Abstract

A system of international safeguards has been established to provide assurance that nuclear materials in civilian use are not diverted from their peaceful purpose. The safeguards system is administered by the International Atomic Energy Agency/Department of Safeguards and devolves from treaties and other international agreements. Inspectors from the Agency verify reports from States about nuclear facilities by audits, observation, and measurements.

1. THE MANDATE AND ITS FULFILMENT

1.1. The beginnings

In 1953 the USA proposed the establishment of an International Atomic Energy Agency (IAEA), which would spread the benefits of nuclear technology in return for an undertaking by each Member State (country) to use it only for peaceful purposes and to accept safeguards to verify this undertaking. After three years of negotiations this concept was eventually reflected in a crucial article (Article III.A.5) of the IAEA’s Statute which authorized it “to establish and administer safeguards designed to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request or under its supervision or control are not used in such a way as to further any military purpose; and to apply safeguards, at the request of the parties, to any bilateral or multilateral arrangement, or at the request of a State, to any of that State’s activities in the field of atomic energy”. The Statute came into force in 1957 and the IAEA began work, in Vienna, the same year.

Representatives of the Member States meet annually in a General Conference. The General Conference, among other responsibilities, elects members of the Board of Governors, which meets about four times per year and has the authority to carry out the functions of the Statute. The Board sets policy, which is implemented by the Secretariat (i.e. staff), headed by the Board-appointed Director General. The Secretariat is in turn composed of six Departments, each headed by a Deputy Director General, one of which is the Department of Safeguards.

From 1957 until 1964 little was done to activate the IAEA’s safeguards. By the end of that period all five permanent members of the UN Security Council, China, France, the USSR, the USA and the United Kingdom, had tested nuclear weapons. It was clear that neither strict controls on the transfer of technology nor safeguards applied by exporting countries had been effective in preventing the spread of nuclear weapons.

In 1965 the first major step was taken to develop systematically the IAEA’s safeguards by adopting a safeguards system to replace an earlier one which covered only reactors. This new system, which was extended in 1966 and 1968 (IAEA document INFCIRC/66/Rev. 2), is still applied in Safeguards Agreements with non-nuclear-weapon
States that have nuclear programmes and that have not expressly submitted all their nuclear activities to IAEA safeguards. States under such safeguards agreements are India, Pakistan, Israel and Cuba.

1.2. The treaty on the non-proliferation of nuclear weapons

Prolonged negotiations at the United Nations’ Eighteen Nation Disarmament Committee finally bore fruit in 1968 in an agreement on the text of a treaty designed explicitly to prevent the spread of nuclear weapons: the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The NPT was subsequently endorsed by the General Assembly and entered into force in March 1970. In May 1995, The Review and Extension Conference decided to extend the NPT indefinitely.

Each non-nuclear-weapon State that becomes party to the NPT undertakes not to acquire nuclear weapons or other nuclear explosives (Article II). It also undertakes to conclude an agreement with the IAEA for the application of safeguards to all its peaceful nuclear activities with a view to verifying the fulfillment of its obligations under the Treaty (Article III). In return the Treaty recognizes the right of all Parties to participate in the fullest possible exchange of equipment, materials, and scientific and technological information for the peaceful uses of nuclear energy; the Treaty also asserts that all Parties undertake to facilitate those rights (Article IV). The Parties also undertake to pursue negotiations in good faith towards nuclear disarmament (Article VI) and re-affirm their determination to achieve the discontinuance of all tests of nuclear weapons (Preamble); these commitments obviously apply principally to the nuclear-weapon States themselves, who alone, under the Treaty, may develop and test nuclear weapons.

Several of the concepts reflected in the NPT had already been incorporated into the regional Treaty for the Prohibition of Nuclear Weapons in Latin America, which the Latin American countries had negotiated and opened for signature in February 1967. This treaty is known as the Tlatelolco Treaty after the location in Mexico where it was concluded. A similar nuclear-free zone has been established in the South Pacific through the Rarotonga Treaty.

To carry out the safeguards obligations assigned to the IAEA by the NPT it, was clearly necessary for the IAEA to devise a safeguards system appropriate for the entire fuel cycle of the advanced industrial countries that were expected to become party to the Treaty. This NPT safeguards system, which was formulated in 1970 and approved by the IAEA Board of Governors the same year, is set forth in IAEA document INFCIRC/153 (corrected). This is in the form of suggested language for a bilateral agreement between a State and the IAEA for the application of safeguards in connection with the NPT.

The Safeguards Agreements which States party to the NPT have concluded with the IAEA follow very closely the wording of this document. They usually differ only in minor provisions not related to the scope and procedure of safeguards, e.g. the financing of safeguards, the obligation of the State to grant certain privileges and immunities to inspectors, and amendments to the agreement.

