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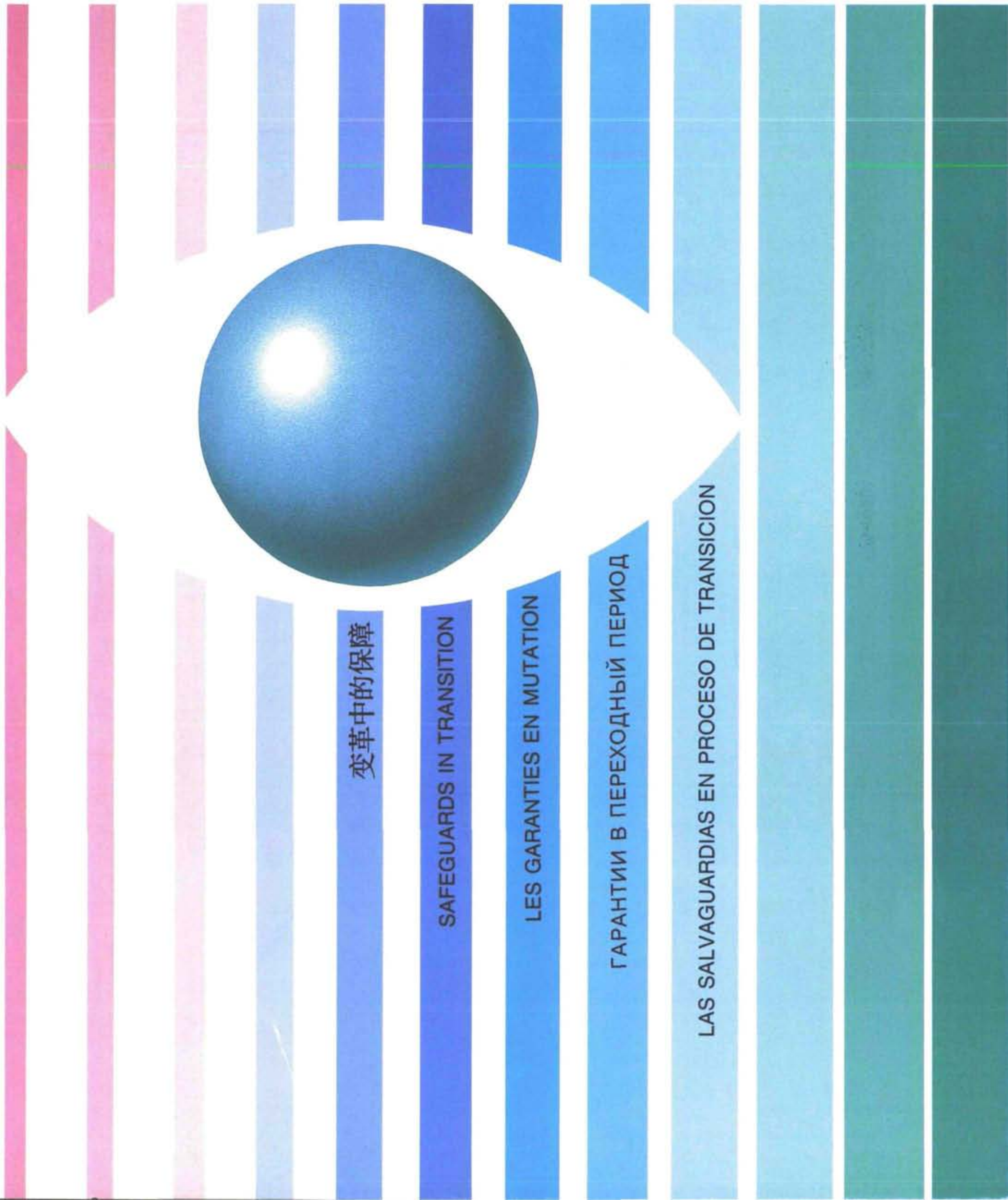


