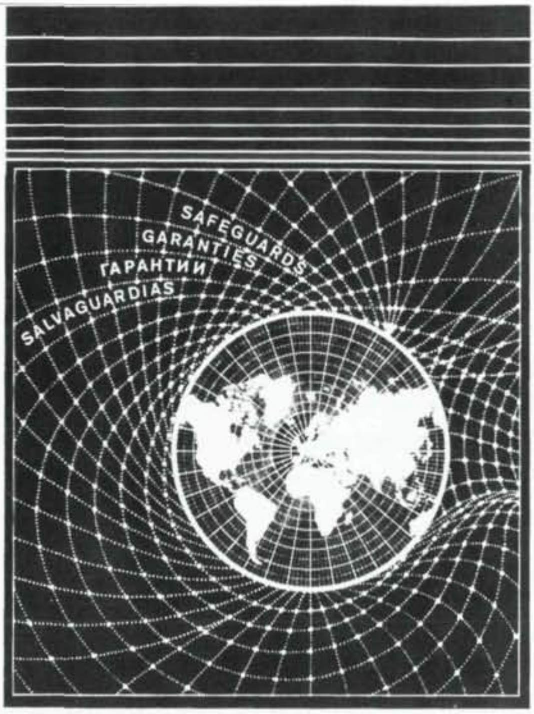
IAEA safeguards: Milestones in development & implementation

From the first in 1962 to more than 2000 inspections in 1986, the world's first international verification system has worked to strengthen the non-proliferation regime



by H. Grümm

The years after World War II saw intensive efforts — mainly through embargo measures related to nuclear material, equipment, and know-how — aimed at preventing the acquisition of nuclear weapons by more and more States. This "policy of denial" failed and the USSR and United Kingdom became nuclear-weapon States a few years after the United States. France was at that time well on the way to developing its own nuclear capability. It became clear that the know-how and the means to build nuclear weapons in the course of time would unavoidably come within the reach of any State having a reasonable industrial base and a political will to do so. Concern was that the delicate "balance of terror" might be upset and the risk of nuclear war increased by the emergence of new nuclear-weapon States.

This bleak outlook fortunately did not materialize. Since 1964, when China exploded its first nuclear weapon, no additional nuclear-weapon State has emerged in spite of vigorous development of nuclear technology by more than three dozen States.* This containment of "horizontal proliferation" has been due to intensive efforts of many States which shifted their non-proliferation policy from denial to co-operation. The change was initiated in 1953 by US President Eisenhower's programme, "Atoms for Peace". It proposed a liberal transfer of nuclear technology under the condition that receiving States undertake not to use this technology for any military purpose. To ensure that the receiver would adhere to this commitment, the programme foresaw verification arrangements: safeguards. In this context, the IAEA was founded in 1957 and entrusted with the dual task of promoting and at the same time of safeguarding the international development of nuclear energy.

Quantum leaps

Thirty years ago the USA had already begun to export nuclear technology, reserving in bilateral agreements the right to control the uses of the supplies by the receiving State. In the early 1960s, the USA slowly began to transfer its rights to apply safeguards to the IAEA. The example was soon followed by most other exporting countries. Thus the IAEA had to embark on an endeavour unprecedented in the history of international relations: to act as an impartial international auditor by sending inspectors to many countries to verify on their territory the legitimacy of activities in a field generally considered as sensitive. This was a political quantum leap changing the perception of unlimited national sovereignty — a consequence of the technical quantum leap in destructive power prompted by the discovery of nuclear energy.

In the beginning, the motivation of States to accept safeguards was perhaps dominated by the desire to participate in a new technology with unforeseeable prospects. Later on, the main motive became the understanding that it is in the very security interest of non-nuclear-weapon States to refrain from acquiring nuclear weapons. To encourage other States to follow suit and to allay any suspicion by others, they were prepared to submit their nuclear activities to verification.

