and any other deuterium compound in which the ratio of deuterium to hydrogen atoms exceeds 1:5000.

(x) The manufacture of nuclear grade graphite.

Nuclear grade graphite means graphite having a purity level better than 5 parts per million boron equivalent and with a density greater than 1.50 g/cm^3.

(xi) The manufacture of flasks for irradiated fuel.

[46] Annex II of the AP can be found at: https://www.iaea.org/Publications/Documents/Infcircs/1997/infcirc540c.pdf

A flask for irradiated fuel means a vessel for the transportation and/or storage of irradiated fuel that provides chemical, thermal and radiological protection, and dissipates decay heat during handling, transportation and storage.

(xii) The manufacture of reactor control rods.

Reactor control rods means rods as described in entry 1.4 of Annex II.

(xiii) The manufacture of criticality safe tanks and vessels.

Criticality safe tanks and vessels mean those items as described in entries 3.2 and 3.4 of Annex II.

(xiv) The manufacture of irradiated fuel element chopping machines.

Irradiated fuel element chopping machines means equipment as described in entry 3.1 of Annex II.

(xv) The construction of hot cells.

Hot cells means a cell or interconnected cells totaling at least 6 m^3 in volume with shielding equal to or greater than the equivalent of 0.5 m of concrete, with a density of 3.2 g/cm^3 or greater, outfitted with equipment for remote operations."

Purpose and use of the information

The purpose of this provision is to obtain sufficient information to provide a basis for assurances that manufacturing activities in the limited but very important areas covered by Annex I are consistent with a State's declared programme and that these activities are used only to support the declared programme. This information will provide the Agency with an overview of the infrastructure directly supporting the State's nuclear fuel cycle and contribute to the transparency of the State's nuclear and nuclear-related activities. The information on the scope and scale of these activities, together with the information on exports and imports of equipment and non-nuclear material identified in Annex II and provided pursuant to Article 2.a.(ix), will be compared for consistency with the State's declared nuclear programme. This may provide indications of where an infrastructure exists that could support nuclear activities that are not part of the declared nuclear programme.

Article 16.b of the Model Protocol provides for amendment of Annex I and Annex II.

Proposals for amendment could result from technological developments or experience with the physical model of the nuclear fuel cycle from which Annex I is derived. The physical model, a major component of the Agency's expanded analysis of information developed as a Part I measure of "Programme 93+2", describes each nuclear activity that could be involved in the nuclear fuel cycle from source material acquisition to the production of weapons useable nuclear material.

Declaration submission times

In accordance with Article 3.a, the initial declaration for Article 2.a.(iv) should be dispatched to the Agency within 180 days of the entry into force of the Protocol. The declaration period should be the "as of" of the general descriptions provided. This "as of" date may be any date between entry into force of the Protocol and 180 days after entry into force.

In accordance with Article 3.b, the annual updates of this declaration should be dispatched to the Agency by 15 May of each year. These declaration updates should be labeled in the header with the time period covered by the declaration. The information provided should be valid as of the ending date of the declaration period.

With the exception of the time period between the initial declaration and the first annual update, it is expected that the declaration period will be the most recent calendar year.

Open pit at the Ranger uranium mine, Northern Territory, Australia, with the mill in the background. This mine had been in operation for over 30 years.

Photo Credit: P. Woods, IAEA imagebank

Article 2.a.(v)

"The State shall provide the Agency with a declaration containing:

(v) Information specifying the location, operational status and the estimated annual production capacity of uranium mines and concentration plants and thorium concentration plants, and the current annual production of such mines and concentration plants for the State as a whole. The State shall provide, upon request by the Agency, the current annual production of an individual mine or concentration plant. The provision of this information does not require detailed nuclear material accountancy."

Purpose and use of the information

The purpose of this article is to contribute to the completeness of the Agency's knowledge of all of the State's holdings of nuclear material. This includes the capacity to produce source material, both in operating or closed-down mines. The information, together with information on inventories, imports and exports of nuclear material, would be used to assess the consistency of these holdings with the State's declared nuclear programme.

Declaration submission times

In accordance with Article 3.a, the initial declaration for Article 2.a.(v) should be dispatched to the Agency within 180 days of the entry into force of the Protocol. The declaration period should normally reflect the "as of" date for the information provided. This "as of" date may be any date between entry into force of the Protocol and 180 days after entry into force. However, while an "as of" date is appropriate in the initial declaration regarding operational status, it is anticipated that the declared annual production capacities and the declared current annual production will be for the most recent calendar year.

A drum with Yellow Cake being prepared for shipping to a conversion facility

Photo Credit: Cameco/WNA reproduced with permission

In accordance with Article 3.b, the annual updates of this declaration should be dispatched to the Agency by 15 May of each year. These declaration updates should be labeled in the header with the time period covered by the declaration. The information provided should be valid as of the ending date of the declaration period. With the exception of the time period between the initial declaration and the first annual update, it is expected that the declaration period will be the most recent calendar year.

Article 2.a.(v) provides for declarations of the current annual production of an individual mine or concentration plant upon specific Agency request, but neither Article 2 nor Article 3 specifies a time for the response to such a request. Such responses should be dispatched within 60 days of the request (consistent with the required response time in Article 3.g for response to a request, pursuant to Article 2.a.(ix)(b), for confirmation of an import) using the same format as for other Article 2.a.(v) declarations. Responses may be made as a separate declaration or by inclusion in an annual Article 2.a.(v) declaration if dispatched within 60 days of the request.

Article 2.a.(vi)

"The State shall provide the Agency with a declaration containing:

(vi) Information regarding source material which has not reached the composition and purity suitable for fuel fabrication or for being isotopically enriched, as follows:

(a) The quantities, the chemical composition, the use or intended use of such material, whether in nuclear or non-nuclear use, for each location in the State at which the material is present in quantities exceeding ten metric tons of uranium and/or twenty metric tons of thorium, and for other locations with quantities of more than one metric ton, the aggregate for the State as a whole if the aggregate exceeds ten metric tons of uranium or twenty metric tons of thorium. The provision of this information does not require detailed nuclear material accountancy;

(b) The quantities, the chemical composition and the destination of each export out of the State, of such material for specifically non-nuclear purposes in quantities exceeding:

(1) Ten metric tons of uranium, or for successive exports of uranium from the State to the same State, each of less than ten metric tons, but exceeding a total of ten metric tons for the year;

(2) Twenty metric tons of thorium, or for successive exports of thorium from the State to the same State, each of less than twenty metric tons, but exceeding a total of twenty metric tons for the year;

(c) The quantities, chemical composition, current location and use or intended use of each import into the State of such material for specifically non-nuclear purposes in quantities exceeding:

(1) Ten metric tons of uranium, or for successive imports of uranium into the State each of less than ten metric tons, but exceeding a total of ten metric tons for the year;

(2) Twenty metric tons of thorium, or for successive imports of thorium into the State each of less than twenty metric tons, but exceeding a total of twenty metric tons for the year;

it being understood that there is no requirement to provide information on such material intended for a non-nuclear use once it is in its non-nuclear end-use form."

<u>Purpose and use of the information</u>

The purpose of this article, together with the information provided under Articles 2.a.(v), 2.a.(vii) and 2.a.(viii), is to complement the information already provided through nuclear material accounting reports pursuant to paragraphs 59-65 and 67 of INFCIRC/153 and, thereby provide the Agency with as complete a picture as practical of all nuclear material within the State relevant to actual or potential nuclear activities within the State. The information would be used to confirm the consistency between the State's declared nuclear programme and its holdings of nuclear material.

The information on exports and imports of nuclear material for non-nuclear purposes, in conjunction with the information on exports and imports for other than non-nuclear purposes reported pursuant to paragraphs 34(a) and (b) of INFCIRC/153, provides the Agency with as complete a picture as is practical of the State's international transfers of nuclear material. It would be used to confirm the consistency of the exports and imports of this material with the State's declared holdings and with imports and exports declared by other States.

Some of the information required by this article is already provided by some States under the Voluntary Reporting Scheme. Information provided as declarations under Article 2.a.(vi) does not need to be repeated under voluntary reporting.

Declaration submission times

In accordance with Article 3.a, the initial declaration for Article 2.a.(vi)(a) should be dispatched to the Agency within 180 days of the entry into force of the Protocol. The declaration period should normally reflect the "as of" date for the nuclear material holdings being described. The "as-of" date may be any date between entry into force of the Protocol and 180 days after entry into force.

In accordance with Article 3.b, the annual updates of this declaration should be dispatched to the Agency by 15 May of each year. These declaration updates should be labeled in the header with the time period covered by the declaration. The information provided should be valid as of the ending date of the declaration period. With the exception of the time period between the initial declaration and the first annual update, it is expected that the declaration period will be the most recent calendar year.

In accordance with Article 3.c, the annual declarations for Articles 2.a.(vi)(b) and (c) (exports and imports) should be dispatched to the Agency by 15 May of each year. These declarations should be labeled in the header with the time period covered by the declaration. The initial declarations should cover the time period between entry into force of the Protocol and the end of that calendar year. With this exception it is expected that the declaration period will be the most recent calendar year.

Article 2.a.(vii)

"The State shall provide the Agency with a declaration containing:

(vii) (a) information regarding the quantities, uses and locations of nuclear material exempted from safeguards pursuant to paragraph 37 of INFCIRC/153[47];

(b) Information regarding the quantities (which may be in the form of estimates) and

[47] These references are made to articles in the model CSA, INFCIRC/153. Some States' actual CSA may have a different numbering in their safeguards agreement in force.

uses at each location, of nuclear material exempted from safeguards pursuant to paragraph 36(b) of INFCIRC/153 but not yet in a non-nuclear end-use form, in quantities exceeding those set out in paragraph 37 of INFCIRC/153. The provision of this information does not require detailed nuclear material accountancy.

Purpose and use of the information

The purpose of this article, together with the information provided under Articles 2.a.(v), 2.a.(vi) and 2.a.(viii), is to complement the information already provided through accounting reports pursuant to paragraphs 59-65 and 67 of INFCIRC/153 and, thereby provide the Agency with as complete a picture as practical of all nuclear material within the State relevant to actual or potential nuclear activities within the State. The information is used to help confirm the consistency between the State's declared nuclear programme, its holdings and use of nuclear material and other information available to the Agency, including the results of complementary access.

Methods and technologies for the disposal of radioactive waste are tested at Germany's former Asse Salt Mine.

Photo credit: WNA/Gesellschaft für Strahlen und Umweltforschung mbH, München, with permission

Declaration submission times

In accordance with Article 3.a, the initial declaration for Article 2.a.(vii) should be dispatched to the Agency within 180 days of the entry into force of the Protocol. The declaration period should normally reflect the “as of” date for the nuclear material quantities being described. The “as of” date may be any date between entry into force of the Protocol and 180 days after entry into force.

In accordance with Article 3.b, the annual updates of this declaration should be dispatched to the Agency by 15 May of each year. These declaration updates should be labeled in the header with the time period covered by the declaration. The information provided should be valid as of the ending date of the declaration period. With the exception of the time period between the initial declaration and the first annual update, it is expected that the declaration period will be the most recent calendar year.