The implementation of safeguards which follow the NPT model (INFCIRC/153) is specified on the State level in Subsidiary Arrangements and associated Facility Attachments.

Subsidiary arrangements are a codified set of technical and administrative procedures designed primarily to implement the safeguards procedures laid down in safeguards agreements; they deal with matters such as design review, records requirements, reporting
requirements and inspections. They consist of a general part applicable to all nuclear activities of the country concerned and Facility Attachments, which contain specific procedures for each facility.

1.3. The assurance given by safeguards

Safeguards are essentially a technical means of verifying the fulfillment of political obligations undertaken by States in concluding international agreements relating to the peaceful uses of nuclear energy. Today most of these obligations flow from the NPT and similar treaties. The main political objective of safeguards is to assure the international community that States are complying with their non-proliferation and other peaceful use undertakings. By 31 December 1996, 179 States had signed the NPT. 214 safeguards agreements were in force with 131 States (and with Taiwan). The five nuclear-weapon States have made Voluntary Offers to place all or part of their nuclear facilities under safeguards. All five nuclear-weapon States have safeguards agreements under these voluntary offers in force, with IAEA safeguards applied at designated facilities. A complete list of the States and facilities under safeguards can be found in the IAEA Annual Report.

States conclude safeguards agreements voluntarily and the IAEA has no authority to apply safeguards unless the State concerned so requests since the State is obliged to do if it is a party to such legal instruments as the NPT, or Tlatelolco or Rarotonga Treaties. In view of the voluntary nature of this acceptance of safeguards, it is reasonable to expect that the normal results of applying safeguards will be to confirm that there has in fact not been any diversion. Confirmation that this is so results from independent verification by the IAEA inspectorate of declared nuclear material and facilities. The assurance obtained from the IAEA’s activities as an independent and objective auditor increases confidence between States.

The carrying out of safeguards activities is also aimed at dissuading any State that might contemplate diversion of nuclear materials or the misuse of nuclear facilities. It follows that, to constitute an effective deterrent, safeguards must be technically capable (and be seen to be capable) of promptly detecting a diversion.

The Agency’s safeguards activities thus have two effects:

1. they increase confidence between States that no nuclear material has been diverted to weapon purposes; and
2. they deter potential diverters by making it likely that diversion will be discovered and made public.

1.4. Strengthened IAEA safeguards

In 1991 the Board of Governors of the IAEA declared, on the basis of inspections carried out under the terms of United Nations Security Council Resolution 687, that Iraq had violated its NPT safeguards agreement with the IAEA by not declaring certain nuclear materials, activities, and facilities to the Agency. This has initiated a re-evaluation of the Agency’s safeguards system, with a view toward acquiring additional relevant information about undeclared nuclear activities and the means to check on them. Increased access to information about nuclear programmes and broader inspector access to sites within States are fundamental prerequisites for a strengthened safeguards system. To obtain this, was the main purpose of Programme 93+2 which in turn resulted in a Model Protocol (INFCIRC/540) to comprehensive safeguards agreements which was endorsed by the Board of Governors in May 1997.
Some other events which have influenced the development of an expanded safeguards system are, e.g.:

When South Africa concluded its Safeguards Agreement with the Agency in 1991, the Agency was confronted with the problem that major unsafeguarded facilities, including one plant for the production of highly enriched uranium, had been operated outside any kind of international control for many years.

In order to verify the completeness of the initial report, an IAEA team made a number of visits to South Africa to consult with officials and to examine historical accounting and operating records of both operating and closed-down facilities.

South Africa’s co-operation with the Agency has clearly shown the importance of transparency and increased inspector’s access as confidence-building measures in international safeguards.

The DPRK concluded a Safeguards Agreement with the Agency in January 1992 and submitted the initial report in May 1992. During the verification of the initial declaration in 1992, the Agency’s analyses of samples indicated inconsistencies that led the IAEA to conclude that more plutonium exists than the declared amount of a few grams.

For quite different circumstances, the cases just mentioned have brought home to everyone concerned the fact that verification of the initial inventory is not easy in States that had extensive nuclear programmes before concluding an NPT safeguards agreement.

1.5. Non-compliance

Detection of diversion must also be seen to entail effective penalties for the diverting country. The IAEA Statute specifies a number of formal sanctions against the breach of a Safeguards Agreement. They consist chiefly of an alert to the international community (the UN Security Council, the UN General Assembly, all IAEA members), curtailment of IAEA assistance, and suspension of the privileges and rights of IAEA membership.

