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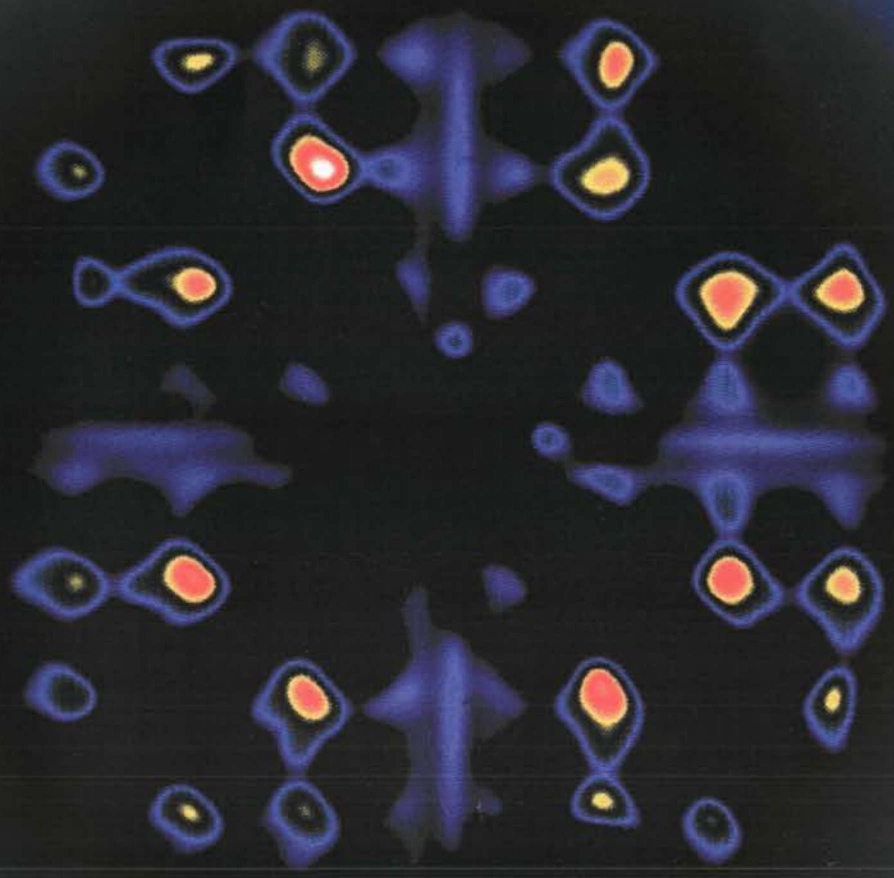
LES GARANTIES ET L´INDUSTRIE

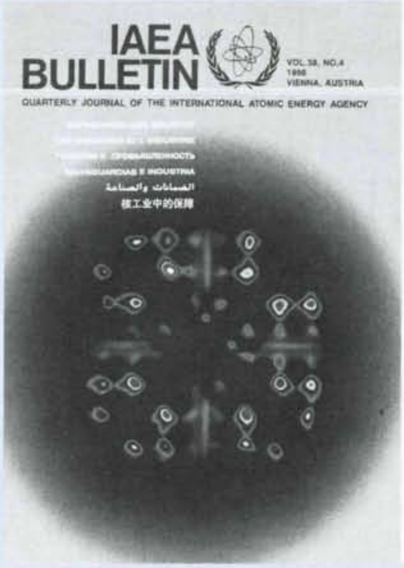
ГАРАНТИИ И ПРОМЫШЛЕННОСТЬ

SALVAGUARDIAS E INDUSTRIA

الضمانات والصناعة

核工业中的保障





Front cover: The IAEA's system of international safeguards — which States have built over the past 40 years to serve as one of the world's barriers against the spread of nuclear weapons — depends upon close co-operation between State authorities and the Agency's inspectorate. Under steps being taken to strengthen the system, even greater co-operation is taking place in the interests of efficiency and effectiveness, as described in articles featured in this edition of the *IAEA Bulletin*.
Cover design: Hannelore Wilczek, IAEA; Stefan Brodek, Vienna
See the item on page 50 for an explanation of the image.

Facing page: In the Pacific atolls of Mururoa and Fangataufa, the IAEA's Pier Danesi was among scientists this year taking samples in basalt rock for laboratory analysis. The work is part of an international study to assess the radiological situation at the former nuclear test site. Being done under the guidance of a distinguished International Advisory Committee, the study was requested by France. A final report is expected in early 1998.
(Credit: Mouchkin/IAEA)

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Safeguards: The evolving picture

The strengthened IAEA system of international safeguards stands to be not only more effective, but also more efficient in many ways

by Bruno Pellaud

The effectiveness of the IAEA safeguards system depends on what the Agency knows about nuclear-related activities. With a broad knowledge of such activities and a good understanding of their relationships, the IAEA can with a fair degree of confidence assess the non-proliferation credentials of a country. Up to now, the system has been rather narrowly focused, leading to perhaps overly thorough safeguards activities on large and visible facilities such as nuclear power plants, while other smaller facilities with a potentially larger proliferation risk would receive less attention. During the last years, the IAEA — the Secretariat, Board of Governors, and Member States — has taken a fresh look at the safeguards system. A shift in focus is under way, a drive to look beyond the current horizon to gain a broader *horizontal* view, rather than piling up controls vertically on existing nuclear facilities. This article examines key aspects of efforts to strengthen IAEA safeguards, and addresses some concerns that have been raised from the viewpoint of the nuclear industry.

Towards more efficient safeguards

Since 1991, the IAEA has begun to revamp the safeguards system through various initiatives and programmes. In 1993, a programme of strengthening and efficiency improvement was initiated on a broad scale in close association with Member States. Nicknamed "Programme 93+2", it led to a series of specific proposals that were approved by the IAEA Board of Governors and broadly endorsed by the Review and Extension Conference of Parties to the Treaty on the Non-Proliferation of Nuclear Weapons in May 1995. Prime movers were the negative experiences that the IAEA encountered in Iraq and in the Democratic People's Republic of Korea, as well as the positive experiences gained in the verification of the dismantlement of the South African nuclear weapon programme. By that time, it had become clear that the old approach of improving the effectiveness of standard safeguards only on ***declared*** facilities was approaching its limit. The IAEA had to broaden the focus of its safeguards system to ***undeclared***, clandestine activities. This new approach requires by necessity access to more information and more access to several kinds of facilities, whether such facilities contain nuclear materials or not. This double objective of additional access — to information and to facilities — lies at the core of the strengthening proposals contained in Programme 93+2.

In early 1996, the IAEA began to implement under its existing legal authority new measures contained in Programme 93+2. The collection of environmental samples and unannounced inspections stand in the forefront. From Kazakstan to South America and Australia, in tens of countries, the inspectors have introduced these new measures. This was done after consultations with the national authorities to ensure that the modalities of applications would satisfy the Agency's requirements and the operators' needs for safe and unhampered use of their facilities. *(See the following article for fuller details on the implementation of Part 1 measures of Programme 93+2.)*

Negotiations now are taking place in an open-ended Committee of the IAEA Board regarding other proposals for strengthened safeguards that require additional authority, Part 2 of Programme 93+2. In these negotiations, some delegations, reflecting the views of facili-

Mr. Pellaud is the IAEA Deputy Director General for Safeguards. This article is adapted from his address to the annual meeting of the Uranium Institute in September 1996, a summary of which was subsequently published in the Institute's *Core Issues* magazine.

ty operators with nuclear materials, have expressed concerns about providing extended access to buildings on their sites beyond strategic points, to such places as workshops, storage areas, and administrative buildings. Furthermore, some governments doubt their own ability to provide the Agency with information about and access to facilities without nuclear materials, that is, to locations where their own authority may be quite limited.

The Board's open-ended Committee met in July 1996 for a first reading of the proposals that had been put forward by the IAEA Secretariat for the measures requiring additional authority. The discussions were pursued in October 1996 in the course of a two-week session that included a thorough second reading with a review of the amendments that had been previously submitted by delegations. Much work remains to be done to reach an agreement on the substantial issues reflected in the current bracketed text (rolling text). Intensive multilateral consultations are under way and it can be hoped that substantial progress can be achieved in the negotiations during the next Committee session in late January 1997.

Proposed strengthened safeguards measures in a nutshell

The new measures include the provision to the IAEA of ***additional information***. For existing nuclear sites, the State would provide additional information containing a description and an explanation of the use of all buildings on the site, and, in some cases, additional operational data of safeguards relevance. The State is also called upon to provide information on pre- and post-safeguards nuclear materials (mines, export-import, nuclear wastes, etc.), on fuel cycle research and development facilities that do not involve nuclear materials, as well as on supporting facilities directly related to the operation of nuclear facilities.

As far as ***additional physical access*** is concerned, the Agency would be given an assured access to nuclear sites (where required "managed" to prevent exposure of commercially sensitive information) and a conditional access to non-nuclear sites.

The additional authority sought by the Agency rests on a few essential principles that show clearly the difference from the conventional verification measures applied to nuclear materials:

In co-operation with State authorities and facility operators, the IAEA applies safeguards at more than 800 nuclear facilities worldwide. *(Credits: KEPCO)*

- The focus will extend beyond nuclear materials to the factors that might indicate the presence or production of undeclared nuclear materials. The treatment of the additional information and access will be *qualitative* rather than quantitative;
- The IAEA will not routinely verify *on site* the additional information received; it will most of the time assess such information in its own offices and when necessary ask questions to check its consistency; and
- For the locations under complementary access, the IAEA will not install traditional safeguards equipment as for nuclear materials. Its inspectors will mostly walk around for visual observation and, when appropriate, they will take an environmental sample.

This short description should bring to light an important fact that has been somewhat overlooked, namely that ***the main burden of implementing the additional authority sought by the IAEA will fall on the shoulders of the State authorities and not on the nuclear industry.*** The authorities cannot always easily provide information about all "nuclear related facilities" in a State, and even less so ensure automatic access upon request. By contrast, the operator of a nuclear site maintains at all times an overview of his own facility, with a solid organization and a staff well trained in the related areas of security, safety, and safeguards. The additional information can be provided and updated by the operator with a minimal effort, and the complementary access granted with only a marginal perturbation and burden.

Concerns of the fuel cycle industry

The nuclear fuel cycle industry has a record of clear support for non-proliferation and for the safeguards system put in place by the IAEA.

Confronted with new proposals for the strengthening of the existing system, the industry wonders what is in stock for it, what could be the consequences in terms of costs or competitiveness. Those are of course legitimate concerns that governments participating in the negotiations of the new legal instrument for the IAEA need to take into account. Yet, in reality, the impact of the new measures should not affect much, if at all, their commercial interests.

An information paper issued by the nuclear industry of one State illustrates many of the concerns expressed by operators. Some of the objections put forward (here in italics) call for a comment:

- "*...the safeguards approaches implemented have so far proved successful in States with democratic societies*". Yes, but as an international organization, the IAEA does not distinguish between political systems. In carrying out its verification mandate, the Agency can only take into account the readiness of its partners to demonstrate transparency in the relevant nuclear activities.
- About the additional information that the IAEA wishes to receive, it was stated that the collection *"will require considerable effort on the operator's part if it is to correspond to the demands expected"* and *"will mean direct interference with facility operation"*. At the least, such a statement reflects a fundamental misreading of the proposals, since the additional information requested from nuclear facility operators will remain of a common nature with generally infrequent updates. As already noted, the situation could be quite different for State authorities in regard to facilities without nuclear materials. Incidentally, the proposals acknowledge concerns regarding commercially sensitive information and that constraints may need to be imposed by operators to maintain confidentiality.
- A fear expressed about increased physical access to nuclear facilities is that the "*number of personnel involved will increase quite considerably as opposed to earlier practice.*" An occasional visual visit to the workshop, the storage rooms or the laboratories by the very same inspectors coming for materials verification may well add a few hours to the duration of the inspection. But it will hardly require the hiring of additional personnel.
- Environmental sampling is labelled as a *"method unacceptable for routine use"*. The objections cover the rights of the operator (yes, the IAEA does leave duplicate samples in the facility), the lack of representativity of individual samples (yes, but conclusions will be drawn only from multiple samples), the fear of cross-contamination (yes, but detailed sample collection and handling procedures have been implemented that limit this possibility). The method is indeed quite sensitive — but not sensitive to the point of detecting *"transborder nuclear transports and illicit transfer of nuclear materials"*, tens or hundreds of kilometres away. The field trials carried out by IAEA staff in collaboration with many Member States between 1993 and 1996 have demonstrated that the method provides a powerful tool and that it is acceptable for routine use. Therefore, as instructed by the IAEA Board of Governors, the IAEA inspectorate will implement it in all States having comprehensive safeguards agreements.
- Another serious concern is that the discovery of inconsistencies coming to light through additional information and access could discredit operators and nuclear energy as a whole. Over the years the IAEA has handled a large number of inconsistencies of varying importance without much publicity. Common sense in managing inconsistencies calls for checking and rechecking, for a dialogue with operators and national authorities, a dialogue that normally resolves the matter. Only when this dialogue fails does the IAEA ring the bell.

The proposed measures have been discussed with industrial representatives of many countries having large nuclear industries. While concerns were also expressed about the still unknown burden that these strengthening measures would entail, the measures themselves and the ability of the IAEA to implement them were not much questioned. The bottom line, the bottom question was rather: "What are the benefits — for us?"

Reducing the safeguards burden

Strengthening — that is, better effectiveness — is not the last word in Programme 93+2. As a matter of fact, efficiency — that is, the better use of resources — is part of the Programme's full official title. The Programme's original scope in matters of efficiency included two distinct elements: the first covered the accelerated development of all the technical and administrative measures which could be readily identified; the second dealt with additional efficiencies that would result from the strengthening of the system itself. Indeed, one important early dimension of Programme 93+2 has since then been under-emphasized, namely that a strengthening of safeguards can be a step towards a simplication of safeguards for existing facilities of the nuclear fuel cycle.

The search for greater efficiency has always been an essential element of good safeguards management. The reduction from US $3000 in 1980 to $1000 in 1995 of the annual cost of safeguarding one "significant quantity" of nuclear material reflects this ongoing commitment.* This effort includes such things as the optimization of safeguards planning (e.g., through the use of regional offices) or the use of technological innovations that permit unattended modes of monitoring and verification.

In this respect, one technology stands out: the remote monitoring at IAEA headquarters, through line or satellite communications, of safeguards information in a facility located anywhere in the world. Several field trials are under way or planned: one in Switzerland started in February 1996 and another in the United States is scheduled to start in late 1996. The purpose of these field trials is to test the concept of remote monitoring via satellite and telephone links in real safeguards situations. Additional field trials are planned in South Africa, Canada, and Japan. The experience from these trials, as well as from the use of remote monitoring in Iraq by the UN/IAEA Action Team, will help identify and resolve issues associated with remote monitoring, as well as provide data on costs. This experimental work provides a solid basis to simultaneously establish the safeguards approaches and criteria for various types of facilities where remote monitoring is to be implemented, with priority given to material stores and nuclear power plants. A special Remote Monitoring Project has recently been established in the IAEA Department of Safeguards to prepare, through testing and planning, for the implementation of remote monitoring in January 1998.

But there is more to greater efficiency than technological improvements.

Confronted with severe budgetary constraints, the IAEA has no choice but to pay attention to the optimum use of resources — to ascertain that the money available is best used to achieve its broad non-proliferation objectives — by properly distributing its resources on the verification of declared facilities on the one hand, and providing assurances regarding the absence of undeclared activities on the other hand. In fact, for many years, the promoters of Programme 93+2 — in and outside the IAEA — have recognized that the strengthened measures, by giving more teeth to the safeguards system, could also permit a simplification of conventional verifications on declared facilities, thereby resulting in a better efficiency of the system as a whole. Simply stated, if the controls carried out in the most sensitive facilities of a country from the point of view of proliferation — research centres and some processing facilities — are conclusive, why should the IAEA inspect so frequently and thoroughly nuclear power plants? The greater degree of transparency that a State would demonstrate through the availability of more information and by offering generous access to its facilities would create a solid basis for a reduction in the inspection load in facilities of less concern. The IAEA Secretariat has not yet spelled out in any detail what these benefits would be — what it could "give" — preferring to await the end of the negotiations on Programme 93+2 in the Board Committee. However, the Secretariat's commitment to implement the revised safeguards system, within costs acceptable to Member States and with a burden acceptable to operators, has been repeatedly formulated, in particular by IAEA Director General Hans Blix.

A new look at spent fuel

The strengthening of the safeguards system envisaged by the full implementation of Programme 93+2 would open up new vistas and indeed allow a fresh look at some fundamental tenets of classical safeguards. The spent fuel from nuclear reactor operations might be one such possibility.

Over the last decades, the IAEA has developed specific procedures and criteria to apply safeguards to various forms of nuclear materials. In the case of uranium, safeguards application takes into account the nature of the materials — natural, depleted, low-enriched, or highly enriched uranium. The degree of proliferation concern varies and this fact is duly reflected. Up to now, a differentiated approach has not been considered for plutonium, except to take account of whether it is separated or still mixed in spent fuel. Seen in the broad con-

*A significant quantity corresponds to the approximate amounts of plutonium or uranium-233 (8 kg) or highly enriched uranium (25 kg) which is required for the manufacture of a first nuclear explosive device.

text of all nuclear materials; verification might be insufficient for separated plutonium and excessive for high burnup spent fuel. The time may well have come to revisit the issue.

A relevant initiative in this direction has been taken in the report published in August 1996 by the Canberra Commission, a group of eminent personalities brought together by the Government of Australia: Nobel Peace Prize recipient Joseph Rotblat, Sri Lankan Ambassador Jayantha Dhanapala (Chair of the 1995 NPT Conference), former French Prime Minister Michel Rocard, former US Secretary of Defense Robert McNamara, Dr. Ronald McCoy (International Physicians for the Prevention of Nuclear War), and General Lee Butler (former Commander in Chief of the US Strategic Air Command), among others. The Commission dealt with the broad issue of nuclear disarmament and the required verification mechanisms.

The report contains interesting ideas about the use of civilian and demilitarized fissile materials. Noting that a proper balance must be struck between the legitimate civilian use of such materials and the objectives of nuclear non-proliferation and disarmament, the Commission states that striking such a balance might be feasible:

"One possibility may be to draw a distinction between plutonium of different isotopic grades and to use this distinction both for safeguards purposes and for a proscription on the separation of plutonium of an isotopic composition which makes it attractive for weapons use...It is an unfortunate consequence of the current practice of not differentiating between plutonium grades for safeguards purposes that special attention is not directed to plutonium having the isotopic characteristics of greatest proliferation concern. Therefore, there would be merit in investigating various categories of plutonium in terms of applicable safeguards measures and resulting verification costs".

All those interested in strengthening safeguards, as well as those keen to reduce costs, should have an interest in such an investigation. For example, in analogy with the various categories of uranium, one could possibly define two or even three categories of plutonium: 1) *degraded* plutonium, such as high burnup spent fuel, 2) *low-grade* plutonium, such as separated high-burnup plutonium from light-water reactors; and 3) *high-grade* plutonium, e.g. from weapons, in breeder blankets, or in low-burnup spent fuel.

A sense of perspective

The proposals formulated by the Agency to strengthen its safeguards system have opened a broad debate on how the fight against proliferation should be led. Most of the discussion has been of a political nature — the lessons of Iraq, the need to reinforce the NPT regime, the drive towards nuclear disarmament. Many operators of nuclear facilities — in particular in those countries with a large fuel cycle — feel that the burden to achieve these grandiose objectives will fall on their shoulders. The following points must certainly be carefully thought about:

- The debate is indeed first of all political. Non-proliferation is part of the efforts of the international community to build a more secure world. While protecting its legitimate interests, while questioning what would be done in their facilities and the costs incurred, industrial associations should also maintain a broad vision of the political dimension and recognize that credible safeguards are vital to preserve public confidence in nuclear power.
- To truly assess the potential burden of Programme 93+2, the open-minded observer in industry should look at the fine print. He or she will see that the proposed new measures will not really affect the competitiveness of the business, that they will not in fact stand out through the burden they cause, but rather through their different nature: unannounced inspections, and request for access to unusual places, such as the workshop. Observers should also know that the safeguards budget of the IAEA will most likely stay at about the same level in the forthcoming years — it has been frozen for more than 10 years. Hence, there will be no resources for a profusion of burdensome inspections. Like any organization operating under the conflicting demands of "high-quality service" and "low cost", the IAEA Department of Safeguards will have to focus routine verification measures on the essential — namely, on the nuclear materials and facilities of real proliferation concern — and will have to plan its activities pragmatically, possibly by tuning down some of the old verification measures in order to make room for new ones.

As a community, the nuclear fuel cycle industry has few reasons to object to Programme 93+2. As a matter of fact, nuclear operators should wholeheartedly support the additional authority sought by the IAEA, since the better transparency and better non-proliferation assurances offered by the new measures will open the door to simpler, less frequent controls on nuclear materials. ❐

New safeguards measures: Initial implementation and experience

States have approved a number of measures for strengthening the IAEA's safeguards system, and now are considering others

by Dirk Schriefer

Soon after Iraq's armies invaded Kuwait in 1990, the IAEA discovered — through its inspections in the aftermath of the Gulf conflict — the size and scope of the Iraqi clandestine nuclear weapons programme. Subsequently, the international community agreed, almost unanimously, that the Agency's safeguards system needed to be strengthened in its ability to detect undeclared inventories of nuclear materials and installations.

In 1991 additional steps were proposed by IAEA Director General Hans Blix with respect to an increased assurance regarding the absence of undeclared nuclear activities in States having comprehensive safeguards agreements: access to more information and better physical access to sites. In 1992 the Agency's Board of Governors took some measures to strengthen the safeguards regime. It reconfirmed the right of the IAEA to carry out special inspections under the existing provisions of comprehensive safeguards agreements, approving the requirement for the early provision to the Agency of design information on new and modified nuclear facilities and endorsing an expanded reporting scheme. Under this scheme, States are beginning to provide the IAEA with information on exports, imports, and production of nuclear material and exports of specified equipment, beyond that required by their safeguards agreements.

In April 1993, the Director General's Standing Advisory Group on Safeguards Implementation (SAGSI) submitted recommendations for improving the effectiveness and efficiency of the safeguards system. In the summer of the same year, the Agency began a new activity with a view to developing a strengthened and more cost-effective safeguards regime. Considering the Review and Extension Conference of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), then two years in the future, it was termed "Programme 93+2", or P93+2 for short. The activity was accompanied from the very beginning by the direct involvement of a number of Member States, who had agreed to test the measures as they were developed. Proposals under P93+2 were presented to the Board of Governors in 1994, with a special presentation of results in March and June 1995. Prior to the June Board meeting, it was decided that there were certain measures that had a legal basis in the existing comprehensive safeguards agreements (CSAs) and, thus, could be implemented immediately, and other measures that required a complementary legal basis. This approach was endorsed in June 1995 by the Board and in the following September by the General Conference. Upon the endorsement of the proposal, the Department of Safeguards established a plan with a schedule for the beginning of the implementation in January 1996.

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Components of Programme 93+2

Following the extensive discussions up to the March 1995 Board of Governor's meeting, a document on P93+2 was submitted for the Board's consideration in June 1995. The measures proposed were arranged in two parts. Part 1 consisted of those which could, in the Secretariat's view, be implemented under existing legal authority and which would be practical and useful to implement at an early date. Part 2 consisted of those which the Secretariat proposed for implementation on the basis of complementary authority. While it was recommended that the Board take action on those measures falling within the Agency's existing legal authority (Part 1), the Director General recommended that action by the Board on the remaining measures await his next report, allowing the Secretariat the benefit of further informal consultations with Member States. Following extensive discussion of the report, the Board took note of the Director General's plan for early implementation of the measures described in Part 1. The Board urged States party to comprehensive safeguards agreements to co-operate with the Secretariat to facilitate such implementation, on the understanding that elaboration of the implementation arrangements and the clarification of States' concerns would be required. Comments and suggestions made during the discussion have been taken into account in planning the implementation of the Part 1 measures. The Agency is proceeding with the implementation of Part 1 measures as rapidly as time and resources allow.

Subsequent to the June Board meeting, a detailed implementation plan was developed, and in early November 1995 communications were sent to States party to comprehensive safeguards agreements. These letters described the actions that the Department of Safeguards had identified as necessary to proceed. The letter indicated also that implementation of Part 1 measures would be undertaken beginning in 1996, after consultations, as broadly and extensively as possible, subject to operational and budgetary constraints.

This article reports on major selected aspects of the IAEA's experience in implementing Part 1 measures. It addresses activities related to the IAEA inspectorate's broader access to information, through measures such as environmental sampling, information analysis, the provision of increased physical access to IAEA inspectors, and the use of unannounced inspections. The article further addresses the optimal use of the present safeguards system, including unattended and remote monitoring systems, greater co-operation with State Systems of Accounting and Control of Nuclear Material (SSACs), and the provision of training courses.

Broader access to information

Letters requesting additional information from States. The SSAC questionnaire was sent to 59 States with operative comprehensive safeguards agreements and two regional systems (EURATOM and the Brazilian-Argentine Agency for the Accounting and Control of Nuclear Materials, ABACC) in December 1995. At the same time an information letter was sent to all States with a suspension protocol, to all nuclear-weapon States and to the States with INFCIRC/66-type safeguards agreements in force. It was requested that the responses be returned to the Agency by the end of February 1996. By mid-November 1996, thirty-six responses had been received, including five with incomplete or not completed questionnaires. Work is ongoing to assess the information received and to review criteria which may apply for closer co-operation with the State systems.

A letter requesting information on certain closed-down or decommissioned nuclear facilities and locations-outside-facilities (LOFs) and on nuclear facilities which were built, but where nuclear material was never introduced, was sent to all States with CSAs at the end of March 1996 with responses requested by the end of April 1996. A number of responses were received, most of which confirm the absence of such facilities; however, others acknowledge the existence of such facilities, and more information is provided. A letter requesting additional information regarding the nuclear fuel cycle that can be sought under existing legal authority is still being prepared.

Environmental sampling. Initial implementation of environmental sampling is being focused on enrichment and hot-cell facilities. This consists of taking swipe samples at locations which would be accessible to the IAEA inspectors during inspections or during design verification visits. General guidelines for these applications have been developed and approved, candidate facilities have been identified, facility-specific sampling objectives, and plans and procedures have been developed. Consultations with Member States regarding implementation were initiated throughout the year as resources were available. The consultations were held at different levels, as required by the complexity of the specific sampling or at the explicit request of the State.

Analytical equipment for the clean laboratory in Seibersdorf near the Agency's headquarters in Vienna has been installed. The laboratory has been able to receive and handle samples since mid-May, with full operation commencing in July 1996. Baseline sample collections began as early as February 1996 and have been conducted in a majority of relevant countries. Samples were taken in enrichment plants and hot cells in more than 20 countries; by mid-November 1996, more than 400 samples from different sampling points had been taken, shipped, and received for analysis in Vienna. Analysis results are now being returned to the Department of Safeguards for assessment and evaluation. Consultations with Member States on the baseline results are beginning; as results become available, and as resources permit, these will increase in the first half of 1997.

Improved information analysis. A general framework and methodology for improved information analysis has been developed. Some computer-based tools for its implementation are in place. The work of a group of experts from several Member States on the development of the physical model of the nuclear fuel cycle is complete. In addition, the role of existing country officers is being expanded, and open source and other additional information is being added for overall assessment of non-proliferation and safeguards agreement pledges. Modifications regarding the organizational structure are in progress.

Information confidentiality. A review of procedures for protecting safeguards confidential information has taken place to ensure the adequacy of protective measures. Particular attention is being paid to the means of controlling access to safeguards confidential data in computer files. A Note by the Secretariat on the confidentiality of safeguards information was distributed to Member States in August 1996. Regarding the Agency's procedures for the distribution of environmental samples and for reporting analytical results, intended to protect the anonymity of samples and the confidentiality of results, a Consultants Group of experts from Member States reviewed the IAEA's procedures in December 1995. The Group agreed that implementation of the procedures met the objective of the Agency and of Member States.

