Special reports

International transfers of nuclear material
An overview of the Agency's safeguards role and activities in this area
by Joseph Nardi

The development of the peaceful use of nuclear energy has led to increased international co-operation and to expansion of international transfers of nuclear material. States participating in co-operative activities conclude bilateral agreements, which contain the requirements on the exclusively peaceful use of transferred nuclear material and the application of IAEA safeguards.

Under safeguards agreements, it is incumbent upon the IAEA to establish and maintain an inventory of safeguarded nuclear material in the State that is based on the agreement's corresponding reporting requirements. (See accompanying box for an overview of the types of safeguards agreements.) The inventory changes over time, with the changes resulting from alterations in the material itself as a result of its use in the nuclear fuel cycle or because material was received in or shipped from the State.

This article describes IAEA safeguards activities and procedures associated with the international transfers of nuclear material, presents the results of Agency efforts in this area, and indicates areas that the IAEA has under investigation to further improve system operations and procedures as they pertain to international transfers of nuclear material.

The Agency's main safeguards goal in this area is to verify the amounts that a State reports it has transferred at a particular time to another State. Agreements between the IAEA and States provide for certain reporting requirements and inspection activities in order to enable the Agency to carry out this task. The inspection activities usually are performed at shipping and receiving areas. Nuclear material that leaves a shipping area and has not yet arrived at a receiving area is considered as material in transit. The States concerned establish necessary arrangements, related to the transfer point, for

Overview of safeguards agreements

Safeguards is a statutory function of the IAEA. Article III. A.5. of the IAEA Statute authorizes the Agency "... to establish and administer safeguards designed to ensure that special fissionable and other materials, ... 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 Agency's safeguards system was first set forth in INFCIRC/26 in 1961. Subsequent developments took place and the system today is documented in INFCIRC/66/Rev. 2, dated 16 September 1968, which is known as the safeguards document.

Upon endorsement by the United Nations General Assembly and entry into force on 5 March 1970 of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), the IAEA assumed further responsibility in the field of safeguards to act as the international body which would negotiate and conclude agreements with non-nuclear-weapon States party to the NPT "... 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 explosives devices".

To specify its safeguards obligations in connection with the NPT, it was clearly necessary for the IAEA to have a model for safeguards agreements with States party to the Treaty. This model for NPT safeguards agreements, approved by the IAEA Board of Governors in February 1972, is set forth in INFCIRC/153 (corrected), which is 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.
nuclear material ownership and responsibilities, as well as physical protection measures to be implemented for nuclear material in transit.

**Reporting requirements**

Under agreements concluded in accordance with the safeguards document known as INFCIRC/66/Rev.2, provision is made for the State to submit reports to the Agency with respect to safeguarded nuclear material. For that purpose the State and the IAEA agree on the system of reports with respect to each facility.

In general, specific agreements pursuant to INFCIRC/66/Rev.2 provide for two kinds of reports that indicate the movement of safeguarded material through international transfers. Accounting reports show amounts of safeguarded nuclear material received in and transferred out of facilities. This report also shows the nuclear and chemical composition and the physical form of the material. The frequency of reports varies with each agreement, ranging from monthly to twice yearly. In addition, each agreement normally provides for advance notification of specific shipments and receipts. Notification may be either unilateral or together with the State involved in the transfer. In the case of unilateral notifications, the States involved in the transaction notify the IAEA independently of another in a format of their choosing. For joint notifications, a reporting format defined by IAEA is used. It requires a standard form that must be signed by the shipper of the material and a copy countersigned by the receiver of the material which is then forwarded to the IAEA. This standard notification shows the shipping and receiving States, the date of shipment, the type, description, and amounts of material.