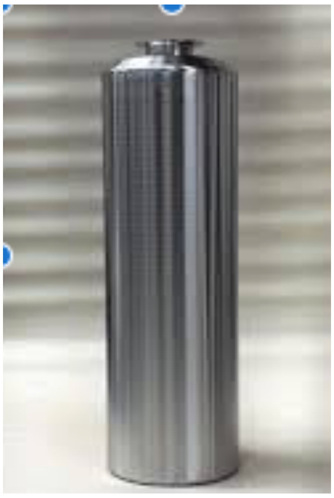
Article 2.a.(viii)

“The State shall provide the Agency with a declaration containing:

(viii) Information regarding the location or further processing of intermediate or high-level waste containing plutonium, high enriched uranium or uranium-233 on which safeguards have been terminated pursuant to paragraph 11 of INFCIRC/153. For the purpose of this paragraph, "further processing" does not include repackaging of the waste or its further conditioning not involving the separation of elements, for storage or disposal.

Purpose and use of the information

The purpose of this article, together with the information provided under articles 2.a.(v), 2.a.(vi) and 2.a.(vii), is to complement information already provided through accounting reports pursuant to paragraphs 59-65 and 67 of INFCIRC/153 and, thereby, provide the Agency with as complete a picture as practical of all nuclear material within the State relevant to actual or potential nuclear activities within the State. The information is used to confirm the consistency between the States' declared nuclear programme and its holdings of nuclear material.



Vitrified high level waste container

Photo Credit: WNA Gallery, with permission

Most of the plutonium, high enriched uranium and uranium-233 in retained waste and irradiated fuel is under safeguards. However, there are increasing quantities of conditioned (vitrified) waste with very low concentrations of plutonium, high-enriched uranium and uranium-233 upon which safeguards have been terminated. Reports under article 2.a.(viii) keep the Agency informed regarding the location of this waste and any plans to process it further where the processing involves the separation of elements. Among the elements that could be separated from reprocessing plant waste neptunium-237, and to a much lesser extent the isotopes of americium, are weapons-useable materials. The quantities of neptunium produced are relatively small (~2% of the produced plutonium). The quantities of *separated* neptunium are too limited today to justify the imposition of detailed material accountancy safeguards (i.e., amend the definition of special fissionable material). This situation could change should States implement advanced nuclear waste treatment strategies that involve the separation of minor actinides (including neptunium or americium) from waste generated in the reprocessing of irradiated fuel. Under this article, States could also report holdings of neptunium and americium in waste generated by reprocessing plants on a strictly voluntary basis.

Declaration submission times

In accordance with Article 3.e, information on the location of and plans for further processing of waste as specified in Article 2.a.(viii) should be dispatched to the Agency no later than 180 days before the processing takes place.

In accordance with Article 3.e, the annual declaration on changes in the location of wastes covered by Article 2.a.(viii) should be dispatched to the Agency by 15 May of each year for the period covering the previous calendar year.

Article 2.a.(ix)

"The State shall provide the Agency with a declaration containing:

(ix) The following information regarding specified equipment and non-nuclear material listed in Annex II:

(a) For each export out of the State of such equipment and material: the identity, quantity, location of intended use in the receiving State and date or, as appropriate, expected date, of export";

(b) Upon specific request by the Agency, confirmation by the State, as importing State, of information provided to the Agency in accordance with paragraph (a) above.

The text of Annex II is not reproduced here because of its length.

Purpose and use of the information

The purpose of this article is to obtain information on the State's international transfers in the areas covered by Annex II. The information will contribute substantially to the transparency of the State's nuclear and nuclear-related activities and to the Agency's understanding of these activities. It is expected that Annex II will be revised according to the provisions of Article 16 of the additional protocol when necessary.

The information on international transfers of equipment and non-nuclear material covered by Annex II will be compared for consistency with States declared nuclear programmes. This will provide indications of where transfers are occurring or where an infrastructure exists that could support nuclear activities that are not part of declared nuclear programmes. Should questions arise, an importing State may be asked to confirm an exporting State's declaration.

Some of the information required by this article is already provided by some States under the Voluntary Reporting Scheme. Information provided as declarations under Article 2.a.(ix) does not need to be repeated under voluntary reporting. However, the voluntary reporting may contain additional information not required by the additional protocol and the Agency welcomes the continued provision of that information.

Declaration submission times

In accordance with Article 3.d, the quarterly declarations of exports covered by Article 2.a.(ix)(a) should be dispatched to the Agency within 60 days of the end of the quarter.

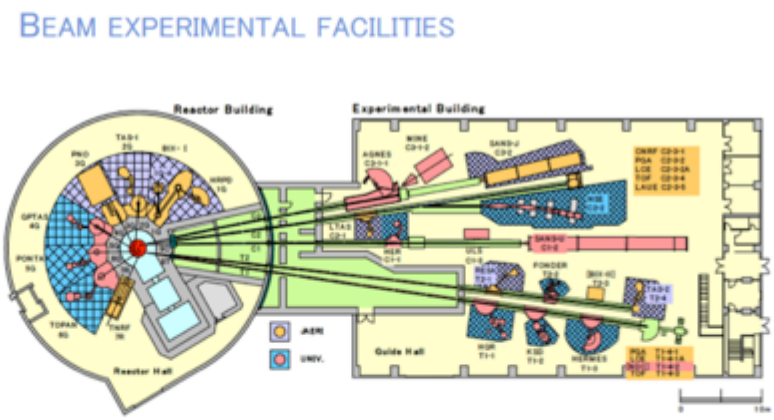
In accordance with Article 3.g, the information on each import covered by Article 2.a.(ix)(b) and specifically requested by the Agency should be dispatched to the Agency within 60 days of the Agency's request.

Article 2.a.(x)

"The State shall provide the Agency with a declaration containing:

(x) General plans for the succeeding ten-year period relevant to the development of the nuclear fuel cycle (including planned nuclear fuel cycle-related research and development activities) when approved by the appropriate authorities in the State".

Purpose and use of the information



The JRR-3 Research Reactor of JAEA has been utilized for beam experiments and neutron irradiations: There are 9 irradiation facilities for irradiation tests on nuclear fuel and material, production of RI and silicon semiconductor and neutron activation analysis. Also, there are 32 instruments for neutron beam experiments including 13 and 19 instruments belonging to universities and the JAEA, respectively.

Declarations of plans for development of the State's nuclear fuel cycle will assist the Agency in its long-term planning and contribute to increased transparency and assurance that the declared present nuclear programme and nuclear fuel cycle-related R&D are generally consistent with the declared plans for future development of the fuel cycle. Information about planned nuclear R&D to support the future development of the nuclear fuel cycle will contribute to the transparency of the State's nuclear programme. The phrase "appropriate authorities" is intended to mean those governmental offices or governmental entities with long-range planning responsibilities for development of the nuclear fuel cycle. The declaration should include all general government and private sector plans approved by the appropriate authorities for the succeeding ten-year period. Declarations under this article are not to be understood as a substitute for early provision of design information.

Declaration submission times

In accordance with Article 3.a, the initial declaration for Article 2.a.(x) should be dispatched to the Agency within 180 days of the entry into force of the Protocol. The declaration period should be the "as of" date of the general plans submitted. This "as of" date may be any date between the entry into force of the Protocol and 180 days after entry into force.

In accordance with Article 3.b, the annual updates of this declaration should be dispatched to the Agency by 15 May of each year. These declaration updates should be labeled in the header with the time period covered by the declaration and should be as of 31 December of the previous year. With the exception of the time period between the initial declaration and the first annual update, it is expected that the declaration period will be the most recent calendar year.

Article 2.b.(i)

"The State shall make every reasonable effort to provide the Agency with the following information:

(i) A general description of and information specifying the location of nuclear fuel cycle-related research and development activities not involving nuclear material which are specifically related to enrichment, reprocessing of nuclear fuel or the processing of intermediate or high-level waste containing plutonium, high enriched uranium or uranium-233 that are carried out anywhere in the State *but which are not funded, specifically authorized or controlled by, or carried out on behalf of, the State.* For the purpose of this paragraph, "processing" of intermediate or high-level waste does not include repackaging of the waste or its conditioning not involving the separation of elements, for storage or disposal."

Purpose and use of the information

Information provided under Article 2.b.(i), together with information provided under Article 2.a.(i) and information on fuel cycle R&D involving nuclear material provided under the Safeguards Agreement, give the Agency as complete a picture as practical of the State's R&D relevant to the development of enrichment, reprocessing and processing of intermediate or high level waste as well as a picture of developments of other parts of the fuel cycle involving the State. This combined information will increase the transparency of a State's nuclear programme and will improve the basis for confirming the overall consistency of the State's declared nuclear programme with its nuclear-related activities, exports and imports (of specified equipment and non-nuclear material listed in Annex II of the Model Protocol).

The submission schedule and the content of the information to be declared under Article 2.b.(i) are identical to those under Article 2.a.(i), except Article 2.b.(i) is limited to three areas of the fuel cycle (enrichment, reprocessing and processing of intermediate or high level waste) and the obligation of the State is to make *every reasonable effort* to provide the information. In case doubts exist about under which Article, 2.a.(i) or 2.b.(i), a declaration should be made, consultations between the State and the Agency are recommended.

Declaration submission times

In accordance with Article 3.a, the initial declaration for Article 2.b.(i) should be dispatched to the Agency within 180 days of the entry into force of the Protocol. The declaration period should normally reflect the "as of" date for the status of the R&D being described. This "as of" date may be any date between the entry into force of the Protocol and 180 days after entry into force.

In accordance with Article 3.b, the annual updates of this declaration should be dispatched to the Agency by 15 May of each year. These declaration updates should be labeled in the header with the time period covered by the declaration. With the exception of the time period between the initial declaration and the first annual update, it is expected that the declaration period will be one calendar year.

Article 2.b.(ii)

"The State shall make every reasonable effort to provide the Agency with the following information:

(ii) A general description of activities and the identity of the person or entity carrying out such activities, at locations identified by the Agency outside a site which the Agency considers might be functionally related to the activities of that site. The provision of this information is subject to a specific request by the Agency. It shall be provided in consultation with the Agency and in a timely fashion."

Purpose and use of the information

A primary objective of strengthened safeguards is to provide assurance that no undeclared nuclear material or activities are co-located with nuclear facilities and LOFs in order to utilize the infrastructure of manpower, technology, equipment and services that is in place to support declared activities. That is the purpose of this article, Article

2.a.(iii) and the associated access provisions. Article 2.b.(ii) provides an Agency right to information concerning activities at a particular location which the State has not included as part of a site but which the Agency considers may be functionally related to the activities on the site.

The information in the Article 2.b.(ii) declarations will be used to help resolve Agency questions about a specific activity. In the event the information provided by the State is not sufficient to resolve the Agency's questions, the information will be used for planning any needed complementary access to the location in question and for comparison for completeness and consistency with the results of access activities and with other information available to the Agency.