Front cover: The end of the cold war has opened a new vision for the future, one bringing renewed hope for universality against the spread of nuclear weapons. Helping to shape that vision is the IAEA's nuclear safeguards and verification system, the world's first on-site international inspectorate. The IAEA's work in Iraq, South Africa, Democratic People's Republic of Korea, and elsewhere, for example, has answered — and raised — critical questions about the nature of nuclear programmes. As importantly, it has yielded valuable lessons that now are being evaluated and applied to improve the system's capabilities, especially with respect to possible undeclared nuclear activities. The Agency's long-standing experience further is being singled out for tomorrow's verification tasks. These include verification responsibilities under a Comprehensive Nuclear Test Ban Treaty, toward which work has started, and under a US-proposed treaty prohibiting the production of plutonium and highly enriched uranium for nuclear explosives. *(Cover design: Ms. Hannelore Wilczek, IAEA)*

Facing page: An Iraqi technician helps prepare irradiated nuclear fuel for shipment out of the country earlier this year. Under the IAEA's supervision, all declared stocks of nuclear weapon-grade material have been removed from Iraq . *(Credit: Iraq Atomic Energy Commission)*

CONTENTS

Safeguards in transition: Status, challenges, and opportunities

Political and technological developments are strongly influencing the IAEA's system for verifying the peaceful uses of nuclear energy

by Bruno Pellaud

After phases of intensive development in the 1970s and consolidation in the 1980s, the IAEA's international safeguards system is now in a phase of transition. The 1990s look to be a time when verification activities are further expanded in response to global developments and challenges in the field of nuclear non-proliferation.

How far have safeguards come, and where are they headed? I would like to offer some thoughts and perspectives on the main challenges and opportunities facing IAEA safeguards, in the context of some recent developments and the overall evolution of the safeguards system.

Building the foundation

In mid-1971, just 3 years after the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) opened for signature, the Safeguards Committee of the IAEA Board of Governors finished its work on the model NPT safeguards agreement. Its efforts were formulated in what would become a fundamental document of the safeguards regime, namely Information Circular 153 (INFCIRC/153).

The INFCIRC/153 safeguards system depends strongly on nuclear material accountancy and its international verification. It is based on a basic concept: as long as all nuclear weapon-usable material is verified to be in peaceful activities, one can be confident that it is not used to produce nuclear explosive devices. Since weapon-usable nuclear material is essential for any such device, a tight control on material was considered to be sufficient for international non-proliferation verification purposes.

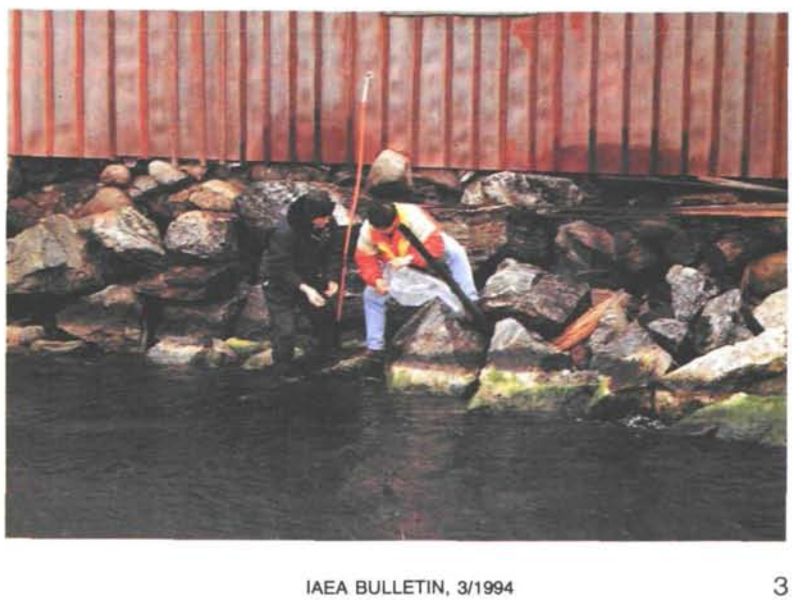
Mr. Pellaud is Deputy Director General of the IAEA Department of Safeguards. This article is based on his address at the IAEA Symposium on International Safeguards in March 1994.