2. SAFEGUARDS IMPLEMENTATION

The technical organization for verifying the political obligation not to use nuclear material for weapons, as described above, is the safeguards arm of the IAEA, particularly the Safeguards Department. The work of the Department of Safeguards has been designed to provide continuing assurance to the international community (Fig. 1) that any significant diversion would be promptly detected. At least equally important is that if, as has up to now always been the case, no diversion of safeguarded material has occurred, the IAEA should be able to provide assurance by verifying the correctness of the statements it has received from the State concerning its safeguarded nuclear material and facilities. The political value as well as the effectiveness of the IAEA’s safeguards work thus depends significantly on the way in which its detection capability is perceived by those States which expect the IAEA to provide assurance as well as by any State which might contemplate diversion and wished to know how much risk there is of being detected.

The challenge for the future is to ensure that all nuclear material and facilities subject to safeguards are declared so that they can be verified.

A schematic of the Agency’s system for safeguards implementation is shown in Fig. 2.
2.1. The technical objective of NPT safeguards

The technical objective of safeguards in agreements concluded under the NPT is defined in Article 28 of INFCIRC/153 as "the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other nuclear explosive devices or for purposes unknown and deterrence of such diversion by risk of early detection". In Safeguards Agreements concluded under the non-NPT system (INFCIRC/66/Rev. 2) there is no specific definition of technical objective but in practice today essentially the same concepts apply.

[Diagram: IAEA Safeguards Operations A B C]

NPT and Weapon States
Russia   France
United States   China
United Kingdom

*FIG. 1. IAEA safeguards operations.*

The definition given in Article 28 contains two expressions requiring quantification: 'significant quantities' of nuclear material and 'timely detection' of diversion.

For international safeguards the significant quantity is the approximate quantity of nuclear material which could possibly be used to manufacture a nuclear explosive device. It is of the order of magnitude of 8 kilograms of plutonium or 25 kilograms of highly enriched uranium.
Similarly, in the context of international safeguards timely detection can be related to the time required to convert diverted material into the components of a nuclear explosive device (namely, conversion time). The conversion time is of the order of weeks or months depending on the nature of the material concerned (see Table I).

NPT Safeguards Agreements require the State to establish and maintain a national system of accounting for and control of nuclear material (SSAC) within its territory, jurisdiction or control. In NPT States (and increasingly in others as well), the nuclear materials accountancy and verification carried out by the Agency are based on reports submitted by the SSAC as well as on records kept at facilities. It is the responsibility of the national authority to ensure that plant operators comply with the requirements of the Safeguards Agreement. These requirements include proper and accurate keeping of records, and timely and accurate reporting of stocks and transfers of nuclear material according to an agreed format. The national authorities are also responsible for ensuring that IAEA inspectors are granted all necessary access to facilities and material for accountancy verification. They also provide the support the inspectors require to discharge their duties effectively.
TABLE I. SIGNIFICANT QUANTITIES AND TIMELINESS GOALS

<table>
<thead>
<tr>
<th>Material category</th>
<th>Material type</th>
<th>Significant quantity</th>
<th>Timeliness goal</th>
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<tbody>
<tr>
<td>DIRECT USE MATERIAL</td>
<td>Plutonium * (separated) high enriched Uranium ≥20% Plutonium in spent fuel Uranium -233</td>
<td>8 Kg Pu 25 Kg U-235 8 Kg Pu 8 Kg U-233</td>
<td>1 month 1 month (UNIRR) 3 months (IRR) 3 months</td>
</tr>
<tr>
<td>INDIRECT USE MATERIAL</td>
<td>low enriched ** Uranium &lt;20% Thorium</td>
<td>75 Kg U-235 20 t Th</td>
<td>12 months 12 months</td>
</tr>
</tbody>
</table>

* for Pu containing less than 80% Pu-238
** including natural and depleted Uranium

2.2. Tools of the trade

Safeguards practices can be summarized in one word: verification. To verify means “to establish the truth of.” In safeguards, to verify is to establish the truth of declarations regarding the amounts, presence and use of nuclear material or other items subject to safeguards as recorded by facility operators and as reported by the State to the IAEA.

Accountancy, together with containment and surveillance, is the fundamental basis on which safeguards verification rests.

The verification process consists of three distinct stages:

(1) The examination of the information provided by the State in:
- design information describing installations under safeguards;
- accounting reports listing, primarily, nuclear material inventories, receipts and shipments;
- documents amplifying and clarifying reports; and
- advance notification of international transfers.

(2) The collection of information by the IAEA as a result of
- inspections for the verification of the design information;
- inspections to examine local records and reports, to measure the nuclear material, and to examine the results provided by containment and surveillance devices; and
- special inspections in case of unusual findings.

(3) The evaluation of the information provided by the State and of that collected by inspectors to determine the completeness, accuracy and validity of the information provided by the State, and to resolve any anomalies and discrepancies.