Increased physical access

Visas. As a prerequisite for enhanced physical access to nuclear facilities or other nuclear installations, it is required that Member States provide Agency inspectors with long-term visas that include the right for multiple entry and exit to and from the country, or visa-less entry. The Agency requires and requests a one year minimum for the validity of the inspector's visa.

A large number of States has already accepted this type of visa (usually in the subsidiary arrangement to the safeguards agreement), so that in these States the possibility for immediate implementation exists. Letters have been sent out to all Member States that grant Agency inspectors less than what is deemed to be the minimum with regard to visa requirements.

Unannounced inspections. Work is under way to identify how unannounced inspections could lead to more effective and efficient safeguards for a number of facility types. This will usually be done in conjunction with other measures. An approach is being tested in a low-enriched uranium fuel fabrication facility, and detailed consultations are under way in an attempt to define an approach for similar facilities in other countries. For research reactors, plans have been made to introduce unannounced inspections in several reactors to provide a higher degree of confidence regarding the absence of unreported production of plutonium.

Administrative procedures necessary to support unannounced inspections as part of the routine implementation of safeguards have been developed. This is particularly difficult in countries where language barriers are high, and where the use of travel and communication facilities is restricted.

Optimal use of the safeguards system

Unattended and remote monitoring. A variety of advanced technology for remote monitoring and transmission, and unattended measurements with remote transmission is being examined, tested and demonstrated. This includes digital surveillance cameras, electronic seals and motion and radiation detectors, with remote transmission by satellite and phone lines.

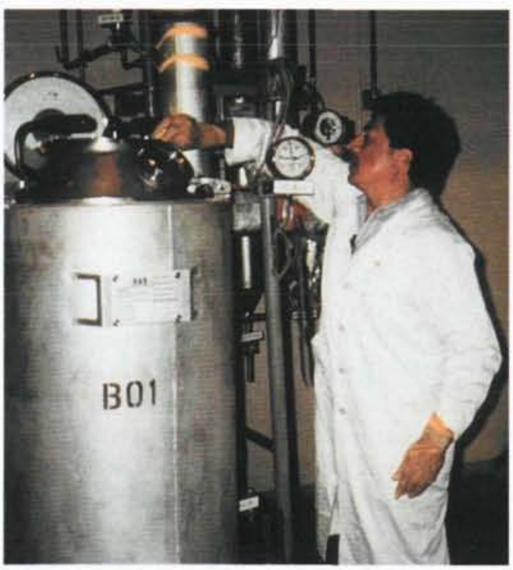
Two digital surveillance cameras and an electronic seal using remote data transmission through a satellite link to Vienna have been operational from a facility in Switzerland since mid-January 1996. The location under remote monitoring is a vault containing a semi-static store of direct-use material. A variety of query and transmission strategies is being evaluated. It is planned to expand this capability to a network involving five facilities in Switzerland by the end of this year.

The objective is the development of new safeguards approaches for these locations which combine the new technology with unannounced inspections thereby permitting reductions in inspection frequency and effort. Similar applications of advanced technology are scheduled to be demonstrated in the United States and in South Africa. In all cases the installations include the authentication requirements of the Agency and the encryption requirements of the State. Other automatic systems have been providing data on facility and process status in unattended mode for some time in other countries.

Increased co-operation with SSACs. The development of, and States' responses to, the SSAC questionnaire sent out in February 1996 provide a mechanism for a systematic exploration of areas of increased co-operation which could benefit both the Agency and the SSAC. At the same time the process of increasing co-operation between the Agency and regional systems and a large, single state SSAC is continuing.

Implementation of the New Partnership Approach (NPA) continues with EURATOM; areas of increased co-operation will feature in the consultations with ABACC; and a modified NPA safeguards approach to light-water reactors will be tried in a Member State with a large number of light-water reactors.

Training courses. A number of training courses necessary for the implementation of the Part 1 measures are in various stages of development, pilot testing and implementation. Training courses on environmental sampling have taken place. By the end of September 1996, the training had been provided to approximately 100 inspectors. Training courses on the physical model and enhanced observational skills have been pilot-tested. Other courses dealing with the conduct of unannounced inspections and design information verification of closed-down and decommissioned facilities are under development.



Swipe samples being taken in field trials for laboratory analysis.

For increased co-operation with SSACs, courses for the training of SSAC personnel are under development to familiarize them with IAEA requirements. Additional training courses have been requested and are in the process of being designed. More training in support of the new measures is necessary; it is restricted by the inspectors' availability from their normal safeguards implementation duties.

Conclusions and outlook

The implementation of Part 1 measures began according to schedule, but numerous problems were encountered. Most significantly, safeguards staff had to give priority to the implementation of activities planned and scheduled under the existing safeguards regime. Implementation, as well as educating and training safeguards staff on measures and procedures relevant to Part 1, has taken more time than anticipated, due to constraints on the availability of inspectors and support staff. Consultations and discussions at various technical levels in individual States have consumed an unexpected amount of time.

The partitioning of the measures for implementation according to the legal basis as presented to the Board in June 1995, and the decision to proceed immediately with the implementation of those measures that are within existing authority, were made for pragmatic reasons only. This mode is not designed to diminish in any way the integrated nature of the entire Programme 93+2. The full benefits in strengthened effectiveness and efficiency will be derived only from a full implementation of all measures in the package.

Finalization of the measures presented in Part 2, the implementation of which requires complementary legal authority and the associated draft legal instrument, will proceed. The IAEA Board of Governors agreed in June 1996 to establish a Board Committee to continue the work on Part 2 measures and the legal instrument. The Committee has held two sessions, in July and October, and next will meet in January 1997.

The IAEA Secretariat will facilitate the work of the Committee. Progress, including the date for implementation of Part 2, will depend now on the willingness and readiness of the IAEA's Member States to talk to each other and reach agreement, and to authorize the Secretariat to continue with the implementation of the new safeguards measures.

Safeguards at LEU facilities: Current practices, future directions

An overview of the IAEA's verification activities for low-enriched uranium facilities and steps toward greater co-operation with operators

by Anita Nilsson

Low-enriched uranium, or LEU, fuel cycle facilities comprise an important product of the nuclear industry, and are intimately related to nuclear power production. Such facilities include those for production of uranium hexafluoride, enrichment of uranium (to less than 20% uranium-235), conversion to uranium oxide powder, and the production of nuclear fuel assemblies for subsequent use in reactors. They also normally include facilities (excluding reprocessing plants) for encapsulation and deposition of spent fuel, which contains plutonium. This article primarily deals with fuel cycle facilities using LEU, and only briefly touches upon safeguards for spent fuel to be deposited in geological repositories.

In all LEU facilities, the presence of uranium is the reason for IAEA safeguards under agreements concluded pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). Natural or low-enriched uranium is nuclear material that only can be indirectly used for nuclear weapons production. Further enrichment of uranium in the isotope uranium-235, to a level above 20%, is necessary to obtain material that can be utilized in a nuclear explosive device.

This fact is central to the implementation of IAEA safeguards on LEU. The Agency has an obligation to draw independent conclusions that the nuclear material subject to safeguards has not been diverted from peaceful uses, i.e. to nuclear explosives or for purposes unknown. The safeguards approaches and criteria used by the IAEA to obtain that goal are defined with due consideration to the potential use of the nuclear material for nuclear weapons. The enrichment in the isotope uranium-235 that would be required for turning natural or low-enriched uranium to weapons usable material is an expensive and time-consuming process, in particular if it is concealed. It has been estimated through technical analysis that a State could have the material enriched to the desired degree for weapons production in about one year's time. Recent reviews within the Agency, however, have shown that while the establishment of an enrichment facility, in particular if is concealed, is a costly and lengthy process, the subsequent enrichment of LEU, once the enrichment facilities have been established, could be achieved in less than one year.

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Current safeguards for LEU facilities

The application of IAEA safeguards on LEU is based on a number of criteria, specifying *inspection goals* whereby the *significant quantity* is an amount of uranium containing 75 kilograms of uranium-235, and the *timeliness goal* is one year. This means that the Agency, when implementing its safeguards system, shall be able to detect a diversion of at least 75 kilograms of uranium-235 contained in LEU during a time period of one year.

An LEU fuel cycle facility processes nuclear material in bulk form. During the industrial process, nuclear materials used as feedstock may be changed isotopically, chemically, and physically. In the process, some nuclear materials also become waste products and minute quantities are discarded in waste water or otherwise discharged. A common objective for both safeguards and financial reasons is to keep the wastes and losses to the lowest levels possible.

To reach its safeguards goals for an industrial process where bulk nuclear material is handled in various forms, the IAEA establishes a safeguards approach enabling its annual evaluation and independent verification of the facility's *material balance* over specific periods of time.

The IAEA must reach its conclusions independently from both operators and Member States. The activities to reach those conclusions, however, can be performed jointly with a State System of Accountancy and Control (SSAC) or Regional System of Accountancy and Control (RSAC). To reach the conclusions, the quantities of safeguarded material must be verified with a certain degree of confidence.

According to the present safeguards criteria, both nuclear material in flow throughout the facility and in the facility's inventory should be independently verified. For an LEU fuel fabrication plant, the verification is to cover at least 20% of the nuclear material *in flow,* and, once a year, the operator's complete physical inventory of all nuclear material at the facility; this is done when the material balance is closed for accounting purposes.

The Agency uses statistical methods for cost-effective verification, based on its knowledge of the facility's industrial process, and the accuracy and precision of nuclear material measurements performed by both the operator and the IAEA. Information regarding the process and measurement system applied at the facility is included in the *design information* provided to the Agency.

The information on which the Agency bases its activities is provided by the State, through the SSAC or the RSAC. Formal State reports on inventory changes are given periodically, often monthly, reflecting changes in the previous month.

Inspections and verification activities. During routine inspections, the Agency verifies the operator's declarations of material accountancy, i.e. the accountancy records and supporting source documents, and compares, often at headquarters, the result with the formal Inventory Change Reports submitted by the SSAC or RSAC. According to the IAEA safeguards criteria now applied, routine inspections are performed to meet the inspection goals. For an LEU fuel fabrication plant, normally five inspections should be performed for flow verification, and one for physical inventory verification during a material balance period. At an enrichment plant, monthly inspections are performed, primarily to confirm the declared enrichment (absence of enrichment above 20% uranium-235). The inspection planning is based on operational information given semi-annually and advance notifications of receipts and shipments of nuclear material. Verification of nuclear material in flow is performed by weighing and sampling for subsequent chemical analysis, as well as by non-destructive assay (NDA) for enrichment control. The importance of performing "flow inspections" becomes clear when considering that fuel cycle facilities handling nuclear material in bulk form are designed to have a large throughput and a relatively small inventory of nuclear material.

The verification of the physical inventory builds on the application of statistical methods. When comparing the inventory as registered (book inventory) with the measured inventory (physical inventory) for a facility handling nuclear material in bulk form, there is always a difference. This difference is called material unaccounted for (MUF). The statistical evaluation of the material balance leads to a conclusion whether or not the MUF is within acceptable limits. Although a large value of the MUF *can* indicate a possible diversion, the overall assessment of a possible diversion of nuclear material must be made in the broader context of a State's nuclear material declarations and the IAEA's independent verification of these declarations.

Under the present safeguards system, the SSAC or RSAC always receives advance notification of inspections. Historically, this has been deemed necessary in order for the State and operator to prepare the nuclear material declaration and other documentation required for the inspection.

Accountancy and control. The safeguards system requires the operator to keep an updated register (general ledger) of the nuclear material according to agreed standards and recommendations. However, it is likely that nuclear material accountancy would be performed even if there were no safeguards requirements or system in place. Nuclear material is expensive, and accounts for a significant part of the operating cost of a nuclear reactor. It is thus in the interest of the nucleaer material's owner that the losses are kept to a minimum, and that the highest possible level of quality control is maintained.

Nuclear material accountancy is one way for the operator to keep track of the nuclear material processed, as part of the operator's responsibilities to the owner of the material. In addition, nuclear safety and reactivity calculations require precise enrichment specifications. Unknown spikes in the enrichment of pellets in a fuel rod may cause burnout, and subsequent leakage of fission products to the cooling system, with entailing losses in the production of electricity. Even at a low level, such leakage could contribute to the general public's exposure to sources of radioactivity. For the same reason, operators of a fuel cycle facility minimize and control releases of nuclear material to the environment, as is also shown by the measurement and accountancy system.

To maintain high quality in production, the operator of a nuclear fuel cycle facility uses advanced instruments. Rod scanners are used for enrichment control, and precision scales are used for weight determinations. In some facilities, routines have been established by which the Agency can use equipment owned by the operator. In such cases, in order to maintain independence, the Agency keeps, under seal at the facility, sources or nuclear material standards for calibration purposes. Such co-operative schemes improve efficiency during inspections, and maintain or improve the effectiveness of safeguards.

One other reason for the operator to maintain a control system is the requirement in bilateral or multilateral agreements related to nuclear non-proliferation. Nuclear supplier States require that safeguards are maintained and that nuclear material is accounted for according to specified standards. In other words, nuclear material accountancy and IAEA safeguards are prerequisites for nuclear trade, and it has been recognized that without a safeguards system of high quality, trade would be severely hampered, if not impossible.

Possible new elements of safeguards

Recent events have pointed out the need for improved safeguards, whereby the IAEA's system should not only verify the correctness and completeness of States' declarations of nuclear material but also provide credible assurances of the absence of undeclared nuclear activities. A strengthened safeguards system has been proposed under the IAEA programme known as "93+2". Part 1 of the programme is being implemented under comprehensive safeguards agreements, while the new measures comprising Part 2 require additional legal authority for the IAEA. In June 1995, the IAEA Board of Governors agreed that the Agency should start implementing Part 1, and in June 1996, a Board Committee was established to work on a Protocol to complement existing comprehensive safeguards agreements. The Protocol would give the Agency the additional tools required to implement the entire strengthened safeguards system envisaged.

For LEU fuel cycle facilities, Part 1 includes increased physical access and increased co-operation with the SSAC or RSAC, as applicable. Increased physical access includes unannounced inspections, i.e. inspections where the State is not notified in advance. Unannounced inspections can provide effectiveness and efficiency benefits when near-real-time declarations on material flows and facility operations are available. With increased access, all buildings at a *nuclear site* will be accessible for the inspector. Also important for strengthened safeguards is the *optimal use of the present system.* Enhanced information from SSACs, given by the States, provides for increased co-operation between the Agency and the national or regional authority. Increased co-operation can encompass sharing of measurement instruments, early submission to the IAEA of data available to the national or regional authority, and joint activities, provided the IAEA's independent control function can be maintained. Through greater co-operation, inconsistencies or questions could be solved in a timely manner.

Field trials. Field tests of strengthened safeguards systems have been performed in Canada, Finland, and Sweden. They provided good examples of how the strengthened safeguards system could work in practice.

Tests in Canada. Tests in Canada showed that unannounced access could be gained to locations that are not normally accessible for safeguards purposes at a wide range of fuel cycle facilities. The facilities involved included a uranium conversion facility, a fuel fabrication facility, two multi-unit power reactor facilities, a partially decommissioned research reactor, and a nuclear research and development complex. The tests also demonstrated (as communicated by the Atomic Energy Control Board) enhanced co-operation between the Canadian SSAC and the Agency in several respects: the site-specific procedures for unannounced access developed by the operators and the SSAC were shared with the IAEA so that they would be taken into account in the development of the inspection arrangements. Specifically, the tests ranged from broad access requested during a scheduled inspection to unannounced access outside normal working hours; the measures used included environmental sampling, design information verification, visual observation, and non-destructive analysis. In every case, access was granted without delay and the IAEA was able to carry out the required activities. In a broad sense, the tests showed that procedural arrangements can be made by the SSAC, the operator, and the IAEA that will result in the successful implementation of unannounced and short-notice access to any location at nuclear facilities in Canada.

Tests in Finland. Field tests in Finland were focused on environmental sampling and increased co-operation with the SSAC. In-field environmental monitoring techniques were evaluated and, as a result, commercially available instrumentation was described that could be used in the environmental monitoring of LEU facilities without extensive development work. Also successfully demonstrated was the applicability of autoradiography for screening environmental swipe samples. The Finnish laboratories analyzed different types of samples collected during the field trials in various countries and provided valuable analytical results. A satellite navigation and desktop mapping system was developed for determining and recording environmental sampling locations in the field. This computerized mapping and navigation system was demonstrated to be very useful in environmental sampling outside facilities.

Increased co-operation with the SSAC was tested by submitting the SSAC questionnaire and expanded declaration to the IAEA and by performing unannounced inspections at LWRs and at a research reactor. As a result, experience was gained in carrying out such inspections with broader access to information and sites. Procedures for unannounced inspections were developed and a new improved safeguards approach for WWER-type reactor facilities was worked out.

Tests in Sweden. The tests in Sweden were related to environmental monitoring and increased co-operation with the SSAC, including the submission of additional information to the IAEA with near-real-time accountancy reports, unannounced inspections, SSAC information, and an expanded declaration.

More specific parts of the tests in Sweden focused on the implementation of unannounced inspections at an LEU fuel fabrication plant. A scheme of unannounced, randomized inspections was implemented in such a way that there was a non-zero probability of inspection at any day and any time during the period. The scheme required, *inter alia*, that information was provided on a weekly basis on the operational forecast of the facility. The information was provided electronically, by a secured link to the Agency. Before the test, procedures had been agreed regarding inspector visas, entry at the facility, escorts of inspectors by facility staff, and access to data in the operator's computerized nuclear material accountancy system. The results of the unannounced inspections, together with a physical inventory verification that completed the test, provided a firm basis for evaluating the approach.

The overall test results pointed to positive effects of a strengthened safeguards system for the IAEA, the national authority, and the operator. In short, due to the randomness of the unannounced inspections, the verification results obtained in these inspections could be projected to *all* the material involved in production during the material balance period. This meant a significant increase in effectiveness, from partial to full coverage of the nuclear material in flow. The increased access for inspectors allowed the performance of activities to assure the absence of undeclared activities at the facility site.

In summary, the tested approach was shown to provide more cost-effective safeguards: the system was signficantly strengthened while the inspection effort remained at the same level. The routines applied were less intrusive for ongoing facility operations than inspections within the normal "classical" system because they were directed towards the process rather than the product. These advances compensated well for the additional work that was imposed on the operator in providing a weekly operational forecast and the establishment of routines to allow unannounced inspections at the plant to take place.

Within the Agency, a task force has recently been established to evaluate the possible safeguards approaches for LEU fuel fabrication plants, taking into consideration the applicability of different approaches in different facilities and States.

Future directions

Elements in a strengthened system. Further measures for strengthening safeguards being considered by the IAEA Board build on broader access to information on the State's nuclear programme, increased physical access of Agency inspectors to nuclear facilities and other nuclear sites, and the use of new techniques, primarily environmental sampling and the optimization of the present system. The objective will be *both* to verify that no diversion of nuclear material has taken place *and* the absence of undeclared nuclear activities. The total effect on a country of a strengthened safeguards system depends on its nuclear programme. The system would provide for the allocation of efforts to sensitive nuclear facilities, where high-enriched uranium or plutonium is handled, and provide for less effort on less sensitive material such as low-enriched uranium, depending on assurances obtained about undeclared nuclear activities. As noted earlier, unannounced inspections can provide greater assurance of non-diversion of nuclear material, and, at the same time, provide confidence of the absence of undeclared nuclear activities. The possibility of taking environmental samples will be important for the latter. If environmental samples are taken during regular inspections, there will be no need for separate inspections with the attendant costs for both the IAEA and the operator.

The increased information to be provided by the State will constitute the basis for the Agency's evaluation of information. The gradually increasing confidence as to the absence of undeclared activities may provide justification for a reduction in the intensity of safeguards on declared nuclear material. Spent nuclear power fuel may be taken as an example. Although spent fuel contains plutonium, the enhanced assurance of the absence of clandestine reprocessing in a State will influence the safeguards approach.

In some States, spent fuel will be encapsulated for permanent disposal in deep geological repositories without changes to the integrity of the fuel. In an advisory group meeting convened by the IAEA, representatives of participating States agreed that safeguards cannot be terminated for spent nuclear power fuel that is aimed to be, or has already been, deposited in a geological repository. However, it was also agreed that the measures applied should build on "continuity of knowledge", and take account of developments in the safeguards regime. Although a geological repository would contain large quantities of plutonium, safeguards measures for the site could be both effective and highly efficient — for example by applying containment and surveillance measures at the site and maintaining information about the deposited material — given the assurances provided with the strengthened safeguards system about the absence of undeclared reprocessing.

In a broad joint effort through an IAEA Safeguards Support Programme, a number of States are engaged in work related to the safeguards approach for spent fuel to be deposited in geological repositories. A joint report is due to be prepared before the next scheduled advisory group meeting that will address the matter of safeguards for the back-end of the fuel cycle.

The application of modern techniques could mark a significant change in the safeguarding of LEU fuel cycle facilities. Electronic, near-real-time transmission of accountancy and operational data could provide for both increased efficiency and effectiveness. Encryption techniques and specific transmission protocols would provide for secure transmission of data. Remote electronic transmission of authenticated measurement data would open the same opportunities for LEU facilities as remote surveillance would for nuclear reactors. Available measurement techniques provide, increasingly, the result in digital format, which is necessary for remote transmission of measurement results. The application of new techniques can, therefore, further reduce the actual inspection frequency at facilities, while maintaining or increasing the level of confidence.

Towards enhanced co-operation. For LEU fuel cycle facilities, the strengthened safeguards system is likely to provide a change in the relationship of the State (through the SSAC or RSAC) and the operator with the IAEA. It envisages greater co-operation through the provision of more timely information of selected operational events and the acceptance of unannounced inspections in the interests of enhancing the effectiveness and efficiency of safeguards.

During this evolutionary phase of safeguards development, it is worth considering that on-site inspections provide a value over and beyond their role in verifying the non-diversion of nuclear material. When the inspectors meet the operator at the facility, matters of concern can be discussed and inconsistencies or questions resolved. In all inspections or control regimes, the confidence between the parties is important.

The IAEA's safeguards inspectors are basically there to provide a service: the assurances required by the international community that the nuclear material at the facility is used according to the non-proliferation undertakings of the State. With these assurances, the facility can maintain its credibility with the public that it is only engaged in peaceful activities, and contributes, with its industrial production, to the welfare of society. The evolving safeguards system requires, and promotes, increased co-operation between the IAEA, national or regional authorities, and the operator. In the end, its effective and efficient application is a credit to facility operators, as well as to the State and the international community. ❐

Safeguards at light-water reactors: Current practices, future directions

Advanced verification methods for LWRs are being tested as part of IAEA efforts toward more effective and efficient safeguards

by Neil Harms and Perpetua Rodriguez

Safeguards measures at the world's light-water-cooled reactors (LWRs) — the major type of nuclear power reactor in use today for the production of electricity — are well established. More than 220 LWRs and other types of power reactors presently are under IAEA safeguards in non-nuclear weapon States.*

This article addresses current IAEA safeguards practices at LWRs and also safeguards measures under consideration and development that go beyond the practices of today.

Why does the IAEA implement safeguards at nuclear power plants? How are these facilities a threat to nuclear proliferation? To answer these questions, it is important to look at the kind of nuclear materials at nuclear power plants. Excluding the use of mixed uranium-plutonium oxide (MOX) fuels for the moment, LWRs use low-enriched uranium (LEU), categorized as "indirect-use" material from the standpoint of its potential use in the manufacture of nuclear weapons. After these nuclear materials have been fueled in the reactor core, the spent fuels are categorized as "direct-use" material. Plutonium contained in spent fuel, as well as fresh MOX fuels, represent a strategic material from a safeguards standpoint. This is one of the determining factors that affects the safeguards approach and the inspection goal for a facility.

Implementation of safeguards at these facilities is covered by agreements between the State, or States, and the IAEA. To fulfill its obligations under the agreements, the IAEA carries out verification activities in order to draw its own independent safeguards conclusions. For agreements concluded under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), the technical objectives of safeguards are defined in Article 28 of INFCIRC/153 (Corrected) 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". Safeguards agreements under the non-NPT system are based on guidelines contained in the document INFCIRC/66 Rev. 2; it requires that safeguards be applied to nuclear materials, facilities, equipment, and non-nuclear material and to certain technological information. The manner in which the IAEA designs the safeguards activities at these facilities is referred to as the "safeguards approach".

The classical safeguards approach

The safeguards approach is based on an analysis of all technically possible diversion paths at a facility and on the requirements of the particular safeguards agreement. The approach is also designed to counter the possible undeclared production of direct-use material. It refers to the system of nuclear materials accountancy, containment, surveillance, and other measures chosen for implementation of safeguards. The following are also taken into consideration: (i) measurement methods and techniques available to the Agency; (ii) the design features of the facility; (iii) the form and

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*As of January 1996, there were 226 power reactors under IAEA safeguards in non-nuclear weapon States. Worldwide there were 437 nuclear power plants; the difference is accounted for by power reactors in nuclear-weapon States that are not under IAEA safeguards.

accessibility of the nuclear material; (iv) the possible existence of unsafeguarded nuclear activities; and (v) inspection experience.

The inspection goal

The inspection goal for a facility consists of a quantity component and a timeliness component. (*See table.*) The quantity component relates to the scope of the inspection activities necessary in order to provide assurance that there was no diversion of a significant quantity (SQ) of nuclear material over a material balance period (MBP). The timeliness component on the other hand relates to the periodic inspection activities necessary to provide assurance that no abrupt diversion has taken place. The inspection goal for each facility is regarded as attained if all the criteria relevant to the material types and categories present at the facility have been satisfied. In its implementation of safeguards, the Agency strives for full attainment of both components of the inspection goal.

Current safeguards implementation

How are IAEA safeguards being implemented at the present time? Fundamentally, the Agency's safeguards implementation is regulated by the IAEA Statute and by the safeguards agreements. Paragraph 2 of INFCIRC/153 (Corrected), the model for safeguards agreements, stipulates more specifically that safeguards will be applied "...for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices..." In the case of LWRs, the safeguards approach considers two basic tools to achieve the inspection goals:

Item accountancy. This includes item counting and identification, non-destructive measurements and examination to verify the continued integrity of the item.

Containment and surveillance (C/S) measures. These are used to complement the accountancy verification methods for safeguarding the spent fuel. Since LWR cores are usually not opened more than once per year, it is often possible to seal the reactor pressure vessel head.

The installation of a surveillance system that surveys the area where spent fuel is stored allows the Agency to detect undeclared movements of nuclear material, and potential tampering with containment and/or Agency safeguards devices.

In summary the following activities are performed to achieve IAEA inspection goals:

- ***Audit of accounting records and comparison with reports to the Agency;***
- ***Examination of operating records and reconciliation with accounting records;***
- ***Verification of fresh fuel before core loading.*** In order to detect possible diversion of fresh fuel, the verification is carried out by item counting, serial number identification, and non-destructive assay (NDA). For facilities using fresh MOX fuel, the verification activities are carried out on a monthly basis by item counting, serial number identification, and seal verification assuming that the fuel is received from an IAEA safeguarded facility. However, in the case where fresh MOX fuel is received from unsafeguarded facilities, additional NDA measurements are performed and the fuel is maintained under seal if kept in a dry store, or under surveillance if kept in a wet store. Seal verification and/or surveillance evaluation is also carried out on a monthly basis in addition to the usual accountancy verification methods.
- ***Verification of fuel in the core.*** The fuel is verified by item counting and serial number identification following refuelling and before the reactor vessel is closed. For facilities using fresh MOX fuel in the core, loading is either maintained under human or underwater surveillance. Soon after verification, C/S measures are applied to ensure that the reactor core remains unchanged.
- ***Verification of spent fuel pond.*** The spent fuel is verified after sealing the transfer canal gate or upon closure of the reactor core. In addition to evaluating the C/S measures applied,

Significant quantities of nuclear materials and timeliness goals

Category	Type	Significant Quantities	Timeliness Goals
Direct-use material	Plutonium*	8 kg plutonium	1 month
	High-enriched uranium	25 kg uranium-235	1 month (fresh) 3 months (spent)
	Plutonium in spent fuel	8 kg plutonium	3 months
	Uranium-233	8 kg uranium-233	1 month
Indirect-use material	Low-enriched uranium**	75 kg uranium-235	12 months
	Thorium	20 t thorium	12 months

*for plutonium containing less than 80% plutonium-238

**less than 20% uranium-235; includes natural and depleted uranium verification of the spent fuel by observation and evaluation of the Cerenkov glow using NDA techniques is performed.