Starting from scratch

The IAEA had to develop theory and practice of international safeguards from scratch. In 1958 a small division of safeguards was established. In 1959 it con-

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* In 1974 India exploded a nuclear device. The nuclear material used had not been under IAEA safeguards.

sisted of five professionals and two secretaries. It had no separate budget, no safeguards agreements in force or under negotiation, no inspectors, and no facilities to safeguard. As a first step it was necessary to get a clear understanding of the political purpose, the technical objective, and the verification procedures of the IAEA's unique new activity. It was only in 1961 that the Board of Governors of the IAEA approved a document (INFCIRC/26) which set forth various legal conditions for the application of safeguards. It covered only reactors up to 100 thermal megawatts and served as a basis for the first safeguards agreements. In 1962 the first inspection took place at a research reactor in Norway.

The early safeguards document had mainly assistance supplied by the IAEA in mind. This reflected concepts developed immediately after World War II when an international authority controlling all nuclear activities in the world was envisaged. However, in practice it turned out that most assistance was provided by advanced States on a bilateral basis. In 1965, INFCIRC/26 was replaced by a more elaborated document (INFCIRC/66), which was revised in 1966 and 1968. The latest version (INFCIRC/66/Rev.2) is still in use and covers all main facilities of the nuclear fuel cycle except enrichment plants. It describes the circumstances requiring safeguarding of nuclear and other materials, services, equipment, facilities, and information. It defines as the purpose of safeguards to ensure that the items covered are not used in such a way as to further any military purpose.* It also describes safeguards procedures, such as, for example, design review, audit of records and reports, as well as the purposes and intensity of inspections.

The Non-Proliferation Treaty

Most safeguards agreements concluded pursuant to INFCIRC/66/Rev.2 resulted from decisions to transfer to the IAEA the application of safeguards with respect to specific items described in earlier bilateral agreements. Safeguards of this kind are *inter alia* still applied in six States that operate nuclear facilities capable of producing nuclear weapons material and that are not yet prepared to submit all their nuclear activities to IAEA safeguards.

In the mid-1960s, while the IAEA gained more and more experience in the actual implementation of safeguards, industrially potent non-nuclear-weapon States made substantial progress in developing nuclear activities which did not depend exclusively on foreign supplies requiring safeguards. It thus became clear that more comprehensive safeguards were necessary that would cover all present and future peaceful nuclear activities of States.

The first treaty requiring such "full-scope safeguards" by the IAEA was the Treaty for the Prohibition of Nuclear Arms in Latin America (generally known as the Tlatelolco Treaty), which was opened for signature in 1967. Shortly thereafter, on 1 July 1968, the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) was opened for signature after endorsement by the General Assembly of the United Nations. It came into force in March 1970. The exclusive purpose of NPT-type safeguards, which were to cover all peaceful nuclear activities of the State concerned, consists in the verification that the State observes its undertaking not to divert nuclear material from peaceful uses to nuclear weapons or other nuclear explosive devices. As one of the most important international instruments in the domain of nuclear arms control, the NPT gave great impetus to IAEA safeguards and provided a framework for free nuclear trade and more liberal transfer of peaceful nuclear technology.

Formative years of safeguards

To carry out the obligations entrusted by the NPT to the IAEA, it was necessary to define a safeguards system adequate for the entire fuel cycle of the advanced industrial non-nuclear-weapon States that were expected to join the treaty. Such a system was drawn up during 1970 and approved by the Board of Governors in the same year. This system — in effect a model agreement — was set forth in document INFCIRC/153/Corrected.

A major task at that time was the translation of the document's stipulations into a manageable methodology. This could be based on the experience already gained under pre-NPT conditions. Nuclear material accountancy as a primary verification measure was systematized based on statistical considerations and the first instruments — stabilized assay meters — were introduced for non-destructive checks. Containment and surveillance as important complementary measures started with the application of seals on enclosures containing nuclear material and with the development of a tamper-resistant automatic camera system. It enabled surveillance of strategic points in the absence of inspectors.