A site boundary will not automatically change upon receipt by the Agency of a 2.b.(ii) declaration regarding a location. If required, any change in a site boundary can be reflected by the State in the next update for Article 2.a.(iii).

Declaration submission times

An Article 2.b.(ii) declaration need only be provided in response to a specific request by the Agency. The response is to be provided in conjunction with consultations with the Agency and in a timely fashion. Each Agency request will include an indication of the urgency of a response and a proposal for a time for the consultations at which the response would be provided.

Article 2.c

"Upon request by the Agency, the State shall provide amplifications or clarifications of any information it has provided under this Article, in so far as relevant for the purpose of safeguards."

Purpose and use of the information

The purpose of this article is to facilitate implementation of the additional protocol and to help ensure the correct understanding by the Agency of the information in the State's declarations. It may also contribute to resolving Agency questions without recourse to complementary access. This article is used routinely for amplification and clarification of issues related to declarations.

Declaration submission times

The Model Protocol does not specify due dates for the responses under this article. In its requests for amplifications and clarifications the Agency will include an indication of the urgency of a response.

5. IAEA VERIFICATION ACTIVITIES

The IAEA has the right and obligation to verify States' compliance with commitments under their safeguards agreements and, where applicable, additional protocols. In particular, as part of the implementation of the additional protocol and integrated safeguards, inspectors must be able to confirm the absence of undeclared nuclear materials and activities during inspections and complementary access.

As explained in point 3.1.2 of this handbook, the basic verification measure used by the IAEA is nuclear material accountancy. In applying nuclear material accountancy, IAEA safeguards inspectors perform audits of facility records and reports and make independent measurements to verify quantitatively the amount of nuclear material presented in the State's accounts. For this purpose, inspectors count items (e.g. fuel assemblies, bundles or rods, or containers of powdered compounds of uranium or plutonium), measure attributes of these items during their inspections using non-destructive assay (NDA) techniques, and compare their findings with the declared amounts and the operator's records.

The purpose of this activity is to detect missing items (gross defects). The next level of verification aims to detect whether a fraction of a declared amount is missing (partial defect) and may involve the weighing of items and measurements using NDA techniques such as neutron counting or γ-ray spectrometry. These techniques are capable of measuring an amount of nuclear material with accuracy of the order of a few per cent. For detecting bias defects, which would arise if small amounts of material were diverted over a protracted length of time, it is necessary to sample some of the items and to apply physical and chemical analysis techniques of the highest possible accuracy, typically less than 1%. In order to apply these destructive analysis techniques, the IAEA requires access to laboratories that employ such accurate techniques on a routine basis.

Containment and surveillance (C/S) techniques, which are complementary to nuclear material accountancy techniques, are applied in order to maintain continuity of the knowledge gained through IAEA verification, by giving assurance that nuclear material follows predetermined routes, that the integrity of its containment remains unimpaired and that the material is accounted for at the correct key measurement points. They also lead to savings in the safeguards inspection effort (e.g. by reducing the required coverage of accountancy verification). A variety of C/S techniques are applied, primarily optical surveillance and sealing. These measures serve as a backup to nuclear material accountancy through monitoring access to nuclear material and detecting any undeclared movement of material while reducing overall costs.

Unattended and remote monitoring is a special mode of application of NDA or C/S techniques, or a combination of these techniques, that operates for extended periods without the presence of inspectors. In remote monitoring, the unattended equipment transmits the data off-site. For unattended and remote monitoring, additional criteria must be met, including high reliability and authentication of the data source. Expanded deployment of unattended and remote monitoring systems has become an increasingly important element of IAEA efforts to maintain and increase safeguards effectiveness Environmental sampling, which allows the detection of minute traces of nuclear material, was added to the IAEA's verification measures in the mid-1990s as a powerful tool for detecting indications of undeclared nuclear activities. The non-detection of even minute traces of a specific nuclear material can provide assurance that no activities utilizing the material took place in the area where the environmental samples were taken.

5.1 INSPECTIONS AND DESIGN INFORMATION VISITS

The Agency's in-field verification activities are aimed at achieving objectives consistent with the safeguards obligations of States: the detection of diversion of declared nuclear material (including the misuse of facilities or LOFs to produce undeclared materials); and the detection of undeclared nuclear material or activities for the State as a whole.

Under a CSA, the Agency's in-field verification activities focus primarily on verifying the State's declarations on facility design/operation and on nuclear material flows and inventories. Nuclear material verification activities are aimed at verifying the nuclear material accounting records of inventories and inventory changes of nuclear material maintained by operators for each facility or LOF and reported through the State authorities to the Agency. This nuclear material accountancy verification is often complemented by C/S measures (e.g. seals, observation by camera). All of these measures (accountancy, C/S, Design Information Verification, DIV) contribute to detecting the diversion of declared material and any misuse of a declared installation to produce undeclared material. The scope of the verification activities to be performed at the facility/LOF level is governed by a State's safeguards agreement and by the Subsidiary Arrangements to that agreement, which are also concluded with the State. These arrangements are set out in detail in Facility Attachments that are negotiated with the State.

The IAEA may carry out three types of inspections: ad hoc, routine and special. States must take measures to facilitate the IAEA's activities during inspections, by providing access to locations and to information necessary for the inspectors to meet the objectives of the inspection. States have the right to have IAEA inspectors accompanied during inspections, provided that in doing so, inspectors are not delayed or otherwise impeded in carrying out their functions. The IAEA's authority regarding inspection activities (for any of the three kinds of inspections) is described in paragraphs 74 and 75 of INFCIRC/153.

Ad hoc inspections are normally conducted to verify the information contained in the initial report, before Subsidiary Arrangements have been concluded and Facility Attachments have been prepared and agreed upon, or to verify nuclear material before it is exported or upon receipt in the importing State. Ad Hoc inspections, in practice, are conducted by the Agency's inspectors in a similar pattern as a routine inspection and take place while the IAEA and the State negotiate the Subsidiary Arrangements' Attachments for the facility.

Routine inspections are conducted after the Facility Attachments to Subsidiary Arrangements have been agreed and specific information has been incorporated in the attachments, including information on "strategic points" in each facility. The purposes of routine inspections are listed in paragraph 72 of INFCIRC/153.

The IAEA has the right to conduct a portion of the routine inspections without advance notification to the State or operator, according to the principle of random sampling. This supplementary measure can achieve increases in both effectiveness and efficiency, and is an important component of the State level concept for safeguards planning and implementation. States have the right to have inspectors accompanied during unannounced inspections, but as stated in paragraph 89 of INFCIRC/153, such accompaniment must not delay or otherwise impede the inspectors in the exercise of their functions. States may find the logistics of arranging for accompaniment during unannounced inspections to be challenging, but the IAEA may nonetheless exercise its right to conduct unannounced inspections. The IAEA periodically communicates to the State its general programme of inspections (both announced and unannounced), to help minimize impacts on the facilities. Inspectors conducting a routine inspection must be granted access and support to carry out their activities to meet the verification objectives of the inspection.

Special inspections may be either additional to the routine inspection effort, or involve access to information or locations which are additional to those involved in routine and ad hoc inspections, or both. While special inspections have not often been carried out, they are an important element of the IAEA's legal authority to implement safeguards, and may be necessary in order for the IAEA to achieve the objectives of the safeguards agreement.

As described above, inspections are an important part of the verification process. The activities that Agency inspectors perform during inspections include:

- Examining and auditing facility records and comparing them with reports submitted by the State;
- Verifying declared inventories and flows of nuclear material (e.g. through item counting, non-destructive assay measurements, material sampling for destructive analysis);
- Verifying, under item-specific agreements, certain non-nuclear material and equipment;
- Applying containment and surveillance measures;
- Confirming the absence of undeclared activities (e.g. unreported nuclear production at reactors, or the undeclared use of reprocessing and enrichment plants or hot cells), such as through the taking of environmental samples; and
- Confirming the absence of borrowed nuclear material from another facility in the State that could be used to conceal a diversion.

IAEA inspectors attaching a seal at a reactor

Photo credit: IAEA imagebank

Design information verification (DIV) involves confirming that the actual facility design corresponds to the design information submitted by the State. DIV is performed periodically throughout the lifetime of a facility (i.e. from the construction phase, throughout operation, and during decommissioning) until the facility has been decommissioned for safeguards purposes[48]. INFCIRC/153 defines a DIV as a "visit", not as an inspection that has the specific scope as described above. Agency inspectors also verify, during a DIV, the safeguards-relevant elements of the design of the facility as

[48] The additional protocol, however, provides the option to implement complementary access to any decommissioned facility or LOF. Access allows the confirmation of the decommissioned status of facilities or LOFs.

declared by the State. For reasons of efficiency this is typically done in conjunction with an inspection. The SRA and the safeguards implementation officer at a facility should cooperate with the Agency's inspectors in performing a DIV by providing access to the facility and explanations regarding the features of the facility, particularly to those of safeguards significance.

5.1.1 Frequency, notice and access

The number, intensity, duration and timing of routine inspections is agreed between the State and the Agency and included in the general part of Subsidiary Arrangement to the CSA and the separate attachments for each facility. The general part includes a general programme of announced and unannounced inspections, which are contingent on adequate advance information on the operational programme contained in "concise notes", provided by the State. The general part also includes a "Periodic Inspection Programme" where the number of announced routine inspections for facilities and locations outside facilities is included. The general part also lists the facilities where unannounced inspections will take place. One Physical Inventory Taking (PIT) at yearly intervals should be conducted at facilities and LOFs. Agency inspectors have the right to verify those inventories by performing a Physical Inventory Verification (PIV) subsequent to or in parallel with the PIT and several interim inventory verifications in between PIVs. In practice, facilities and LOFs handling direct use and significant quantities of nuclear material are subject to several inspections per year. Nuclear power plants and storages of spent fuel could expect four inspections per year, one every three months and one to verify the PIT. Facilities handling significant quantities of indirect use NM could expect one inspection per year. Facilities and LOFs having less than one Significant Quantity (SQ) of material are randomly chosen to be inspected. Here below is a table with the amounts defined as one Significant Quantity:

Material	SIGNIFICANT QUANTITY
Direct use nuclear material	
Pu[49]	8 kg Pu
^{233}U	8 kg ^{233}U
HEU ($^{235}U \geq 20\%$)	25 kg ^{235}U
Indirect use nuclear material	
U ($^{235}U < 20\%$) [50]	75 kg ^{235}U (or 10 t natural U or 20 t depleted U)
Th	20 t Th

Target detection times are applicable to specific nuclear material categories. These goals are used for establishing the frequency of inspections and safeguards activities at a facility or a location outside facilities during a calendar year, in order to verify that no abrupt diversion has occurred. Where there is no additional protocol in force or where the IAEA has not drawn and maintained a conclusion of the absence of undeclared nuclear material and activities in a State (Broad Conclusion), the detection goals that determine the *frequency of inspections* are as follows:

- One month for unirradiated direct use material,
- Three months for irradiated direct use material,
- One year for indirect use material.