Each year, the IAEA issues the Safeguards Implementation Report, which records the main conclusions reached, draws attention to deficiencies, and recommends corrective actions. The problems encountered include inconclusive surveillance, lack of appropriate equipment, incomplete safeguards measures, difficulties in the verification of some nuclear materials, restrictions on planning inspections, inspector designations, and some other administrative problems indirectly affecting the IAEA's goal attainment.

With the experience gained from these problems, recommended steps to minimize their occurrence have greatly improved safeguards implementation. In countries of the European Union, an agreement has been reached between the Agency and EURATOM to work on co-operative activities (referred to as the New Partnership Approach) which has resulted in a reduction of inspection effort and introduction of new surveillance systems. Equipment has been improved to cope with difficult facility conditions where traditional equipment has failed to provide conclusive verification results. Co-operation from the operators has also resulted in additional improvements for the safeguards approach of some facilities.

Programme 93+2 and future directions

Recent events have demonstrated the need for the IAEA's safeguards system to provide credible assurances not only regarding declared nuclear activities but also regarding the absence of undeclared nuclear activities. The system based on material accountancy has proved to be reliable in providing assurance about the peaceful use of declared material and declared facilities and installations. However, the system can be strengthened and made more efficient with new measures, in particular by improving the Agency's capability to detect undeclared activities in States having comprehensive safeguards agreements. The need for strengthening measures that would go beyond the scope of the existing safeguards agreements has been emphasized. This gave birth to what is called "Programme 93+2", the purpose of which is to provide the most effective overall approach to strengthen safeguards and, concurrently, to reduce the frequency of some other measures, thereby saving costs.

Remote Monitoring Systems. As a step towards the IAEA's objective of reducing inspection costs at LWRs while improving safeguards efficiency and effectiveness, a field trial using a Remote Monitoring System (RMS) has been undertaken in a semi-static storage facility in a co-operative effort between Switzerland and the Agency. The RMS currently being tested is based on an all digital approach which facilitates image and data handling (for example, information on Agency seals), transmission, processing, and storage. The communication system is independent of the monitoring system. The equipment has sufficient internal data storage and battery power, allowing the system to gather images and data in the event of loss of the network connection and/or facility power. The "state of health" data regarding system operation and its environment is provided to monitor equipment performance and malfunctions. The system provides near-real-time information, depending on how images and data acquisitions are set up. The use of RMS at an LWR facility is anticipated to be in conjunction with a reduced number of interim inspections, either announced or unannounced. An unannounced inspection would mean that the State and the operator would be informed of the Agency's intention to perform such an inspection only when the IAEA inspector arrives at the entrance to the facility.

Assuming the use of advanced technology, for example an RMS in an LWR facility, how would it affect the current safeguards implementation? At LWRs where currently three to four quarterly interim inspections are done per year, the number of inspections could be less, probably one unannounced inspection in addition to the physical inventory verification. At LWRs having fresh MOX fuel present, the current monthly interim inspections performed per year could be reduced, possibly to two to four unannounced inspections. The result — from the synergistic effect of combining routine inspections, unannounced inspections providing broad access at locations identified in the Expanded Declaration, increased co-operation with State Systems of Accounting and Control (SSAC), advanced C/S technology, and more frequent declarations by facility operators of certain operational and nuclear material transfer data — would be increased assurance regarding the exclusively peaceful use of facilities and the absence of undeclared activities.

When considering an alternative safeguards approach, it is useful to include the perspective of those parties directly affected by IAEA safeguards at LWRs, that is, facility operators and the SSAC in a particular State.

Every IAEA safeguards inspection is seen as an "interruption" to the nuclear facility operator's routine activities. How do facility operators regard safeguards inspections during a refueling outage when their time is heavily occupied with maintenance and shutdown activities? How much time is involved for a normal routine safeguards inspection? The following items could be given due consideration:

- Reduction of the number of IAEA inspections, especially during refueling and maintenance outages;
- For LWRs receiving fresh MOX fuel, possible co-ordination of IAEA verification with other State (shipper) regulatory functions to minimize handling and reduce radiation exposure to personnel;
- Implementation of improved unattended monitoring and surveillance systems to reduce inspection frequency and costs, while maintaining and improving safeguards effectiveness; these systems may transmit the information directly to the Agency for near-real-time analysis;
- Increase in the use of computerized operator records by IAEA inspectors to facilitate auditing in a timely and efficient manner;
- Reaching a practical working agreement between the SSAC and the specific Operations Division in the IAEA to utilize a manageable number of designated inspectors familiar with the specific plant layout and procedures. The intent is to avoid seeing new inspectors every time. If a "core" of designated inspectors who would most likely conduct inspections were identified at the beginning of the calendar year, the SSAC could take the necessary measures to facilitate the administrative requirements of the operators with reference to security and radiation safety and ease the bureaucratic procedures sometimes encountered during inspections; this, however, may require more freedom in scheduling inspections, or more inspectors;
- Scheduling of IAEA inspections to be performed within the day shift (e.g., 08:00 hrs to 18:00 hrs) to ensure availability of facility personnel knowledgeable about IAEA safeguards. There may be unavoidable exceptions to this, e.g., refueling activities involving loading of fresh MOX fuel into the core. Also, it is important that the shift staff is informed of IAEA equipment needs, for example, maintaining adequate lighting in areas where IAEA surveillance equipment is installed, or concerning actions to be taken in case an IAEA seal is broken.

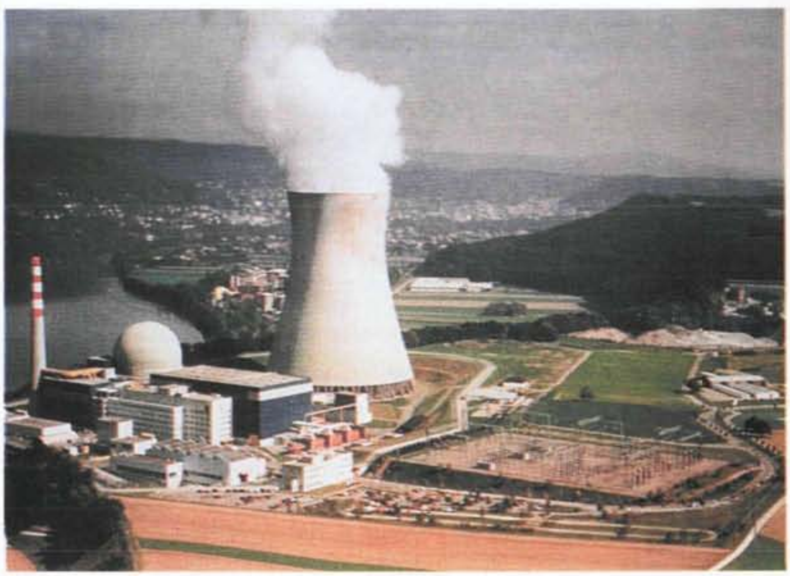
Towards greater co-operation

The classical safeguards approach is applied to the majority of LWRs currently under IAEA safeguards around the world. It utilizes a combination of routine interim and physical inventory verification inspections. It incorporates nuclear material item accountancy, containment and surveillance, and other measures required to establish confidence that no unsafeguarded nuclear activities have taken place.

As part of IAEA efforts to devise an improved safeguards approach for light-water reactors, the IAEA is currently studying the possibility, under the mandate of Programme 93+2, of establishing a network of unattended near-real-time surveillance systems at selected LWRs within a State. The information gained from such a network would be supplemented by IAEA inspections at some reduced frequency, and would likely be unannounced. It might also be expected that the inspector, during his infrequent inspections, would need greater access to the plant site. Cost savings resulting from this new approach would, in part, depend upon the particular fuel cycle and number of facilities to be inspected.

A reformulation in the requirements for IAEA timeliness goals — through the use of advanced technology and/or through accumulating assurance regarding the absence of undeclared activities (particularly undeclared reprocessing or enrichment) — would also provide a basis for reducing costs in implementing safeguards on declared material in the natural and low-enriched uranium fuel cycles. ❐

Switzerland's Leibstadt nuclear power plant.



Safeguards at research reactors: Current practices, future directions

Some new verification measures are being introduced to improve the efficiency and the effectiveness of the Agency's safeguards

by Giancarlo Zuccaro-Labellarte and Robert Fagerholm

Approximately 180 research reactors and critical assemblies currently are under IAEA safeguards. The vast majority of the research reactors operate at relatively low power levels (10 megawatts-thermal or lower) and the critical assemblies at virtually zero power.* From a safeguards standpoint, this is important since a reactor's power level is a determining factor of its capability to produce plutonium. Along with high-enriched uranium (HEU) and uranium-233, plutonium is considered a "direct use" material which could be diverted for the production of nuclear weapons.

In this article, the IAEA's safeguards implementation at research reactors is addressed, including aspects related to diversion and clandestine production scenarios and main verification activities. Additionally addressed are new safeguards measures that are being introduced for purposes of providing assurances about the absence of undeclared nuclear materials and activities.

Safeguarding research reactors

Several types of research reactors are in operation. A very common type of research reactor is the swimming pool reactor which typically operates at power levels around or below 10 megawatts-thermal. The fuel elements normally consist of HEU (enriched to contain 20% or more of the isotope uranium-235) or low-enriched uranium (LEU, containing less than 20% uranium-235) contained in aluminum alloy plates, rods, or tubes. The reactor core is immersed in a large pool of water that provides both cooling and neutron moderation. The fuel assemblies in the core of a swimming pool reactor are normally visible and accessible for safeguards measurements.

Other types of research reactors operate at higher power levels (exceeding 10 megawatts-thermal). They need more powerful heat removal systems and are therefore normally enclosed in core vessels and equipped with coolant pumps and heat exchangers. The fuel elements in the reactor core at these installations are usually not visible or accessible for safeguards measurements.

Research reactors are widely used for scientific investigations and various applications. Neutrons produced by research reactors provide a powerful tool for studying matter on nuclear, atomic, and molecular levels. Neutrons often are used as probes by nuclear and solid state physicists, chemists, and biologists. Neutron experiments can also be performed outside the biological shield by means of installed beam tubes. Additionally, specimens can be positioned in or near research reactor cores for neutron irradiation, e.g. to produce radioactive isotopes for medical or research use.

Diversion scenarios. Under existing comprehensive safeguards agreements, the IAEA has the right and obligation to verify that no nuclear material is diverted from peaceful use to nuclear weapons or other nuclear explosive

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*A critical assembly is a research tool consisting of a configuration of nuclear material which, by means of appropriate controls, can sustain a chain reaction. As distinct from a research or power reactor, it normally has no special provision for cooling, is not shielded for high-power operation, has a core designed for great flexibility of arrangement, and uses fuel in a readily accessible form which is frequently repositioned and varied to investigate various reactor concepts.

devices. States conclude these agreements with the IAEA pursuant to their obligations under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

For research reactors, the following diversion scenarios are considered:

Diversion of fresh or slightly irradiated fuel for clandestine chemical extraction of fissile material. This scenario — for which commonly available chemical engineering equipment would be adequate — is given particular safeguards attention at facilities where the fresh fuel contains HEU or plutonium, for which no further transmutation or enrichment would be needed for use in a nuclear explosive device. About 20 research reactors under IAEA safeguards are currently using such direct-use fissile material in amounts equal to more than one significant quantity (SQ). For safeguards purposes, one SQ is currently defined as 8 kilograms plutonium or uranium-233 or 25 kilograms of uranium-235 in HEU.

International efforts — for example, under the US Reduced Enrichment Research and Test Reactor programme — have been directed at developing the technology needed to use LEU instead of HEU fuel in research and test reactors without significant degradation in their performance for experiments, costs, or safety aspects.

Diversion of spent or extensively irradiated fuel for clandestine chemical extraction of fissile material in a reprocessing facility. This scenario is technically more demanding and time-consuming than the one mentioned above because of the high level of radioactivity from the fuel which is involved. However, it is of particular concern at about 15 research reactors under IAEA safeguards due to large accumulated quantities of spent fuel, and it is of importance at more than 10 others.

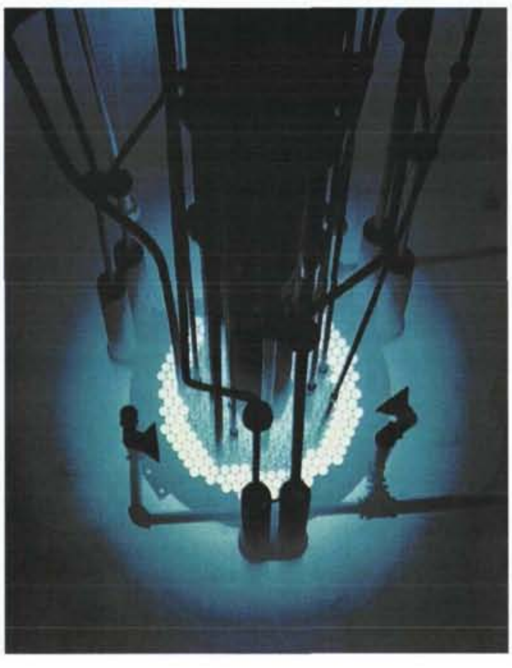
Clandestine production scenarios. The possibility exists for clandestine production of plutonium or uranium-233 through irradiation of undeclared fertile material. As techniques for using neutrons have developed, there has been an accompanying need for higher levels of neutron flux in order to carry out more complex and time-consuming experiments in a shorter time. Large research reactors have been constructed to provide these flux levels. At such reactors, production of substantial quantities of plutonium or uranium-233 through irradiation of undeclared fertile material would be technically feasible. This could be achieved, for example, by placing target materials in irradiation positions in or near the core, or by replacing reflector elements by fertile material targets. However, studies have shown that it is not possible to produce one SQ of plutonium in one year at a research reactor that operates below about 25 megawatts-thermal. The actual production capability depends on the individual reactor design and operating parameters.

The Agency's current safeguards system requires that all research reactors operating at power levels above 25 megawatts-thermal are evaluated with respect to their capability to produce at least one SQ of plutonium (or uranium-233) per year.

At present, there are about 30 thermal research reactors with power levels of 10 megawatts-thermal or higher which are subject to IAEA safeguards. About 10 of these operate at power levels exceeding 25 megawatts-thermal and are subject to additional safeguards measures with respect to the clandestine production scenarios.

Elements of "classical" IAEA safeguards

Currently, the IAEA's principal inspection activities at research reactors are an annual physical inventory verification (PIV); inspections serving timely detection purposes for fresh (unirradiated) fuel, core fuel, and spent fuel; auditing of records and reports; verification of specific types of fuel transfers; and verification activities to confirm the absence of clandestine irradiation of fertile material.



A research reactor in Japan is used for tests of fuel behaviour as part of nuclear safety studies. ***(Credit: JAERI)***

The research reactor at Bataan in Indonesia. *(Credit: Meyer/IAEA)*

At the PIV, the fresh fuel and spent fuel are verified using non-destructive assay (NDA) methods to confirm that all declared fuel is accounted for. Core fuel is verified by NDA methods or by a criticality check corroborated by other reactor data.* Interim inspections are performed at research reactors at intervals determined by the safeguards timeliness requirements for specific inventories of different material types.** If more than one SQ is present at a facility, verifications of the core fuel and spent fuel are carried out four times per calendar year at quarterly intervals, while verification of fresh fuel containing HEU and plutonium are carried out 12 times per calendar year at monthly intervals. Verifications of fresh fuel containing less than one SQ of HEU or plutonium are carried out four times per calendar year at quarterly intervals if more than one SQ of HEU or plutonium (fresh and irradiated) is present at the facility.

Transfers of fuel and experimental material containing HEU, plutonium, or uranium-233 into or out of a facility are verified either at the shipping or receiving facility if shipments are sealed by the Agency, or at both the shipping and receiving facilities if the shipment is not sealed.

To check that there has been no unrecorded production at high-power research reactors (greater than 25 megawatts-thermal) of one SQ of plutonium or uranium-233, one of the following procedures are used:

- analysis of the facility design and operations;
- containment and surveillance (C/S), among other measures (e.g. power monitoring), which confirm that the reactor is shut down or has not operated for a sufficient period;
- performance of one of the following activities: 1) the use of C/S measures to confirm that no unrecorded introduction of fertile materials or their removal after irradiation has taken place; or 2) evaluation of the fresh fuel consumption and the operator's data on spent fuel burnup to confirm that they are in conformance with declared design information and reactor operations.

Information of relevance to safeguards about the design of the research reactor is provided to the Agency by the State. It is examined and verified according to established Agency procedures and is re-examined at least once a year. When modifications or changes in design information relevant to safeguards occur, they are verified to establish the basis for adjustment of safeguards procedures, and the necessary adjustments are then implemented.

Elements of strengthened safeguards at research reactors

In June 1995, the IAEA Board of Governors endorsed the general direction for a strengthened and cost-effective safeguards system, under Part 1 of what is known as "Programme 93+2". Part 1 measures are those that can be implemented under the Agency's existing legal authority provided in comprehensive safeguards agreements.

Some measures designed to increase the efficiency and improve the effectiveness of safeguards are of a general nature. They include early provision of design information; and description of the State's nuclear fuel cycle.

Other measures are more specific to particular facilities. They include the description and status of the research and development activities, in particular related to uranium enrichment and reprocessing; environmental sampling at strategic points selected for routine inspections; unannounced routine inspections to confirm declared nuclear activities and the absence of undeclared nuclear activities; unattended monitoring and remote transmission of safeguards information.

The continuous development of new technologies also brings to light the possibility of new safeguards measurements and surveillance systems, which allow the remote operation of equipment and remote transmission of safeguards data.

*A criticality check is an inspection activity which provides evidence that a reactor has reached criticality and that a controlled nuclear reaction is sustained, i.e. the core contains at least minimal critical amounts of nuclear material.
**Safeguards timeliness is related to the time needed to convert the nuclear material from its present status to HEU or plutonium metal.

The impact of these new measures on the operators and States will depend very much on the type of nuclear facilities and the particular States or areas where these facilities are located.

An essential component in introducing the proposed measures is the increased co-operation with the States and the State System of Accounting and Control (SSAC) for nuclear material. This is needed to enable the IAEA to plan and conduct inspection activities more efficiently. The SSACs and IAEA may also carry out inspections or selected support activities jointly in order to economize resources and to make optimal use of the present system.The co-ordinated and efficient use of the new measures will reduce the current effort of safeguarding declared nuclear material and at the same time will enhance detection capability of possible undeclared nuclear activities and material.

As mentioned earlier, the frequency of inspections at research reactors varies from one to 12 per year, depending on the type and quantity of nuclear material present at the facility. The current inspection activities are planned in such a way as to provide assurance that the declared nuclear material remains under safeguards. It is more difficult within the present system to give assurance that the reactor has not been used to produce undeclared plutonium or uranium-233 by undeclared operations, in particular if the produced quantity of undeclared fissile material is much less than one SQ (e.g. 2 kg or less of plutonium per year).

For facilities now inspected 12 times per year, measures can be taken during these frequent inspections to check for possible undeclared operations. In other research facilities where the quantities of declared nuclear material are below one SQ, the frequency of inspections is normally once per year, or for some larger research reactors, two inspections per year. In these cases the new measures can considerably contribute to improving the Agency's capability to provide assurance regarding the absence of undeclared activities.

Measures which are presently being introduced under the IAEA's existing legal authority include:

Environmental sampling. The irradiation of targets and their subsequent dissolution in a hot cell to extract, for example, plutonium might be successfully concealed from the classical safeguards measures, particularly if the quantities produced are much less than one SQ. Where the inspections are announced and the frequency is limited to once per year, it might be possible to conceal the undeclared activity and interrupt it before the IAEA inspection is carried out. However, in any chemical process used to separate fissile material, small amounts of material would migrate to the surroundings of the area where this material is processed. Even though great care were taken to prevent losses, traces of this activity could remain and could be detected by the sophisticated and highly sensitive analytical methods used on environmental swipe samples.

The impact which these analytical techniques will have on facility operations is low, since the sampling is carried out by taking swipe samples inside or outside hot cells during regular inspections; little preparation is required by the operator.

Overview of safeguards measures and detection capabilities at research reactors

Detection Capability

	Declared nuclear material		Undeclared nuclear material/activities	
	Determination of Quantity	Timeliness	Determination of Quantity	Operation/Production
Present safeguards measures	Yes	Yes	No	Yes*
Environmental sampling	No	No	No	Yes**
Unannounced inspections	Yes	Yes	No	Yes
Remote monitoring:				
video surveillance	No	No	No	Yes
transmission of accountancy data	Yes***	Yes***	No	No
NDA, radiation monitors	Yes***	Yes***	No	Yes

*The present safeguards system is based on detecting undeclared operations to produce one SQ/year (or more) of undeclared plutonium or uranium-233.
**Environmental sampling is effective also in cases of production of much less than one SQ /year.
***In connection with unannounced inspection arrangements

Unannounced inspections. Unannounced inspections are those where the State and the operator are first informed of the Agency's intention to carry out an inspection at the time when the IAEA inspector arrives at the entrance of the site. The State's co-operation is necessary since the implementation of such inspections requires that the State grant multiple-entry visas or allow entry without visas to the inspectors. In addition, arrangements have to be made by the operator to grant access to the Agency inspector to the facility in a short time. The facility operator needs to be prepared for an unannounced inspection at any time. The benefit is that an assurance about the absence of undeclared activities at the facility at the time of the inspection implies that this has been the case with certain probability over the whole time interval since the last on-site inspection.

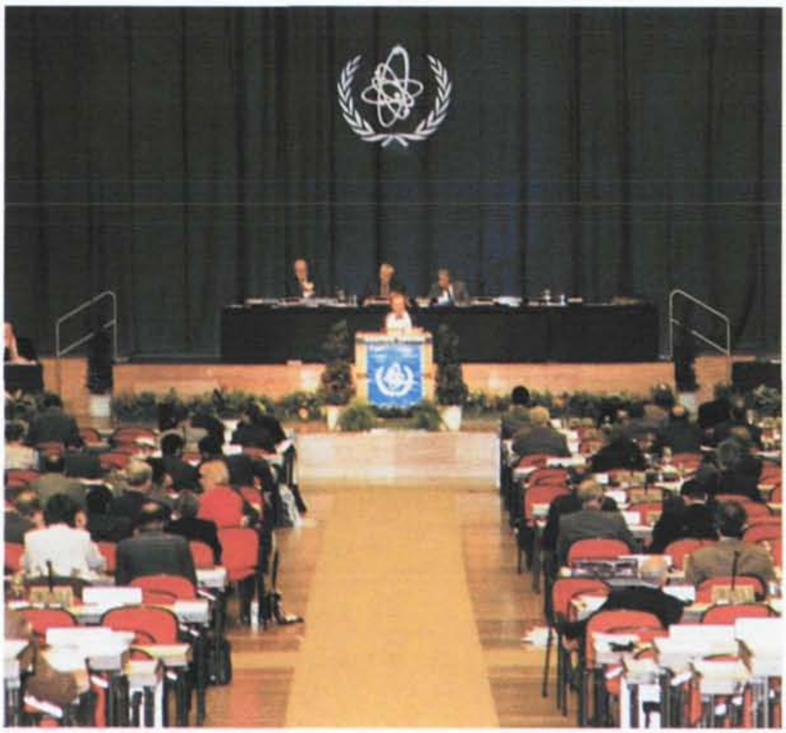
Remote monitoring. These types of systems include:

Video surveillance. The installation of cameras which can be operated remotely would allow continuous surveillance of facility operations and reduce the possibility that undeclared activities could be carried out undetected. This technique is not intrusive to the operator, since the only requirement is continuous and sufficient illumination of the area under surveillance.

Measurement and accountancy data. Remote transmission of inspection data would provide additional assurance that no undeclared activities have taken place, particularly when used in connection with unannounced inspections. The extent to which the necessary equipment can be used in a facility depends on the facility conditions and operating practices and requires the co-operation of the State, the SSAC, and the facility operator, who will be operating the equipment that provides the data for use by the IAEA.

The utilization of remote monitoring will enable a reduction in the requirement for inspectors to be physically present, with additional reductions in intrusiveness in facility operations. *(See table on previous page for a general overview of the verification capabilities provided using new safeguards measures at research reactors.)*

IAEA Member States have endorsed some new safeguards measures and are considering others. ***(Credit: Pavlicek/IAEA)***



Future co-operative efforts

Over the past years, the IAEA and its Member States have been taking steps to strengthen the effectiveness and improve the efficiency of the safeguards system. The objective is to provide assurances that a State's declared nuclear material remains in peaceful use and that no undeclared nuclear activities and material are known to exist.

The "classical" safeguards system based on the accountancy of nuclear material has proved to be reliable in providing assurances about the peaceful use of declared material and declared facilities and installations. However, the system needs to be further strengthened with respect to providing assurances about undeclared nuclear materials and activities.

Some of the new safeguards measures that have already been approved are aimed to strengthen the system and have to some extent already been introduced. They considerably improve the capability of detecting the diversion of declared nuclear material and the production of undeclared nuclear material. However, they are not capable of determining the quantity of undeclared nuclear material produced through undeclared activities. Attaining such verification objectives would require greater co-operative efforts and additional safeguards measures.

At the present time, the IAEA Board of Governors is considering further measures for strengthening the effectiveness and efficiency of safeguards. The extent to which additional measures can be implemented will depend upon the outcome of its work. ❐

International safeguards: An industry perspective

The civilian nuclear industry has long backed the need for an effective system of nuclear verification

by Gerald Clark

There was considerable relief among the Members of the Uranium Institute in May 1995 that the Conference in New York to discuss the extension of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) had agreed without a vote on permanent extension of the Treaty. The Institute had campaigned for this result. It was a matter of vital importance to its members that the international safeguards regime which had served the civil nuclear industry well for more than 25 years should be thus extended permanently. The terms which were agreed as the price of permanent extension were also fundamentally in the industry's long-term interests.

It is worth examining why this should have been so. Ever since US President Eisenhower launched the civil nuclear age with his Atoms for Peace speech at the United Nations in December 1953 the civil industry has been at pains to show that it is an independent endeavour, quite separate from and in no way linked to the ambitions of ministries of defence. For many years this was an exceedingly difficult, almost impossible task. The civil applications of nuclear energy had their origins in the Manhattan project culminating in the two atom bombs which brought the Second World War to an end, and for many decades after that nuclear rivalry between the superpowers inevitably was uppermost in the public mind. The horrors of a possible nuclear war, fortunately never realised, held a far stronger grip on the public imagination than the developments, however impressive, of the closely related civilian technology.

Nevertheless, as the civilian technology became more distinctive, and its objective, the economic safe and efficient generation of electricity, became an end in itself, it became easier to show that the putative linkage between the two was more imaginary than real. It was also possible to take internationally inspected measures to demonstrate that the work of the civil industry need have no connection with attempts, overt and clandestine, real and imagined, to embark on a nuclear weapons programme.

The civil/military split

Historically none of the existing five acknowledged weapons States used a civilian programme of nuclear power generation as a stepping stone to their nuclear arms manufacture. Rather the reverse was true. Electricity was a by-product of the early plutonium producers, but once electricity generation became the primary aim, it was also seen that it should be pursued for its own sake, and weapons material production became the province of specially dedicated installations. One reason for this was the usual obsession with national security, but the need to discriminate between appropriate technologies became a more important reason. The retrieval of weapons grade plutonium is incompatible with maximising the output of electricity even from channel reactors. The natural or low-enriched uranium fuel of present day power reactors is unusable as bomb material. Enrichment to the required degree to deliver weapons grade highly enriched uranium involves taking the process much further, involving far more extensive cascades than would be found in a civilian plant.