A stumbling block in the development of a methodology was the need to translate the document's terms — for example, *significant quantity, timely detection,* and *risk of detection* — into quantities suitable for the definition of detection goals. This required a compromise between detection goals which seemed to be politically desirable on the one hand and technically attainable on the other. This task required several years of efforts accompanied by the advice of the Standing Advisory Group on Safeguards Implementation (SAGSI).

In 1975 the first conference to review progress made in implementation of the NPT met in Geneva and considered the experience gained in its operation. The conference expressed *inter alia* its strong support for effective

* Later on, the IAEA confirmed its understanding that the development of peaceful nuclear explosives had to be regarded as furthering such purposes.

IAEA safeguards and recommended that intensified efforts be made towards the standardization and the universality of its application.

Hectic expansion

After the first NPT conference a sharp increase in the number of reactors submitted to IAEA safeguards occurred. So did an increase in the number of complex and strategically important fuel cycle facilities, such as reprocessing plants and mixed oxide fuel fabrication plants. These facilities require special efforts in methodology and implementation of verification. The reason for the increases was the ratification in 1975 and 1976 of the NPT by Euratom and Japan, respectively. For a while, the expansion and training of new staff could not adequately follow the quick increase in the workload, and great efforts were necessary to cope with the situation.

The time from the first to the second NPT review conference in 1980 can be characterized as a time of rapid expansion of the verification task placed on the safeguards department. This expansion and the new types of facilities that had to be dealt with required adaptation and change of the methodology used, the implementation practice, and the department's organizational structure. Verification procedures were reviewed and the safeguards implementation practices (SIPs) that existed for individual facilities were replaced by standardized model approaches for each facility type. These approaches emerged from a systematic analysis of hypothetical diversion paths and design of corresponding detection measures. Efforts were also made to improve the field work of IAEA inspectors by applying standardized methods in nuclear material verification and the more extensive use of containment and surveillance measures.

During this expansion period, it was not only necessary within a short time to increase the number of inspection days in the field but to improve the quality of the verification work. To get an objective judgement on the level attained, the functions of the safeguards evaluation section as an internal auditor were strengthened. It critically reviewed the inspection reports and conclusions of the operations divisions. This also led to improved content and presentation of the annual Safeguards Implementation Report (SIR). A second measure to improve the quality of the implementation work was establishment of a training section to educate newcomers and to retrain staff on board.

Electronic reprocessing was also required to handle the documentation and intercomparison of the large amount of data contained in reports submitted by States and collected by inspectors. Up to the end of 1979, about one million data entries had been processed and stored in the Agency's computer. An early data processing system ("Release 2", developed during 1971-75) became inadequate for the increasing flood of incoming data and development of a new comprehensive safeguards information system (ISIS) was started.

Various types of equipment are used in safeguards training and field activities.

The expansion period was accompanied by an acceleration in the development of dedicated safeguards equipment — the equipment then available off-the-shelf proved inadequate. Active and generous support by several Member States helped the department to cope with this task. As a result, in 1980, improved multichannel analysers and neutron coincidence counters were ready for field tests. They were urgently needed for the determination of composition and amount of nuclear material. Twin-camera systems and simple closed-circuit TV systems were available for routine work; so were seals with improved tamper resistance. On the grounds of the Austrian Reactor Center in Seibersdorf, a Safeguards Analytical Laboratory (SAL) was established with the task of verifying, by advanced methods, the composition of samples of nuclear material taken in the field.

In March 1980, an exercise known as the International Fuel Cycle Evaluation (INFCE) came to an end. It started in 1977 following a decision of the USA to forego the extraction and use of plutonium in its fuel cycle and to change correspondingly its co-operation policy. INFCE found that there were no "technical fixes" to prevent the acquisition of special fissile material from fuel-cycle facilities. It recommended regarding proliferation chiefly as a political and security problem to be dealt with, above all, by improving and strengthening the international safeguards system.