For example, the IAEA will inspect a light water reactor every three months after the closing of a Material Balance Period in order to fulfill their requirements for timeliness. The IAEA inspectors will verify receipts of fresh fuel or the storage of spent fuel, service their cameras and replace some seals at the reactor. Then, when the reactor needs to be refueled the inspectors will be present again and will verify the transfer of spent fuel from the core to the spent fuel pond by measuring the fuel present at the spent fuel pond, check the core fuel and verify the fresh fuel, hence performing a PIV.

In the case of a facility handling more than one SQ of fresh HEU, the inspectors will verify the material once per month and replace some seals randomly if the material is kept in closed sealed containers. A storage containing a static inventory of natural and depleted UF_6 would be subject to inspections once per year to perform a PIV.

Longer timeliness detection goals may be applied in a State where the IAEA has drawn

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49 For Pu containing less than 80% ^{238}Pu

50 Including low enriched, natural and depleted uranium

and maintained a conclusion of the absence of undeclared nuclear material and activities in that State, also known as "broader conclusion". In such a case, facilities may be inspected randomly, hence reducing the Agency's field efforts (see point 6.1 later in this Handbook).

According to the CSA, the Agency should provide advance *notice* for ad-hoc and routine inspections before the arrival of the inspectors. In most of the cases the advance notice should be one week, but in cases of facilities handling significant amounts of plutonium and high enriched uranium, one day would be the required notice.

Additionally, the Agency conducts a portion of their routine inspections in unannounced mode. The general program and the number of unannounced inspections are agreed with the State concerned beforehand and stipulated in the Subsidiary Arrangement.

Additionally in cases when the Agency considers that it cannot fulfill its obligations under the Agreement there is a provision to conduct "Special Inspections" additional to the agreed routine inspection effort. To conduct such inspections the State and the Agency should consult regarding details for implementation. Special inspections have been rarely implemented by the IAEA and only in cases where there were serious suspicions of a breach of the obligations of a State with a Safeguards Agreement in force.

IAEA inspectors should be granted *access* to any strategic point specified in the Subsidiary Arrangements in place and to the accounting and operating records maintained at a facility/LOF . Those strategic points are within the declared material balance areas declared in the design information provided by States. Strategic points include any location where key measurements related to material accountancy are made i.e. key measurement points (KMP), and where containment and surveillance measures are implemented. There are two types of KMPs: Flow and Inventory KMPs. Flow KMPs are used to measure and report receipts and shipments of NM, nuclear transformations (e.g. production of plutonium and consumption of uranium), transfers to waste, process losses, and accidental gains or losses of material. Flow KMPs are denoted by numbers as stipulated in Subsidiary Arrangements. Inventory KMPs are denoted by letters and refer to strategic points where nuclear material is present at the time of an inspection (interim or PIV inspection). For example, typical inventory KMPs at a light water reactor are the fresh fuel storage, core fuel and spent fuel storages and are declared and measured at KMPs A, B and C, respectively[51].

[51] As shown in Point 4.3, MBAs and KMPs.

5.1.2 Inspection Activities

5.1.2.1 Records examination and auditing

When inspectors arrive at a facility, one of the first activities they typically perform is examining and auditing the records kept at the facility. (Accounting and operating records as well as supporting documents were described in point 4.4). During an inspection, IAEA inspectors should be granted access to the accounting and operating records kept at the facility for "examination"[52] and auditing with the intention to establish a correct set of data upon which to base the verification of the flow and inventory of nuclear material. The examination and auditing activities carried out by the inspectors consist of reconciling operating and accounting records and updating the book inventory. For instance, the inspectors will check that the amounts, number of items and batch identification codes of fuel assemblies received by a facility and included in an "Inventory Change Document" and will compare this information with the data recorded in the respective "Shipping Document" from the provider of fuel. Once they confirm that both sets of documents are consistent, they will verify if the information was properly recorded in the subsidiary and general ledgers of the facility and will establish the updated book inventory as of the day of the inspection. In other words, the inspectors will verify the internal consistency of supporting documents and operating and accounting records, including the arithmetic correctness of all entries in the accounting records.

Following the receipt of a notice of inspection, the designated facility operator in charge of safeguards should prepare all accounting and operating records as established in the Facility Attachment of the Subsidiary Arrangement and should confirm, before the arrival of the inspectors that all information and data is complete and correct. An itemized List of Inventory Items (LII) and the general and subsidiary ledgers should be updated and prepared. Accounting and operating records could be provided beforehand to the State Regulatory Authority, if required by national regulations or procedures.

[52] See Article 74. (a), "Scope of Inspections, INFCIRC/153

5.1.2.2 Nuclear Material Measurements (NDA/DA)[53]

As established in Article 28 of INFCIRC/153, the fundamental verification measure used by the IAEA is nuclear material accountancy. In applying nuclear material accountancy, IAEA safeguards inspectors perform independent measurements to verify quantitatively the amount of nuclear material presented in the State's accounts. For this purpose, inspectors count items (e.g. fuel assemblies, bundles or rods, or containers of powdered compounds of uranium or plutonium), measure attributes of these items during their inspections using non-destructive assay (NDA) techniques, and compare their findings with the declared amounts of NM and the operator's records.

The purpose of this activity is to detect missing items (gross defects). The next level of verification aims to detect whether a fraction of a declared amount is missing (partial defect) and may involve the weighing of items and measurements using NDA techniques such as neutron counting or γ ray spectrometry. The verification activities carried out by IAEA inspectors are aimed at the verification of the entire inventory present at facilities at the time of an inspection, however, inspectors use sampling plans and random selection of items to reduce the number of items that are actually measured to reduce the inspection effort during ad hoc or routine inspections. In other words, the IAEA uses a probabilistic verification approach.

NDA techniques are capable of measuring an amount of nuclear material with accuracy on the order of a few percent. For detecting bias defects, which would arise if small amounts of material were diverted over a protracted length of time, it is necessary to sample some of the items and to apply physical and chemical analysis techniques of the highest possible accuracy, typically less than 1%.

The IAEA uses more than 100 different NDA systems to verify, check and monitor nuclear materials without changing their physical or chemical properties. NDA instruments range in size and complexity from small portable units used by safeguards inspectors during on-site verification activities to large in situ NDA systems designed for continuous unattended in-plant use. The most widely used NDA instruments rely on detection of nuclear radiation such as gamma (γ) rays and/or neutrons. Physical measurement techniques are also used, with available instruments that measure heat, weight, volume (of liquids), and thickness and light emission/absorption. NDA instruments could be classified into four categories: gamma ray spectrometry, neutron

53 Credit: "International Atomic Energy Agency, Safeguards Techniques and Equipment: 2011 edition", International Nuclear Verification Series No. 1 (Rev. 2), IAEA, Vienna (2011), reproduced with permission, op. cit.

counting, spent fuel measurement and other NDA techniques. They are described summarily below:

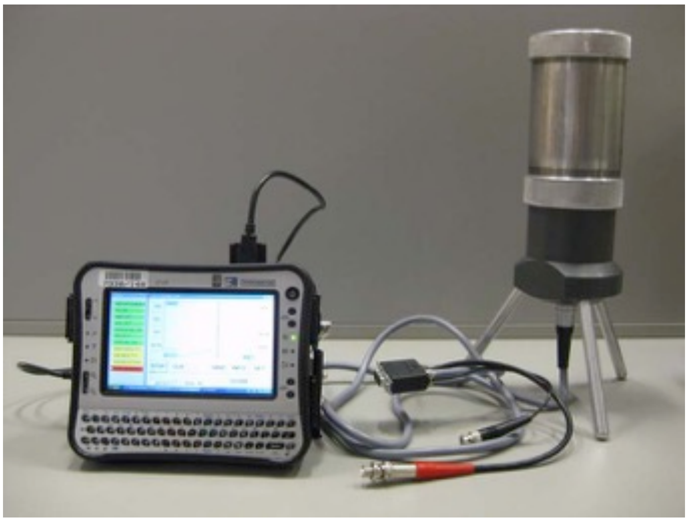
5.1.2.2.1 GAMMA RAY SPECTROMETRY

Most nuclear materials under IAEA safeguards emit gamma (γ) rays that can be used for NDA of the materials. Gamma rays have well defined energies that are characteristic of the isotopes emitting them. Determination of the γ ray energies and their relative intensities serves to identify the isotopic composition of the materials. When combined with a measurement of absolute intensities, the γ ray energies can provide quantitative information on the amount of material that is present:

(a) Enriched uranium fuel, for example, has a strong 186 keV gamma ray associated with the α decay of ^{235}U, and the ^{235}U enrichment can be verified by measuring this γ ray.

(b) Plutonium samples generally contain the isotopes ^{238}Pu, ^{239}Pu, ^{240}Pu and ^{241}Pu as well as decay products, which give rise to a highly complex mix of characteristic γ ray energies. Plutonium spectra can be analyzed to determine the isotopic composition.

(c) The date of irradiated fuel discharge from a reactor can be verified by measuring the relative intensities of γ rays associated with fission and activation products. The 662 keV γ ray from ^{137}Cs is particularly important for this type of determination.



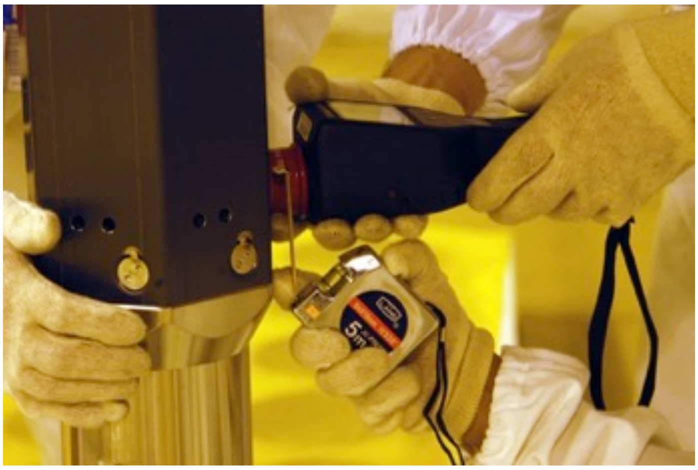
Miniature multichannel analyzer with NaI detector and portable computer.

Photo credit: IAEA

To detect γ rays, the radiation must interact with a detector to give up all or part of the photon energy. The basis of all spectroscopic γ ray detector systems is the collection of this liberated electrical charge to produce a voltage pulse whose amplitude is proportional to the energy deposited by a γ ray in a detector. These pulses are then sorted according to amplitude (energy) and counted using appropriate electronics, such as a single or multichannel analyzer. With a multichannel analyzer, the γ rays of different energies can be displayed or plotted to produce a γ ray energy spectrum that provides detailed information on the measured material.

One example of NDA equipment used routinely by the IAEA is the miniature multichannel analyzer (MMCA) that is a miniaturized spectrometry system that supports all detectors used by the IAEA, including NaI, CdZnTe and HPGe detectors. The MMCA paired with a NaI detector (MMCN) is often used to verify the enrichment of uranium in pure, homogeneous powders and pellets. The enrichment is derived from the intensity of γ rays attributed to ^{235}U (e.g. γ ray at 186 keV). Under a well-defined geometry, the measured count rate of the 186 keV photons is proportional to the ^{235}U abundance. The 'infinite thickness' approximation to the 186 keV γ rays is required for such an approach, and in practice it is achieved with rather thin samples (3 mm for uranium metal, 5 mm for uranium dioxide (UO_2) pellets and 27.5 mm for UO_2 powders). The standardized procedure controls the geometry and utilizes specially designed support stands with collimators to provide a quantitative assessment of enrichment within minutes.