While in the 1970s, the concepts and verification techniques were indeed developed and implemented, we saw in the 1980s the full implementation of the system and its continuous improvement. The system was never considered to give total assurance of non-proliferation because of the possibility that weapon-usable material could be produced clandestinely in an unsafeguarded, unreported parallel programme. There was also the theoretical possibility that a country could prepare for a large-size nuclear weapon development programme without using any significant quantity of nuclear material. It would stockpile the necessary weapon-usable material in peaceful installations under IAEA safeguards and only divert this material from safeguards at the last moment, when the Government would be certain that its experts could produce functioning nuclear weapons within a very short period of time.

At any rate, in the INFCIRC/153 concept, the timeliness of detection of diversion was considered to be critical. Of course, this concept turned out to be expensive in terms of inspection effort. There was, certainly, some expectation that any strategy to produce nuclear weapons from unreported weapon-usable material could most probably be detected at an early stage by national intelligence organizations, for example, through the use of satellite surveillance. The case of Iraq has taught us otherwise. Even though the Government of Iraq had spent enormous resources in terms of money and manpower on a large complex of dedicated facilities for the nuclear-weapon development programme and made remarkable progress in some parts of the programme, this effort became known after the Gulf war and only then did the locations involved become accessible to IAEA inspections.

As a consequence, the safeguards community began to seriously re-think some fundamental tenets of safeguards. Already in September 1991, IAEA Director General Hans Blix told the Board

Scenes from IAEA safeguards and verification activities *(clockwise from top left):* Examining seals at IAEA headquarters through the use of laser disk recording; preparing for fuel measurements at the damaged research reactor at Tuwaitha in Iraq; inspectors using a special viewing device to verify irradiated fuel in storage ponds; taking environmental samples during field trials in Sweden; visiting a reactor in the Democratic People's Republic of Korea (DPRK); and rendering harmless the Kalahari test shafts associated with the terminated nuclear-weapon programme in South Africa. *(Credits: Iraq photo — Pavlicek, IAEA)*



of Governors that the Agency's safeguards system would have to undergo a threefold strengthening to cope effectively with suspect cases — namely through the access to additional information, through the unrestricted access to any relevant location, and through the strong support by the world community, explicitly the United Nations Security Council.

Among the strengthening options considered by the Board in 1992, the most important involves the clarification of the Agency's rights to conduct, when appropriate, special inspections at locations that might be relevant for safeguards. Others refer to the need for the early provision and verification of design information commencing during construction of facilities, and extending over their lifetimes through commissioning and normal operation. This will provide an improvement in the foundations for implementing nuclear materials accountancy and containment and surveillance measures, in particular, as may relate to undeclared activities within declared facilities. Next, more extensive information will be analyzed to look for patterns that might suggest undeclared nuclear activities within a State. Additional reporting on exports and imports of nuclear material, specified equipment, and non-nuclear material will constitute one means to gain access to such information.

From that time on, it became indeed mandatory to contemplate a safeguards strategy that would no longer be based exclusively on nuclear material accountancy. Rather, it would also look for and follow up inconsistencies in information that might be an early indication of a possible nuclear-weapon programme.

Here a word of caution. As it took years to achieve political agreement on the INFCIRC/ 153 system, it might take quite some effort and time to achieve a political consensus on its expansion.

Influence of recent events

A number of recent events in the safeguards field have influenced or are still influencing the development of the expanded safeguards system.

The case of Iraq exposed some apparent weaknesses of the INFCIRC/153 system. Here was a country — which had agreed to a comprehensive safeguards agreement — launching and proceeding far into a nuclear-weapon development programme, and all this without reaching the level of alarm within this safeguards system. This event not only opened the way for some re-thinking of the INFCIRC/153 system but also promoted the willingness of many countries to permit IAEA safeguards in a less restrictive and more open way. Several countries have since invited the IAEA to visit any location it wishes to, even if the location was not reported to the safeguards system.

In general terms, one can say that through the events in Iraq — and certainly also through the end of the cold war — the co-operation and openness in many countries has further improved. But the case of Iraq has also given the IAEA valuable experience that went well beyond normal safeguards practice: for the first time the Agency learned to recognize the signs of a clandestine nuclear weapons programme, its components, its industrial infrastructure, its research and development requirements, and its overt and covert procurement paths.