At the second NPT review conference in 1980 in Geneva, differences arose between the developed States, These graphs help to illustrate the formative and growth years of the IAEA's safeguards system. In 1970 about 70 research reactors, 10 power reactors, 4 fuel fabrication plants, and 78 minor locations were under safeguards. They contained about 1 tonne plutonium, 3 tonnes high-enriched uranium, 300 tonnes low-enriched uranium, and over 1000 tonnes of source material. The safeguards department's staff numbered 70, among them 40 inspectors. During that year 172 inspections were made at 90 facilities in 22 States. To enable this remarkable activity, the department had to negotiate facility attachments, develop safeguards approaches, perform inspections, evaluate and report the inspection results and, last but not least, train staff for a new profession, that of an international inspector. The safeguard department's 1970 budget amounted to approximately US $1 million, about 10% of the IAEA budget.

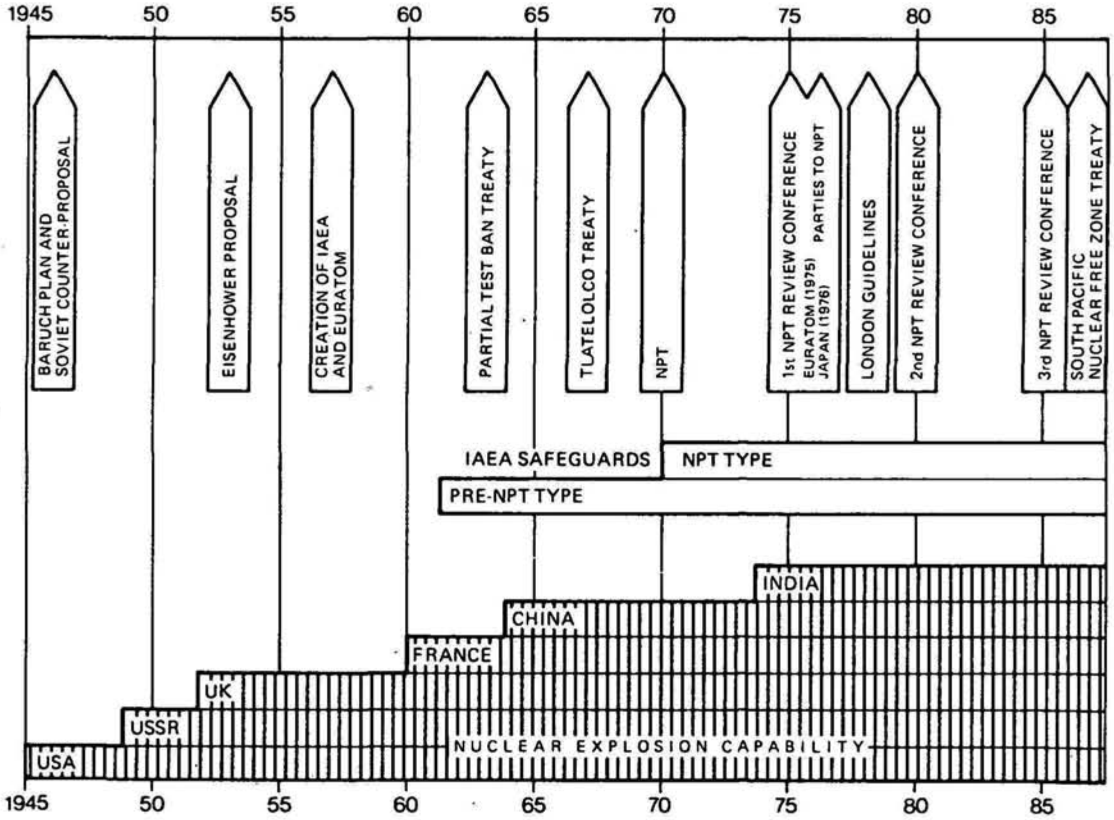
By the end of 1980, the number of nuclear installations to be inspected reached 410 facilities plus 307 less important locations, representing an increase of more than 470% over 1970. Forty-eight safeguards agreements were in force with non-nuclear-weapon States having significant nuclear activities. One nuclear-weapon State had voluntarily submitted facilities of its peaceful nuclear fuel cycle to IAEA safeguards. About 80 tonnes plutonium, 11 tonnes high-enriched uranium, 14 000 tonnes low-enriched uranium and 19 000 tonnes of source material were subject to safeguards. Of the department's 270 staff members, 120 were inspectors. Expenditures amounted to US $18 million, or about 24% of the IAEA's budget.