In other words, for both technical and economic reasons, misuse of the civil technology for weapons production is not the best way to proceed, and in practice the weapons States and the "would be" weapons States have not gone down that route. The development of a civil nuclear power programme is neither a necessary nor a sufficient condition for the pursuit of a weapons programme. However, the civil indus-

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try does make use of materials and technical skills which are commonly also used in nuclear weapons programmes. There is thus an onus on it to collaborate fully with any regulatory system which is designed to show that there has been no diversion of material away from legitimate civilian purposes.

It is implicit in the IAEA Statute that it should devise a safeguards system which does just that. The system developed naturally as the technology spread. The arrangements already established by EURATOM for its members were a model. The arrival of the NPT, which came into force in 1970, was the signal for a much more comprehensive system: that of full-scope safeguards, where a signatory country has to apply the Agency's safeguards system to all its nuclear materials. In the course of the next 25 years the value of the system gradually became apparent, not only to the arms-control community, but to the civil nuclear industry, which came to realise the value of the certificate of good conduct which its willing collaboration with the safeguards system provided.

It is easy to deduce from what has been said above that safeguards are more essential for ensuring non-diversion in some parts of the nuclear fuel cycle than in others. Mining, milling, processing and conversion, all of which take place with natural uranium only, are relatively innocuous. The material is far from usable directly in a weapon, and, were it to be diverted, the diverter would still face an enormous task to achieve his ends. It is much more important for the civil industry to be able to demonstrate that the materials arising from enrichment and from recycling are subject to safeguards, and that no diversion has taken place.

Forty years of success

The IAEA and the civil nuclear industry have together developed a safeguards system which has worked well for nearly 40 years. Diversion of material from the civil industry has not taken place. Even those examples which have been held to call the safeguards regime into question, and are the catalysts for current measures to extend the system, are not so much failures of the system but demonstrations that it has worked. Iraq realised that diversion from its existing civil programmes (all of which by 1991 were research reactors and not power generating reactors) would inevitably be detected, so went to very expensive lengths to start its weapons programme from scratch, quite separately from its civil research programme. The imbroglio over the Democratic People's Republic of Korea (DPRK) arose because the IAEA noticed that its rules for the implementation of an INFCIRC-153 type agreement were being flouted, and the DPRK refused to put its house ostensibly in order.

The civil industry had thus come by 1995 to have a lot at stake in the continued health of the international safeguards system. Nuclear power generation is a very long-term business. The existence of a long lasting, preferably permanent, system of international regulation and control has become a necessary condition for the continued existence of a healthy trade in civil nuclear materials and technology. The general acceptance of the IAEA system of safeguards and related measures of materials accountancy and other forms of control is of great benefit to companies and countries involved in the civil nuclear trade. There are now general rules of practice. Much of the trade is mundane and normal. The shipment for which special arrangements have to be made is the exception not the norm. The designers of the Treaty presumably had this in mind in drafting its Article IV. From an industrial perspective, the Treaty has worked. Nuclear power generation has spread from the handful of countries which were pioneers in the 1950s and early 1960s to 30 countries, and nuclear electricity is now 17% of the world's supply.

The spread of nuclear technology has not been confined to nuclear power generation. Much of the world relies to a far greater extent than most people realise on the medical, industrial and agricultural applications of radioisotope technology. While some may think that this is relatively small beer, an interesting paper by the American Nuclear Society has demonstrated that in the United States the industries which rely on these technologies are about four and a half times as large as the power-based nuclear industry. Since 1980 the IAEA has processed over $500 million worth of technical assistance in these technologies. None of it would have been possible without the international safeguards system.

Universal application

After 25 years of operation the application of the NPT has become almost universal. Compared with the early years when there were many important countries which were not members of the Treaty, and other regulatory arrangements for the civil nuclear trade were still in widespread use, the present membership of the Treaty has expanded to 184, with very few exceptions remaining outside its ambit. It has therefore become the main regulatory system, with most other arrangements dependent upon it. Even if some of the NPT's achievement of virtually global coverage is of very recent date, the accreditation of members in the last five years is as important for the regulation of the civil trade as for arms control.

The world political climate has completely changed compared with the 1960s when the Treaty was negotiated. The existence of the Treaty has contributed to that change. Countries have gradually become comfortable with the regulatory regime it imposes. The change in climate is perhaps best demonstrated by the contrast between governmental attitudes to the safeguards system in the early years and now. When the Treaty was under negotiation, the proposal for international inspection of areas of activity so close to vital national security interests was an unprecedented intrusion into national sovereignty. This could clearly be seen in the minimalist view of international inspection in support of the safeguards regime which animated the drafting of Article III of the Treaty, and

Today's commercial nuclear industry provides about 17% of the world's electricity. *Above:* Inside the control room at Sellafield's reprocessing plant in the UK. Left: Takahama nuclear plant in Japan. *(Credits: BNFL, JAIF)*

the related "INFCIRC 153" type agreements on the application of safeguards.

Whereas safeguards were originally seen as very intrusive, to the extent that some important States hesitated long before joining the Treaty, there is now strong pressure to extend the system. While there may be differences about the scope of measures to strengthen the system, the principle that it should be strengthened is almost universally accepted. This presents no problems of principle to the civil nuclear industry as it has every interest in the wide acceptance of a well respected and effective regulatory regime. The civil industry is well aware that, if the Treaty had not existed the spread of the benefits of civil nuclear energy would not have been as widespread as they are. But obviously we want to ensure that the implementation of any such "improvements" does not raise serious obstacles to the legitimate trade permitted under the Treaty.

I have so far set out the general arguments why the civil nuclear trade supported the permanent extension of the international safeguards system enshrined in the NPT. Above all, its application over the first 25 years of the Treaty has demonstrated that the expansion of the civil nuclear industry across the world has not led, and does not need to lead, to proliferation of nuclear weapons. (In the 1960s it was widely assumed that by now there would be 20-30 nuclear weapons States. There are still only five declared weapons States, and fewer "threshold" States.) The Treaty has achieved what it set out to achieve in this regard.

Costs and benefits

But it is not without cost to nuclear operators. It is often forgotten in the hurly-burly of diplomatic in-fighting that the system is not an abstract construct but has to be implemented meticulously and constantly, not so much by the inspectors of EURATOM or the IAEA, as by the industrial enterprises which they inspect.

The safeguards requirements stemming from the facility attachments required as an integral part of the INFCIRC 153-type agreements which the Treaty enjoins upon its signatories clearly vary from installation to installation. Little has hitherto been published concerning the costs which the nuclear industry has to bear in order to comply with these requirements. The Uranium Institute did some work on the subject when preparing briefings for the delegates to the NPT Extension Conference, and the figures which follow are based on that work. Our estimates are inevitably very broad, as there are a number of factors, some of which balance each other out, which are very difficult to quantify. These costs arise both in the construction of installations and in operating them.

We estimate that for a new nuclear power station the increase in capital cost, attributable to measures which make it possible to demonstrate that safeguards requirements are being met, lies in the range 0.1- 0.2% of the total cost of the station. This implies a total capital cost of between \$2 million and \$4 million for a nuclear power station costing \$2 billion. For nuclear facilities in which plutonium is being processed, such as reprocessing plants and MOX fuel-fabrication plants, the costs of safeguards equipment are an order of magnitude higher, and lie in the range 1-2%. Thus the additional capital cost in the case of a reprocessing plant costing \$4 billion would be from \$40 million to \$80 million. For a MOX fabrication plant costing \$400 million, the extra capital cost would be from \$4 million to \$8 million.

We estimate that the effect on operating costs of the aggregated effort, and associated expenditure of the industrial enterprises in countries which are party to safeguards, is comparable to the safeguards-related expenditures of the inspecting organisations, the IAEA and EURATOM. In other words, the industry's collective annual operational costs worldwide, ascribable to safeguards-related activities, are of the order of \$100 million.

The industry has come to see that this is a price well worth paying for an effective Non-Proliferation regime as it carries with it the associated bonus of a smooth flow of trade in nuclear technologies round the world. It is not surprising that the permanent extension of the NPT was regarded by the Uranium Institute's members as a triumph of good sense. They were not in the least dismayed by the fact that the concessions its supporters had to make in order to achieve it on something akin to a consensus basis included negotiations towards a Comprehensive Test Ban Treaty, preliminary moves towards a fissile materials cut-off agreement, and of most relevance to the civil industry, the IAEA's plans for strengthening safeguards, "the 93+2 Programme". The industry has kept a close watch on these developments, and while it accepts that a strengthening of the system is desirable, it is concerned that the resultant arrangements should be in accord with the principles of good materials accountancy, and should not bear unduly on countries with a good record of compliance. ❐

Safeguards & illicit nuclear trafficking: Towards more effective control

In important respects, elements of effective safeguards can assist States in their efforts against illicit trafficking in nuclear materials.

by Svein Thorstensen

Over the past few years, reported cases of illicit trafficking in radioactive sources and nuclear materials have focused international attention on an emerging phenomenom of the 1990s. By far, most of the nearly 130 confirmed cases reported to the IAEA have involved individuals trying to illegally sell radioactive sources used in medicine or industry whose unauthorized use or movement poses a danger to public health. Some other cases have involved samples of weapons-grade material confiscated from individuals. The incidents have raised public and governmental concerns and have prompted stronger efforts to prevent illicit nuclear trafficking by State authorities, including their greater co-operation with supporting international organizations such as the IAEA.

In April 1996, the Nuclear Safety and Security Summit convened in Moscow underlined the importance of States working together to combat the trafficking problem. In reaffirming their concerns, State leaders recognized the need for countries to co-operate bilaterally, multilaterally and through the IAEA to ensure effective national systems for controlling nuclear materials.

Over recent years, States have requested the IAEA to assist relevant State, regional, and international authorities working to prevent cases of illicit trafficking. The Agency's work encompasses maintaining an authoritative database on trafficking incidents; assisting in the development of national systems of control; and providing technical support related to areas of physical protection. It involves establishing closer collaboration with organizations on the front line of efforts to combat illicit trafficking, especially law enforcement bodies and customs authorities principally responsible for detection and prevention.

This article looks at the issue of illicit nuclear trafficking from the perspective of nuclear safeguards. It examines some ways in which essential elements of an effective safeguards system can contribute to the efforts of States against illicit trafficking in nuclear materials that could be of use for weapons production. Particularly addressed are aspects related to the accounting and control of nuclear material and technical assistance that States can receive to establish or strengthen such control systems. The article does not address aspects related to radiation protection and safety involving radioactive sources that could pose a public health danger but that are of little or no concern from the standpoint of nuclear proliferation.*

For context, it is important to note that the main purpose of IAEA safeguards is not directed at illicit nuclear trafficking, which is a complex and multi-dimensional safety and security issue. All States — including those having no known nuclear material on their territories — are vulnerable to such trafficking. This fact underscores the need for co-ordinated actions — not only within a State but also among States — including consideration of relevant support that could be derived through elements of an effective system of nuclear safeguards.

Establishing effective countermeasures. Legitimate trade in nuclear material is conducted under the authority and within the limitations of State regulation. States have the direct responsibility to assure proper security for nuclear material, as well as its proper handling, control and accounting. Consequently, any State which is determined to combat illicit trafficking must create a solid regulatory

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*For a comprehensive report on illicit trafficking and IAEA activities, see the 1996 edition of the IAEA *Yearbook*, available for purchase from the IAEA Division of Publication.

infrastructure that includes *prevention, response,* and *training.*

Prevention. The most important precondition for preventing illicit trafficking is an effective national control system for nuclear materials. These control systems must be based on legislation and regulations that incorporate modern standards and meet the State's obligations and commitments arising from international treaties and conventions to which it is a party. They must also include mechanisms at the State level for preventing, detecting, and deterring unauthorized activities. Nuclear materials require systems and procedures for accountability and control, physical protection, and export/import control.

Accounting and control of nuclear material. A primary deterrent to the theft of nuclear material is a strong regulatory system that recognizes the complementary nature of material accounting and control and physical protection regulations and associated procedures. Material accounting and control is designed to ensure that the location of all nuclear material in a State is known and its continuing presence confirmed through the taking of periodic inventory.

Of relevance here is the fact that under comprehensive safeguards agreements concluded with the IAEA, a State must establish a State System of Accounting and Control (SSAC) of nuclear material on a national or regional basis. The SSAC co-operates closely with the IAEA in the implementation of safeguards, regularly providing information on matters related to the nuclear material accountancy system in force and the State's adherence to the reporting requirements. Both at the time a comprehensive safeguards agreement is concluded as well as upon specific request, the IAEA assists States in establishing effective procedures and routines for the SSAC, both at the State and facility levels.

Legislation and regulations. The foundation of a strong national control system is appropriate legislation and regulations. For most States, the basic international obligations for nuclear material are contained in the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the mandated comprehensive safeguards agreements with the IAEA. In States where such a safeguards agreement is in force, the IAEA is obliged to verify the presence of nuclear material subject to safeguards, and the State is obliged, among other things, to report to the IAEA if the State believes there is or may have been a loss of nuclear material.

When requested by a State, the IAEA has supported national activities in the area of legislation and regulations. This is being done because the State wants to ensure that its legal and regulatory framework meets international standards, taking into account its commitments to international conventions and agreements.

Physical protection. Another component involved in prevention of illicit trafficking is a system of physical protection against the theft or unauthorized diversion of nuclear material and against sabotage of nuclear facilities. The responsibility for establishing and operating a comprehensive physical protection system for nuclear material and facilities within a State rests entirely with the Government of that State. In order to ensure that adequate physical protection is provided, State systems must establish conditions which minimize the possibilities of unauthorized removal of nuclear material or of sabotage; provide rapid and comprehensive measures to locate and recover missing nuclear material; and minimize the effects of sabotage. Physical protection regulations and associated procedures must thus be designed to thwart any attempted theft and to promptly detect an actual theft.

In this area, nuclear authorities from a number of States have asked the IAEA for technical support and advice. In April 1996, a new IAEA service known as the International Physical Protection Advisory Service was formed to assist interested IAEA Member States which request specific types of assistance. Under the service, an international team of experts reviews national regulatory programmes for the physical protection of nuclear material and/or for the implementation of physical protection systems at specific nuclear facilities. The IAEA also has provided extensive training courses in physical protection for responsible personnel in a number of States.

Export/import control. Prevention of illicit trafficking further requires an effective State control system on exports and imports which serves to prevent unauthorized movement of nuclear material across borders. States initiate and establish such measures by means of legislation and their national systems of controls on the handling and use of such materials.

Besides the systems and procedures specifically implemented in the area of nuclear activities, such measures must engage conventional components in a State's anti-trafficking infrastructure, for example, law enforcement authorities and customs officials. The extent to which such components are utilized, and the way in which they are organized and co-ordinated, depends on the specific conditions in each country.

Some elements associated with nuclear safeguards are of relevance on the general matter of exports and imports. Under the proposed IAEA strengthened safeguards system, complementary legal authority is being sought that would obligate States having comprehensive safeguards agreements to report to the IAEA exports and imports of nuclear material and specified non-nuclear material and equipment. This would also enable assessment of whether import and export patterns are consistent with other information available about States' nuclear programmes. The IAEA's information database also is being improved by including available information derived from open source literature, obtained through the IAEA's verification activities, provided to the IAEA by governments, or obtained elsewhere. These activities are important components of a strengthened safeguards system which can also support States' co-operative efforts in combating illicit trafficking.

Response to illicit trafficking. Only State authorities can be responsible for detecting and responding to illicit trafficking activities on their territory. However, no clear minimum requirements exist on what measures are necessary to meet this responsibility.

In some countries, the anti-trafficking infrastructure — which encompasses responsible authorities including customs, police, nuclear, intelligence and defense agencies — are co-operating and co-ordinating their efforts against trafficking. Threat and response scenarios are identified. Personnel are also trained in nuclear-related matters (e.g. at schools for customs and police staff). Detection equipment for nuclear material is available. Regulations and procedures are established and the public is informed. These are good models from which other States may benefit.

Each State will need to determine the extent to which it must establish a strong infrastructure and related measures, based on the threat it perceives from illicit nuclear trafficking. For some States, this may involve making less formal arrangements; for others, however, the needs may be more extensive.

At the present time, some States, including those having an SSAC for controlling nuclear materials, may lack the regulatory knowledge and inter-agency co-ordination to effectively combat illicit trafficking. At the same time, many other countries without nuclear materials have neither a nuclear control system nor anti-trafficking measures, even though they may be in a high-risk trafficking area.

Training. If a State decides to take serious measures against illicit trafficking, then it will also need to train staff from all relevant authorities on various aspects, including the utilization of equipment and in forming co-operative programmes for effective inter-agency co-ordination. The extent of training requirements for establishing or improving anti-trafficking measures depends upon how many States decide to establish them, as well as the minimum objectives to be achieved.

Of relevance here from the standpoint of nuclear safeguards is that States can receive support that would contribute to their overall training needs. This training support would be directed at establishing or improving the nuclear control system, including the SSAC, in States having comprehensive safeguards agreements.

An evolving supporting role. In a number of respects, essential elements of effective nuclear safeguards can play an important supporting role in States' efforts to combat illicit trafficking in nuclear materials. Further implementation of safeguards strengthening measures will increase the assurance that *all* nuclear material in such countries is safeguarded and under effective SSAC control. As more States decide to institute national control systems, illicit trafficking involving the safeguarded nuclear inventory will become less of a threat. However, threats posed by *cross-border* illicit trafficking would not be affected as long as some States lack nuclear control systems and co-ordinated anti-trafficking measures.

As the Moscow Summit noted, co-operative anti-trafficking efforts must be initiated to prevent the unauthorized movement and sale of nuclear materials. It is in this spirit that the IAEA, as part of its overall supporting role, is responding to requests from States seeking to establish or improve their anti-trafficking capabilities, including inter-agency co-ordination. An important component in this connection is establishing and maintaining close collaboration with relevant organizations, in particular the World Customs Organization and Interpol, and with regional bodies such as Euratom and Europol, to ensure practical co-ordination among the different national agencies invariably involved in this complex issue.

In keeping with the desires of its Member States, the IAEA will support interested States as its expertise and resources allow to assist in the prevention of illicit nuclear trafficking. ❐

Nuclear plant safety & performance: Elevating standards of quality assurance

Under its Nuclear Safety Standards (NUSS) programme, the IAEA has revised the standards for quality assurance of nuclear power plants

by Nestor Pieroni

Over the past five years, nuclear experts have worked to review and revise a wide body of documents that lay down quality assurance standards for the world's nuclear power plants. The work was done within the framework of the IAEA's Nuclear Safety Standards (NUSS) programme, which was set up in 1974 to lay down advisory standards useful to national authorities responsible for regulating the safety of nuclear plants. A comprehensive revision of the complete set of NUSS standards on quality assurance was approved and issued in 1996.

The result of the extensive and complex revision was the production of 15 NUSS documents: one Code and 14 supporting Safety Guides, which the IAEA issued in 1996 as a single publication, Safety Series No. 50-C/SG-Q. The revised standards offer a simplified set of basic requirements and implementation methods that facilitate for regulatory bodies the establishment of requirements and the measurement of their fulfillment; formulate clear responsibilities for responsible organizations for achieving improved quality and safety performance; and provide additional guidance on methods to fulfill the basic requirements.

This article highlights major elements of the revision process and key features of the revised quality assurance standards in selected areas.

Revision of quality assurance standards

Under the NUSS programme, more than 60 documents, including Codes and Safety Guides, have been published over the past two decades. The Codes establish the objectives and basic requirements that must be met to ensure adequate safety in the operation of land-based nuclear power plants. The Safety Guides describe acceptable methods of implementing particular parts of the relevant Codes. Although Codes and Safety Guides establish an essential basis for safety, they may require the incorporation of more detailed requirements in accordance with national practice. The NUSS programme covers five areas: governmental organization, siting, design, operation and quality assurance. Each area includes one Code and several supporting Safety Guides. Revisions and reissues of the Codes and Safety Guides are made as needed in order to take account of lessons learned and to incorporate new developments in technology and methods.

The development of the NUSS standards — whether the production of new documents or the revision of the existing ones — is accomplished by an elaborate and comprehensive process directed to achieve consensus among the IAEA's Member States. The resulting documents, therefore, reflect harmonized views and experience collected from around the world.

As in each of the NUSS areas, a specific Code on quality assurance and the corresponding Safety Guides were first developed during the period 1974-84. After the Chernobyl accident in 1986, the Code was revised with the intention to verify if lessons learned from that accident should be reflected in the document. The resulting revision was issued in 1988, though it was found that no essential change as a consequence of the accident was necessary. In fact, it was indicated that the Chernobyl case showed the consequences of *not* following the procedures and requirements normally implemented through an effective quality assurance programme such as recommended in the NUSS documents.

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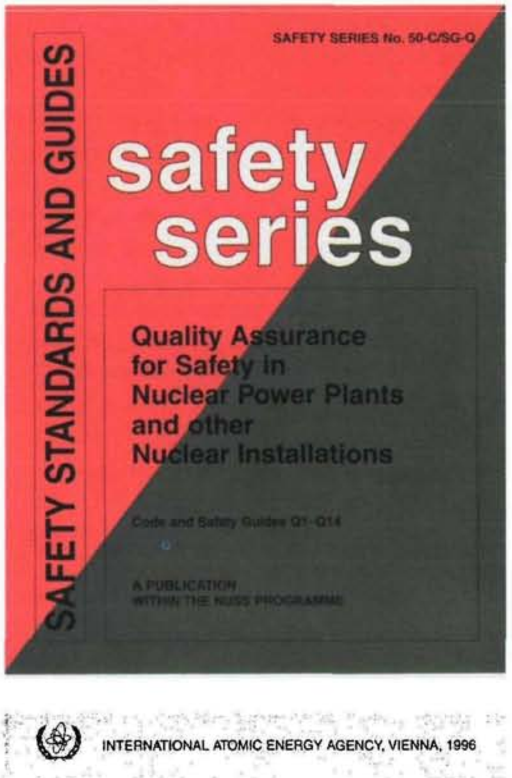
The review in the 1980s also showed that effective implementation of requirements encountered a number of difficulties depending on the particular country or organization. The IAEA thus tried to identify specific causes. Some typical issues that were identified include:

- interpreting quality assurance requirements as solely regulatory, as if they had no beneficial effect on work performance;
- viewing a good quality assurance programme as only demanding many written documents and procedures, i.e., it is only concerned with "paper work";
- assigning responsibility for quality only to the quality assurance unit;
- auditing for compliance with formal requirements without analyzing the final results;
- not recognizing that management and workers have the main responsibilities in the achievement of quality assurance results;
- being unaware of the importance of adequate qualification and motivation of personnel;
- not assessing the effectiveness of the quality assurance programme;
- not providing clear management support and commitment to the implementation of the quality assurance programme.

This situation largely prompted the need to revise NUSS documents on quality assurance, and the work was initiated in 1990. The revision process took almost five years because of the need to reach consensus, a requirement for the issuance of IAEA safety standards. Seventeen advisory and consultancy meetings were held, involving more than 70 experts. Altogether they represented 22 IAEA Member States and three international organizations, namely the European Community (EC), European Atomic Forum (Foratom), and the International Organization for Standardization (ISO). All the proposed revisions were submitted to IAEA Member States and international organizations for review before approval. A total of 3300 comments were received, an indication of the interest, vigorous participation, and effective support provided to the revision process.



Above*: Japan's Genkai nuclear power plant.** ***(Credit: JAIF)

***Left:* Revised standards for quality assurance at nuclear plants were issued in 1996 in the IAEA's Safety Series.**

Highlights of specific changes

As part of the revision process, the IAEA performed an analysis of the main reasons for variation in the performance of the world's nuclear power plants. A summary of the findings from this analysis includes the following key conclusions:

- practices that ensure operational safety are the same as those that improve overall plant performance;
- top management that supports disciplined operations is essential for achieving plant safety, and therefore reliability and economic performance objectives;

The focus on overall performance, including safety and other plant objectives, and the emphasis on the essential role of management were considered the driving elements that contributed to avoiding misinterpretations of, and failures to effectively implement, quality assurance requirements.

Main changes incorporated in the revision. The concept applied in the revision procedure sought to instill a performance-based approach to quality assurance, an approach that positively influences plant safety, reliability and economics. The overriding principle is that safety shall not be compromised for reasons of production or economics, or for any other reason. The approach emphasizes the key management responsibility and accountability for all aspects of quality of performance, including planning, organization, direction, control and support.

Since the approach looks for total quality, it helps to align people and activities towards the achievement of established requirements. To succeed, it is necessary to integrate the contributions that are made to quality and safety by the people managing it, those performing the work, and those assessing it.

The substance of the changes incorporated by the IAEA in the revision process emphasized the following:

- achievement of overall performance objectives;
- the responsibility of everyone regarding achievement of the objectives;
- the key role and commitment of managers;
- provision of additional guidance on quality assurance activities directed to assessment, siting, commissioning, decommissioning, research and development, non-conformance control and corrective actions, training and qualification, and instrumentation and control.

Simplified standards. In order to reflect the world experience evaluated by the IAEA, the revised documents enhance the essential responsibility of everyone in achieving performance objectives. The revised Code divides the responsibilities into three functional categories: management, performance and assessment. In correlation with these categories, ten basic requirements are established. They are the ones whose fulfillment has to be demonstrated by the responsible organization to the satisfaction of the regulatory body.

Some changes were made to provide guidance on the implementation of each basic requirement of the Code in each of the six licensing stages. Specifically, the content of the existing Safety Guides was rearranged and new Safety Guides were developed. The guidance contained in the Safety Guides, although not the only means of fulfilling the basic requirements of the Code, represents implementation methods that are generally accepted and have been proven by experience. The Code and Safety Guides integrate a complete and consistent set of guidance structured within a clear framework for safety regulation.

Global safety standards. The revised standards take into account international industry standards, such as ISO 9000 standards for quality management. There are fundamentally two application levels of standards set by NUSS and the ISO. The *establishment level* concerns the interface between the regulatory body and licensee/responsible organization (owner or operator of the nuclear power plant). The nuclear safety requirements are established by the regulatory body and their accomplishment must be demonstrated by the responsible organization. The NUSS documents provide the safety requirements and methods that may be applied at this level. The *implementation level* concerns the interface between responsible organizations and suppliers. The contractual agreements, including nuclear safety and other requirements, technical specifications, schedule, costs and other obligations, have to be arranged. The ISO standards (as well as other national or international industry standards) may be applied at this level. Additional measures are sometimes needed to complement the industry standards so as to meet the safety requirements for nuclear items and services.

Quality system respective to suppliers. The NUSS standards require that a quality assurance programme be established and implemented for all items and services affecting the safety of nuclear power plants. The supplier organization might have established a quality system as part of its way of doing business. If a quality system exists in the supplier organization, the establishment of the required quality assurance programme would be facilitated. However, the mere existence of a quality system is not enough to fulfill the safety requirements. The NUSS standards require a specific quality assurance programme for the nuclear items and/or services, irrespective of whether the organization has a quality system in place or not. It is the performance of the delivered products that is relevant and not (only) the implementation of the quality system of the supplier organization.

Quality certification. Since they are focused on performance and quality of the final product, the NUSS standards do not require reliance on any type of certification. Certification may lead to the undesirable consequence that priority is shifted to a mere compliance with procedures and documentation instead of conformance with specifications. Concentration on documentation and procedures — which are certainly necessary — is not sufficient to ensure the effective implementation of a quality assurance programme. The NUSS quality assurance approach, by re-emphasizing product quality as the main goal, de-emphasizes reliance on certification programmes provided by third parties. It is the pursuit of quality rather than the pursuit of certificates that is intended.

Personal attitudes. As indicated earlier, the performance-based quality assurance approach does not place the responsibility, initiative and effort solely upon managers and supervisors. Emphasis is given to the essential role of managers, but it is also placed on the inescapable responsibility of everyone: managers as well as operators and verifiers. They all contribute to the final achievement of quality.