The HM-5 field spectrometer (HM-5) is a battery-powered, hand-held, digital, low resolution γ spectrometer. This lightweight, easy to operate device is regularly used by safeguards inspectors. It combines various functions such as dose rate measurement, source search, isotope identification, active length determination for fuel rods and assemblies, determination of the enrichment of non-irradiated uranium materials, and plutonium/uranium attribute verification.



HM-5 spectrometer used for measuring the active length of a fuel assembly.

Photo credit: IAEA imagebank

The basic HM-5 modular design includes a NaI detector. For special applications the NaI detector can be replaced with a more stable, higher resolution CdZnTe detector. Up to 50 γ spectra, each with 1024 channels, can be stored in the non-volatile memory of the HM-5 and later transferred to a computer for further processing or plotting. With such versatility, the HM-5 is used for traditional safeguards inspections and for investigations during complementary access performed under additional protocol provisions.

The commercial development of the electrically cooled germanium system (ECGS) in recent years extends the application of high-resolution gamma spectroscopy (HRGS). The predecessor of the ECGS consists of a germanium detector; a multichannel analyzer, computer and liquid nitrogen based cooling system. This configuration has limited mobility, takes a long time to set up (owing to the time required to cool the crystal) and relies on a continuous supply of liquid nitrogen. The ECGS integrates all the aforementioned components into a hand-held, battery-powered system which is electrically cooled (and thus does not require liquid nitrogen). Existing HRGS systems — such as those used for UF_6 cylinder assay, cascade header pipe uranium enrichment assay and complementary access kits — are being be upgraded with this new technology.

An electrically cooled germanium system used to verify the enrichment of UF_6.

Photo credit: IAEA imagebank

5.1.2.2.2 NEUTRON COUNTING

The IAEA uses several different types of neutron counting equipment. This section gives information on the source of the neutrons and on the importance of neutron coincidence counting to obtain the mass of fissile material in the measured sample, as well as a few examples of passive and active detector systems.

Neutron emission and detection in non-irradiated fissile fuel: Neutrons are emitted from non-irradiated nuclear fuel primarily in three ways:

(1) Spontaneous fission of uranium and plutonium, mainly in the even isotopes of plutonium;

(2) Induced fission from fissile isotopes of uranium and plutonium by neutrons from other sources (including external sources);

(3) Alpha particle induced reactions (α,n) involving light elements such as oxygen and fluorine.

High-level neutron coincidence counter, HLNC, used to measure plutonium mass in combination with a determination of Pu isotopes.

Photo credit: IAEA

Fission neutrons in the first two categories are emitted in numbers ranging from 0 to 10 per fission event. The goal of neutron coincidence counting is to distinguish the neutrons emitted from a single fission event from neutrons created from other processes, including other secondary fission events detected with a uniform time distribution. Nearly all the isotopes of uranium, plutonium and other transuranic elements emit α particles. These interact with light elements present in compounds (e.g. oxides and fluorides) or as impurities (e.g. boron, beryllium and lithium) to form an undesirable neutron background; neutron coincidence counting discriminates against this (α,n) background. This is done by keeping track of the time of neutron detection. Neutrons from the same fission event are detected relatively close to each other in time, whereas neutrons from non-fission processes are randomly distributed in time.

Passive coincidence detector systems determine the mass of plutonium based on spontaneous fission, primarily in the even numbered isotopes (^{238}Pu, ^{240}Pu and ^{242}Pu, with ^{240}Pu being the dominant contributor). The major fissile isotope, ^{239}Pu, has a typical abundance in fuel of 60% or higher, yet it makes an insignificant contribution to the spontaneous fission neutron signal. Isotopic abundance must be known or verified, typically by means of a high resolution γ ray measurement. Using the isotopic abundance, the ^{240}Pu effective mass determined from coincident neutron count rates can be converted into the total plutonium mass of the sample. For uncontaminated, well-characterized samples, measurement accuracy can be of the order of 1% or less.

The fissile isotope ^{235}U does not undergo sufficient spontaneous fission for practical passive detection. In this case, an active system incorporating neutron sources, typically americium–lithium (AmLi) is used to 'interrogate' (induce fission in) the ^{235}U content through neutron-induced fission. For low energy incident neutrons, induced fission in the ^{238}U of a sample contributes insignificantly to the measured coincident neutron count rate, even though ^{235}U may be enriched to only a few percent (e.g. low enrichment fuels).

In general, neutron detectors employ various neutron capture reactions to generate pulses. Helium-3 gas detectors are the most commonly used neutron detectors in safeguards. The detection principle is based on the ^{3}He (n,p)^{3}H reaction. This reaction produces a proton and a triton which share the recoil energy of 764 keV that ionizes the surrounding gas and generates an electronic signal. The neutron absorption cross-section decreases with orders of magnitude as the neutron energy increases; hence moderation of neutrons is essential to achieving a reasonable detection efficiency of the counting system. This is typically achieved by embedding the detectors in hydrogenous materials such as polyethylene. The less commonly used boron trifluoride (BF_3) detectors are based on the $^{10}B(n,\alpha)^{7}Li$ reaction. Boron trifluoride detectors are less sensitive to γ radiation fields but are intrinsically less efficient. Recently, solid-state neutron radiation devices with boron carbide (B_4C) diodes have been developed which demonstrate very promising potential for future applications such as miniaturized hand-held neutron detection devices.

Fission chambers have a thin layer of ^{235}U plated on the inner wall of a gas filled chamber. Neutrons will cause fission of ^{235}U, producing high-energy fission fragments (~90 MeV/fragment). The fission fragments cause ionization in the stopping gas, which is then transformed into an electronic signal. Because of the large quantity of energy deposited by the fission fragments, fission chambers have the highest insensitivity to γ rays (roughly 10^4 Gy/h) of any of the available neutron detectors. They are the only neutron detectors capable of measuring highly active spent fuel.

5.1.2.2.3 SPENT FUEL MEASUREMENTS

A Fork detector measuring a spent fuel assembly at a reactor pond.

Photo credit: IAEA

Spontaneous fission in the ^{242}Cm and ^{244}Cm isotopes is the major source of neutrons emanating from spent fuel. These isotopes are produced through multiple neutron capture events when a fuel assembly is exposed to high neutron fluxes in a nuclear reactor. Fission products in the irradiated fuel produce an extremely high radiation background in which the neutrons must be detected. The high radiation environment influences the types of technique that can be deployed for spent fuel verification. One approach is to choose a detector which is basically insensitive to γ rays. Another approach is to shield against the γ rays while allowing neutrons to pass through the shield into the neutron detector. Spent fuel verification methods include not only neutron detection but also γ ray and ultraviolet light (Cerenkov radiation) detection.

The 662 keV γ ray line from ^{137}Cs generally dominates a spectrum for spent fuel that has cooled longer than two years and provides a useful signature for verifying the spent fuel. For shorter cooling times, the 757/766 keV line from $^{95}Nb/^{95}Zr$ is used to verify the presence of spent fuel.

The Fork Detector Irradiated Fuel Measurement System (FDET) incorporates both neutron and γ ray detectors for gross defect verification of fuel assembly characteristics such as irradiation history, initial fuel content and number of reactor cycles of exposure. The FDET measuring system includes the detector head, a several meter long extension pipe, a miniature gamma ray and neutron detector (MiniGRAND) electronics unit and a portable computer. Separate detector heads are used to measure boiling water reactor (BWR) and pressurized water reactor (PWR) type fuels. The detector head incorporates γ ray insensitive neutron detectors (four gas filled fission chamber proportional counters) and γ ray detectors suitable for measuring extremely high γ ray intensities (two gas filled ionization chambers). The neutron and γ ray signatures measured by the detectors are used to verify the highly radioactive spent fuel assemblies stored under water in spent fuel ponds. The FDET is usually installed on the guard rail of the spent fuel pond bridge or near the pond edge. To perform a measurement, the irradiated fuel assembly is lifted by the operator's crane and moved into position between the tines of the fork detector. Interactive software guides the user through the measurement procedure and simultaneously collects neutron and γ ray data. The software can also support unattended measurements. The ratio of the neutron to γ ray data, when combined with other, complementary information, is used to characterize a particular type of fuel assembly, giving information related to its neutron exposure in the reactor, its initial fissile fuel content and its irradiation history (e.g. the number of cycles for which the assembly was in the reactor). Other detector systems are available to measure the γ ray energy spectra from irradiated fuel (spent fuel attribute tester (SFAT) and irradiated fuel attribute tester (IRAT)) and the γ ray intensity as a function of fuel bundle storage position (CANDU bundle verifier (CBVB)). Cerenkov glow viewing devices (improved Cerenkov viewing device (ICVD) and digital Cerenkov viewing device (DCVD)) examine the ultraviolet light that appears in the water surrounding spent fuel pins. The improved Cerenkov viewing device (ICVD) and the digital Cerenkov viewing device (DCVD) are image intensifier viewing devices that are sensitive to ultraviolet radiation in the water surrounding spent fuel assemblies. The hand-held ICVD is the instrument most commonly used by safeguards inspectors to obtain qualitative confirmation (attribute testing) of the presence of spent fuel in storage pools. The viewing device is capable of operating with facility lights turned on in the spent fuel pond area. The ICVD is optimized for ultraviolet radiation by filtering away most of the visible light and by having an image intensifier tube primarily sensitive to the ultraviolet light frequencies. Cerenkov radiation is derived from the intense γ radiation emanating from spent fuel, which, when absorbed in the water, produces high energy recoil electrons. In many cases these electrons exceed the speed of light in water (which is slower than the speed of light in a vacuum) and therefore must lose energy by emitting radiation (Cerenkov radiation). Spent fuel also emits β particles (which are also energetic electrons), adding to the Cerenkov radiation. Spent fuel assemblies are characterized by Cerenkov glow patterns that are bright in the regions immediately adjacent to the fuel rods. The variation in light intensity is apparent when viewed from a position aligned directly above the fuel rods. With careful alignment and appropriate assessment of the object being viewed, an

Inspectors at a bridge over a spent fuel pond verifying fuel assemblies with the ICVD.

Photo credit: IAEA imagebank

irradiated fuel assembly can be distinguished from a non-fuel item that may look the same to the naked eye. Typically, a row of fuel assemblies is viewed vertically from the bridge while the facility operator slowly runs the bridge down the row. One inspector views the items in the row through the ICVD and verbally declares inspector compares the observed results with the facility declarations. The DCVD is used to verify assemblies with long cooling times and/or low burnups, which have weak Cerenkov signals that cannot be seen with a standard ICVD. Apart from its higher sensitivity, the DCVD can record and document individual scans for subsequent re-analysis. It has the potential to quantify the Cerenkov glow from spent fuel assemblies as a function of irradiation history and cooling time.