Six years later, at the end of 1986, there were safeguards agreements in force with 53 non-nuclear-weapon States having significant nuclear activities. Over 95% of the nuclear facilities in all non-nuclear-weapon States are now covered by IAEA safeguards. Most of the agreements are of NPT-type (full-scope). Among the 53 States, there are 11 in which the safeguards agreements do not cover all nuclear facilities, and six of these States are capable of producing special fissile materials.* Four of the five nuclear-weapon States (France, USSR, UK, and USA) have now concluded voluntary offer agreements with the IAEA covering nuclear material in some civilian installations. Negotiations with the fifth nuclear-weapon State (China) are under way. At the end of 1986, the number of nuclear installations under safeguards amounted to 485 facilities and 414 other locations. They contain 158 tonnes plutonium, 13 tonnes high-enriched uranium, 22 000 tonnes low-enriched uranium and 33 000 tonnes of source material. The staff of the department had increased to about 440, among them 190 inspectors. Department expenditures were US $38 million, or 35% of the Agency's total.** During 1986 the inspectors performed 2050 inspections in 53 non-nuclear-weapon States and four nuclear-weapon States. In 36% of the inspections, nuclear material was verified by non-destructive assay. More than 325 automatic photo and TV surveillance systems operated in the field and over 10 000 seals applied to nuclear material were detached and subsequently verified at headquarters. Over 1000 plutonium and uranium samples were analysed. Accountancy and other safeguards data comprising 870 000 data entries were processed and stored in the Agency's computer.

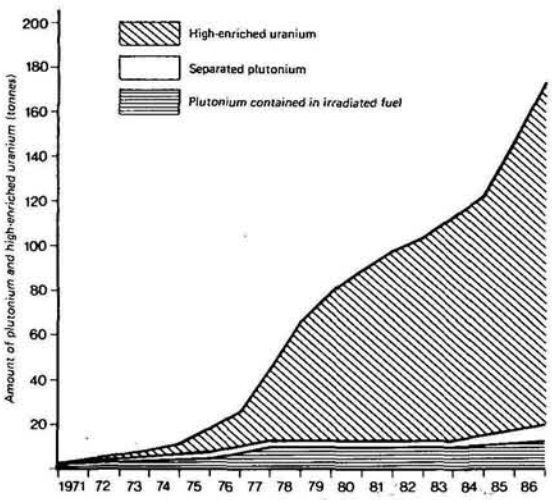
* It is disturbing that the number and importance of unsafeguarded nuclear facilities in these countries is growing.

** In contrast, world military expenditures in 1980 amounted to US $567 billion, based on data from the Swedish International Peace Research Institute (SIPRI).

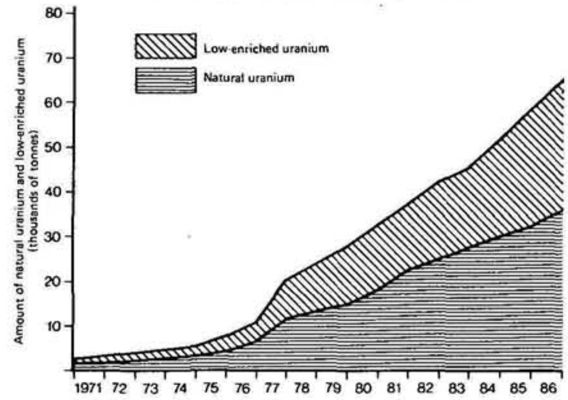
Main international steps or proposals for stopping the spread of nuclear weapons