Secondly, there was the case of South Africa. When South Africa concluded its safeguards agreement with the Agency in 1991, the Agency was confronted with the problem that major unsafeguarded facilities, including one plant for the production of highly enriched uranium, had been previously operated outside any kind of international control for many years. Therefore, the IAEA General Conference requested the Director General to verify to the extent possible the completeness of the inventory of nuclear material and installations included in South Africa's initial report to the IAEA. As a result of this request, an IAEA team made a number of visits to South Africa to consult with officials and to examine historical accounting and operating records of both operating and closed-down facilities. The team's general conclusion was that it had found no evidence to suggest that the declared inventory of nuclear installations and material was incomplete. Then came unexpectedly, in March 1993, South Africa's announcement that it had abandoned its former nuclear-weapons programme. South Africa extended at that time an invitation to the IAEA to examine with full transparency the scope, the nature, and the facilities of the weapons programme. The IAEA accepted the invitation.

After numerous additional visits and the examination of records, facilities, and remaining non-nuclear components of the dismantled nuclear weapons, the IAEA came to a number of conclusions: it concluded that the cumulative amount of highly enriched uranium produced by the South African pilot enrichment plant was consistent with that programme; and that no indications suggest that there remain any sensitive components of the nuclear-weapons programme not having been either rendered useless or converted to commercial non-nuclear applications or peaceful nuclear use. From the findings, one can state that, firstly the nuclear-weapons programme of South Africa was terminated; secondly, that all nuclear devices were dismantled prior to South Africa's adherence to the NPT; and thirdly that all nuclear material involved in the weapons programme was returned to peaceful uses prior to the conclusion of the safeguards agreement. No violation of the NPT or the safeguards agreement by South Africa has therefore been detected. The South African case has certainly further expanded the experience of the Agency, sharpened its inspection skills and heightened its capability to look into non-nuclear material-related activities of a clandestine nuclear-weapon development programme.

The situation in the Democratic People's Republic of Korea (DPRK) has been different. Among the latest developments are the DPRK's withdrawal from membership of the IAEA in June 1994. The action followed the IAEA Board of Governors' adoption of a resolution in which it found that the DPRK is "continuing to widen its non-compliance with the safeguards agreement" and called upon the DPRK to extend full co-operation to the IAEA by providing access to all safeguards-relevant information and locations. As IAEA Director General Hans Blix informed the Board in June 1994, at this point the Agency is enabled to implement adequate safeguards with regard to the DPRK's declared nuclear material, but it is not in any position to verify whether the nuclear material which the DPRK has declared is in fact all that should have been declared. As long as the IAEA continues to be denied access to information and locations relevant to the DPRK's nuclear programme, the Agency will not be able to say whether the DPRK's declaration of its nuclear material subject to safeguards is accurate and complete.

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

In South America, the Agency recently has begun the process of verifying the completeness of the initial inventory of two large countries. After an earlier ratification by Argentina, the Brazilian Parliament and Senate have now approved the quadripartite safeguards agreement between the IAEA, Argentina, Brazil, and the Brazilian-Argentine Agency for the Accounting and Control of Nuclear Material (ABACC). Both Argentina and Brazil have operated nuclear facilities, including small enrichment plants, over extended periods of time outside the IAEA safeguards system. We are nevertheless confident that the question of completeness of the initial inventory will, like in the case of South Africa, be rapidly resolved with the full co-operation of the parties concerned.

A similar problem, but which may turn out to be more complex, faces the IAEA as some of the new independent States of the former USSR join the NPT as non-nuclear weapon States. Belarus and Kazahkstan have done so; Ukraine will also, sooner or later. In these cases it may indeed be extremely difficult to reconstruct historical data on nuclear material, even with the utmost support and openness of the governments involved. Yet the Agency will have to satisfy itself that all nuclear material is declared.

New and emerging verification technologies

Improvements in conventional safeguards should remain high on the priority list of the IAEA Department of Safeguards. The great majority of work involves the day-to-day verification of nuclear operations under existing safeguards agreements. This is by no means a static activity. In such conventional activities, the Agency will have to cope with an expanded workload. For nearly a decade, the IAEA has been required to meet these challenges under zero growth budget constraints, which has added an additional dimension of complication.