**Material balance concept**

Before discussing reporting requirements under other agreements, namely those pursuant to INFCIRC/153, it is first necessary to explain the material balance concept. For accounting purposes, material balance areas (MBA) are established in nuclear facilities. An MBA is an area into and out of which all transfers can be determined and in which a physical inventory can be taken to establish a nuclear material balance. The MBAs are agreed between the State and the IAEA and are recorded in “subsidiary arrangements” to the safeguards agreement. Thus, under such agreements all reports furnished to the IAEA are in respect of MBAs. (As of July 1986, 902 MBAs were defined in 819 nuclear facilities.)

Under these agreements, two types of reports are not only provided for but precise requirements are specified both in content and timeliness. First is the material balance report (MBR), which is a consolidated report showing a material balance including the results of a physical inventory of nuclear material present in the MBA. One component of the report is the consolidated amounts of material that are a result of international shipments or receipts. These amounts must be consistent with those reported in a second type of report — called an inventory change report (ICR) — for the same period covered by the MBR.

**The “batch” concept**

Mention also must be made here of another concept essential for accounting purposes under agreements pursuant to INFCIRC/153. This is the concept of “batch”, which is defined as a portion of nuclear material handled as a unit for accounting purposes and for which the composition and quantity are defined by a single set of specifications or measurements. Furthermore, each batch should be uniquely identified within an MBA. For each batch, the ICR must show the type of inventory change, of which international transfers is a particular type. Associated with each inventory change, the ICR must also specify, *inter alia*, the amount of material, the date of inventory change, and, in cases of transfers out of the MBA, the receiving MBA (if a transfer within the State) or the recipient State (for international transfers). The agreement calls for the report to 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. States having agreements pursuant to INFCIRC/153 also must provide the IAEA with advance notification of international transfers.

**Nuclear-weapon States**

Nuclear-weapon States are not required to enter into any safeguards agreements with the Agency similar to those of non-nuclear-weapon States. Realizing, however, that they themselves are involved as either a shipper or receiver in the majority of international transfers of nuclear material, nuclear-weapon States have decided that the IAEA should be provided with information concerning those transactions to assist its safeguards activities.* In general, the information provided to the IAEA is similar to that reported (by non-nuclear-weapon States) in notifications pursuant to INFCIRC/66 and in ICRs pursuant to INFCIRC/153.

In addition to this undertaking, nuclear-weapon States have also concluded voluntary-offer agreements with the IAEA, whereby an agreed-upon number of nuclear facilities in the civil sector are subject to safeguards application. In these cases, these facilities must report in the same fashion as facilities in non-nuclear-weapon States that report under agreements pursuant to INFCIRC/153, as described above.

**Inspection activities**

The purpose of the advance notification of an international transfer of nuclear material is to enable the IAEA, if necessary, to identify and, if possible, to verify the

* This undertaking by the nuclear-weapon States is documented in INFCIRC/207 and INFCIRC/207/Add.1 and is entitled Notification to the Agency of exports and imports of nuclear material.
quantity and composition of nuclear material subject to safeguards under an agreement before it is transferred out of or into a State. Upon receipt of an advance notification, the IAEA will, if necessary, send inspectors to the State concerned for the purpose of verifying nuclear material prepared for shipment and affixing a seal or seals to the shipping container or containers. Sealing is a safeguards procedure used by the IAEA to detect a possible diversion of nuclear material — for example, during a transfer or storage — by making it difficult to tamper with the container device without leaving signs that this has occurred.

Another activity carried out by IAEA inspectors in the normal course of inspections is a comparison of records and reports. Agreements pursuant to either INFCIRC/153 or INFCIRC/66 provide for certain records to be kept at nuclear facilities. It is from these records that the reports which are eventually forwarded to the IAEA are derived. During an inspection, IAEA inspectors ensure that supporting documents, such as shipping invoices, are correctly reflected in the facility records and that the State reports provided to the IAEA are consistent with these records.

Information treatment

In order to achieve the safeguards goal of verifying the information contained in the reports of a State concerning its international shipments, an internal IAEA system has been developed employing computerized and manual procedures. The term "transit matching" is used for procedures performed in the process of identifying which receivers’ reports match shippers’ reports that nuclear material has been transferred to another State.