5.1.2.2.4 OTHER MEASUREMENTS

There is a number of other verification techniques used by the IAEA at different facilities and for different situations. Some of them use radiation measurements while others measure the physical characteristics of nuclear material. An example of this is the Hybrid K-edge densitometry (HKED) which is a technique used for measuring the concentration of uranium and plutonium in mixed solutions by combining X Ray Fluorescence Analysis (XRFA) and K-edge densitometry. Depending on the concentration of plutonium and uranium, the higher element concentration is identified by K-edge measurement and the lower concentration from the ratio of plutonium to uranium of the XRFA. HKED is also used to determine neptunium in the presence of fission products.

The combined procedure for uranium concentration and enrichment assay, COMPUCEA (CMPU), is a transportable system used to perform accurate on-site analytical measurements of elemental assay and enrichment of liquid, non-irradiated uranium samples. Solid uranium samples require preparation by quantitative dissolution of the sample. The technique combines absorption edge spectrometry to establish the uranium concentration (the L-edge for uranium is at 17.17 keV) and a ^{235}U enrichment spectrometer with a $LaBr_3$ detector. The L-edge technique uses a small X ray generator of low energy and an ultra-high resolution silicon γ detector operated under modest Peltier cooling.

Load cell based weighing system with a capacity of 5000 Kg.

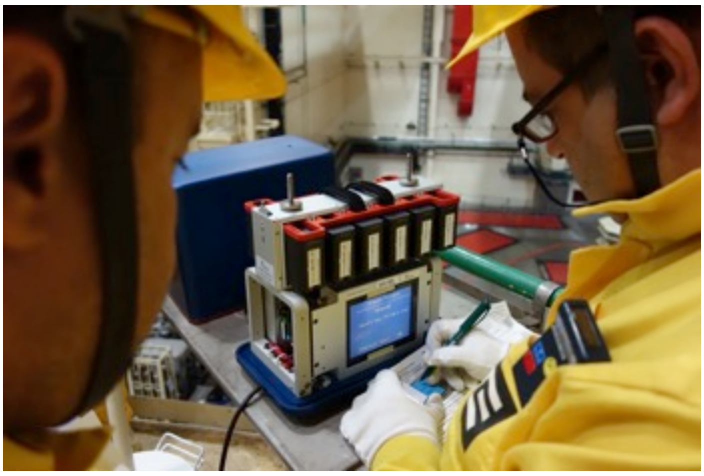
Photo credit: IAEA

The IAEA also uses equipment to measure such quantities as the weight of an object (LCBS), the wall thickness of a container (ULTG), physical sizes (3DLR), electromagnetic reflections (GPRT) and the liquid level in a tank (PPMD).

The load cell based weighing system (LCBS) operates in two load ranges of up to 5000 and 20 000 kg and provides a convenient and rapid means of determining the gross weight of bulky, massive objects such as UF_6 shipping cylinders. The load cell construction includes two shackles separated by a load-supporting element that is bonded to a strain gauge. When a load is lifted with the hoist, the strain gauge deforms, changing its electrical resistance. The resistance change is converted into a weight displayed on a digital readout unit that is attached through a cable to the load cell. Typically, gross weights are determined with this system to accuracies better than 0.1%.

The ultrasonic thickness gauge (ULTG) is a small hand-held device with a digital readout that measures the wall thickness of an object based on the round trip flight time of ultrasonic waves that are reflected from the inner wall. The thickness information is sometimes needed to adjust for radiation attenuation in walls of containers such as UF 6 shipping containers, UO_2 hoppers and UO_2 cans. These corrections are particularly important when container wall thicknesses vary. Using the ULTG standard probe, the typical measurement range for steel extends from 1.2 to 200 mm. The ULTG cannot determine multiple layers and measures only the outer layer. Silicone grease is used as a couplant and eliminates any air between the sensor and measurement surfaces. In the standard mode of operation, the speed of the ultrasonic waves in a particular medium is stored in the memory of the ULTG, so that the flight time can be internally converted directly into a wall thickness and displayed on the readout.

5.1.2.3 CONTAINMENT & SURVEILLANCE, UNATTENDED MONITORING SYSTEMS[54]



The All-in One- Surveillance Portable System being serviced at an inspection

Photo credit: IAEA imagebank

The IAEA makes extensive use of containment and surveillance techniques to indicate that material was neither introduced into nor removed from a container or a location under safeguards. This provides the Agency continuity of knowledge on nuclear material it has verified and confirms that the facility under safeguards is operating as declared in its design information provided by the State. The traditional regime for verifying that an NDA instrument, a camera or a seal has not been tampered with requires that an inspector be able to visually inspect the instrument or camera housing, or the entire length of the seal cable.

Containment and surveillance (C/S) techniques, based mainly on optical surveillance and sealing systems, are applied to supplement nuclear material accountancy by providing means by which access to nuclear material can be controlled and any undeclared movement of nuclear material detected. The IAEA uses C/S techniques extensively because they are flexible and cost effective. They reduce inspection costs and the level of intrusiveness of the IAEA into normal operational activity of nuclear facilities under safeguards. Furthermore, C/S measures are applied in a systematic manner to monitor all diversion paths considered credible at the boundary of a facility, to

[54] Credit: "International Atomic Energy Agency, Safeguards Techniques and Equipment: 2011 Edition", International Nuclear Verification Series No .1, IAEA, Vienna (2011), reproduced with permission, op. cit.

ensure that transfers of nuclear material take place only at declared key measurement points. This application becomes increasingly important in large facilities where the IAEA's quantitative safeguards goals are difficult to realize exclusively through conventional nuclear material accountancy measures.

Optical surveillance is most effective in storage areas (such as spent fuel storage ponds) with relatively few activities that could be interpreted as involving the removal of nuclear material. A typical application consists of two or more cameras positioned to completely cover the storage area. The field of view of the cameras is such that any movement of objects that could involve the removal of nuclear material is easily identified. Optical surveillance is intrinsically an unattended operation that may be enhanced by the remote transmission of image data or system operation data (i.e. the status of the surveillance system).

A VACOSS seal being attached by an IAEA inspector to a reactor core lid

Photo Credit: IAEA Imagebank

Seals are typically applied to enclosures containing nuclear materials or protecting signals from IAEA Unattended Monitoring Systems (UMSs) or surveillance systems. Seals and their enclosures are designed to indicate tampering, to ensure that nuclear material has not been introduced into or removed from a container, or that data signals have not been tampered with. In addition to tamper indication, sealing systems must be authenticated by providing a unique identity. Most IAEA seals are applied for extended periods, often several months or years. Seals may be either single use (returned to Headquarters for verification) or verifiable in situ. If seals are verifiable in situ then the verification activity must limit radiation exposure of the inspector and be extremely reliable and robust. Seal verification activity consists of carefully examining an item's enclosure and the seal's integrity for any sign of tampering.

For added confidence in cases where nuclear material is difficult to access, credible diversion paths are often covered by two C/S devices which are functionally independent and are not subject to a common tampering or failure mode, for example, two different types of seal, seals plus surveillance, or surveillance using two types of equipment based on different techniques. Surveillance includes both human and instrument observation. Because it is prohibitively expensive to provide round-the-clock human surveillance, the IAEA has developed a range of optical surveillance systems that can provide effective, ongoing surveillance when no inspector is physically present on-site. Unattended optical surveillance techniques are used widely by the IAEA to support and complement nuclear material accountancy and to provide continuity of knowledge about nuclear materials and other items of safeguards significance between on-site inspection visits.

Optical surveillance is also used to identify items during unattended NDA measurements and indications of tampering on the instruments in use.

Effective surveillance is achieved when a camera's field of view covers the entire area of safeguards interest and is able to capture any movement of safeguarded items. Additionally, the picture-taking interval is set to record at least two images should the item be moved, so that its direction of movement can be determined. The image recording frequency may be set at a fixed time interval which is significantly shorter than the fastest removal time, or may be triggered by scene change detection or other external triggers.

Some of the IAEA's surveillance systems can also transfer data to IAEA Headquarters or to an IAEA regional office automatically.

The "next generation of surveillance systems" or NGSS[55] provides the complete surveillance infrastructure needed to make use of optical image and equipment state of health data to assist in the drawing of safeguards relevant conclusions. Visual evidence of events is recorded and processed in a front end camera and stored locally, or is forwarded to a data consolidator unit where data are stored and in turn forwarded via a remote monitoring connection (where allowed). At the back end, surveillance review software allows for the analysis of

The "Next Generation of Surveillance Systems", NGSS.

Photo credit: IAEA imagebank

[55] The NGSS is also known with the commercial name "Digital Camera Module DCM-C5"

image files with automatic data filtering and preprocessing, and provides tools to facilitate an efficient review by safeguards inspectors. The entire NGSS was designed for ease of use and maintenance, with a modular infrastructure that allows for simpler inventory management, uncomplicated (plug and play) exchange of faulty modules in the field and easier upgrading as new technologies become available.

The NGSS, which is scalable to any number of cameras, has advanced security features, low power consumption and solid-state storage media, and is highly reliable under harsh environmental conditions. All safeguards sensitive data and parts are protected inside an electronically sealed, tamper-indicating core module, which allows replacement and installation of parts by third parties without compromising data authenticity. The intrinsic sealing and the advanced data security provided by public key cryptography enable the NGSS to be easily used jointly with other inspectorates or States without additional security or authentication measures.

The NGSS can be configured as a single, all in one camera system or as a scalable multi-camera system with dedicated, rack mounted modules for each camera for data storage, data processing and power supply. Furthermore, the NGSS supports various trigger signals from other sensors or electronic seals, remote monitoring, high resolution and full color images, and picture taking rates as fast as one image per second. Another advantage is a choice of lenses, for example, a fisheye lens can be easily installed which will then provide greater than 180° coverage. A single NGSS camera can record up to four different fields of view simultaneously and can thus replace several traditional cameras in certain situations. The Agency has embarked in a next generation surveillance system (NGSS) replacement campaign, replacing a large number of old and obsolete DCM-14 cameras.

The SRA and the safeguards implementation officer and facility operator need to cooperate with the Agency to install and service C/S equipment, including the provision of mains and the layout of cables of surveillance equipment. The SRA should make arrangements to provide access to the C/S equipment installed at the facility to IAEA inspectors and technicians servicing or repairing IAEA equipment.

5.2 Complementary Access

A State with an AP in force is required to provide information to the IAEA on a regular basis. This information is evaluated by the IAEA and compared with all other information known about the State. The IAEA may confirm the information provided under an AP, as appropriate, during complementary access (e.g. through activities such as visual observation, collection of environmental samples, and utilization of radiation detection and measurement devices.) Visual observation permits the taking of photographs (digital or other) as part of that activity. The IAEA is required to give States advance notice for complementary access, in accordance with Article 4 of INFCIRC/540. In addition to locations associated with State declarations under an AP, complementary access may also be requested to any location in the State. An AP establishes requirements regarding the implementation of complementary access.