Regarding new safeguards technologies in general, the use of computers by inspectors in the field obviously is having a profound impact on safeguards implementation; yet we are at a very early stage of this revolution. In the area of safeguards instrumentation development, the emergence of unattended verification systems and of digital image surveillance also is making a significant difference.

Unattended verification systems have already been used successfully to reduce inspection effort, decrease the burden on facility operators, and provide expanded verification coverage. They combine computer-operated non-destructive assay systems with containment and surveillance, such that the measurements are made under controlled and authenticated arrangements. Such systems are sometimes the only way to implement safeguards at complex nuclear facilities, especially in automated plants. Several unattended monitoring systems are now under consideration, under development, and even in use. Examples are the plutonium assay systems for use in Japanese mixed-oxide conversion and fuel fabrication facilities; a Core Discharge Monitor developed in Canada for on-load power reactors; the Consulha system developed in France for monitoring the unloading of spent fuel; and the integrated verification system under development in Germany.

The development of the second generation bundle counter is particularly important since it is the prototype for the next generation of unattended monitoring systems. The goal is to develop modular hardware and modular software incorporated in an open architecture system. With this concept, the flexibility for accommodating a variety of applications will be designed into the basic architecture, without the need to establish a customized system for each facility. Moreover, since an international standard will be employed, developers in various laboratories around the world can contribute sensors that can be accommodated within such a system, confident that appropriate interfaces will be available.

In the last 2 years, there has been a tremendous growth in digital image transmission, together with the adoption of agreed standards for high-speed, real-time data compression, digital imaging, digital processing, digital storage, as well as digital encryption of image data. Digital image technology will have a fundamental impact on the surveillance measures used by the Agency. The overall effectiveness of our optical surveillance will be significantly improved and the technology will allow innovative applications, such as the use of mail-in arrangements and remote monitoring. The mail-in concept foresees the mailing of encrypted surveillance information by the facility operator to the IAEA offices. This concept would save inspection resources by reducing the need for inspectors to visit certain facilities, such as light-water reactors, as frequently as currently required.

Furthermore, the Agency continues to investigate innovative methods to apply randomization principles in safeguards. Recently, a field test was performed on the application of short-notice random inspections for inventory change verification at a fuel fabrication plant. According to this approach, the plant operator declares the contents of nuclear material items before knowing if an inspection will occur to verify them.

Indeed, the IAEA safeguards development programme includes many requirements and tasks related to the current routine implementation of safeguards. Much of the work is carried out within the framework of Member State Support Programmes. They provide both financial help and technical expertise.

Beyond the development of hardware and software, the catalogue of work covers a host of other activities to ensure that IAEA safeguards continue to provide the assurance sought by Member States. This work includes updating the safeguards criteria currently in effect for 1991-95, to strengthen them as soon as techniques and inspection modes are judged appropriate and feasible. Examples of such elements are the application of safeguards to small quantities of nuclear material; the streamlining of departmental procedures for granting requests for an exemption of nuclear material from safeguards; and for the termination of safeguards for measured discards.

Initiatives for strengthening safeguards

In reviewing the Iraqi experience, it is clear that Agency safeguards did not provide adequate assurance that States subject to comprehensive safeguards agreements would submit all nuclear materials to safeguards or that undeclared operations were not carried out in facilities that were submitted for safeguards. As a result, the IAEA has initiated a substantial amount of work on new approaches aimed at strengthening the safeguards system. While most of the evaluation and planning activities necessary to realize these improvements will not be completed for some time, the outcome of this work will have a fundamental impact on technical aspects of IAEA safeguards in the future.

Last year, the IAEA General Conference and the Board of Governors asked the Secretariat to explore alternative means to strengthen the safeguards system and to improve its cost-efficiency. In April 1993, the Director General's Standing Advisory Group on Safeguards Implementation (SAGSI) had under the same heading formulated a set of specific recommendations. After having been discussed by the Board in its June meeting, these recommendations were translated into the Secretariat's development programme for a strengthened and more cost-effective safeguards system, a programme that has become known as "93+2". This effort will provide for the evaluation of the technical, legal, and financial implications of various recommendations, first of all those of SAGSI.