Upon receipt of reports at IAEA headquarters in Vienna, they are loaded into the computerized safeguards database. These data are then checked for validity and consistency with relevant requirements. After this quality control process, an interrogation is made to identify which reports refer to international shipments. This list of shipments is recorded and the interrogation continues in an attempt to find a corresponding report from the country to which it has been indicated the shipment was made. When such a correspondence has been made, the shipment report in the computer database is marked as “matched”. In particular, this type of correspondence is called "machine matching". The criteria for machine matching of shipper and receiver reports demand critical exactness so that there is extremely small chance that the match is not correct.

This approach has been adopted because of the very large number of transactions reported to the IAEA. If computer results had to be checked thoroughly by manual processes, it would defeat the purpose for which the computer was being utilized. Those shipment reports for which a corresponding receiver report cannot be found are then treated in a manual process. Transactions that are confirmed by these means are said to be manually matched.

Periodically the IAEA reports its findings and results to Member States concerning the status of international transfers. The IAEA is required to report semi-annually to the State on the international transfers the State has made during the period and which are still in an unconfirmed (unmatched) status. In addition to this, on a quarterly basis the IAEA provides a Member State with an "import communication", if applicable, which is a listing of nuclear material transfers into the State that have been reported to the IAEA by another State as shipments. In effect, the import communication provided to a receiving State complements the semi-annual statement of unconfirmed shipments provided to the shipping State as prescribed in the safeguards agreements.

Experience to date

The IAEA safeguards database contains approximately 3.5 million records concerning the status, location, and movement of nuclear material in 54 States.

The table shows the number of international transfers since 1982 with respect to their matching status.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of international shipment records</th>
<th>Total matched</th>
<th>By machine</th>
<th>Manually</th>
<th>Unmatched*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>19 500</td>
<td>19 304 (99%)</td>
<td>2 595 (16%)</td>
<td>16 930 (84%)</td>
<td>296</td>
</tr>
<tr>
<td>1983</td>
<td>20 116</td>
<td>19 940 (98%)</td>
<td>5 242 (14%)</td>
<td>14 698 (72%)</td>
<td>176</td>
</tr>
<tr>
<td>1984</td>
<td>20 265</td>
<td>20 042 (99%)</td>
<td>5 474 (27%)</td>
<td>14 568 (73%)</td>
<td>253</td>
</tr>
<tr>
<td>1985</td>
<td>20 670</td>
<td>19 806 (97%)</td>
<td>4 416 (22%)</td>
<td>15 390 (71%)</td>
<td>1 864</td>
</tr>
<tr>
<td>1986*</td>
<td>3 533</td>
<td>3 663 (47%)</td>
<td>720 (43%)</td>
<td>943 (57%)</td>
<td>1 970</td>
</tr>
</tbody>
</table>

* As of end May 1986.

In general, more than one data record is needed to report all the nuclear material in a physical shipment. The table consolidates the 20 670 data records for shipments by States in 1985. It shows the actual number of physical shipments and the weight of nuclear material contained in those shipments.

<table>
<thead>
<tr>
<th>Number of shipments</th>
<th>Weight of material</th>
<th>Highly enriched uranium (&gt; 20%)</th>
<th>Low-enriched uranium (≤ 20%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irradiated</td>
<td>193</td>
<td>6007 kilograms</td>
<td>57 kilograms</td>
</tr>
<tr>
<td>Fresh</td>
<td>42</td>
<td>1051 kilograms</td>
<td>231 kilograms</td>
</tr>
</tbody>
</table>
These data date back to 1961 when the IAEA first began receiving reports required under the provisions of agreements pursuant to INFCIRC/26.

It is anticipated now that an incremental increase of approximately 50,000 records a year can be expected. Of the total data reported to the IAEA, about 1.75 million records report some type of inventory change. Data which pertain to international transfers account for about 9% of the inventory changes reported. (See accompanying figures.)