This entails the acceptance of personal responsibility for the assigned task. This responsibility is not diluted because of responsibilities assigned to others. Everyone understands that the assigned work has to be performed "right the first time". Each person feels the sense of responsibility, endeavours to correctly accomplish the work and enjoys the satisfaction of achieving the final aim if this is successful. If it is not successful, the person will try to improve his/her contributions, if this is possible, because he/she is not indifferent or passive, but part of the overall achievement.

The approach thus demands particular efforts, such as: deeper and frequent training, a permanent search for information, improved communication, strong discipline, creativity and permanent striving for improvements. The pursuit of quality ends up being an entirely voluntary and personal attitude.

Grading of quality assurance. The IAEA standards are primarily directed towards the safety of nuclear power plants and make no explicit statement regarding costs. This does not imply a disregard of the impact that costs have in nuclear power production, as they do in any other human activity.

In connection with the fulfillment of quality assurance requirements, part of the costs are related to the content and volume of documents and records, details of procedures, the type of verification and testing, and qualification skills. The NUSS quality assurance Code establishes the use of a graded approach, based on the relative importance to nuclear safety of each item, service or process. The approach reflects a planned and recognized difference in the application of specific quality assurance requirements.

Management — which is responsible for planning, direction and resource considerations — has to define the essential procedures, activities and documentation that must be controlled, on the basis of their relative importance to nuclear safety. Management further establishes the content of important records, the essential data that are to be maintained and the applicable scope of quality assurance verification activities. This assures that time and money are not wasted on activities not essential to the quality of the product or service, thereby preventing unnecessary and uncontrolled costs associated with nuclear quality assurance programmes.

Benefits to users

The revised Code holds the following benefits for users:

Regulatory bodies. The contents of the revised Code are arranged in a form that is much more suitable for incorporation in a national regulation than its predecessor. It contains only basic requirements that must be satisfied to ensure safety. Therefore the main text has been significantly condensed and contains only "shall" statements, meaning strict requirements.This facilitates the functions of the national regulatory body that desires to make the contents directly applicable to the activities under its jurisdiction. All the guidance on how to implement the ten basic requirements has been included in the corresponding Safety Guides.

Responsible organizations. The requirements to be fulfilled by the responsible organization also are more clearly formulated. This helps the function of the regulatory body because it provides precise elements against which work performed by the licensee can be subjected to regulatory inspections and follow up. Quality assurance further is integrated with normal plant management, making quality assurance an effective contributor to nuclear power plant safety and reliability. Since all personnel are involved actively, they remain committed to a process that supports and enhances their work results.

Additional guidance. New or revised specific recommendations are included to fulfill quality requirements regarding siting, commissioning, decommissioning, research and development, grading, instrumentation and control, non-conformance control and corrective actions, training and qualification, and assessment.

Overall benefits. The standards serve to enhance plant safety, by focusing on the performance and the effectiveness of day-to-day work in all stages of the nuclear power plant.

A look ahead

In recent years, quality assurance activities have become intrinsic components of managing, performing and assessing work. As a consequence, these activities are progressively detached from the exclusive fulfillment of requirements from a particular quality assurance standard. They are instead incorporated as common practices. As a consequence, activities that would currently be identified as part of a quality assurance programme are not necessarily perceived in that way anymore.

In some organizations trying to enhance the quality of performance, a specific unit or department with specifically assigned responsibility for quality assurance does not appear in the organizational charts. This is because such responsibility is shared and accepted by every individual involved. These organizations have built up an environment that integrates people qualified and motivated for accepting and accomplishing responsibilities; systems and procedures tailored to the particular work; and hardware and installations operating in accordance with established specifications.

The successful organizations are characterized by an effective quality culture, manifesting itself by the following features:

- Management is consistently involved in plant activities, promotes staff accountability and sets high expectations for performance.
- Performance objectives are included in the organization's policy documents and procedures, integrated into staff training and work programmes, communicated to contractors prior to work commencement and reinforced by management staff in daily communications and meetings.
- Management dedicates permanent attention to performance data and their trend analysis, identification of performance deficiencies and associated root causes and development of performance improvement programmes with provision of adequate resources.
- Responsibility to achieve quality and to verify its achievements is assigned to those performing the task and their associated line management, who in all their activities make safety precede production objectives.

In accomplishing their policy and objectives, organizations with vigorous quality-raising initiatives have evolved beyond the fulfillment of requirements established in safety and industrial quality assurance standards. In fact, environments with this type of culture are progressively less dependent on the fulfillment of requirements established in quality assurance standards. This is because these requirements are automatically accomplished by the normal way of work performance.

If we allow our imagination to project into an ideal future where such a culture would be universally implemented, the need for quality assurance standards would be minimized. The successive revisions of present standards would be consistently streamlining the contents, because fewer and fewer requirements would need to be established.

The final goal in this ideal picture would be a future standard making all quality assurance requirements converge into just one single and unmistakable item. This could, for example, be plainly stated as "doing things right the first time and improving thereafter".

This vision does not intend to suggest that quality assurance standards will cease to be needed, particularly in the field of nuclear safety. It only invites us to look ahead, with the intention of progressing towards the creation of a quality culture that integrates quality assurance requirements as an indivisible component of every work performance. This will allow simpler standards and will contribute to an improvement of the present situation where sometimes proliferating, overlapping and contradictory requirements, methods, and terminology impair the understanding and achievement of the quality objectives.

The IAEA's revised NUSS standards on quality assurance for nuclear power plants offer a simplified set of basic requirements and implementation methods. They clearly convey the application of global nuclear safety requirements and provide guidance consistent with worldwide industry standards. They thus address the interests and concerns of regulatory bodies, operating organizations, and suppliers. In years ahead, the stronger development of a culture aimed at achieving a rising excellence of performance will allow formulation of even simpler and more effective quality assurance standards. ❐

Dr. Blix addresses UN Security Council and General Assembly

Director General Hans Blix addressed the UN Security Council in early November on the Agency's ongoing nuclear inspections in Iraq, among other matters. In a report to the Council, he underlined the Agency's continuing rigorous implementation of its plan for the monitoring and verification of Iraq's compliance with relevant Security Council resolutions in co-ordination with the United Nations Special Commission. He said that the IAEA's in-depth appraisal of Iraq's reissued full, final, and complete declaration is expected to take several months to complete.

United Nations address. Speaking before the United Nations General Assembly in New York, Dr. Blix underlined the Agency's growing role to help prevent the spread of nuclear weapons and to verify nuclear arms control and disarmament agreements. He also reviewed the changing agenda in other areas of nuclear energy's safe development worldwide. He addressed the General Assembly 28 October 1996.

"With the nuclear arms race over, a number of arms control or disarmament treaties have been concluded or are in the making that may require additional verification tasks from the IAEA," he said. In this context, he noted that the United States and Russian Federation are exploring with the IAEA technical and other issues connected to the further verification of certain nuclear material from dismantled nuclear weapons. Verification in nuclear-weapon States, he said, can provide "assurance that fissionable material from dismantled weapons does not go into new weapons." Additionally, he noted, it could assure that a possible future cut-off agreement prohibiting the production of plutonium or highly enriched uranium for weapons is respected.

In reviewing the IAEA's verification role, Dr. Blix also pointed to the increasing number of regional nuclear-weapon-free zone treaties and to the long-standing multilateral Treaty on the Non-Proliferation of Nuclear Weapons (NPT) which all require and rely upon IAEA safeguards. Though the recently adopted Comprehensive Test Ban Treaty will have its own verification organization, Dr. Blix emphasized the IAEA's existing role under the NPT, which obliges non-nuclear-weapon States to refrain from nuclear weapons tests and entrusts the verification of these obligations to the IAEA.

Dr. Blix underlined the IAEA's ongoing efforts to strengthen its safeguards system, noting that many measures already have been introduced under the Agency's existing legal authority. Other measures that go beyond this authority remain under discussion by the IAEA's Board of Governors. Most of these measures have been tried out in several States without great problems for the Agency or the State concerned, Dr. Blix said. While a few other countries have raised objections about the burden they may impose, Dr. Blix said the measures were needed for improving the IAEA's verification capabilities. "Regrettably, as we all know from our experience of controls at airports, security against possible violations by a few requires some inconveniencing of many," he said.

In addressing other areas, Dr. Blix noted how the changing global agenda continues to significantly influence the IAEA's programmes and resources: "There is no lack of challenges in the nuclear sphere," he said, "Over time the work of the Agency has both expanded and changed considerably... Suffice it to mention the names Three Mile Island and Chernobyl, Iraq and the DPRK, Semipalatinsk and Mururoa to evoke the growing engagement of the IAEA in the fields of nuclear safety, safeguards verification, and assessment of the radiological situation at nuclear weapons test sites." He emphasized, however, that the IAEA's budget frequently "limits what can be tackled." Many new tasks, he said, such as measures countering illicit trafficking in nuclear materials or projects concerning nuclear safety and waste are, in fact, handled in large measure on the basis of extrabudgetary voluntary contributions from countries. "This is not satisfactory," he said, "but far better than inaction."

In outlining progress in areas of nuclear safety, Dr. Blix noted steps toward the establishment of binding international norms, citing the Convention on Nuclear Safety and work on conventions related to radioactive waste management and nuclear liability.— *The full text of the statement is on line through the IAEA's World Atom Internet services at http://www.iaea.org/worldatom.*

IAEA Board of Governors

Mr. Peter Walker, Ambassador of Canada

At meetings in late November 1996, the IAEA Board of Governors' Technical Assistance and Co-operation Committee considered matters related to the Agency's proposed programme for 1997-98 and the evaluation of technical co-operation activities. Also before the Committee was a report on the IAEA's current technical co-operation programme, whose implementation rate continues to rise to new high levels. The Committee's recommendations were considered by the full Board at meetings in early December. Also included on the Board's provisional agenda was a report on the work of its Committee on Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System. The Committee has held two sessions, one in July and the second in October, to negotiate a new legal document that would be attached to existing comprehensive safeguards agreements. This document would define *inter alia* the nature of additional access to information and to nuclear-related locations for the Agency's inspectors. A third session of the Committee is scheduled for late January 1997.

Board membership. Ambassador Peter Walker of Canada is the newly elected Chairman of the IAEA Board for the period 1996-97. He succeeds Ambassador Johan T.H.C. van Ebbenhorst Tengbergen of the Netherlands. Mr. Walker is Canada's Ambassador to Austria, Resident Representative to the IAEA, Permanent Representative to the United Nations in Vienna, and Ambassador to the Organization for Security and Co-operation in Europe.

The 35 members on the Board for 1996-97 are Argentina, Australia, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Cuba, Czech Republic, Denmark, Egypt, France, Germany, India, Japan, Republic of Korea, Kuwait, Malaysia, Namibia, Netherlands, New Zealand, Nicaragua, Nigeria, Portugal, Romania, Russian Federation, Saudi Arabia, South Africa, Switzerland, Tunisia, United Arab Emirates, United Kingdom of Great Britain and Northern Ireland, and United States.

Nuclear safety convention enters into force

The Convention on Nuclear Safety — the first international legal instrument on the safety of nuclear power plants worldwide — entered into force 24 October 1996. The Convention commits its Parties to ensure the safety of land-based civil nuclear power plants. This includes a legislative and regulatory framework; general safety considerations such as quality assurance, assessment, and verification of safety; human factors; radiation protection; emergency preparedness; and specific obligations on the safety of nuclear installations, siting, design and construction, and operation. The Convention obliges Parties to submit reports at periodic review meetings. These reports will focus on the measures each State has taken to implement its obligations.

"The Convention marks a major step forward in strengthening international co-operation in the safety field," said IAEA Director General Hans Blix. "Though the safe use of nuclear energy remains clearly a national responsibility, the Convention signals the growing recognition of the global interdependence of safe nuclear development."

Through November 1996, twenty-nine States have consented to be bound by the Convention on Nuclear Safety. These are Bangladesh, Bulgaria, Canada, China, Croatia, the Czech Republic, Finland, France, Hungary, Ireland, Japan, the Republic of Korea, Latvia, Lebanon, Lithuania, Mali, Mexico, the Netherlands, Norway, Poland, Romania, the Russian Federation, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom. The Convention has been signed by 65 States.

A preparatory meeting of States Parties is scheduled to be convened by April 1997. At that meeting, among other matters, guidelines will be established regarding the form and structure of reports that States are required to submit for review at periodic meetings, and the process for reviewing such reports. The Convention calls for this first review meeting to be convened as soon as possible, but no later than 30 months from its entry into force.—*The text of the Convention and its status are accessible through the IAEA's World Atom Internet services at http://www.iaea.org/worldatom*

Safeguarding fissile materials

Under a trilateral initiative announced in September 1996, the first steps are being taken by the United States, Russian Federation, and the IAEA to expand the international verification of weapons-usable nuclear materials through the application of IAEA safeguards. In early November 1996, delegations from the IAEA, United States, and Russian Federation visited three US Department of Energy sites — the Argonne National Laboratory-West in Idaho, the Hanford site in Washington, and the Rocky Flats Environmental Technology site in Colorado. At Argonne, where IAEA Director General Hans Blix gave an invited address, the visits centred on demonstrations of remote monitoring technology. At Hanford and Rocky Flats, they focused on how IAEA safeguards inspections have been carried out to verify that excess plutonium at those sites is not reused for weapons. Following the site visits, the Russian and IAEA delegations met with senior US officials in Washington, DC, to discuss how to proceed in carrying out the trilateral initiative.

The trilateral initiative was announced in September 1996 at the IAEA General Conference in Vienna. At that time, US Secretary of Energy Hazel R. O'Leary, Russian Minister of Atomic Energy Viktor Mikhailov, and IAEA Director General Hans Blix met to consider practical measures to fulfil statements made by the Presidents of the United States and Russian Federation in April 1996 concerning the IAEA's verification of weapon origin fissile materials. The purpose of the initiative is to verify that fissile materials no longer needed for US and Russian defense purposes are not reused to produce new nuclear weapons. It advances the commitments made by Presidents Clinton and Yeltsin to ensure the transparency of nuclear arms reductions and the control of fissile material removed from weapons. To address the various technical, legal, and financial issues associated with implementing IAEA verification of relevant fissile materials, a joint group has been formed which will report on progress by June 1997.

ASSET marks 10 years of service

Since the service started a decade ago, the IAEA has organized 120 nuclear safety missions to more than two dozen countries within the framework of its ASSET programme. The service was launched in 1986 to assist countries having nuclear power plants in areas of safety assessment and analysis. Missions completed so far have included 69 training sessions in 28 countries to demonstrate the practical use of ASSET analysis procedures, and 51 analytical missions in 19 countries that focused on assessing the root causes of safety problems that have affected the plant's operational safety. Krsko nuclear power plant in Slovenia hosted the first ASSET mission in 1986 and it was the site where ASSET experts recently conducted a mission marking the 10th anniversary of the service.

ASSET was initiated shortly after the Chernobyl accident in 1986, and at the time the idea of having IAEA expert teams invited to assess operational events at nuclear power plants was viewed as quite progressive for an intergovernmental organization. Over time, operating organizations and nuclear plant regulators became attracted to ASSET's technical procedures for analyzing root causes and to the usefulness of conclusions directed at the prevention of incidents. By 1990, the ASSET analytical process started to be used as a technical tool to enhance the performance of a plant's operational safety. A notable case in point was Germany's request for an ASSET mission to the Greifswald nuclear plant before its decision to close down four WWER 440/230 operating units and to stop construction of four WWER 440/213 units.

The ASSET methodology has not changed over the past decade and still provides guidance on how to answer the basic questions: What happened? Why did it happen? Why was it not prevented? However, the specific uses of the ASSET methodology have changed dramatically over the years to meet the needs of operating and regulatory organizations. Early on, the IAEA anticipated that Member States would mostly be interested in the analysis of root causes for single events of higher significance to plant safety. In fact, requests from Member States were directed to the application by ASSET teams of the analysis procedures to the whole population of operational events, especially deviations of little or no significance. This was because the analysis of such events is known to provide the basis for enhancing efforts for the prevention of incidents and accidents.

In 1994, in recognition of the progress made in plant analysis capabilities and incident prevention, IAEA Member States urged the ASSET service to shift its emphasis to the promotion of plant self-assessments of safety performance. This should be done, they said, on the basis of the analysis of the operational events which reflect safety problems or deficiencies in safety culture and in association with peer reviews of the self-assessment results by international ASSET teams. This feature is now receiving greater attention as States work to comply with their reporting commitments in the framework of the international Convention on Nuclear Safety.

Technical support in field of non-proliferation

A meeting was held at the IAEA headquarters in Vienna 6-8 November 1996 to review implementation of agreed plans to help newly independent States (NIS) of the former Soviet Union in fulfilling their nuclear non-proliferation commitments.

As most NIS have become parties to the Nuclear Non-Proliferation Treaty (NPT) as non-nuclear weapon States, a number of donor countries have offered bilateral assistance to set up State Systems of Accountancy and Control (SSACs) of nuclear material; physical protection of such material; and import/export controls. The IAEA has played a coordinating role by identifying specific needs in individual states and appropriate donor support.

The meeting was attended by representatives of 14 NIS and nine donor States — Australia, Finland, France, Hungary, Japan, Norway, Sweden, United Kindom and United States. In addition, Argentina, Canada, the Republic of Korea and Turkey attended as observers.

The meeting underlined the need for an integrated approach to nuclear non-proliferation encompassing SSACs, physical protection and import/export controls. Also stressed as basic requirements were the establishment of an appropriate framework of national nuclear laws and regulations in each recipient state, plus the necessary political commitment and co-ordination. The IAEA's continued role in co-ordinating technical support for the NIS was welcomed, and the Agency has offered to organize similar annual reviews in the future, provided the necessary assistance is forthcoming.

UN General Assembly commends the IAEA

A resolution adopted by the UN General Assembly in October 1996 commends the IAEA for its work for the safe and peaceful development of nuclear energy, specifically citing ongoing verification activities in Iraq and the Democratic People's Republic of Korea. The General Assembly also welcomed the measures and decisions taken to maintain and strengthen the effectiveness and cost efficiency of the safeguards system and the Agency's activities in areas of technical co-operation; the entry into force of the Convention on Nuclear Safety, which is under IAEA auspices; and measures taken to support counteractions against illicit trafficking in nuclear materials. Among other activities, the General Assembly also noted the Agency's work to finalize a convention on the safety of radioactive waste management and to strengthen the international nuclear liability regime.

The General Assembly urged all States to strive for effective and harmonious international co-operation in carrying out the Agency's work; in promoting the use of nuclear energy and the application of necessary measures to strengthen further the safety of nuclear installations and to minimize the risks to life, health, and the environment; in strengthening technical assistance for developing countries; and in ensuring an effective safeguards system.

General Conference adopts safeguards, safety resolutions

States meeting at the IAEA General Conference 16-21 September 1996 adopted resolutions to strengthen international safeguards and global co-operation in areas of nuclear safety and technical assistance. The Conference was attended by Ministers and high-level governmental delegates from the IAEA's 124 Member States. Elected President of the Conference was Mr. William G. Padolina, Secretary of the Philippines' Department of Science and Technology.

Highlights of adopted resolutions follow.

Strengthening the IAEA's Safeguards System. Convinced that IAEA safeguards can promote greater confidence among States and contribute to greater collective security, the Conference called upon the Agency to continue its implementation of previously approved ("Part 1") measures to strengthen the effectiveness and cost-efficiency of its safeguards system, and it urged the States concerned to facilitate the process. It further welcomed the IAEA Board of Governors' work begun in July 1996 to draft a model protocol to reinforce and improve the Agency's capacity to detect any undeclared nuclear activities.

Strengthening IAEA Technical Co-operation Activities. Citing nuclear energy's existing and potential social, economic, and environmental benefits in many fields, the Conference requested the Agency to strengthen its technical co-operation activities through the development of effective programmes aimed at improving the scientific and technological capabilities of developing countries in peaceful uses of nuclear energy for electricity production and other applications, and at achieving sustainable development.

Nuclear Inspections in Iraq. Reaffirming the need for full implementation by Iraq of Security Council resolutions 687, 707, and 715, the Conference demanded that Iraq hand over to the IAEA's Action Team without further delay any currently undisclosed nuclear-weapon-related equipment, material, and information. It further demanded that Iraq allow the Action Team immediate, unconditional and unrestricted rights of access in accordance with Security Council resolution 707. It stressed that the Agency's Action Team will continue to exercise its right to investigate further any aspects of Iraq's past nuclear weapons capability, in particular as regards any further relevant information that Iraq may still be withholding.

Safeguards in the DPRK. The Conference expressed its concern over the DPRK's continuing non-compliance with its IAEA safeguards agreement, and noted with regret the limited progress from IAEA-DPRK discussions of outstanding safeguards issues. It called upon the DPRK to comply fully with the safeguards agreement and to take all steps the Agency may deem necessary to preserve all information relevant to verifying the accuracy and completeness of the DPRK's initial report on the inventory of nuclear material subject to safeguards until the DPRK comes into full compliance with the agreement. The Conference further commended the Agency

Inside the Austria Center, Conference President Padolina *(centre)*, flanked by Director General Blix and Mr. Sanmuganathan, Secretary of IAEA Policy-Making Organs. *(Credit: Pavlicek/IAEA)* for its efforts to monitor the freeze of specified facilities in the DPRK as requested by the United Nations Security Council.

Safeguards in the Middle East. The Conference requested the Director General to continue consultations with States in the Middle East to facilitate the early application of full-scope IAEA safeguards to all nuclear activities in the region as relevant to the preparation of model agreements, as a necessary step towards the establishment of a nuclear-weapon-free zone in the region.

African Nuclear-Weapon-Free Zone (NWFZ). The Conference commended the African States for their concerted efforts on the establishment of an African NWFZ, and requested the IAEA Director General to continue to assist them in this regard. It urged African States to make every effort to ratify the Treaty so that it can enter into force without delay, and reaffirmed its convction that the establishment of other NWFZs, especially in the Middle East, would enhance the security of Africa and viability of the African NWFZ.

Illicit Trafficking in Nuclear Materials. Noting the programme for preventing and combatting illicit trafficking agreed upon at the Moscow Nuclear Summit in April 1996, the Conference welcomed the IAEA's activities in support of efforts against illicit trafficking, and invited the Agency to continue working in accordance with relevant conclusions of its Board of Governors.

Nuclear, Radiation, and Waste Safety. The Conference adopted several resolutions. One resolution, on the establishment of waste demonstration centres, invites the Agency to assist interested Member States in expanding the use of suitable existing training centres for practical training and demonstration of techniques for the processing and storage of radioactive waste from the application of nuclear techniques in medicine, research, and industry, so that a demonstration and training facility would be available in respective regions through greater co-operation and co-ordination of resources, including those available in developing countries. A second resolution, on the Convention on Nuclear Safety, welcomed the fact that it will enter into force on 24 October 1996, and expressed satisfaction that the Agency will convene a preparatory meeting of Contracting Parties no later than April 1997 on the Convention's implementation. A third resolution, on the safety of radioactive waste management, expressed appreciation for work done so far by the Open-ended Group of Legal and Technical Experts to draft a Convention on the subject, and hoped that progress at the Group's next meeting, to be hosted by South Africa, will allow timely completion of the preparatory work and adoption of a convention in the near future.

Plan for Producing Potable Water Economically. Emphasizing the need to solve water shortages in many countries and noting the World Bank's call to hold a world water conference in 1997, the Conference welcomed the Agency's work in this field to date, and requested the Director General to assign appropriate priority to the nuclear desalination of seawater in preparing the Agency's programme and budget, and invited him to establish an advisory body on nuclear desalination to take appropriate measures to assist Member States in the process of preparatory actions for demonstration projects.

Isotope Hydrology for Water Resources Management. The Conference requested the Agency to identify and upgrade selected isotope hydrology laboratories in Member States so as to provide easy regional access to analytical facilities for field hydrologists. It further requested the Agency to work with other United Nations agencies to encourage the introduction of isotope hydrology and isotope geochemistry in university courses in Member States so as to provide a stronger foundation for future growth in the area of water resources management.

IAEA Budget for 1997 and Target for Technical Co-operation Fund. The budget resolution approved expenditures in 1997 of $222 million (at an exchange rate of 12.7 Austrian schillings to the US dollar). The Conference further approved the target amount of US $68 million for voluntary contributions to the Agency's Technical Co-operation Fund in 1997.

Staffing of the IAEA Secretariat. Two resolutions were adopted. One requests the Agency to intensify its efforts to increase the number of staff members from developing countries, particularly at senior and policy-making levels, as well as from Member States that are not represented or are under-represented in the Secretariat. The second resolution requests the Agency to pursue a target of equal representation of women at all levels of Agency employment, and it called upon the Director General to further integrate the Platform for Action developed at the United Nations Fourth World Conference on Women into the Agency's relevant policies and programmes.

Representation on the IAEA Board. In a resolution pertaining to Article 6 of the IAEA Statute, the Conference recognized there is a widely held view among Member States on the need to expand the size and composition of the Agency's Board of Governors, and it requested the Board to develop a process of negotiations and to submit its report on a finalized formula for approval by the General Conference at its 41st regular session next year.

General Conference meetings. In conjunction with the Conference, several events were organized. They included a briefing session on the IAEA's safeguards development programme at which Director General Hans Blix presented a long-term perspective on the strengthening of safeguards; a traditional meeting of senior national officials responsible for nuclear safety; and meetings of officials from Member States concerning regional co-operative arrangements in Asia and the Pacific, Latin America, and Africa. Additionally, a scientific programme featured three subjects:

Advanced Nuclear Fuel Cycle: New Concepts for the Future. Opened by Mr. V. Mourogov, IAEA Deputy Director General for Nuclear Energy, the meeting covered key aspects of the advanced nuclear fuel cycle. Topical presentations were made by national representatives on the prospects for utilizing thorium for energy production (India); the fuel cycle option with plutonium burnup and utilization (Russian Federation); the fuel cycle for burning minor actinides (France); burning light-water reactor spent fuel in heavy water reactors (Republic of Korea); and the challenge for energy sustainability of an advanced fuel cycle system (Japan). A panel discussion further explored issues related to the reduction of stockpiles of plutonium; and the reduction of radiotoxicity or hazards in fuel cycle options. Participants noted that the full scope of nuclear fuel cycle issues, focusing especially on the use or disposal of plutonium, will be examined at an IAEA symposium in June 1997. *(See box on page 45.)*

Trends in Research Reactor Utilization. Opened by Mr. S. Machi, IAEA Deputy Director General for Research and Isotopes, the meeting explored issues facing countries that are operating research reactors around the world. Topical presentations were made by national representatives on material science studies (Austria); industrial applications (South Africa); nuclear power development, education, and training (India); isotope production (Canada); and cancer therapy (Germany). A concluding panel discussion explored reactor management issues.

Information Management for Member States. The meeting included an overview of the IAEA's approach to information management and various topical presentations by Agency staff on the benefits derived from the effective use of information technology. The topics covered included access to IAEA databases and electronic documents; the International Nuclear Information System (INIS) on compact disks; the Incident Reporting System; on-line project information management for technical co-operation; and remote data transmission of confidential data for safeguards purposes.--*Full coverage of the General Conference is on line through the IAEA's WorldAtom Internet services at http://www.iaea.or.at/worldatom.*

Displays featured the Agency's range of computer information services. ***(Credit: Pavlicek/IAEA)***

Yearbook features nuclear applications

In the latest edition, the *IAEA Yearbook* for 1996 takes a close look at the role played by the IAEA in helping to advance sustainable development by the transfer of nuclear and radiation technology. The work covers a wide range of subjects — the practical aspects of physics and chemistry, hydrology, industrial applications, human health, and food and agriculture. Specially featured are reports on the use of food irradiation and nuclear monitoring techniques in programmes for improving human nutrition. Irradiation of foodstuffs is gaining acceptance as a viable alternative to other means of preserving foods and eradicating pest infestation. In areas of malnutrition, nuclear techniques offer new ways of determining the best approaches to food supplements.