The programme requires extensive participation by Member States. All strengthening measures that go beyond the scope of safeguards agreements can only be implemented with the agreement of the States concerned. The IAEA should be in a position to make a proposal, including the legal implications, for a strengthened and more cost-effective safeguards system by early 1995.

One area that appears particularly interesting is the application of environmental sampling for safeguards purposes. These methods allow for chemical and isotopic analysis of minute samples (as small as 10^{-15} grams) which may be collected within declared facilities or away from nuclear facilities (e.g., water, soil, biota samples) that might provide indications of clandestine activity. This method has been and will continue to be used in Iraq.

Several Member States have offered their assistance in the conduct of environmental monitoring field trials and related technical areas. A plan for environmental sample collection and analysis has been established for 1994 with a series of participating Member States. The usefulness of field trials is not limited to environmental monitoring. Ways and means to increase the co-operation with national accounting systems are also candidates for field trials.

Challenges and opportunities

The INFCIRC/153 safeguards system has not yet achieved the desired broad degree of universality. As any worldwide arms limitation arrangement, the non-proliferation regime will only achieve its full intended purpose if all relevant countries participate. Substantial progress has been made over recent years: South Africa joined the NPT; Argentina, Brazil, and Chile ratified the Treaty of Tlatelolco; China and France joined the NPT as nuclear-weapon states; and full-scope safeguards will soon be in force in Brazil and Argentina. Moreover, Algeria has announced its intention to join the NPT.

In other areas as well, things are moving. New confidence-building initiatives have been put forward by the United States. In particular, if and when the process of nuclear arms reduction in nuclear-weapon States reaches the phase of releasing substantial quantities of direct-weapon-usable material from weapon programmes into civil use or possibly only to storage, IAEA safeguards on such material could provide assurances that the material would not be used in a nuclear-weapon programme again. Until now only the highly enriched uranium released when South Africa terminated its nuclear-weapon capabilities falls into this category of direct-use material previously used in a weapon programme. This material is now placed under IAEA safeguards and is dedicated to peaceful uses. In this connection the US initiative to submit excess fissile material from the US defense programme to IAEA safeguards is an important step.

The Agency may also be given a role in the verification of the Comprehensive Test Ban Treaty now under discussion at the Conference on Disarmament in Geneva and possibly also in the verification of a cut-off in the production of fissile materials.

Alongside these challenges and opportunities stand certain developments that may threaten the safeguards system's credibility.

Firstly, there is the ambiguity in the DPRK. If the Agency remains unable to verify that there is no nuclear-weapon programme in the DPRK, the application of safeguards there will at some point be of questionable value. We can only hope that, eventually, a credible solution will be found by which the peaceful character of the nuclear programme of the DPRK will be confirmed.

Secondly, there are the longstanding restrictions on IAEA resources. More than 10 years of zero-growth budget at a time of greatly increasing workloads has unfortunately led to a reduction in the Agency's attainment of its inspection goals, if not yet to an unacceptable degree. Although I am fully aware of the economic situation in many Member States, it must be emphasized that with a continuing zero-growth budget the Agency will not be able to cope with the extended programmes and demands placed on it. For the successful execution of its functions, the Agency needs the continuing full support of its Member States, individually and collectively, if the reputation of the safeguards system is to be maintained.

Certainly, the Agency has reacted to the challenges of recent years and has tackled the opportunities by launching important initiatives. It is, however, up to the Member States and their political judgement to determine the objectives and scope of our work. The discussions on our programme and budget in the IAEA Board of Governors and the General Conference, and certainly also the results of the NPT Review and Extension Conference in April 1995, will have a strong influence on the direction in which IAEA safeguards will develop.

I am convinced that through its safeguards activities the IAEA has also contributed substantially to the promotion of the peaceful use of nuclear energy throughout the world, by providing assurance that nuclear trade and co-operation would not lead to the proliferation of nuclear weapons. Without the verification activities of the IAEA, nuclear commerce would have hardly found the present degree of public acceptance.