Complementary access refers to access provided to IAEA inspectors by a State under an AP, to enable the inspectors to carry out specific activities to meet the objectives of the access. The IAEA may request complementary access to a variety of locations in a State with an AP in force. The IAEA may request access to any location on a site; complementary access at sites is often conducted in conjunction with DIVs or inspections at facilities on or at the site. Complementary access is also used to confirm the continued decommissioned status of a facility or LOF. The IAEA may also request complementary access to locations at which activities take place which are declared pursuant to Article 2 of INFCIRC/540 by a State to the IAEA. Each type of access requested by the IAEA has specific advance notice requirements; in some cases the advance notice may be less than two hours. A summary of complementary access, activities and notifications can be found in point 5.3.1 below.

Access to any location in a State under such conditions requires effective coordination within the State, and as with inspections, the State has the right to accompany IAEA inspectors on complementary access, provided that such accompaniment does not impede or delay the access.

Under an AP, the IAEA may request complementary access to locations in the State in order to:

- Assure the absence of undeclared nuclear material and activities;
- Resolve a question or inconsistency relating to information provided by the State;
- Confirm the decommissioned status of a facility or location outside facility;
- Carry out location-specific environmental sampling; or
- Carry out activities at the request of the State pursuant to Article 8 of INFCIRC/540.

5.2.1 AP ADVANCE NOTICE OF ACCESS, MANAGED ACCESS

The additional protocol stipulates that the Agency shall give States an advance notice of access of at least 24 hours. However, for access to any place on a site that is sought in conjunction with design information verification visits or ad hoc or routine inspections on that site, the period of advance notice shall, if the Agency so requests, be at least two hours. In exceptional circumstances, it may be less than two hours.

Advance notice is given in writing to the SRA, typically by fax. The advance notice specifies the reasons for access, the activities to be carried out during such access and the names of the inspector or inspectors carrying out the complementary access activities. When the complementary access is performed in conjunction with a DIV, or an ad hoc or routine inspection the advance notice is typically delivered by hand by the inspector present at an MBA.

In the case of a question or inconsistency, the Agency shall provide the State with an opportunity to clarify and facilitate the resolution of the question or inconsistency. Such an opportunity will be provided before a request for access, unless the Agency considers that delay in access would prejudice the purpose for which the access is sought. In any event, the Agency shall not draw any conclusions about the question or inconsistency until the State has been provided with such an opportunity.

The AP stipulates that complementary access takes place only during regular working hours, unless agreed otherwise by the State and the IAEA.

Managed access refers to steps taken by the State to prevent the dissemination of proliferation-sensitive information, to meet safety or physical security requirements, or to protect proprietary or commercially sensitive information, in such a manner as to not impede the IAEA's activities to fulfill the purpose of the access. An example of managed access is the designation of routes through buildings which avoid areas where inspectors' safety is a concern but which allow inspectors to gain a thorough understanding of the function and purpose of the building. Ultimately, the State must provide sufficient access to information and locations during complementary access to allow the IAEA inspectors to fulfill the purpose of the access.

The tables below show, for complementary accesses, the locations, purposes, advance notice requirements and activities allowed to be performed.

Table 2. Summary of Complementary Access Activities

Location (where)	Declarations (what)	Purpose (why)	Advance notice (when)	Allowed activities	Statement
5.a.(i): Any place on a site	2.a.(iii): Description of buildings on site and site map.	4.a.(i): To assure the absence of undeclared nuclear material and activities	4.b.(i): at least 24 hours 4.b.(ii): at least 2 hours in conjunction with DIV/ ad hoc or routine inspection	See article 6.a.: • Visual observation • Environmental sampling • Use of radiation detection & measurement devices • Application of seals & other identifying & tamper-indicating devices • Other objective measures	10.a.
5.a.(ii): Location specified in 2.a.(v)-2.a.(viii)	2.a.(v): Uranium mine and concentration Plant 2.a.(vi): Source material 2.a.(vii): Exempted material 2.a.(viii): Change of location or further processing of intermediate or high-level waste	4.a.(i): To assure the absence of undeclared nuclear material and activities	4.b.(i): at least 24 hours	See article 6.b.: • Visual observation • Item counting • NDA & DA sampling • Use of radiation detection and measurement devices • Examination of records relevant to quantities, origin & placement • Environmental sampling • Other objective measures	10.a.
5.a.(iii): Decommissioned facility/LOF	Design information or other State declaration	4.a.(iii): To confirm the State's declaration of the decommissioned status	4.b.(i): at least 24 hours	See article 6.a.: • Visual observation • Environmental sampling • Use of radiation detection and measurement devices • Application of seals & other identifying & tamper-indicating devices • Other objective measures	10.a.
5.b: Location specified in 2.a.(i), 2.a.(iv), 2.a.(xi)(b), 2.b. (except those referred to in 5.a)	2.a.(i): Government funded fuel cycle R&D not involving nuclear material 2.a.(iv): Annex I (manufacturer) 2.a.(vi): Exempted material 2.a.(ix).(b): Annex II (import) 2.b.: Privately funded R&D not including nuclear material (enrichment, reprocessing, waste processing)	4.a.(ii): To resolve a question/ inconsistency	4.b.(i): at least 24 hours	See article 6.c.: • Visual observation • Environmental sampling • Use of radiation detection and measurement devices • Examination of production and shipping records • Other objective measures	10.a., 10.b.
5.c: Any location other than those referred to in 5.a and 5.b.	Location specified by IAEA	4.a.(ii): To resolve a question/ inconsistency	4.b.(i): at least 24 hours	See article 6.d.: • Environmental sampling In the event that environmental sampling analysis results do not resolve the question or inconsistency: • Visual observation • Use of radiation detection and measurement devices • Examination of production and shipping records • Other objective measures	10.a., 10.b.
8.: Additional location(s)	Specified by State (State offer pursuant to Article 8)	As appropriate	Upon offer by State (without delay)	Activities as agreed with the State	10.a.

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Source: IAEA Services Series No. 30, Safeguards Implementation Practices Guide on Facilitating IAEA Verification Activities, IAEA, Vienna, 2014

5.2.2 ADDITIONAL PROTOCOL ACTIVITIES

Inspectors perform activities as necessary to address the purposes of the complementary access. The kinds of activities inspectors may perform during the different types of access are described in Article 6 of INFCIRC/540. When implementing complementary access, the Agency may carry out the following activities:

a. For access in accordance with Article 5.a.(i) or (iii): visual observation; collection of environmental samples; utilization of radiation detection and measurement devices; application of seals and other identifying and tamper indicating devices specified in Subsidiary Arrangements; and other objective measures which have been demonstrated to be technically feasible and the use of which has been agreed by the Board of Governors and following consultations between the Agency and the State.

b. For access in accordance with Article 5.a.(ii): visual observation; item counting of nuclear material; nondestructive measurements and sampling; utilization of radiation detection and measurement devices; examination of records relevant to the quantities, origin and disposition of the material; collection of environmental samples; and other objective measures which have been demonstrated to be technically feasible and the use of which has been agreed by the Board and following consultations between the Agency and the State.

c. For access in accordance with Article 5.b.: visual observation; collection of environmental samples; utilization of radiation detection and measurement devices; examination of safeguards relevant production and shipping records; and other objective measures which have been demonstrated to be technically feasible and the use of which has been agreed by the Board and following consultations between the Agency and the State.

d. For access in accordance with Article 5.c.: collection of environmental samples and, in the event the results do not resolve the question or inconsistency at the location specified by the Agency pursuant to Article 5.c., utilization at that location of visual observation, radiation detection and measurement devices, and, as agreed by the State and the Agency, other objective measures.

5.3 IAEA STATEMENTS

Following an inspection, the IAEA provides the SRA, through the established official channels, with a statement describing the results of the inspection. This is called a 90(a) statement following the requirements of paragraph 90(a) of INFCIRC/153. IAEA provides the SRA with a report regarding the conclusions it has drawn for the MBA. This is called a 90(b) statement. Likewise, for States with an AP, the IAEA provides a 10(a) statement to the SRA describing activities carried out under the AP, no more than 60 days following the conduct of the activity. The results of activities carried out to address a question or inconsistency are provided to the SRA in a 10(b) statement as soon as possible but no more than 30 days after the results have been established.

Conclusions drawn from activities carried out under an AP are provided to the SRA in a 10(c) statement on an annual basis. The IAEA does not provide information directly to facility operators regarding inspections carried out at a facility. However, the SRA may wish to communicate the results of inspections and complementary access to facility operators, both to promote continuous improvement and to acknowledge high quality performance.

Each year, the IAEA summarizes and reports the results of safeguards implementation to the Board of Governors its Safeguards Implementation Report (SIR). The results are aligned with the three safeguards objectives common to all States with CSAs and are based on activities carried out under both CSAs and APs:

- to detect any diversion of declared nuclear material at declared facilities or locations outside facilities where nuclear material is customarily used (LOFs);
- to detect any undeclared production or processing of nuclear material at declared facilities or LOFs; and
- to detect any undeclared nuclear material or activities in the State as a whole.

6. Optimization of Safeguards

As explained in point 3.2, additional protocols provide the Agency with important additional authority that allows for broader access to information about the State's nuclear programme, increased physical access by the Agency and improved administrative arrangements. The implementation of an AP significantly increases the IAEA's ability to detect undeclared nuclear material and activities in States with CSAs. It is only for those States with both CSAs and APs in force that the Agency draws the broader conclusion that all nuclear material remains in peaceful activities in the State. For those States with CSAs but without APs, the Agency only draws the conclusion that declared nuclear material remains in peaceful activities, as the Agency does not have the legal tools available under an AP to enable it to provide credible assurance of the absence of undeclared nuclear material and activities. In the past, safeguards implementation was focused mainly on nuclear material and facilities declared by the State and was based on safeguards approaches for specific facility types. These approaches were based on safeguards criteria, which, among other rules, set out the frequency, scope and intensity of safeguards activities to be performed at declared facilities within a State.

The implementation of the strengthened safeguards measures provided the Agency with increased information about a State and added to the Agency's capability to consider the State in its entirety. The Agency reflected how this information could be used in the determination of safeguards activities, both in the field and at Headquarters and concluded that it was possible to maximize the effectiveness and efficiency of safeguards implementation for those States for which the broader conclusion had been drawn.

The conceptual basis for State evaluations results from the fact that a State's nuclear programme (past, present and future) involves an interrelated set of nuclear and nuclear-related activities that require, and/or are indicated by, the presence of certain equipment, a specific infrastructure, observable traces of nuclear material in the environment and a predictable use of nuclear material. The picture presented by these features provides the basis for an assessment of the internal consistency of the State's declarations to the Agency and of the consistency between the State's declarations and other information available to the Agency. A key methodology for evaluating the available, safeguards-relevant information about a State is based on a 'physical model' of the nuclear fuel cycle. The physical model identifies, describes and characterizes every known technical process for converting source material to weapon-usable material and identifies indicators for each process in terms of equipment, nuclear material and non-nuclear material.