Special sections of the *Yearbook* cover topical developments in areas of nuclear power and its fuel cycle, waste management, nuclear and radiation safety, and the verification of nuclear energy's peaceful uses. Also included is background information on the IAEA and the framework within which it continues to carry out its programmes.

In another recent publication, international experts review the safety record at industrial radiation facilities. *Lessons Learned from Accidents in Industrial Irradiation Facilities* describes accident scenarios that have occurred in industrial irradiation facilities, analyzes the main causes, determines the lessons learned, and makes recommendations for safety in the radiation processing industry. Gamma and electron beam irradiators are widely used for radiation processing of manufactured products and for food preservation purposes.

Other recent IAEA publications include *Radiological Conditions at Bikini Atoll: Prospects for Resettlement*, a technical report of an International Advisory Group convened by the IAEA in 1995. At the request of the Marshall Islands, the Group made an independent assessment of the radiological conditions at the Bikini Atoll former nuclear test site that included examining options for further reducing levels of radioactivity. Scientists in the Group were from Australia, France, Japan, New Zealand, Russia, the United Kingdom, the United States, the World Health Organization, the United Nations Scientific Committee on the Effects of Atomic Radiation, and the IAEA. More information about IAEA publications and how to order them may be obtained from the Agency's Division of Publications.

World Food Summit

Global leaders from nearly 200 countries and delegates from national, regional, and international organizations met at the World Food Summit in Rome 13-17 November 1996 to renew the commitment to the eradication of hunger and malnutrition and the achievement of universal food security. The Summit was convened by the Food and Agriculture Organization (FAO) of the United Nations. Attending from the IAEA were Mr. Sueo Machi, Deputy Director General heading the Department of Research and Isotopes, and Mr. James Dargie, Director of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. The Department carries out a range of projects and research programmes that assist countries in areas such as child nutrition, soil fertility, crop production, food preservation, plant breeding, animal productivity and health, agrochemicals, and insect and pest control.

The Summit provided a forum at the highest political level to address the need for action to achieve food security around the world. States considered and adopted appropriate policies and strategies at international and national levels, as well as a plan for implementation involving governments, international institutions, and the private sector. Today more than 800 million people in developing countries face chronic undernutrition and almost 200 million children under the age of five suffer from protein or energy deficiencies, the FAO reports. At the same time, levels of financial commitment to food assistance are falling. If no action is taken to reverse present trends, the number of chronically undernourished people may still be some 730 million by the year 2010, over 300 million of them in Sub-Saharan Africa. More information on the Summit may be obtained from the FAO in Rome, Italy, or through the FAO's Internet services at http://www.fao.org.

The Nuclear Fuel Cycle:
Plutonium Issues on Agenda of June 1997 International Symposium

The production, use, and disposal of accumulating stockpiles of plutonium will be a prime topic of discussion in June 1997 at the IAEA in Vienna, when high-level governmental delegates meet at the International Symposium on Nuclear Fuel Cycle and Reactor Strategy: Adjusting to New Realities. The meeting is being organized by the IAEA together with the European Commission, the Nuclear Energy Agency of the Organization for Economic Co-operation and Development, and the Uranium Institute.

The symposium has four principal objectives: to prepare, for decision-makers and the public, a scientific assessment of the different fuel cycle and reactor strategies with particular reference to the production, use, and disposal of plutonium; to examine the policy options and explore the scope for international common understanding on these options; to enhance the transparency of the management and disposition of plutonium; and to examine the scope for future international collaboration in matters relating to the production, storage, use, and disposal of plutonium.

Six Working Groups have been set up to prepare key issue papers for distribution and discussion at the symposium. The Groups involve representatives from the sponsoring organizations and 12 countries: Argentina, Canada, China, France, Germany, India, Japan, Russian Federation, South Africa, Sweden, United Kingdom, and United States. Topics being addressed are the present status and immediate prospects of plutonium management; the global energy outlook; fuel cycle and reactor strategies; safety, health, and environmental implications of the different fuel cycle options; non-proliferation and safeguards aspects; and international co-operation.

New realities affecting the nuclear fuel cycle industry are an outgrowth of several factors. One factor is that nuclear power generation and related commercial development of reactors have not progressed as once expected. The result is that stockpiles of plutonium have been growing in civilian nuclear programmes. Another factor is tied to political developments after the Cold War, as large amounts of plutonium are expected to be recovered from dismantled nuclear warheads.

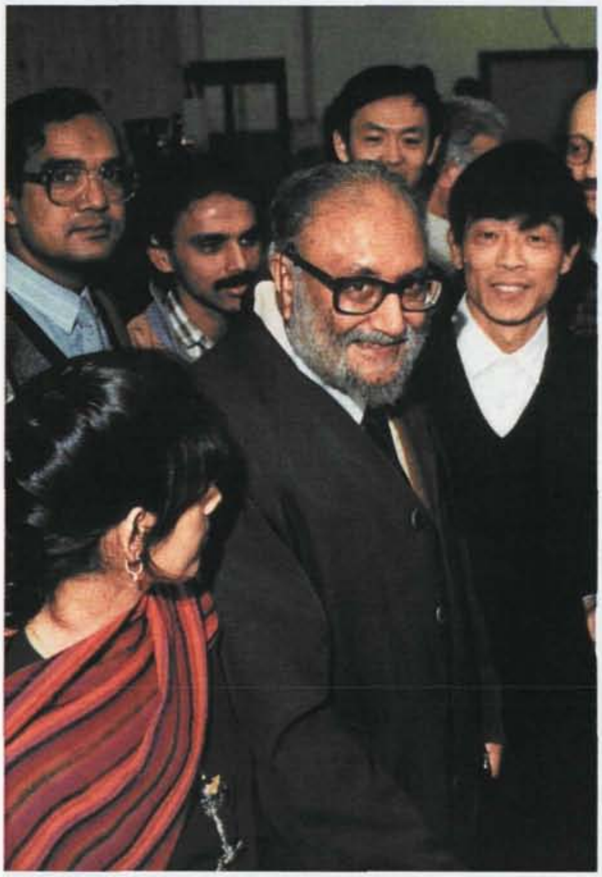
The symposium is timely, as international attention to plutonium and related fuel cycle issues has intensified in recent years. In 1995, States meeting at the Review and Extension Conference of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) called for greater transparency on matters relating to the management of plutonium and highly enriched uranium for civil purposes, including stock levels and their relationship to national nuclear fuel cycles. They further called for continued international examination of policy options concerning the management and use of plutonium, including the arrangement for the deposit with the IAEA as well as the possibility of regional fuel cycle centres.

Storage facility for spent fuel at Olkiluto in Finland. ***(Credit: TVO)***

Professor Abdus Salam: 1926 - 1996

Professor Abdus Salam, Nobel Laureate in Physics (1979), Director of the International Centre for Theoretical Physics (ICTP), Trieste, Italy, from 1964 to December 1993, died in Oxford on 21 November 1996, after a long illness. He was to be buried in Pakistan where he was born in 1926.

The name of Abdus Salam will be linked forever to the International Centre for Theoretical Physics. Not only did he envisage the Centre as a place where scientists could carry out research of the highest level but through the ICTP he also managed to set an example for other nations to follow. Professor Salam became a widely known and charismatic figure in international scientific and political milieus. He travelled extensively throughout the world and, in his discussions with heads of State and governments, he was able, in a convincing manner, to put forward his views regarding the paramount importance of supporting science in their own countries for the betterment of humanity. His pursuit of a science for peace capable of filling the gap between the North and South of the planet shall remain as an example for those who endeavour to achieve the cultural and social development of the Third World. Thanks to Professor Salam, the ICTP has been a major forum for the international scientific community and a model for similar establishments both in Trieste and abroad. Over a period of more than thirty years, 60,000 scientists from 150 countries have taken part in its activities.



Prof. Salam at the ICTP, an Agency-supported research centre that he founded and directed for 30 years. *(Credit: ICTP)*

Professor Salam has been one of the greatest exponents in physics this century. Born in Jhang, Pakistan in 1926, he was educated at Panjab University, St. John's College, Cambridge and Cavendish Laboratory, Cambridge where he obtained his Ph.D. in 1952. He then returned to Pakistan where he served as Professor at Government College, Lahore and Panjab University. There he suffered the isolation which scientists experience when they are not supported by their home countries. There was no tradition of doing any postgraduate work; there were no journals; there was no possibility of attending any conferences. He suffered the tragic dilemma of having to make the choice between physics or Pakistan. So he returned to Cambridge to take up the position of Lecturer. In 1957 he was appointed as Full Professor of Theoretical Physics at Imperial College. Fired by his own unhappiness at having had to leave his own country, he determined to find a way of making it possible for those like him to continue working for their own communities while still having opportunities to remain first-rate scientists. It was thus in 1960 that he conceived the idea of setting up an International Centre for Theoretical Physics with funds from the international community.

Professor Salam is famous for that electroweak theory which is the mathematical and conceptual synthesis of the electromagnetic and weak interactions — the latest stage reached until now on the path towards the unification of the fundamental forces of nature. With this motivation, Professor Salam received the Nobel Prize for physics together with the Americans Steven Weinberg and Sheldon Glashow in 1979. The validity of the theory was ascertained in the following years through experiments carried out at the superprotosynchrotron facility at CERN in Geneva which led to the discovery of the W and Z particles. Salam's electroweak theory is still the core of the "standard model" of high energy physics.

Argentina: Nuclear communication

In co-operation with Argentina's Atomic Energy Commission (CNEA), the IAEA organized a public information workshop in Buenos Aires in October 1996 for nuclear communicators, governmental authorities, and invited journalists. The workshop featured national reports from Argentina, Brazil, Chile, Cuba, France, Japan, Peru, the United Kingdom, and the United States, as well as topical sessions on public information approaches for specific issues, including waste transport, food irradiation, and nuclear safety. The seminar was organized under an extrabudgetary public information programme being funded by Japan. More information may be obtained from the IAEA Division of Public Information.

Austria: Nuclear safety

Nuclear experts meeting at the IAEA in Vienna in October 1996 emphasized the importance of safety reviews and feedback systems for exchanging experience and applying lessons learned from operations at the world's nuclear power plants. Attending were nuclear power plant operators, regulators, designers, manufacturers, and technical support experts.

Several types of safety reviews are used to ensure the safety of nuclear power plants, including those built to earlier standards of safety, as one way for judging the need for safety improvements and the acceptability of continued safe plant operations. Similarly, a number of feedback systems have been developed as a means for exchanging experience on a range of activities, from nuclear plant design, through operation, to decommissioning of the plant. The Symposium noted that many past and ongoing safety review and feedback programmes can be applied to obligations that States are undertaking through the international Convention on Nuclear Safety, which entered into force in October 1996.

Bangladesh: Controlling pollution

In work partly supported by the IAEA, scientists at the Bangladesh Atomic Energy Commission (BAEC) are studying levels of pollution in air and water. One study has found that pollution levels of lead in Bangladesh are among the world's highest during the dry season, according to Dr. M. Khaliquzzaman, a chief scientific officer at BAEC, with levels falling during periods of medium and heavy rainfall. Dr. Khaliquzzaman attributed the high lead levels to the use of leaded fuel in vehicles. He said that lead poses a public health danger, especially to children, by penetrating the lungs and entering the blood stream, and can lead to impaired intelligence. The study included work done within the framework of IAEA co-ordinated research and technical co-operation projects. BAEC scientists also are studying water pollution, and they have detected high levels of arsenic in sub-surface water in some parts of the country where countermeasures were then taken.

The IAEA is supporting a number of research programmes and technical co-operation projects to assist Bangladesh and other countries interested in studying heavy metals and other environmental pollutants. Arsenic, cadmium, copper, lead, and mercury, among other toxic elements, are all amenable to study by a variety of nuclear and related techniques. Many of these programmes fall within the framework of the United Nations "Agenda 21", a group of activities relating to sustainable development which arose from the 1992 UN Conference on Environment and Development.

Canada: Fusion energy

The world's leading authorities in controlled fusion met in Montreal in October 1996 to exchange scientific and technical information, and to review progress in fusion research programmes. Results from large experimental devices now in operation and under construction, the advances in the understanding of plasma physics, and the engineering design work for fusion experimental devices are driving the world closer to the demonstration of the "scientific breakeven" point for a fusion device. The Conference featured nearly 300 papers, presentations, and posters, including a presentation on the Agency-supported International Thermonuclear Experimental Reactor (ITER) programme involving the European Community, Japan, the Russian Federation, and the United States.

Greece: Marine studies

Applications of isotope techniques to environmental studies of oceans and seas were critically reviewed in November 1996 at a seminar in Athens by marine scientists involved in national, regional, and global research programmes, including those of the IAEA's Marine Environment Laboratory in Monaco. Research in these fields is directed towards a better understanding of fundamental oceanographic processes and phenomena, the protection and management of the marine environment, including adequate use of marine resources, and the reconstruction of past, and the prediction of future, global change. The tracers used include stable isotopes, natural radionuclides, especially those of the uranium/thorium decay series, and nuclides of anthropogenic origin. There is a growing need in many countries for marine environmental studies, for instance in connection with the protection of their coastal/shelf regions and estuaries from land-based pollution, eutrophication, and other types of anthropogenic effects on marine and aquatic ecosystems.

India: Health and environment

Experts investigating relationships between environmental pollutants and health met in Hyderabad in November 1996 to share the latest information on the application of nuclear and isotopic techniques in research. The meeting covered studies of air particulates, solid waste products, sediments, food, water, human tissues, biomonitors, and other kinds of environmental samples. Experts addressed a range of topics related to quality assurance systems and strategies for nuclear analytical techniques and laboratories. A particular strength of nuclear methods lies in analytical quality assurance, including the validation of analytical methods and the development of analytical reference materials. The methodologies are playing an important role in the application of newly emerging quality management and quality assurance standards, and are helping to meet some of the goals of the UN's Agenda 21 for monitoring and control of environmental pollutants. The symposium was hosted by the Centre for Compositional Characterization of Materials of the Bhabha Atomic Research Centre (BARC).

United States: Nuclear performance

Nuclear power plants in the United States continue to significantly improve their operating performance, the Energy Information Administration (EIA) reports. Over the past eight years, EIA analysts found that the capacity factor for US nuclear plants increased 35% overall. In 1995, the capacity factor reached a new record of 77.5%. The findings are reported in a recent EIA publication, *Nuclear Power Generation and Fuel Cycle Report 1996*.

On other aspects, the EIA report states that many US plants are nearing the end of their operational lifetimes over the next decades. Of the 110 operating plants, 49 will become candidates for decommissioning over the next 19 years, the report states. The EIA is the analytical arm of the US Department of Energy based in Washington, DC. It can be reached on the Internet at http://www.eia.doe.gov.

Norway: The Arctic environment

Norway is the site of major international scientific meetings in 1997 on the environmental health of the Arctic. The meetings — the Third International Symposium on Environmental Pollution of the Arctic and the Third International Conference on Environmental Radioactivity in the Arctic — will take place in Tromso 1-5 June 1997. They are a prelude to the Fourth Arctic Ministerial Conference in Tromso 26-27 June 1997.

Threats posed by various types of pollutants to the Arctic environment and its ecosystems are a topic of growing international interest. Persistent organic contaminants, heavy metals, radioactivity, acidifying substances and oil have been identified as of particular concern. Two IAEA staff members, Ms. K.-L. Sjoeblom and Mr. M. Baxter, are members of the scientific and organizing committee for the environmental radioactivity conference. Working through its Marine Environmental Laboratory in Monaco and with a range of partners, the Agency is supporting projects related to environmental assessments of the Arctic seas.

India: Donates equipment

India's Department of Atomic Energy has donated two laser fluorimeters to the IAEA's Laboratories at Seibersdorf. On 18 October 1996, Dr. D.D. Bhawalkar, *(right)*, Director of the Centre for Advanced Technology in Indore, India, officially presented the instruments to Dr. Sueo Machi *(left)*, IAEA Deputy Director General for Research and Isotopes, and Dr. Pier Danesi, Director of the Seibersdorf Laboratories.

The laser fluorimeter, which India markets commercially, detects uranium salts dissolved in water in very small concentration, as small as 0.1 parts per billion. The instrument uses a sealed nitrogen laser whose pulsed ultraviolet beam excites fluorescence in uranium salts dissolved in water samples. Measurement of the fluorescence intensity provides the concentration of the uranium in the water sample. The Seibersdorf Laboratories will use the instruments for training scientists in nuclear analytical techniques, to provide analytical services to Member States, and to screen samples related to safeguards analysis.

India has previously donated nuclear instrumentation to the Seibersdorf Laboratories, most recently in 1995 when it supplied seven instruments that allow *in situ* determination of many chemical elements of nuclear and environmental relevance, as well as on-line monitoring of low-level radioactivity of noble gases and elements such as iodine-131.

Japan: Nuclear conference

For environmental and other reasons, nuclear power's contribution to the global energy mix needs to be expanded in years ahead in the view of IAEA Director General Hans Blix.

"It is now generally understood that current patterns and trends in the world's energy use are not sustainable," he said. "Hence the call for restraint in the emissions of carbon dioxide through restraint in the use of fossil fuels." Nuclear power releases hardly any carbon or other types of emissions to the world's atmosphere, he noted. The carbon dioxide equivalent emission factors for the entire nuclear fuel chain, from uranium mining to waste disposal, range from 10-50 grams per kilowatt-hour, or about the same as for energy generated by wind power.

Dr. Blix made his remarks in an address to the 10th Pacific Basin Nuclear Conference in Kobe, Japan, 21 October 1996. The speech focused on nuclear energy's current and potential role in helping to meet the world's electricity needs, and the problems, real and perceived, that are often raised in the nuclear debate. The full text of the address is available through the IAEA's *World Atom* Internet services at http://www.iaea.org/worldatom.

United Kingdom: Radon atlas

Radiation protection authorities in the United Kingdom have published a radon atlas of England after monitoring more than 200,000 homes over the past several years. Published by the National Radiological Protection Board (NRPB), the atlas is intended to assist local governments with responsibilities for environmental health and housing. The NRPB recommends an action level of 200 becquerels per cubic metre of radon above which measures should be taken to reduce the concentration.

Radon is a naturally occurring radioactive gas formed when minute amounts of uranium present in all rocks and soils decay; the amount of radon is largely determined by local geology. As radon itself decays, it forms small radioactive particles that could be inhaled, presenting a potential health risk. In outdoor air, radon disperses rapidly and levels are low. More information is available from the NRPB, Chilton, Didcot, Oxon OX11 ORQ. Facsimile: (01235) 833 891.

Canada and Sweden: Developing Digital Safeguards Instrument

Safeguards inspectors have long used an instrument known as the Cerenkov Viewing Device (CVD) to verify spent fuel at nuclear power plants and other installations. The instrument — which looks like a specially equipped camera and was originally developed by Canada — provides inspectors with an image displaying the ultraviolet light patterns resulting from the Cerenkov effect that occurs when spent fuel is submerged in water. Inspectors are trained to search for specific light patterns during their verification of the fuel.

Over the years, through their respective Safeguards Support Programmes, Canada and Sweden have combined expertise and resources to develop improved versions of the instrument. One current joint effort is the development of a digital CVD to provide inspectors with even greater sensitivity and improved images. The digital device will be able to provide images that can be processed and viewed in real time. Individual images will be stored as computer files that could be subsequently processed and transmitted off site for reference or consultation.

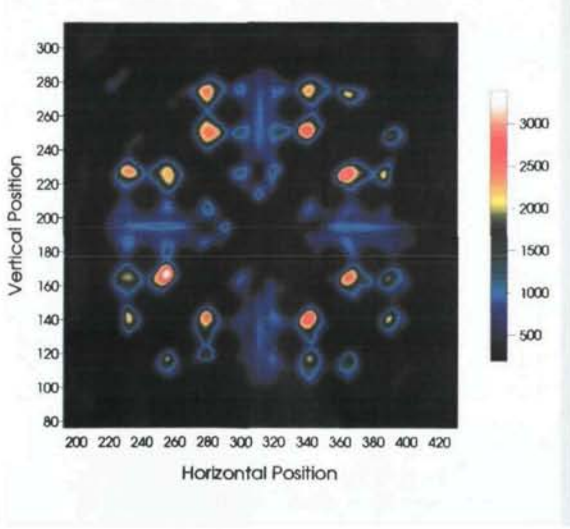
The digital CVD incorporates a number of key features. Specifically, it will be:

- able to increase the range of spent fuel verification beyond that of the present CVD to enable verification of fuel cooled up to 40 years with a burnup as low as 10,000 megawatt-days per tonne uranium;
- as non-intrusive as the present CVD;
- a portable instrument with a hand-held camera head
- capable of presenting real-time dynamic images in high-resolution digital form;
- better able to detect missing fuel rods (partial defects);
- equipped with a solid-state ultraviolet imaging sensor based on scientific charge-coupled device (SCCD) technology that will have the ability to quantify the light output from a fuel assembly;
- equipped with an efficient user interface for instrument control and operation;
- designed to provide the future possibility of real-time image processing and pattern recognition with potential benefits from computer-aided fuel verification.

In terms of the development of safeguards, the digital image data and high sensivity of the digital CVD is expected to open new vistas for the verification of spent fuel. New Cerenkov characteristics of the fuel will be much more easily observable from the images acquired. In particular, unique Cerenkov characteristics of spent fuel can be differentiated from the Cerenkov characteristics of non-fuel.

The acquired digital image can be presented in a number of formats, including a grey scale image and in pseudo colour. The presentation of the image in pseudo colour (as shown here and incorporated into the cover design of this *IAEA Bulletin*) makes it much easier for the human eye to see differences in intensities, making the image very useful for detecting non-fuel.

In October 1996, representatives of the Canadian and Swedish Safeguards Programmes briefed staff of the IAEA safeguards inspectorate in Vienna on proposed design features of the digital CVD under development. Representatives included Mr. Lars Hildingsson, Mr. Oliver Trepte, and Mr. Bo Lindberg of the Swedish Nuclear Power Inspectorate (SKI); Mr. Richard Keeffe and Mr. Peter Ward-Whate of Canada's Atomic Energy Control Board; and Mr. Dennis Chen of Atomic Energy of Canada (AECL) Whiteshell Laboratories.



An example of an enhanced image obtained with the digital CVD under development for the verification of spent fuel.
(Credit: Ringhals NPP)

CORRECTION. In the last English edition of the *IAEA Bulletin* (Vol. 38, No. 3), an error appears in the table on page 25 entitled "Residual radioactive material in the global environment as a result of the Chernobyl accident in april 1986". In the first column, the range of iodine-131 released in 1986 should read "1200-1700" PBq. The editor regrets the error and any inconvenience it may have caused readers.

IAEA ANNIVERSARY. On 26 October 1996, the IAEA marked the 40th anniversary of the adoption of its Statute. The Statute opened for signature following its adoption 26 October 1956 by a Conference at the United Nations in New York. More than 70 countries signed the Statute that day; the Agency officially came into being in July 1957, once the Statute had been ratified by the required number of States.

SEA DUMPING. Contracting Parties to the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter have adopted extensive major changes to the Convention. Meeting at the International Maritime Organization (IMO) in London from 28 October to 8 November 1996, the Parties specifically adopted a protocol that supercedes the original Convention which was adopted in 1972. The IAEA has some responsibilities under the Convention related to radioactive wastes. More information may be obtained from the IMO, 4 Albert Embankment, London SE1 7SR, UK. Fax: (44) 171-587-324.

TEST BAN TREATY. Through October 1996, the Comprehensive Test Ban Treaty has been signed by 129 countries. The Treaty, whose implementing organization is to be headquartered in Vienna, was approved 10 September 1996 by the United Nations General Assembly. More information may be obtained from the United Nations through its Internet services at http://www.un.org.

URANIUM NEEDS. Given present plans, uranium production is likely to fall short of the civil nuclear industry's fuel requirements for producing electricity, the London-based Uranium Institute has reported. In a report entitled *The Global Nuclear Fuel Market: Supply and Demand 1995-2015*, the Institute notes that greater supplies of uranium, beyond current production plans, to meet expected demand could come from a number of sources, including new mines, greater use of reprocessing of spent fuel, and faster entry into the market of blended down highly enriched uranium from military sources. More information may be obtained from the Uranium Institute, Bowater House, 12th floor, 68 Knightsbridge, London SW1X7LT, UK. Fax: (44) 171-225-0308.

CHEMICAL WEAPONS BAN. The Chemical Weapons Convention will enter into force 29 April 1997, the United Nations has announced. The Convention, which opened for signature in 1993, has been signed by 160 States and ratified by 65 through October 1996. It is the first multilateral disarmament agreement that eliminates an entire category of weapons of mass destruction. More information may be obtained from the Provisional Technical Secretariat for the Convention, Laan van Meerdervoort 51, 2517 AE The Hague, Netherlands; Fax: 31-70-3600944.

NUCLEAR SAFETY RESEARCH. The Paris-based Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development has issued a "collective opinion" of experts underlining the need for more research to further improve levels of nuclear safety. In issuing the document, the NEA's Committee on the Safety of Nuclear Installations points out that a number of governments are cutting back on funds for safety research, which could have an adverse impact on safety if not watched carefully. Separately, the NEA has published the proceedings of an international seminar on the management of radioactive waste. Held in Finland, the meeting focused on the importance of involving the public and local authorities in decisions about proposed sites for future waste repositories. The publication, *Informing the Public about Radioactive Waste Management*, includes the text of main presentations and a summary of conclusions. More information is available from the NEA. Facsimile: (33-1) 4524-1110.

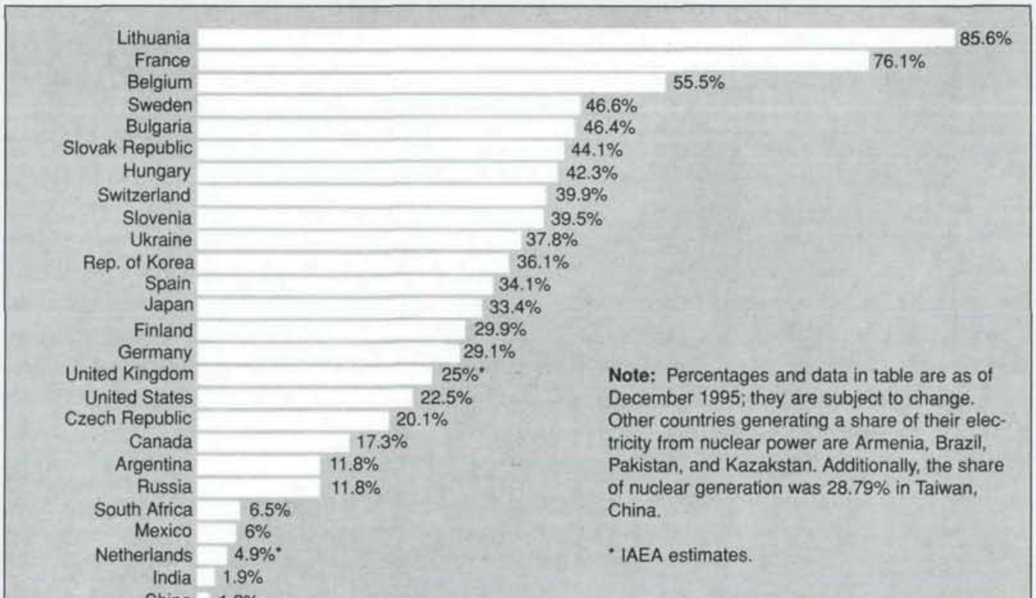
Nuclear power status around the world

	In operation		Under construction	
	No. of units	Total net MWe	No. of units	Total net MWe
Argentina	2	935	1	692
Armenia	1	376		
Belgium	7	5 631		
Brazil	1	626	1	1 245
Bulgaria	6	3 538		
Canada	21	14 907		
China	3	2 167		
Czech Republic	4	1 648	2	1 824
Finland	4	2 310		
France	56	58 493	4	5 810
Germany	20	22 017		
Hungary	4	1 729		
India	10	1 695	4	808
Iran			2	2 146
Japan	51	39 893	3	3 757
Kazakstan	1	70		
Korea, Rep. of	11	9 120	5	3 870
Lithuania	2	2 370		
Mexico	2	1 308		
Netherlands	2	504		
Pakistan	1	125	1	300
Romania			2	1300
Russian Federation	29	19 843	4	3 375
South Africa	2	1 842		
Slovak Republic	4	1 632	4	1 552
Slovenia	1	632		
Spain	9	7 124		
Sweden	12	10 002		
Switzerland	5	3 050		
United Kingdom	35	12 908		
Ukraine	16	13 629	5	4 750
United States	109	98 784	1	1 165
World Total*	437	344 422	39	32 594

*This total includes Taiwan, China where six reactors totalling 4884 MWe are in operation.