The new challenges and opportunities may indeed permit the IAEA to contribute even more directly to world peace and prosperity. ❐

IAEA symposium on international safeguards: Mirror of the times

Built upon the old, a reinforced nuclear verification system is emerging in response to new demands and rising expectations

by Lothar H. Wedekind and James A. Larrimore

If scientific meetings had theme songs, the more than 400 participants at the IAEA's safeguards symposium earlier this year might have entered the opening session to "The times they are a changin..." For some, perhaps too rapidly. For others, not fast enough.

"International safeguards has moved from a phase of consolidation in the 1980s to a phase of transition in the 1990s as we respond to dynamic political and technological developments," Mr. Bruno Pellaud, IAEA Deputy Director General for Safeguards, said in opening the meeting. "Verifying activities in countries having extensive nuclear programmes has led to actions and ideas for new verification activities designed to reinforce the conventional safeguards system." *(See the article beginning on page 2.)*

In many respects, the international safeguards community is carefully bridging its past and future in response to new demands and rising expectations. Yesterday's exclusive focus on safeguarding *declared* stocks of nuclear material is being linked to today's need to detect *undeclared* nuclear activities and to tomorrow's possible demand to verify nuclear material once contained in nuclear weapons.

Exactly where the changing times lead the IAEA as the world's international nuclear safeguards inspectorate remains to be seen. So far, over the past 4 years, they have taken nuclear inspectors on different assignments to some highly publicized places: Iraq, under mandate of the UN Security Council to oversee dismantlement of a clandestine nuclear-weapons programme; South Africa, to examine sites connected to a terminated nuclear-weapons programme; the Democratic People's Republic of Korea (DPRK) to verify declared nuclear activities and clarify associated ambiguities; to Argentina and Brazil, to prepare for safeguards under a comprehensive quadripartite safeguards agreement; and Belarus, Kazakhstan, Ukraine, and other countries of the former Soviet Union to lay the groundwork for verifying the peaceful nature of their large nuclear programmes.

On the horizon, new destinations and tasks are coming into view. Discussions in Geneva and elsewhere include talk of the IAEA's potential role concerning, among other things, verification of a comprehensive nuclear test ban treaty and of a treaty prohibiting production of plutonium and highly enriched uranium for nuclear explosives.

During the week-long symposium at IAEA headquarters in March 1994, experts from 42 countries examined technological and political sides of these subjects — and more. In all, some 200 papers were presented at 20 sessions on safeguards technologies, monitoring systems, analytical methods, operational criteria and approaches, and other topics. Nuclear safeguards is a broad field encompassing an array of technical and scientific disciplines. The highly integrated verification system is applied to nuclear material in more than 800 facilities around the world. Key elements are inspectors, who conduct on-site inspections, and various types of instrumentation and computerized equipment, which are used for verifying operator records; monitoring and analyzing nuclear material; and for evaluating safeguards information.

Many of the new safeguards systems and approaches are in various stages of research and development, including application at specific facilities. Invariably the systems illustrate the growing impact of computerization in the safeguards field. Unattended computer-based verification systems, for example, have been developed for use at complex, highly automated nuclear facilities for measuring and monitoring

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materials. Digital imaging, processing, and storage of data also are seen as having a fundamental impact on the IAEA's surveillance measures. Additionally, techniques of environmental sampling are being tested and applied for verification purposes, as in Iraq, for example, where the method is part of the IAEA's long-term monitoring plan. The techniques allow for chemical and isotopic analysis of minute samples of water, soil, biota, and other materials. *(See the article beginning on page 20.)*

More informally, the safeguards symposium offered insight into the thinking of leaders in the field of nuclear non-proliferation and verification. Mr. Pellaud and four former heads of the IAEA's Department of Safeguards reflected upon the system's evolution and changing operational priorities over the past three decades *(see box, page 13)* while a final panel session of distinguished experts looked to the future from political, financial, and policy perspectives. *(See "Viewpoints", page 16.)*

By week's end, participants had gained valuable insights into the "old" and "new" sides of safeguards, from political, economic, and technological perspectives. One message seemed clear: However the vision for the future unfolds, there appears to be no turning back.