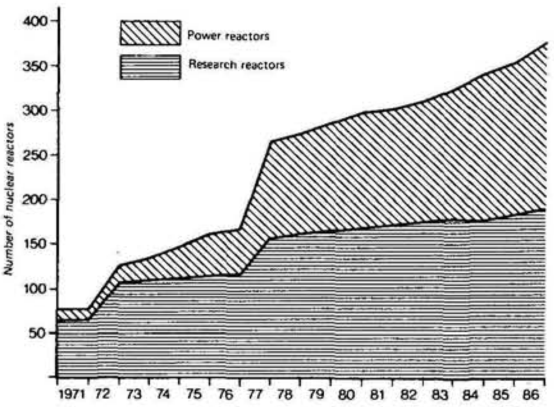
Plutonium and high-enriched uranium under safeguards in non-nuclear-weapon States



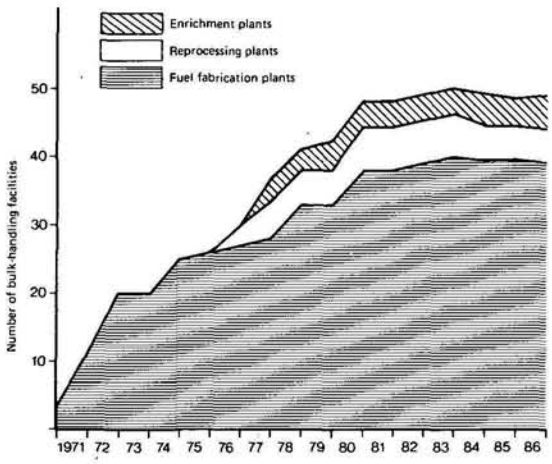
Natural uranium and low-enriched uranium under safeguards in non-nuclear-weapon States



Nuclear reactors under safeguards in non-nuclear-weapon States



Bulk-handling facilities under safeguards in non-nuclear-weapon States



which stressed the importance of stringent safeguards, and the developing countries, which found that the transfer of nuclear technology promised by the NPT had not adequately materialized. The conference closed without adoption of a resolution. Nevertheless all sides encouraged the further development of IAEA safeguards.

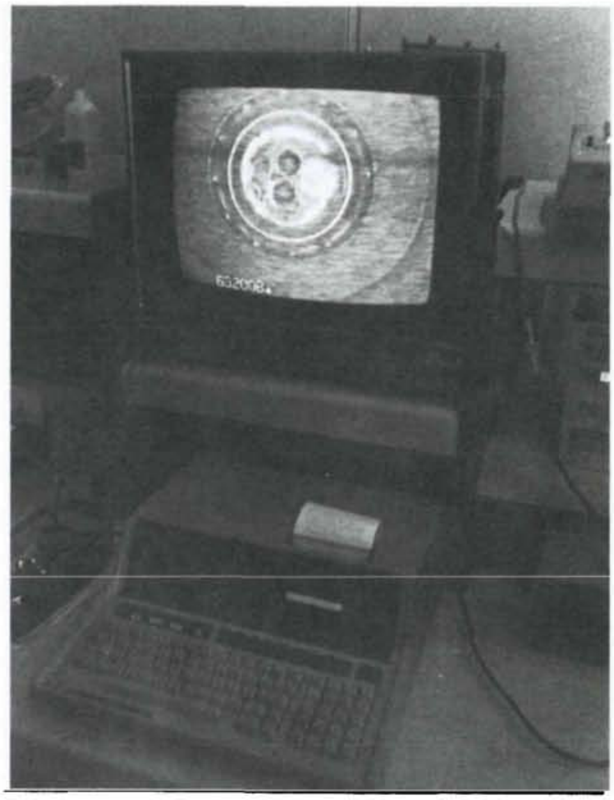
A few months later, the confidence in IAEA's safeguards system suffered a serious setback as a result of the Israeli attack in June 1981 on the Osirak research reactor near Baghdad. Israel tried to justify the bombing by casting doubts on the detection capability of IAEA safeguards. The IAEA produced ample evidence that this accusation was unfounded. As a consequence the IAEA's Board of Governors and the General Conference, in condemning the aggressive act, reaffirmed their confidence in the IAEA's safeguards system. This was echoed by the UN Security Council and the General Assembly.