After the three stages of verification have been completed, statements are provided by the IAEA to the States recording the results of safeguards activities in the State concerned.
2.2.1. Nuclear material accountancy

It is the purpose of nuclear material accountancy to establish the quantities of nuclear material present within defined areas and the changes in these quantities that take place within defined periods of time. The essential steps in such accounting are as follows:

- the nuclear-facility operator identifies and counts or measures the material in the area concerned;
- the operator keeps records of all transactions involving this material;
- the operator prepares accounting reports on these transactions and on nuclear material inventories, and submits these reports via the State to the IAEA;
- the IAEA verifies and analyses the data in these reports to determine their correctness and to estimate the amount of any material unaccounted for and evaluate the causes of any such material unaccounted for.

To make these tasks more manageable, material balance areas (MBAs) are established in nuclear installations. These MBAs are areas into and out of which all transfers can be verified and in which physical inventories can be taken to establish a nuclear material balance. The MBAs are agreed between States and the IAEA and are specified in the Facility Attachments of the Subsidiary Arrangements to the Safeguards Agreements. Within MBAs measurements are made at key measurement points (KMPs), which are locations where nuclear material may be measured for the determination of flow or inventory.

The measurement techniques applied are primarily neutron and gamma techniques, as performed by inspectors on site. Samples for destructive analyses may also be taken and shipped to the Agency's Safeguards Analytical Laboratory (SAL) in Seibersdorf close to Vienna.

2.2.2. Containment and surveillance

Containment and Surveillance measures take advantage of physical barriers such as walls, containers, tanks or pipes to restrict or control the movement of or access to nuclear material. Such measures help to reduce the probability that undetected movements of nuclear material or equipment can take place.

Containment measures may involve the application of devices such as uniquely identifiable tamper-indicating seals to ensure that any access to the sealed inventory would be detected.

Surveillance means both human and instrumental observation in order to verify declared movements of nuclear material and detect and deter undeclared movements of nuclear material. Surveillance shall detect tampering with containment, fabrication of false information or tampering with safeguards devices. Surveillance may involve the use of tamper-resistant automatic cameras or other devices to monitor changes in containment or to observe inventory changes. Personnel may carry out the same tasks by manning key observation points continuously or periodically. Results from the surveillance systems are reviewed from time to time, e.g. every three months.

The IAEA containment and surveillance measures are designed in such a way as to minimize intrusion in the work of a nuclear facility operator.
2.2.3. Measures for strengthening safeguards

The undertakings and obligations described in document INFCIRC/153 (Corrected) are not limited to the nuclear material declared by the State and placed under Agency safeguards; they extend to all nuclear material which should be declared as required by the safeguards agreement.

Measures relating to the early provision of design information and to the voluntary reporting scheme have been implemented to the extent that States have accepted them. This implies that an increased access to information about nuclear programmes and broader inspector access to sites is essential for a strengthened safeguards system. This requirement is laid down in a Model Protocol (INFCIRC/540).

Environmental samples for the establishment of a baseline have been taken at a number of facilities in different countries.

3. TYPICAL INSPECTION ACTIVITIES

Table II describes the various steps involved in a safeguards inspection.

<table>
<thead>
<tr>
<th>TABLE II. INSPECTION ACTIVITIES</th>
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<tbody>
<tr>
<td>1. Follow-up on previous inspections.</td>
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<tr>
<td>2. Examination of accounting records.</td>
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<td>3. Examination of operating records.</td>
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<tr>
<td>4. Reconciliation of accounting records with operating records.</td>
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<tr>
<td>5. Comparison of records with reports.</td>
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<tr>
<td>7. Verification of inventory changes.</td>
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<tr>
<td>8. Verification of inventory.</td>
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<tr>
<td>9. Verification at strategic points other than key measurement points (KMPs) at strategic points for containment and surveillance (C/S) [flow within the material balance area].</td>
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<tr>
<td>10 Use of surveillance equipment.</td>
</tr>
<tr>
<td>11 Use of seals.</td>
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<tr>
<td>12 Verification of operator’s measurement system.</td>
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<tr>
<td>13 Evaluation of inventory differences and of accidental losses, retained waste and measured discards in excess of specified limits.</td>
</tr>
<tr>
<td>14 Other activities.</td>
</tr>
</tbody>
</table>
IAEA: Statute (last amended in 1989).

The Non-Proliferation Treaty, IAEA Document INFCIRC/140.


The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons, IAEA Document INFCIRC/153 (Corr.).


IAEA Safeguards: Glossary, IAEA/SG/INF/1 (Rev.1).

IAEA Safeguards: Guidelines for States’ Systems of Accounting for and Control of Nuclear Materials, IAEA/SG/INF/2.


IAEA Safeguards: Safeguards Techniques and Equipment, IAEA/SG/INF/5.


Model Protocol Additional to the Agreement(s) between States(s) and the International Atomic Energy Agency for the Application of Safeguards, IAEA Document INFCIRC/540.