Notes to table: During 1995, two reactors were shutdown (including Bruce-2 in Canada which could restart in the future.)

Nuclear share of electricity generation in selected countries



Note: Percentages and data in table are as of December 1995; they are subject to change. Other countries generating a share of their electricity from nuclear power are Armenia, Brazil, Pakistan, and Kazakstan. Additionally, the share of nuclear generation was 28.79% in Taiwan, China.

* IAEA estimates.

SYSTEMS ANALYST (Financial Systems) (96/093), Department of Administration. This P-2 post assists in both the development and technical support of the Agency's financial information system and the orderly processing of daily work. It requires a university degree in computer science or an equivalent discipline and a minimum of 2 years of relevant experience in the design and development of computing systems in LAN-based client/server platforms. Also required is knowledge of IBM mainframes using MVS, CICS and COBOL, exposure to computer-based training techniques as well as a sound knowledge of accounting principles and practices. *Closing date: 13 February 1997.*

SYSTEMS ANALYST (Financial Systems) (96/092), Department of Administration. This P-3 post assists in the development and support of the Agency's financial information system and provides advice and assistance to users and in the strategic planning of the future migration of the system to new platforms. It requires a university degree in computer science or an equivalent discipline and a minimum of 6 years of relevant experience in the design and development of computing systems in LAN-based client/server platforms. Also required is knowledge of IBM mainframes using MVS, CICS and COBOL, and exposure to computer-based training techniques as well as a sound knowledge of accounting principles and practices. *Closing date: 13 February 1997.*

HEAD, LAN SYSTEMS SUPPORT UNIT (96/089), Department of Nuclear Energy. This P-4 post manages the staff and responsibilities of the LAN Systems Support Unit which provides central LAN server and computer communications services. It requires a university degree in a computer science related field, or equivalent, and at least 10 years of relevant practical experience, of which at least 2 should be in technical project management and supervision of technical staff, and experience in the effective application of computer technology in a large international data communication environment. *Closing date: 13 March 1997.*

SECTION HEAD (96/088), Department of Safeguards. This P-5 post is responsible for directing and performing safeguards activities in accordance with relevant safeguards agreements, both within the Section and in co-ordination with the other Sections in the Division. It requires an advanced university degree in chemistry, physics, engineering or equivalent, and at least 15 years of experience in the nuclear industry, nuclear research or nuclear related international or government service of which at least 5 years should be in the field of safeguards. *Closing date: 13 March 1997.*

NDA EQUIPMENT SPECIALIST (96/087), Department of Safeguards. This P-4 post co-ordinates the Group for Calibration and Maintenance, which is responsible for the setup, calibration, testing, commissioning, maintenance and repair of all safeguards non-destructive assay (NDA) and unattended radiation monitoring equipment. It requires a university degree in engineering, or nuclear physics, with specialization in electronics and analysis technology; demonstrated capability in co-ordination of tasks and supervision of staff; technical competence in the field of nuclear monitoring electronics and safeguards instrumentation; technical competence in the field of NDA equipment engineering and application; technical competence in the field of equipment installation in nuclear facilities; technical competence in the trouble shooting and maintenance of electronic instrumentation, and 10 years of relevant professional experience, some of which in an international environment. *Closing date: 13 March 1997.*

SENIOR LEGAL OFFICER (96/086), Department of Administration. This P-5 post assists the Legal Division and collaborates with other officers of the division in the preparation of legal opinions, legal instruments and documents, and provides legal advice as required. It requires an advanced law degree with good academic record, experience with international treaty law, including law of international organisations, and nuclear law. *Closing date: 17 January 1997.*

SYSTEMS ANALYST/PROGRAMMER (2 posts) (96/085), Department of Safeguards. These P-3 posts are responsible for specifying, designing, developing and implementing computerized safeguards systems to be an integral part of the PC-based Inspection Field Support System (IFSS) and other PC-based systems. They require a university degree preferably in computer science or a related field, experience in the design and development of PC-based systems in a Windows environment; experience with Windows-based application development tools, and 6 years of relevant experience. *Closing date: 17 February 1997.*

SYSTEMS ANALYST (2 posts) (96/084), Department of Safeguards. These P-4 posts are responsible for specifying, designing, developing and implementing computerized safeguards systems and developing and managing projects which are integral to the PC-based Inspection Field Support System (IFSS) and which require interface with other PC-based systems: these applications are either LAN-based or for field use. They require a university degree preferably in computer science or related field, experience in the design and development of PC-based systems in a Windows environment; experience with Windows-based application development tools; knowledge of and experience in system development methodologies. *Closing date: 17 February 1997.*

READER'S NOTE:

The ***IAEA Bulletin*** publishes short summaries of vacancy notices as a service to readers interested in the types of professional positions required by the IAEA. They are not the official notices and remain subject to change. On a frequent basis, the IAEA sends vacancy notices to governmental bodies and organizations in the Agency's Member States (typically the foreign ministry and atomic energy authority), as well as to United Nations offices and information centres. Prospective applicants are advised to maintain contact with them. Applications are invited from suitably qualified women as well as men. More specific information about employment opportunities at the IAEA may be obtained by writing the Division of Personnel, P.O. Box 100, A-1400 Vienna, Austria.

ON-LINE POST ANNOUNCEMENTS. IAEA vacancy notices for professional positions, as well as sample application forms, now are available through a global computerized network that can be accessed directly. Access is through the Internet. The vacancy notices can be accessed through the IAEA's ***World Atom*** services on the World Wide Web at the following address: http://www.iaea.or.at/worldatom/vacancies Also accessible is selected background information about employment at the IAEA and a sample application form. Please note that applications for posts cannot be forwarded through the computerized network, since they must be received in writing by the IAEA Division of Personnel, P.O. Box 100, A-1400 Vienna, Austria.

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Emergency Planning and Preparedness for Re-entry of a Nuclear Powered Satellite *Safety Series No. 119, 280 Austrian schillings, ISBN 92-0-104296-5*

Procedures for Conducting Probabilistic Safety Assessments of Nuclear Power Plants (Level 3): Off-Site Consequences and Estimation of Risk to the Public *Safety Series No. 50-P-12, 280 Austrian schillings, ISBN 92-0-103996-4*

Human Reliability Analyses in Probabilistic Safety Assessment of Nuclear Power Plants, *Safety Series No. 50-P-10, 360 Austrian schillings, ISBN 92-0-103395-8*

Assessment of the Overall Fire Safety Arrangements at Nuclear Power Plants, *Safety Series No. 50-P-11, 360 Austrian schillings, ISBN 92-0-100996-8*

Inspection and Enforcement by the Regulatory Body for Nuclear Power Plants: A Safety Guide, *Safety Series No. 50-SG-G4 (Rev. 1), 280 Austrian schillings, ISBN 92-0-103296-X*

Design and Performance of WWER Fuel, *Technical Report Series No. 379, 320 Austrian schillings, ISBN 92-0-104096-2.*

Reference Books/Statistics

IAEA Yearbook 1996, *500 Austrian schillings, ISBN 92-0-101295-0*

Nuclear Power, Nuclear Fuel Cycle and Waste Management: *Status and Trends 1996. Part C of the IAEA Yearbook 1996, 200 Austrian schillings, ISBN 92-0-102196-8*

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Energy, Electricity and Nuclear Power Estimates for the Period up to 2015, *Reference Data Series No. 1, 200 Austrian schillings, ISBN 92-0-102896-2*

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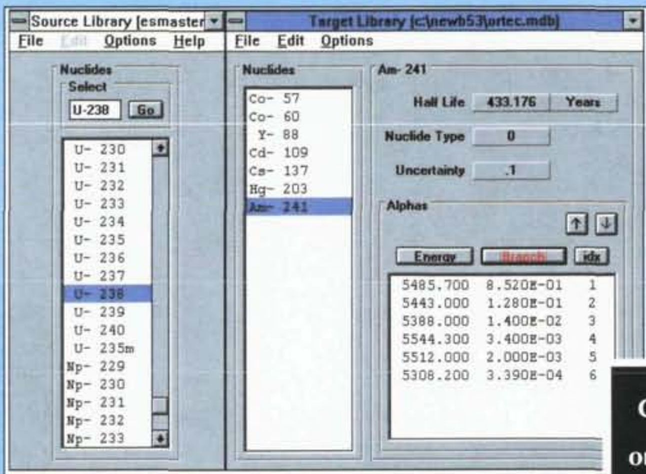

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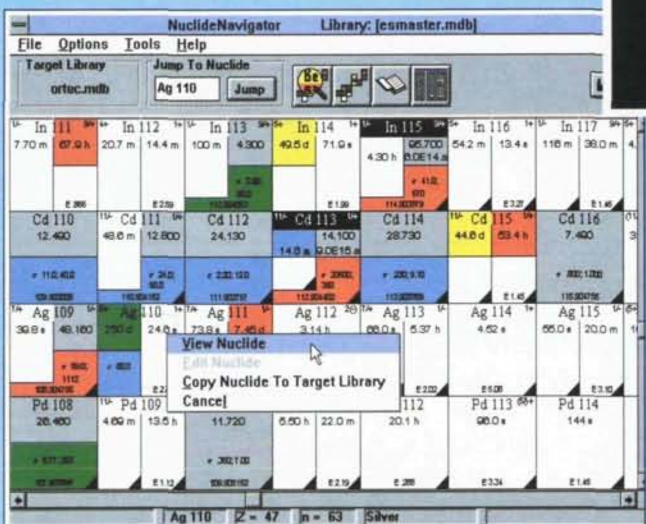

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[1]G. Erdtmann and W. Soyka, "The Gamma-Rays of the Radionuclides," *Verlag Chemie*, ISBN 3-527-25816-7, Weinheim, FRG, ISBN 0-89573-022-7, NY, 1979.
[2]PCNUDAT Nuclear Data file used by permission of NNDC at B.N.L.

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THE GAMMA SPEC

Vol. MCMXCVI, No. 49 E-MAIL:709-6992@MCIMAIL.COM

A New Era Dawns

DSPEC Revolutionizes Gamma-Ray Spectrometry

"Gamma Spectroscopy the Way It Should Be," Say Experts

Thousands of Spectrometers Obsolete Overnight

From our Gamma Spec Correspondent

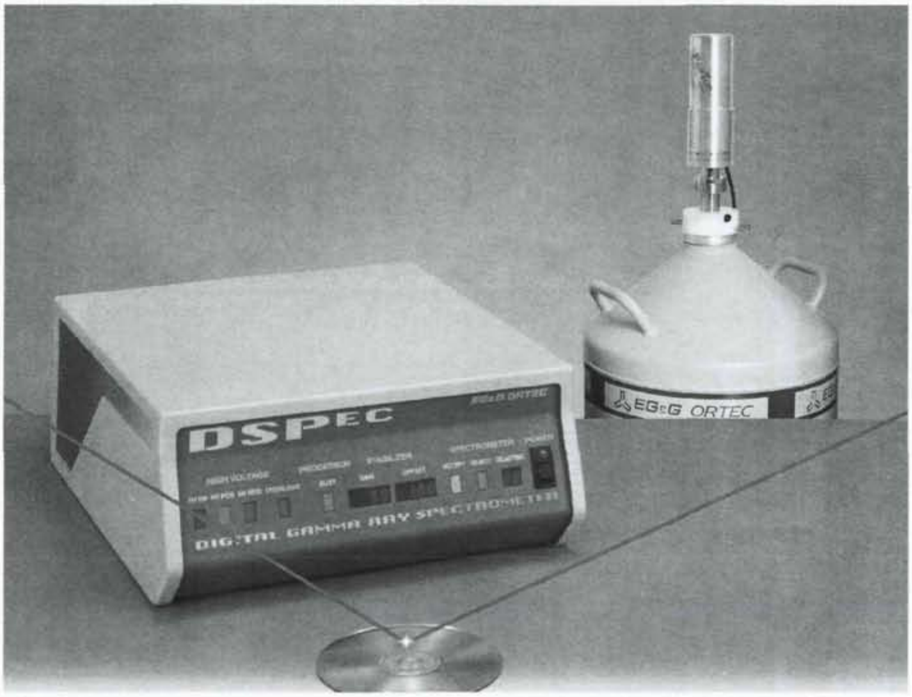
"DSPEC is here and the world of gamma-ray spectrometry will never be the same," – according to EG&G ORTEC, Oak Ridge, TN, concerning the truly digital (DSP-based) gamma-ray spectrometer. Throughout the civilized world, spectroscopists are considering their next move.

Late last evening, EG&G ORTEC scientists emerged from behind closed doors to announce the result of an intense two-year development, involving the cream of their engineering staff. At a hastily assembled press conference, the smiling Manager for New Product Development told the press:

"We are now immersed in the digital spectroscopy age. Less than two years after our initial feasibility discussions, DSPEC is complete, based on the same technology that makes CD players deliver such fidelity in the audio domain.

"DSPEC combines, in a single package, easily connected into Local Area Networks, all the best features of low- and high-rate analog systems, and systems designed to operate with super-large Ge detectors. It is presented in a highly automated, yet flexible, hardware and software combination suitable for nearly every spectroscopy application."

When asked by this reporter for more information concerning this mind-boggling achievement, he suggested contacting **EG&G ORTEC at 800-251-9750 or E-Mail 709-6992@MCIMAIL.COM.**



A Fascinating Road

Gamma Spectrometry Technology Races Ahead

Riding the PC Wave

An Interview by our PC Correspondent

As the Journal's inquiring reporter, I quizzed Dr. "Tim" Twomey, ORTEC's Applied Systems Manager, on the evolution of DSPEC. Tim stated: "The PC revolution created an expectation for continuous improvement in performance, ease of use, and value. In gamma-ray spectroscopy this has been partially fulfilled, with PC-based spectroscopy workstations delivering more in software performance by riding the wave of PC development. ORTEC has led the field since the pioneering ADCAM® PC workstations. New systems include Windows 95/NT compliance, operating within the Microsoft Workgroups™ environment.

"In 1993 we introduced MERCURY™, the ultimate high count-rate spectroscopy system, which still offers unsurpassed stored counts-per-second and has become a standard in demanding applications, particularly in industrial processes.

"Now with DSPEC, the user gets it all, needing only to punch the "Optimize" button to immediately achieve the optimum in resolution – regardless of variations in ambient temperature and regardless of count rate being high, low, or widely varying. The InSight™ Virtual Oscilloscope can be used to obtain the ultimate in performance."

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Digital Technology Ends Analog Trade-Offs

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DSPEC Processes More Samples, at Lower Cost per Sample

From Our Science Correspondent

From scientists performing environmental measurements to those in physics research to those involved in on-line industrial measurements, the question has been repeatedly posed: "Why can't one system provide the absolute best in resolution, throughput, and stability simultaneously? Why do we always have to make less-than-ideal electronic compromises when the detector is innately capable of better performance?" Until now, these questions remained unanswered. Now DSPEC provides the answers.

In Environmental Counting, DSPEC provides extremely high stability over long counting times. DSPEC solves the ballistic deficit problem which often degrades the resolution of large HPGe detectors. It delivers the best resolution of which any detector is capable. A statistical preset allows one to set multiple presets, such as "Stop counting when the precision of the 1.33 MeV peak reaches 5% or when there are 1000 total counts in that peak." This maximizes sample throughput, and delivers lower cost per sample. DSPEC is highly automated, ending the need to use screwdriver or oscilloscope to achieve the best performance. In recognition of non-laboratory conditions in many counting rooms, DSPEC provides unprecedented temperature stability for varying ambient temperatures.

For applications involving high count rates or widely varying count rates – such as intermediate-level waste measurement or post accident sampling – DSPEC has unmatched count-rate stability for both peak position and resolution.

For industrial applications and for Local Area Networks, DSPEC's built-in Ethernet port allows direct connection to the network. No other integrated instrument provides this.

Those wanting to wring the last drop of performance from their detector will appreciate the utility of the built-in InSight™ "Virtual Oscilloscope," which allows precise optimization by displaying the synthesized internal digital "waveforms."

DSPEC at Analytica Improves Resolution of 170% Efficiency Detector

From our Munich Correspondent

DSPEC was the star of the show at *Analytica* in Munich. With dozens of scientists crowding about, eagerly anticipating its arrival, DSPEC made its appearance.

One well-known physicist quipped, "Well, this will be quite a test for you ORTEC fellows . . . we won't give you even one minute to set it up."

DSPEC was removed from the shipping container and connected to an ORTEC 170% Ge detector. A single push on the "Optimize button" delivered a resolution at 661 keV that was 100 eV superior to what had previously been obtained using analog electronics. The audience oohed and aahed.

DSPEC Has No Competition

The Data Speaks with Digital Clarity

From our Correspondent in Boolea

The following comparison of DSPEC to the world's best analog spectroscopy electronics shows DSPEC unsurpassed in every aspect of resolution, throughput, and stability:

	DSPEC Optimized for Resolution	Leading High-Resolution Analog System
Peak Shift (1 to 140 kcps input, at 1332 keV)	165 ppm	6000 ppm
Resolution @1000 cps (at 1332 keV)	1.75 keV	1.77 keV
Resolution Degradation (from 1 kcps to 75 kcps input)	9%	38%

	DSPEC Optimized for Throughput	Leading High-Throughput Analog System
Maximum Throughput (@140 kcps input)	62,000	57,000
Peak Shift (1 to 140 kcps input, at 1332 keV)	85 ppm	100 ppm
Resolution Degradation (1 kcps to 140 kcps input)	2%	14%

Yesterday's Baseball Scores

8 to 5, 7 to 1, 6 to 3, 4 to 0, 11 to 2.

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ON LINE DATABASES

OF THE INTERNATIONAL ATOMIC ENERGY AGENCY

Database name

Power Reactor Information System (PRIS)

Type of database

Factual

Producer

International Atomic Energy Agency in co-operation with 29 IAEA Member States

IAEA contact

IAEA, Nuclear Power Engineering Section, P.O. Box 100
A-1400 Vienna, Austria
Telephone (43) (1) 2060
Telex (1)-12645
Facsimile +43 1 20607
Electronic mail via BITNET/INTERNET to ID:
NES@IAEA1.IAEA.OR.AT

Scope

Worldwide information on power reactors in operation, under construction, planned or shutdown, and data on operating experience with nuclear power plants in IAEA Member States.

Coverage

Reactor status, name, location, type, supplier, turbine generator supplier, plant owner and operator, thermal power, gross and net electrical power, date of construction start, date of first criticality, date of first synchronization to grid, date of commercial operation, date of shutdown, and data on reactor core characteristics and plant systems; energy produced; planned and unplanned energy losses; energy availability and unavailability factors; operating factor, and load factor.

Database name

International Information System for the Agricultural Sciences and Technology (AGRIS)

Type of database

Bibliographic

Producer

Food and Agriculture Organization of the United Nations (FAO) in co-operation with 172 national, regional, and international AGRIS centres

IAEA contact

AGRIS Processing Unit
c/o IAEA, P.O. Box 100
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Number of records on line from January 1993 to date

more than 130 000

Scope

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Coverage

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Database name

Nuclear Data Information System (NDIS)

Type of database

Numerical and bibliographic

Producer

International Atomic Energy Agency in co-operation with the United States National Nuclear Data Centre at the Brookhaven National Laboratory, the Nuclear Data Bank of the Nuclear Energy Agency, Organisation for Economic Co-operation and Development in Paris, France, and a network of 22 other nuclear data centres worldwide

IAEA contact

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Scope

Numerical nuclear physics data files describing the interaction of radiation with matter, and related bibliographic data.

Data types

Evaluated neutron reaction data in ENDF format; experimental nuclear reaction data in EXFOR format, for reactions induced by neutrons, charged particles, or photons; nuclear half-lives and radioactive decay data in the systems NUDAT and ENSDF; related bibliographic information from the IAEA databases CINDA and NSR; various other types of data.

Note: Off-line data retrievals from NDIS also may be obtained from the producer on magnetic tape

Database name

Atomic and Molecular Data Information System (AMDIS)

Type of database

Numerical and bibliographic

Producer

International Atomic Energy Agency in co-operation with the International Atomic and Molecular Data Centre network, a group of 16 national data centres from several countries.

IAEA contact

IAEA Atomic and Molecular Data Unit, Nuclear Data Section
Electronic mail via BITNET to: RNDS@IAEA1;
via INTERNET to ID:
PSM@RIPCRS01.IAEA.OR.AT

Scope

Data on atomic, molecular, plasma-surface interaction, and material properties of interest to fusion research and technology

Coverage

Includes ALADDIN formatted data on atomic structure and spectra (energy levels, wave lengths, and transition probabilities); electron and heavy particle collisions with atoms, ions, and molecules (cross sections and/or rate coefficients, including, in most cases, analytic fit to the data); sputtering of surfaces by impact of main plasma constituents and self sputtering; particle reflection from surfaces; thermophysical and thermomechanical properties of beryllium and pyrolytic graphites.

Note: Off-line data and bibliographic retrievals, as well as ALADDIN software and manual, also may be ob-tained from the producer on diskettes, magnetic tape, or hard copy.

For access to these databases, please contact the producers.
Information from these databases also may be purchased from the producer in printed form.
INIS and AGRIS additionally are available on CD-ROM.

Database name
International Nuclear Information System (INIS)

Type of database
Bibliographic

Producer
International Atomic Energy Agency in co-operation with 91 IAEA Member States and 17 other international member organizations

IAEA contact
IAEA, INIS Section, P.O. Box 100, A-1400 Vienna, Austria
Telephone (+431) 2060 22842
Facsimile (+431) 20607 22842
Electronic mail via BITNET/INTERNET to ID: ATIEH@NEPO1.IAEA.OR.AT

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IAEA UPCOMING CO-ORDINATED RESEARCH PROGRAMMES

Implementation of safety assessment methodologies for near disposal facilities for radioactive waste (ISAM)

To address methodological issues associated with long-term safety assessment of near surface disposal systems This programme will put special emphasis on the practical applications of these methodologies.

Development of protocols for corrosion and deposit evaluation in pipes by radiography

To develop radiographic protocols and instructions for identification and measurement of the corrosion attack and deposits in pipes (across insulation) and during operation of industrial installations.

Combined methods of liquid radioactive waste treatment

To support and facilitate the exchange of information on the use of combined processes in the treatment of liquid radioactive waste in order to improve waste management reliability, efficiency and safety.

Decommissioning techniques for research reactors

To encourage the development and improvement of decommissioning technology, reduce the duplication of efforts by various parties and provide useful results and tools for those Member States planning decommissioning of research reactors.

Validation of nuclear techniques for analysis of precious and rare metals in mineral concentrates

To improve the utilization of nuclear analytical techniques in terms of high accuracy and precision for the analysis of precious and rare metals in mineral concentrates, by preparing and testing appropriate laboratory protocols for sampling, quality control and quality assurance procedures.

Intercomparison and biokinetic model validation of radionuclide intake assessment

To provide possibilities for participating laboratories to check the quality of their methods for assessment of radionuclide intake. It will compare different approaches in interpretation of internal contamination monitoring data and quantify the differences in assessments based on various assumptions and approaches.

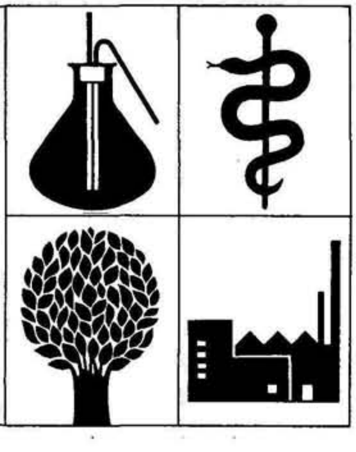
Isotopic evaluations of maternal and child nutrition to help prevent stunting

To measure breast milk intake by using isotopic methods which are accurate and safe for women and children. The CRP will take advantage of the fact that all the equipment for making the isotopic measurements is available in the Latin American region. The CRP will also include selected isotopic measurements of nutrient reserves in the mother or of the bioavailability of micronutrients in complementary (weaning) foods.

Bulk hydrogen analysis using neutrons

To develop new techniques for measuring the amount and spatial distribution of hydrogen in bulk materials, using neutrons. The need to know the amount of hydrogen in a material is important since hydrogen embrittlement in metals can cause structural weaknesses, as for example in aircraft.

These are selected listings, subject to change. More complete information about IAEA meetings can be obtained from the IAEA Conference Services Section at the Agency's headquarters in Vienna, or by referring to the IAEA quarterly publication ***Meetings on Atomic Energy*** (see the *Keep Abreast* section for ordering information). More detailed information about the IAEA's co-ordinated research programmes may be obtained from the Research Contracts Administration Section at IAEA headquarters. The programmes are designed to facilitate global co-operation on scientific and technical subjects in various fields, ranging from radiation applications in medicine, agriculture, and industry to nuclear power technology and safety.



IAEA SYMPOSIA & SEMINARS

APRIL 1997

Symposium on Diagnosis and Control of Livestock Diseases Using Nuclear and Related Techniques: Towards Disease Control in the 21st Century
Vienna, Austria (7-11 April)

International Symposium on Applications of Isotope Techniques in Studying Past and Current Environmental Changes in the Hydrosphere and the Atmosphere
Vienna, Austria (14-18 April)

Seminar on Current Status of Radiotherapy in the World
New York, USA (17-19 April)

MAY 1997

Symposium on Desalination of Seawater with Nuclear Energy
Taejon, Republic of Korea (26-30 May)

JUNE 1997

Symposium on Nuclear Fuel Cycle and Reactor Strategies: Adjusting to New Realities
Vienna, Austria (2-6 June)

SEPTEMBER 1997

Symposium on Radiation Technology in Conservation of the Environment, ***Zakopane, Poland*** (15-19 September)

IAEA General Conference, ***Vienna, Austria*** *(29 September - 3 October)*

OCTOBER 1997

Symposium on International Safeguards ***Vienna, Austria*** (13-17 October)

Regional Seminar on Nuclear Techniques for Optimizing the Use of Nutrients and Water for Maximizing Plant Productivity and Environmental Preservation
Piracicaba, Brazil (27-31 October)

NOVEMBER 1997

International Conference on Physical Protection of Nuclear Materials: Experience in Regulation, Implementation and Operation
Vienna, Austria (10-14 November)

Symposium on Upgrading the Fire Safety of Operating Nuclear Power Plants ***Vienna, Austria*** (17-21 November)

International Conference on the Health Effects Attributable to Low Radiation Doses
Seville, Spain (4-7 November)

96-04616

IAEA BULLETIN

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1991
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Lithuania

1992
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Estonia
Slovenia

1993
Armenia
Czech Republic
Slovakia

1994
Former Yugoslav Republic of Macedonia
Kazakstan
Marshall Islands
Uzbekistan
Yemen

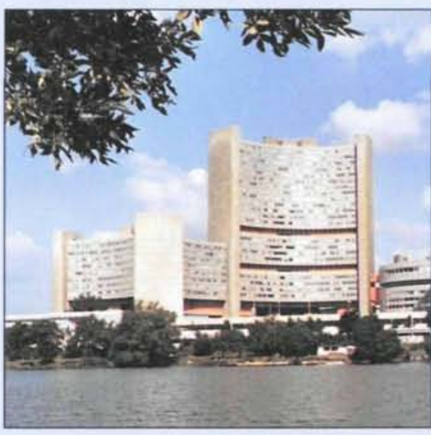
1995
Bosnia and Herzegovina

1996
Georgia
Moldova

Eighteen ratifications were required to bring the IAEA's Statute into force. By 29 July 1957, the States in bold face (including the former Czechoslovakia) had ratified the Statute.