Based on data reports, it can be observed that international transfers have tended to stabilize since 1982. (See accompanying table.) Although some records for the period 1982 through the first three quarters of 1985 have not been matched, they report amounts of material that are considerably less than a significant quantity.* The number of records still in an unmatched status for the last part of 1985 and beginning of 1986 is generally a result of not having received the report of the recipient facility. This in turn is due to the physical transportation time for nuclear material in international transport and the permitted reporting time, which allows for up to 2 months after receipt of the material by a recipient. The Agency must assign priorities in pursuing these unmatched transfers and include follow-up by Agency inspectors where appropriate.

From the data, it can be observed that on average about 75% of all shipment records must be manually treated in order to achieve a matched status. An analysis of these manually matched records indicates one major reason why the computerized system fails to achieve a machine matching. As discussed previously, there are certain criteria which shipper and receiver reports must satisfy. One of these is that the batch identification declared in the shipper’s and receiver’s reports must be identical. In many cases the receiver either does not know the shipper’s batch identification or uses his own designation due to the requirements of his operation. In these cases, the Agency’s computer program cannot make the association between the two reports.

There are two important reasons why shipments remain unmatched even by the manual process. First, there is the case of non-reporting by the receiver. It is evident that if there are no records in the database reporting a receipt from the country to which a shipment has been made, a match is impossible. A reporting delay is a problem similar to non-reporting that temporarily increases the number of unmatched shipments at any given time.

The second reason for failure to achieve any match can be categorized in general terms as inconsistent and incomplete reporting. A simple example suffices to illustrate this category. Country A ships a quantity of material to country B. Country A in its report to the

* A significant quantity is the approximate quantity of nuclear material in respect of which, taking into account any conversion process involved, the possibility of manufacturing a nuclear explosive device cannot be excluded.
IAEA makes an error in the country code designation, reporting it as country X. Country B correctly reports a receipt of material from country A, but it uses a different batch identification. Machine matching obviously fails and until such time as the errors can be detected, the shipment remains unmatched.

Future prospects

The IAEA has initiated or is investigating specific actions to continue improving the process of machine or manual matching of international transfers. These have come about as a result of two consultants' meetings and the IAEA's own accumulation of experience.

A first consultants' meeting on international transfers was held during the last part of 1981. At that time, major emphasis was placed on establishing mechanisms to be agreed between States concerning batch identification with a view to improving the ability of the IAEA to conduct its transit matching operations in a more efficient manner. In 1984, a follow-up meeting was held to review the results of the recommendations of the 1981 meeting and provide further recommendations for the continuing improvement concerning the confirmation of international transfers.

As a result of this meeting, the IAEA has instituted certain procedures. In order to assist Member States in their direct contacts with one another concerning shipments, the IAEA now regularly provides a list of national authorities to be contacted for such purposes. Updates to the list are furnished to States as they are received by the Agency. Further, the IAEA has under consideration the provision to all Member States of all IAEA facility identification codes for installations under safeguards. (Currently the shipping State is only required to furnish the code for the country of destination of a shipment, which makes matching difficult.) Bilateral discussions have been established with several Member States and a group of States who account for a significant number of international transfers. It is anticipated that these discussions also will be established with several other States to cover almost all transfers.

Provisions have recently been incorporated into the IAEA internal system whereby shipments of small quantities, such that they are not of safeguards significance, are separately accounted for, thereby ensuring that shipments of significance are recognized and dealt with promptly. An example of such a small-quantity shipment is milligram samples of nuclear material.

As the computerization of safeguards data matures, the IAEA will investigate means to better integrate these data in the process with a view to establishing more efficient and timely confirmation of international shipments. Finally, an evaluation is in progress to incorporate acquired knowledge into tools, either for the purpose of more computer assistance to IAEA staff in their human matching efforts or in the development of a more sophisticated computerized system utilizing artificial intelligence.