Through an optimized combination of safeguards measures provided for under a State's CSA with those provided for under its AP, by taking into account State-specific factors and through the evaluation of all safeguards relevant information, the Agency was able to enhance the efficiency of safeguards implementation for such States without reducing its effectiveness. The implementation of safeguards in this manner was called "integrated safeguards".

6.1 Integrated Safeguards

The Agency implements integrated safeguards for States with the broader conclusion. Integrated safeguards have been defined in the IAEA Safeguards Glossary, as "the optimum combination of all safeguards measures available to the IAEA under comprehensive safeguards agreements and additional protocols to achieve maximum effectiveness and efficiency in meeting the IAEA's safeguards obligations within available resources. Integrated safeguards are implemented in a State only when the IAEA has drawn a conclusion of the absence of undeclared nuclear material and activities in that State. Under integrated safeguards, measures are applied at reduced levels at certain facilities, compared with the measures that would have been applied without this conclusion". The concepts of integrated safeguards were developed during the timeframe 1999 to 2001, implemented since 2001 and its application resulted in improvements to the efficiency of safeguards implementation. The IAEA Secretariat continued developing further its Safeguards implementation approaches and developed the State Level Concept (SLC).

6.2 The State Level Concept

In order to further optimize safeguards implementation in States with CSAs and APs in force and for which the Agency has drawn the broader conclusion, the State Level Concept is currently being applied by the Agency. The SLC was developed to draw sound safeguards conclusions and to increase confidence that States are complying with their safeguards commitments. The SLC refers to the general notion of implementing safeguards in a manner that considers a State's nuclear and nuclear related activities and capabilities as a whole within the scope of the state's safeguards agreement. In principle, the SLC is applicable to all States with safeguards agreements in force;

however, integrated safeguards have been implemented only for States with the broader conclusion. In any case, the safeguards agreement in force and, where applicable, its Additional Protocol, rule safeguards implementation at States.

The SLC describes safeguards implementation that takes into account systematic consideration and better use of State-specific factors.

Given the broader conclusion for these States, not all technical objectives for all plausible acquisition paths need to be addressed each year; instead, an annual implementation plan for each State identifies activities for selected technical objectives[56] for the particular acquisition paths of that State. For those technical objectives relating to the detection of the diversion of declared nuclear material and the detection of undeclared production or processing of nuclear material in declared facilities and LOFs, the determination of in-field verification effort is based on the attainment of technical objectives in accordance with their assessed priority. Emphasis is placed on those technical objectives and associated measures that address areas of greatest safeguards significance for the State as a whole (e.g. technical objectives associated with nuclear material in the State that can be directly used for a nuclear explosive device) while maintaining appropriate coverage of other technical objectives relevant to the State. To attain those technical objectives relating to the detection of undeclared nuclear material or activities in the State in its entirety, the IAEA applies the measures provided for in the CSA and AP, evaluates all safeguards relevant information about the State and, as necessary, seeks clarifications from the State. Generally, for these States, in-field verification effort is lower than that under the original State-level approaches for implementing integrated safeguards. This means that the implementation of SLAs in the context of integrated safeguards has resulted in further efficiencies and the further optimization of safeguards implementation. The IAEA Secretariat has stated that “the greatest opportunity for further optimizing safeguards implementation continues to be for States with CSAs and Aps and for which the Agency has drawn the broader conclusion”.

The State-level concept has recently been subject to discussions at the IAEA Board of

[56] Technical objectives are established for a State, through the conduct of acquisition or diversion path analysis, to guide the planning, conduct and evaluation of safeguards activities. The Agency seeks to attain the technical objectives in order to detect proscribed activities along a plausible acquisition or diversion path. The technical objectives support the Secretariat in addressing safeguards’ generic objectives.

Governors and General Conference which agreed that the SLC does not, and will not, entail the introduction of any additional rights or obligations on the part of either States or the Agency, nor does it involve any modification in the interpretation of existing rights and obligations. The IAEA Board of Governors also ratified that the SLC is applicable to all States, but strictly within the scope of each individual State's safeguards agreement(s). The SLC is not a substitute for the additional protocol and is not designed as a means for the Agency to obtain from a State without an additional protocol the information and access provided for in the additional protocol. The IAEA General Conference emphasized that the development and implementation of State-level approaches requires close consultation and coordination with the State and/or regional authority, and agreement by the State concerned on practical arrangements for effective implementation of all safeguards measures identified for use in the field if not already in place.

REFERENCES AND BIBLIOGRAPHY

- INTERNATIONAL ATOMIC ENERGY AGENCY, Treaty on the Non-Proliferation of Nuclear Weapons, INFCIRC/140, IAEA, Vienna (1970).
https://www.iaea.org/sites/default/files/publications/documents/infcircs/1970/infcirc140.pdf

- INTERNATIONAL ATOMIC ENERGY AGENCY, The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons, INFCIRC/153 (Corrected), IAEA, Vienna (1972).
https://www.iaea.org/Publications/Documents/Infcircs/Others/infcirc153.pdf

- INTERNATIONAL ATOMIC ENERGY AGENCY, Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards, INFCIRC/540 (Corrected), IAEA, Vienna (1998).
http://www.iaea.org/Publications/Documents/Infcircs/1997/infcirc540c.pdf

- INTERNATIONAL ATOMIC ENERGY AGENCY, Standard Text of a Protocol to an Agreement, GOV/INF/276/Annex B, IAEA, Vienna (1974).
https://www.jaea.go.jp/04/iscn/iscn_old/resource/New text SQP.pdf

- INTERNATIONAL ATOMIC ENERGY AGENCY, Model Text of Subsidiary Arrangements (General Part) to Comprehensive Safeguards Agreements, (1974).
https://www.iaea.org/file/2015/onlineversionsg-fm-1170-modelsubsidiaryarrangementcode1-9pdf

- INTERNATIONAL ATOMIC ENERGY AGENCY, Model Text of code 10 of Subsidiary arrangements
https://www.iaea.org/safeguards/documents/SG-FM-1171_--_Model_Subsidiary_Arrangement_Code_10_Fixed.pdf

- INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Statute, as amended up to 23 February 1989, IAEA, Vienna (2006).
http://www.iaea.org/About/statute.html

- INTERNATIONAL ATOMIC ENERGY AGENCY, Guidelines and Format for the Preparation of Declarations Pursuant to Articles 2 and 3 of the Model Protocol Additional to Safeguards Agreements, IAEA Services Series 11, IAEA, Vienna (2004).
http://www-pub.iaea.org/books/IAEABooks/7072/Guidelines-and-Format-for-Preparation-and-Submission-of-Declarations-Pursuant-to-Articles-2-and-3-of-the-Model-Protocol-Additional-to-Safeguards-Agreements

INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Material Accounting Handbook, Services Series 15, IAEA, Vienna (2008).
http://www-pub.iaea.org/books/IAEABooks/7828/Nuclear-Material-Accounting-Handbook
- INTERNATIONAL ATOMIC ENERGY AGENCY, Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols, Service Series 21 (updated) IAEA, Vienna (2014)
http://www-pub.iaea.org/books/IAEABooks/8842/Guidance-for-States-Implementing-Comprehensive-Safeguards-Agreements-and-Additional-Protocols
- INTERNATIONAL ATOMIC ENERGY AGENCY, Safeguards Implementation Guide for States with Small Quantities Protocols, Services Series 22, IAEA, Vienna (2013)
http://www-pub.iaea.org/books/IAEABooks/10493/Safeguards-Implementation-Guide-for-States-with-Small-Quantities-Protocols
- INTERNATIONAL ATOMIC ENERGY AGENCY, Safeguards Implementation Practices Guide on Facilitating IAEA Verification Activities, Services Series 30, IAEA, Vienna (2014)
http://www-pub.iaea.org/books/IAEABooks/10802/Safeguards-Implementation-Practices-Guide-on-Facilitating-IAEA-Verification-Activities
INTERNATIONAL ATOMIC ENERGY AGENCY, Safeguards Implementation Practices Guide on Establishing and Maintaining State Safeguards Infrastructure, Services Series 31, Vienna (2015)
http://www-pub.iaea.org/books/IAEABooks/10868/Safeguards-Implementation-Practices-Guide-on-Establishing-and-Maintaining-State-Safeguards-Infrastructure
INTERNATIONAL ATOMIC ENERGY AGENCY, Safeguards Implementation Practices Guide on Provision of Information to the IAEA, Services Series 33, Vienna (2016)
http://www-pub.iaea.org/books/iaeabooks/11083/Safeguards-Implementation-Practices-Guide-on-Provision-of-Information-to-the-IAEA
- INTERNATIONAL ATOMIC ENERGY AGENCY, Agreement on the Privileges and Immunities of the Agency, INFCIRC/9/Rev2, IAEA, Vienna (1967).
https://www.iaea.org/publications/documents/infcircs/agreement-privileges-and-immunities-agency
- INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safeguards Glossary, International Nuclear Verification Series No.3, IAEA, Vienna (2003).
http://www-pub.iaea.org/books/IAEABooks/6570/IAEA-Safeguards-Glossary-
- INTERNATIONAL ATOMIC ENERGY AGENCY, Handbook on Nuclear Law, STOIBER, C. et al., IAEA, Vienna (2003).

http://www-pub.iaea.org/books/IAEABooks/6807/Handbook-on-Nuclear-Law

- INTERNATIONAL ATOMIC ENERGY AGENCY, Handbook on Nuclear Law – Implementing Legislation, STOIBER, C. et al. IAEA, Vienna (2010).

http://www-pub.iaea.org/books/IAEABooks/8374/Handbook-on-Nuclear-Law-Implementing-Legislation

INTERNATIONAL ATOMIC ENERGY AGENCY, Safeguards Techniques and Equipment: 2011 Edition, International Nuclear Verification Series No. 1 (Rev. 2)

http://www-pub.iaea.org/books/IAEABooks/8695/Safeguards-Techniques-and-Equipment

ABBREVIATIONS

ABACC	The Brazilian-Argentine Agency for Accounting and Control
AP	Additional Protocol
BoG	Board of Governors
CSA	Comprehensive Safeguards Agreement
C/S	Containment and surveillance
DIQ	Design Information Questionnaire
DIV	Design Information Verification
EURATOM	European Atomic Energy Community
FA	Facility Attachment
IAEA	International Atomic Energy Agency
ICD	Inventory Change Document
ICR	Inventory Change Report
INFCIRC	Information Circular
KMP	key measurement point
LII	Itemized list of inventory items
LOF	Location Outside Facility
LWR	Light Water Reactor
MBA	Material Balance Area
MBP	Material Balance Period
MUF	Material unaccounted for
NDA	Non-destructive assay
NM	Nuclear material
NNWS	Non-Nuclear-Weapon States (party to the NPT)
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
PIL	Physical Inventory Listing
PIT	Physical Inventory Taking
PIV	Physical inventory verification
R&D	Research and Development
SIR	Safeguards Implementation Report
SLC	State level concept
SQ	Significant quantity
SQP	Small Quantities Protocol
SRA	State (or Regional) authority responsible for safeguards implementation
SSAC	State System of Accounting for and Control of Nuclear Material

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