Year denotes year of membership. Names of the States are not necessarily their historical designations.

For States in italic, membership has been approved by the IAEA General Conference and will take effect once the required legal instruments have been deposited.



The International Atomic Energy Agency, which came into being on 29 July 1957, is an independent intergovernmental organization within the United Nations System. Headquartered in Vienna, Austria, the Agency has more than 100 Member States who together work to carry out the main objectives of IAEA's Statute: To accelerate and enlarge the contribution of atomic energy to peace, health, and prosperity throughout the world and to ensure so far as it is able 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.

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INSIDE
TECHNICAL CO-OPERATION

International Atomic Energy Agency

December 1996 Vol. 2, No. 4

CONTENTS:

Global campaign to enhance radiation safety

In Mohammedia, Morocco, an iridium-192 source being used to radiograph welds at a construction site is inadvertently misplaced. A passing labourer picks up the tiny metal cylinder and takes it home. Within a few months, he and seven relatives are dead from radiation poisoning.

Without proper management, radioactive sources can endanger the lives of the unsuspecting. *(Credit: J. Cleave/World Bank).*

In Goiania, Brazil, a rotating head from a discarded cancer therapy unit is stolen from a storage facility and sold to a scrap metal dealer. The dealer breaks up the heavy shielding, and bits of the radioactive source, which glow in the dark, are taken by friends to various parts of the city. Within two weeks, 249 people are contaminated, four people die and more than 100,00 people must be screened.

Along the US-Mexico border, a heavy metal head from a radiotherapy machine is mistakenly melted down to make chair supports for a US fast food chain. The supports are trucked into the US, but the radioactivity triggers sensitive alarms at a nuclear research station as the vehicle passes the facility. Unknown numbers of hamburger lovers barely escape low-level radiation exposure.

continued page 4

Old parts serve new purpose

One man's trash is another man's treasure. The dictum is being borne out beside the river Danube, some 150 kilometres south of the Hungarian capital Budapest. A mock nuclear reactor, made-up of never used parts of abandoned installations, is nearing completion at Paks, the site where four real reactor units now produce half of the country's total electricity. By the end of 1996 the dummy will have all the key components — pressure vessel, steam generator, circulation pumps, piping and other such internals — in place, identical with those of the working units. But it will never produce power.

The parts were manufactured for reactors of the same type (WWER 440/213 designed in the Soviet Union) to be built in East Germany and Poland. Both undertakings were cancelled, by unified Germany and post-Communist Poland, leaving the

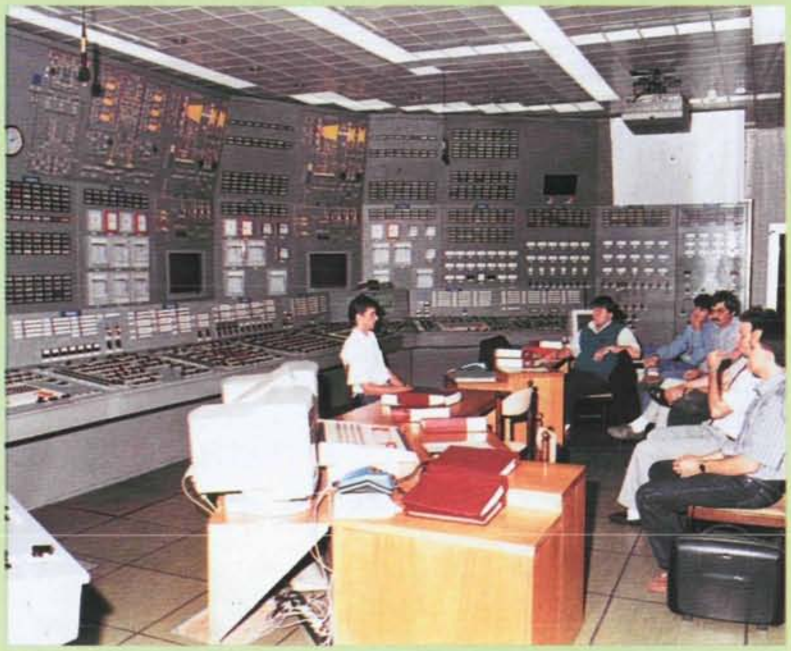
continued next page

Old parts serve new purpose *(from page 1)*

components worth no more than scrap metal. The IAEA bought them at giveaway prices as part of a technical co-operation Model Project to strengthen operational safety at Paks. The imitation unit will be a Maintenance Training Centre (MTC), the first of its kind anywhere for water cooled and water moderated energy reactors (WWER), to be used for training and retraining of plant operators.

Paks has an operational safety record on par with the best in the world, but management is conscious that it needs to have systematic safety procedures of the highest international standard. The Model Project has three main objectives, which were developed by the Hungarian Atomic Energy Commission that oversees the Paks power plant: to set up the MTC; to upgrade overall safety culture practices in the plant and all organizations dealing with nuclear power in Hungary; and to introduce a systematic approach to training of plant personnel.

The MTC is particularly important because the WWER was not designed for regular safety inspections and maintenance, as is normally required worldwide. In fact parts of the core area cannot be reached by humans and, in earlier Agency projects, remote control devices were developed to reach otherwise inaccessible areas. But the safety standards to which Hungary aspires demand regular inspections as well. With its full-size core area the MTC can provide the hands-on feel and experience to enable maintenance workers to work quickly and efficiently. Hungary, moreover, views it as a regional centre, not only for itself but also for the seven other countries (which include Finland and Russia) with operating 440/230, 440/213 or 1000 type WWERs. Also important, many of the maintenance personnel at Paks will be retiring soon. Recruits can now get MTC training and some on-the-job experience to take their places in due time.



On-site simulator training at Paks NPP is building "safety culture" among staff and management at WWER facilities. (Credit: Paks NPP).

"Safety culture" is a recent and somewhat recondite concept. The essence of it is that everybody involved in nuclear activities — from gatekeepers to top managers at a plant, for example — should be part of a "culture" which has safety as its paramount goal. It calls for a questioning ethos, for reporting anything out of the expected so that it can be assessed for its safety significance and for preempting events that could threaten safety.

Industry people are now talking of a "global" safety culture, though it is not something that can be set up by edict. The Model Project aims to implant it ecumenically via workshops and seminars, bringing together Hungarian and international specialists to discuss Paks' shortcomings identified by Agency missions and other issues pertinent to safety culture. The idea is that the way of thinking will be absorbed and take hold.

The third component, systematic approach to training (SAT), is new for Soviet-built reactor operating staff. Different types of safety missions led by the IAEA have identified training as the most important element to be improved. The project is helping to upgrade all the written material, audio visual and computerized aids, as well as equipment - not only for Paks but for all the institutes that provide training prior to that provided in the plant itself. Experts will be sent in to review, modify and advise on the modifications done by the Hungarians, and the Agency will test and evaluate the systems designed to examine trainees during and after courses.

Hungary is investing some US $8 million in the Model Project due to be completed in 1997, several times the IAEA technical co-operation input. The payoff is measured in safety assurance as well assured power supply. There have been no safety threatening events in the four Paks units (started up in 1982, '84, '86 and '87 respectively) but there have been holdups; notably problems which extended refuelling outage periods, the most recent this September. With Paks providing 50% of electricity to the national grid, avoiding such delays is important to the economy and public welfare.

In Brief: News Events

Convention on Nuclear Safety Enters into Force

The Convention on Nuclear Safety — the first international legal instrument on the safety of nuclear power plants worldwide — entered into force, 24 October 1996. The Convention commits States Parties to ensure the safety of land-based civil nuclear power plants. This includes a legislative and regulatory framework; general safety considerations such as quality assurance, assessment, and verification of safety; human factors; radiation protection; emergency preparedness; and specific obligations on the safety of nuclear installations; siting; design; and construction; and operation. Among its requirements, the Convention obliges Parties to submit reports at periodic review meetings. These reports will focus on the measures each State has taken to implement obligations under the Convention.

So far twenty-nine States have consented to be bound by the Convention on Nuclear Safety. They are Bangladesh, Bulgaria, Canada, China, Croatia, Czech Republic, Finland, France, Hungary, Ireland, Japan, Republic of Korea, Latvia, Lebanon, Lithuania, Mali, Mexico, Netherlands, Norway, Poland, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom. The Convention has been signed by 65 States.

"The Convention marks a major step forward in strengthening international co-operation in the safety field," said IAEA Director General Hans Blix.

Regional course builds safety structures in Eastern Europe

At the Munich Summit of 1992, the G-7 declared three priorities for the revitalization of Central and Eastern Europe and the former Soviet Union. Paramount among them is the need to strengthen their nuclear regulatory bodies. An IAEA regional project was subsequently established for this purpose.

Nuclear regulatory infrastructures in the region have been significantly strengthened following the Chernobyl accident in 1986. (Credit: IAEA).

During the last two years, national programmes in Armenia, Bulgaria, Croatia, Czech Republic, Hungary, Kazakstan, Lithuania, Romania, Russian Federation, Slovakia, Slovenia and Ukraine have been developing regulatory bodies with the independence and fundamental powers backed by laws and regulations to license, inspect, order modifications and even shut down plants on safety grounds.

Special attention has been devoted to co-ordinating non-IAEA related bilateral and multilateral projects as well, and the project's success has led to its extension as a new technical co-operation project through 1998. The extension, especially requested by the recipients, has also attracted substantial special contributions, notably by the United States ($200,000) and the United Kingdom ($280,000) for 1997 alone, and as yet unspecified commitments by Finland and Germany.

Although organizational structures and regulatory processes vary from country to country (depending on existing constitutional, legal and administrative systems) this Model Project aims to tackle broad issues common to them by conducting regional workshops and training courses. In the process, national needs to be addressed separately are also identified. So far there have been 10 courses on specific themes, including regulatory control of nuclear power plants and on the general approach to nuclear safety principles and fundamentals, with 180 participants from the 12 countries receiving 250 person-weeks of training.

There have also been workshops on information for the public, safety culture, and commissioning/licensing. Two others scheduled for late 1996 on commissioning/recommissioning and on decommissioning nuclear power reactors are of special importance to the region. Many of the older reactors are nearing the end of design lifetimes, yet possible recommissioning and decommissioning have received little considered in their design and construction. A decade after Chernobyl — a period engrossed with intense assessment of the causes and consequences of the accident — the region's safety infrastructure is building toward internationally accepted standards through coordinated efforts by the international community to provide the required technical training and exchange of information.

Most countries with nuclear power plants and other advanced nuclear facilities have independent regulatory authorities backed by strict law enforcement, well-trained personnel and assured budgets. But as the incidents above illustrate, many developing nations still lack the radiation and waste safety infrastructures to properly manage the sources they currently use.

Indeed, despite fielding over 100 field missions and assisting almost 700 priority national projects since 1984, it became clear to IAEA officials by the early 1990s that safety systems in many developing countries had to be dramatically strengthened to meet the requirements derived from the Basic Safety Standards (BSS) *(see page 8).*

Two technical cooperation Model Projects (MP) launched in 1994 aim to upgrade radiation protection and waste management infrastructures on a regional basis, with 5 to 6 countries targeted each year. But "Country Safety Profiles" subsequently assembled by the IAEA revealed that over 50 countries were in need of immediate assistance. Thus, the IAEA decided to accelerate implementation of these two projects toward a target date of the year 2000 and to set up four regional centres to manage infrastructure upgrading.

The most pressing needs of some 53 countries in four regional groupings have already been determined on the basis of BSS requirements and information gathering, including earlier missions by Radiation Protection Advisory Teams (RAPAT), the Waste Management Advisory Programme (WAMAP) and special expert teams. An action plan has been developed together with each participating country, setting out the key steps that must be taken. To date 28 countries have officially agreed to their action plan. To accelerate the upgrading process, time limited objectives and decentralized management have been established. Four regional field co-ordinators (RFC) have been appointed to manage offices recently opened in Addis Ababa, Beirut, Bratislava and San Jose.

Needs and infrastructure requirements differ dramatically from country to country and also between regions. Africa includes a number of countries that have no designated authority to keep records of where sources are. Many of the Asian project countries have not used many radiation sources in the past but are moving in this direction quickly. By contrast, once-extensive programmes in some Eastern European countries have been stopped, but the sources have remained and records are not properly maintained.

The project's first aim is to inventory what sources are being used, for which applications, and where, as well as where and how no-longer-used sources are stored. A computer database is being developed based on questionnaires sent to the countries about sources they know they have, and to manufacturers and suppliers on what they have provided in the past. The two-track findings — country records plus supplier information — should provide a comprehensive picture for national regulators, many of them only recently established.

Many countries simply have not known what they have because they lacked the mechanisms to keep proper inventories. As regulatory structures are built up, the records will provide a base to monitor, control, ensure safe licensed use and finally to store radioactive sources securely. The initial focus is on larger (more active) sources used for medical purposes such as cancer treatment and in industry (sterilization, food irradiation, radiography).

Establishing laws, regulations and other means of control over sources are only part of the process. In liaison with the technical staff in the IAEA's Nuclear Safety Department, the RFC's will work with the governments to set up infrastructures to keep good records, monitor radiation for workers and emissions that affect the public, and assure the quality of radiation used in medicine. The project will also help procure essential equipment, provide the training to utilize them and monitor the safe transport of sources and disposal and waste handling.

The new approach establishes the first global thematic plan involving country assessments and action plans in Technical Co-operation (TC). It also recognizes the value of developing self-reliance and common experience through technical co-operation among countries developing similar control systems. Thus national organizations and experts with experience gained via earlier IAEA training are recruited to provide technical support services to other countries developing safety infrastructures in the region. The Slovak Republic, for example, which developed a full-scope nuclear regulatory authority almost from scratch within a few years *(see page 6)*, is now helping Ukraine restructure its struggling system.

Besides the country-level information, a second international database is being developed on accidents and near accidents with sources. Three recent studies concentrated on "lessons learned" from mishaps in radiography, radiotherapy and at industrial irradiation facilities. They will help regulators and workers in participating countries as they analyze the causes of more than 100 accidents.

The overall goal is to help countries attain the infrastructure and expertise to avoid the kind of disasters described earlier. By the time the project ends at the turn of the century, those countries that fully co-operate will have everything in place to safely manage the use of ionizing radiation for whatever purposes they choose.

A matter of global safety

Natural sources of radiation occur everywhere on Earth. Our atmosphere protects us from cosmic sources of radiation such as the sun and other energy sources in the universe. In fact, the protective layer of ozone is so thin that radiation doses from cosmic rays increase with altitude as we jet for business or vacation. Radon is a naturally occurring radioactive gas that comes from decaying uranium which is common in the earth's crust. It is emitted from rocks or soil and usually disperses into the atmosphere, except when it encounters a building where it can concentrate. This "ionizing" radiation can cause human health problems and often requires monitoring and remediation. Since atomic energy was "discovered" some 75 years ago, nuclear technologies are applied to a spectrum of activities from processing toothpaste to producing energy.

Living with radiation is part of life on earth, and the IAEA is one of the key organizations with global responsibility for protecting and controlling radiation exposure from natural and man made sources. The Agency, in particular the Nuclear Safety Department has helped establish international standards to ensure safety of all types of radiation sources: industrial, medical, agricultural, environmental, and others. It also supports training activities and national infrastructure development to ensure that governments have the legal framework, experience, human resources, and tools to protect, control and exploit nuclear energy. IAEA Technical Cooperation helps to ensure that the diversity of technologies employing nuclear energy do so in a safe, effective and sustainable manner. This edition of ***INSIDE TC*** explains some of the activities that assist in meeting this challenge.

Radiation levels in schools and homes were surveyed in selected villages in three former Soviet republics under a major international project in the early 1990s on the health and radiological consequences of the Chernobyl accident. (Credit: IAEA).

Slovak regulators gain clout

The remarkable rise in stature of the Slovak Nuclear Regulatory Authority (SNRA) is one the most reassuring developments in Eastern Europe's nuclear power scene. Set up only in January 1993, shortly after the amicable dissolution of the federation of Czechoslovakia, SNRA personnel are now serving as experts in IAEA programmes to advance regulatory capacity in neighboring countries.

IAEA delegation visits SNRA headquarters. From left to right: Slovak Ambassador H.E. Daniela Rozgonova, IAEA Director General Hans Blix, SNRA Chairman Josef Misak, and former IAEA Assistant Director General Morris Rosen. (Credit: SNRA).

Many countries in Eastern Europe were not recognized for having independent regulatory bodies, amply staffed and financed, backed by laws and regulations that gave them authority to shut down power plants on safety grounds. In the case of Czechoslovakia, separation left Slovakia in a dire situation. Only six site inspectors of the former federation remained in the new republic, while it inherited responsibility for four operating power reactors, four more under construction, a research reactor (severely damaged in a 1977 accident) to be dismantled, as well as for fuel cycle, spent fuel and radioactive waste treatment facilities.

Slovakia did have some nuclear engineers and scientists and technical staff from nuclear power plants. Together with personnel from non-nuclear re-gulatory bodies, research institutes and various ministries, SNRA built staff strength to 50 by the end of 1993. But they lacked nuclear regulatory experience, and SNRA had to create, virtually from scratch, a new organization aimed at matching international best practice. An IAEA technical co-operation Model Project, begun in January 1994 provided assistance via foreign experts, training fellowships abroad and some equipment to rapidly meet this goal.

A team of senior regulators, organized by the European Union with IAEA participation, identified areas for improvement. The IAEA then recruited western experts to visit Slovakia to analyze, discuss and advise SNRA on emergency preparedness, radioactive waste control, quality assurance, site inspection, periodic safety assessment and training.

Nearly 30 Slovak regulators have been awarded fellowships (typically for two weeks, some for several months) with mature regulatory bodies in Europe and North America to see how things are done in those countries, take experience back and, where appropriate, absorb them into SNRA procedures. "The Slovak regulators' rapid advance is largely due to their own determination and drive," an IAEA technical officer says. SNRA is now a strong body with good practices, able to recruit and retain staff.

SNRA Chairman Jozef Misak acknowledges the Authority's new found stature in the country. What was once a solitary office in a ministry is now an independent legally constituted authority directly under the Prime Minister. It has more than 70 staff and an assured and adequate budget. Parliament has recognized it as equivalent to an international organization, and it has control powers over all nuclear activities and installations in the country. Arguably the crowning recognition has been the request for SNRA to assist the regulatory bodies of Armenia and Ukraine via IAEA projects. The Agency is convinced that both countries would gain much from the Slovak experience, particularly in handling the considerable amount of foreign assistance that is available. Advice they are likely to hear from SNRA is, "Don't take too much assistance at once, don't have experts coming in every fortnight, because you get overburdened with help". Slovakia got wise to that early in their programme. They were getting flooded, so they backed off, rescheduled and made the pace manageable.

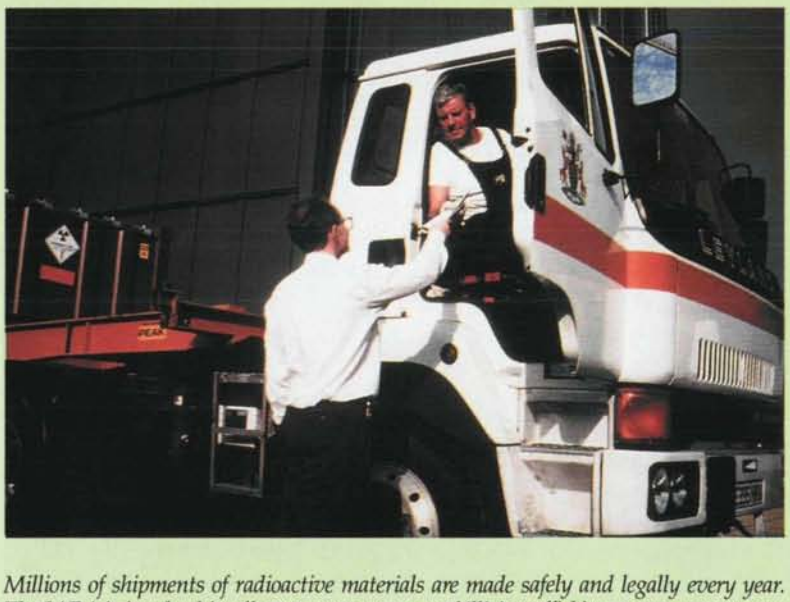
Both Armenia and Ukraine are handicapped by language problems that the Slovaks did not have. Russian-speaking SNRA consultants could overcome that barrier, and already some have joined IAEA teams to the two countries. A team of SNRA experts produced a workplan for Ukraine under an IAEA technical co-operation contract. There have also been two-way visits between Armenia and Slovakia. In short, SNRA activities are helping to realize a major objective of IAEA technical co-operation — the promotion of technical co-operation among developing countries (TCDC).

Illicit trafficking

Since January 1993, just under 130 confirmed events involving illicit trafficking of nuclear materials and other radioactive sources have been recorded in the IAEA database. Most of these incidents have been innocuous. A number have involved plutonium and highly enriched uranium, generally in relatively small amounts, but two cases involved substantial amounts. Do these indicate that there is a lot of loose material for weapons out there waiting for a buyer? Are the small amounts just the tip of a fissile iceberg? Is the contraband, capable of killing or injuring people?

The IAEA launched a programme to address illicit trafficking of nuclear material and other radioactive sources in 1994. In this programme, the IAEA plays a small but vital part in the extensive number of bilateral and multilateral activities which are aimed at stopping the illicit trafficking. This programme is focused on four activities where technical co-operation plays an important role. *To prevent*: by helping countries to strengthen their basic nuclear laws and infrastructures, to upgrade their accounting, control and security of nuclear material and radioactive sources, as well as improve their control of the import/export of strategic goods and materials. *To respond:* by helping countries to detect and react to illegal cross-border movements of radioactive materials and analyze confiscated material; and by providing authoritative and timely information on trafficking incidents reported to the Agency's trafficking database. *To train:* by developing and providing training opportunities for both State regulatory and facility personne; and to enhance the *exchange of information* via international and inter-agency meetings and conferences.

Recognizing that the most important defense against smuggling may be better intelligence, the IAEA is encouraging closer co-operation and co-ordination between the scientific community, law enforcement organizations and transporters by helping to create a network of communication with such organizations as Interpol, Europol, Euratom, International Air Transport Association, International Road Transport Union, World Customs Organization the Universal Postal Union and other organizations concerned with this potentially dangerous new situation.



Millions of shipments of radioactive materials are made safely and legally every year. The IAEA is involved in efforts to prevent cases of illicit trafficking. (Credit: Mairs/IAEA).

Measuring radiation doses

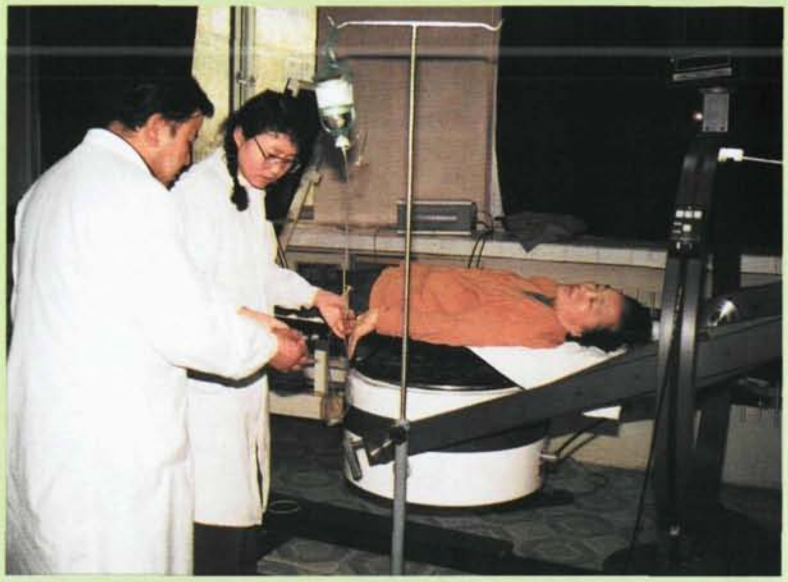
The earth has always been enveloped in "ionizing radiation" which comes up from the earth's crust and down through the atmosphere from the sun. Despite this it can be harmful because it can penetrate matter and adversely affect biological processes in living tissue.

Dosimetry is the field of measuring ionizing radiation — including the instruments, measurement methods, and physical-chemical principles that determine interactions of radiation with matter. Its ultimate target is to determine the "absorbed dose" for people, which is the basic dosimetric quantity. Dosimetry is crucial in radiotherapy, in radiation protection and in radiation processing technologies; though typical doses and requirements for accuracy differ among them. In radiotherapy the dose delivered must be extremely precise. So dosimetric quality assurance (checks and recalibration of dosimeters) and other procedures have to be meticulously applied.

Anyone who works with radiation, however, should have their doses recorded and regularly compared with dose limits. This is done by wearing a dose meter for external radiation, or by checks to measure ingested activity, which requires special equipment and expertise. Except where there is a lot of "loose" radioactivity, less sophisticated methods can be used to work out whether any quantity has been ingested, such as by measuring activity in urine, which is a relatively simpler procedure. Most countries where IAEA has technical co-operation projects do not need the most sophisticated dosimetry. A number deal only with sealed sources, but all countries involved need some capacity in external dosimetry.

New safety standards are people friendly

Strawberries grown in a field straddling the Belgium/France border help to illustrate the chaos, in terms of protecting people from contamination, that followed the Chernobyl nuclear accident in 1986. Fruit from one side of a farm went to market while that of the other was buried; both obeying official edict in the two countries. There were many inconsistencies of that sort ten years ago. The *International Basic Safety Standards (BSS) for Protection Against Ionizing Radiation and for the Safety of Radiation Sources*, is the joint product of six international bodies: the Food and Agriculture Organization; IAEA; International Labour Organization; World Health Organization; Pan American Health Organization and the Nuclear Energy Agency of the Organization for Economic Co-operation and Development. All six sponsor organizations have now adopted the BSS and apply them in all their activities. Since the adoption of the new BSS, all countries now have clear guidelines on how to act in virtually every circumstance.



Quality control is very important in operating high technology medical equipment.(Credit: Y.Xie/IAEA).

The standards prescribe safety requirements which, if followed, make accidents much less probable. And beyond guidance on preventing accidents, they also clarify in great detail what to do if an accident does occur in any of a full range of nuclear activities. Non-accident situations are also included, such as high levels of naturally occurring radon gas in a house. Radon is produced by the decay of uranium in the earth's crust and is both widespread and harmlessly dispersed into the atmosphere. But it can cause health problems when it accumulates inside buildings. The BSS explain when and how to intervene and at what radon level to evacuate a household.

Precise guidance and strong regulations are recommended for medical practices. A big problem area, particularly though not exclusively in developing countries, is the rapidly increasing use of medical sources for diagnosis and treatment. There have been many accidents in clinics, and even more occasions when they have been carelessly used or mis-used. One example is in cancer treatment, where the prescribed radiation dose has to be very precise to be useful on the one hand but not cause unnecessary injury to the patient on the other. The BSS cover all typical examinations as well as for nuclear medicine. Even the levels of residual radioactivity in patients, at the time they are discharged from the hospital after radiotherapy, are provided.

A key group of standards spotlight activities related to security and detection. Among these applications is the quite common radiological examination for legal or health insurance purposes. Another practice is radiological examination for theft detection: people working with gold or diamonds who may swallow the odd stone. The BSS do not "ban" these applications, but suggest that justification is essential for certain conditions.

The Basic Safety Standards devote an entire chapter to occupational exposures from sources in industry. Industrial products that could cause radiation exposure shall not be supplied to members of the public. Suppliers must ensure that products for industrial use — that could cause exposure in normal use, misuse, accident or loss — satisfy a long list of conditions. Additionally, industrial sources should be properly labelled and accompanied by clear and appropriate information on installation, use, maintenance, servicing, repair and recommended disposal procedures.

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