Consolidation of structure and work

Since about the end of the 1970s, the rate at which research reactors and bulk-handling facilities came under safeguards has decreased markedly. The same applies to some extent to power reactors. For some time this had no effect on the expansion of the department because of considerable backlog in fulfilling manpower requirements and the inherent lead time of instrument development. Then budget restrictions set limits to the growth of the department before it could reach the capacity deemed necessary. In this period, which still continues, the department's lifestyle changed somewhat: Most growing pains were over, major changes in policy and methodology became rare, and the task-force type of management gave way to a more systematic consolidation.

Safeguards approaches for "conventional" types of facilities were once more reviewed and perfected. Approaches were developed and implemented for Candu-type reactors with sophisticated instrumentation, as were approaches for high-temperature gas-cooled reactors and fast breeders. A novelty was the design of an approach and its implementation for ultracentrifuge enrichment plants with the support of the technology holders. Finally, a safeguards approach for a heavy-water production plant had to be developed.

An important step in the rationalization of data processing was the switch to a separate safeguards com-



Metal tamper-resistant seals are routinely applied by IAEA safeguards inspectors to nuclear material in storage or transit, for example, and then electronically verified later at the Agency's headquarters.

puter mainframe for ISIS operations and the standardization and computerization of inspection reports. ISIS was extended to enable it to process and store the results of sample analysis, seal verification, and surveillance film evaluation.

The development work, undertaken with the support of Member States, of equipment and instruments began to bear fruit. High-resolution gamma spectrometers, reliable neutron measurement instruments, and night viewing devices for identification of spent fuel were introduced into field work. The performance of film cameras was significantly improved, the verification of recovered seals upgraded, and the development of closed-circuit TV cameras accelerated.

A viable international verification system

In 1985, the third NPT review conference in Geneva stressed *inter alia* its conviction that the treaty is essential to international peace and security, commended the IAEA on its implementation of safeguards, and noted that improvement of safeguards had occurred during a period of rapid growth in the number of safeguarded facilities.

Looking back at the modest beginning of IAEA safeguards three decades ago, one understands that without the strong support of Member States and the dedication of the safeguards staff it would have been impossible, within this short period, to develop the first international inspectorate into what it is today. Indeed its achievements are impressive. As one sees from safeguards data, the non-proliferation statements of the IAEA are derived from a comprehensive and thorough verification activity. *(See accompanying graphs.)* Of course, safeguards as a human system is not perfect and the IAEA must endeavour to improve and extend its safeguards services.

In addition, one must recognize that the safeguards system is aiming at a moving target: Quantities of nuclear material subject to IAEA safeguards increase continuously. The focus in the fuel cycle is shifting from the front-end to the back-end and improved fuel management techniques require the development and implementation of more sophisticated safeguards techniques and procedures. In spite of the crisis of the UN system and several years of zero-growth budget, the IAEA has up to now managed to adapt its safeguards system to the requirements. Extended training, enhanced computerization, improved standardization, and evaluation have made it possible to increase continuously the efficiency of the inspectorate. Long-term criteria for safeguards performance have been elaborated. They will not only improve the direction of safeguards research and development and the motivation and determination of safeguards personnel, but promote the international comprehension of IAEA safeguards as well.

The recent coming into force of the South Pacific Nuclear Free Zone Treaty and the request that the requisite safeguards be performed by the IAEA demonstrate that the hope for a nuclear-weapon free world is alive and that the IAEA safeguards system is recognized as an important component of it.

At present IAEA safeguards are confined to verification in the area of horizontal proliferation and it has contributed successfully to the international non-proliferation effort. Technically speaking, the experience gained by the operation of this first international verification system could also be utilized within the framework of efforts to curb vertical proliferation — the nuclear arms race of the nuclear-weapon States. The IAEA could, for example, transfer its experience to any system created for this purpose or it could be entrusted with this task. A possible first step could be the extension of the present voluntary safeguards agreements with nuclear-weapon States to their entire civilian nuclear fuel cycle.