A selective topical overview of the symposium follows:

Safeguards experience

In reviewing the IAEA's safeguards experience since 1986, three senior Agency officials — Messrs. D. Schriefer, D. Perricos, and S. Thorstensen — looked closely at operational demands being faced in response to what they described as "an entirely new scenario of events". More States have placed facilities and nuclear material under international safeguards, and new approaches have had to be devised for new types of facilities, all done under "severe contraints" from the IAEA's budget. Over the 1986-92 period, they noted, the amount of nuclear material under safeguards, in terms of significant quantities (SQs), almost doubled, reaching 65 878 SQs in 1992. Plutonium, both separated and that contained in irradiated fuel, makes up most of these SQs.

The growth is expected to continue through this decade, as nuclear programmes in Argentina, Brazil, Belarus, Kazakhstan, and Ukraine, for example, come under comprehensive IAEA safeguards. Estimates of nuclear material under safeguards up to 1999 indicate an increase of about 60% for plutonium, 40% for low-enriched uranium, and 35% for source material. Projected increases for highly enriched uranium depend upon how much material from former weapons programmes is placed under IAEA safeguards. Additionally, in terms of facilities, about 40 more power reactors will begin operating under safeguards before the end of 1996, they reported. Other, more complex nuclear installations, including reprocessing and enrichment plants, also are coming under IAEA safeguards.

Encouraging progress in reducing the IAEA's inspection effort in the European Union was reported by Mr. Thorstensen and Mr. K. Chitumbo of the IAEA Department of Safeguards. This is occurring through a programme for greater co-operation between the IAEA and Euratom called the New Partnership Approach.

In an informative session on systems for accounting and control of nuclear material, a number of presentations offered insights from national and regional perspectives. Mr. W. Gmelin of the Commission of the European Communities (CEC) reviewed the role of the Euratom inspectorate in international safeguards; Mr. Y. Motoda, Executive Director of Japan's Nuclear Material Control Centre, updated its activities and looked at Japan's expectations from the IAEA's work to strengthen and streamline safeguards; Mr. Dong-Dac Sul, Director of the Nuclear Control Division in the Republic of Korea's Ministry of Science and Technology, reviewed the country's substantial inspection effort and noted that a technical centre had been set up to interface with the IAEA and to interact with the Democratic People's Republic of Korea; and Mr. Jorge A. Coll, Secretary of the Brazilian-Argentine Agency for the Accounting and Control of Nuclear Material (ABACC), reported on ABACC's role and activities. *(See related article beginning on page 30.)*

Experience in Iraq. The IAEA's activities and experiences in Iraq under terms of United Nations Security Council resolutions were reviewed by Prof. Maurizio Zifferero, Head of the IAEA's Action Team. After more than 20 inspections in Iraq since May 1991, the emphasis now has shifted to preparing for, and gradually implementing, elements of the IAEA's long-term monitoring plan. *(See the article on nuclear inspections in Iraq beginning on page 24.)*

Verification in South Africa

When South Africa in March 1993 announced its dismantlement of a former nuclear-weapons programme, the IAEA's ongoing verification of the country's extensive nuclear programme took on an added dimension, reported Messrs. Garry Dillon and Demetrius

Perricos, senior IAEA safeguards officials. IAEA inspectors already had been verifying South Africa's declared nuclear inventory under a safeguards agreement concluded in 1991 pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). When the former nuclear-weapons programme was disclosed, the IAEA's role was extended to assess the abandoned programme's status and to ascertain that all related nuclear material had been recovered and placed under safeguards. With the co-operation of South African authorities under its stated policy of "transparency", the IAEA augmented its verification teams with nuclear-weapons experts and other specialists from outside the Agency. Teams visited all facilities identified as having connection with the former nuclear-weapons programme. They found "no indication to suggest that there remained any sensitive components of the nuclear-weapons programme which had not been either rendered useless or converted to commercial non-nuclear applications or peaceful nuclear usage."

From the South African perspective, the verification was an exercise in the application of "post-Iraq safeguards". Messrs. N. von Wielligh and N.E. Whiting of South Africa's Atomic Energy Corporation said that "the totally changed safeguards environment" following the discovery of a clandestine nuclear-weapons programme in Iraq influenced the verification process in South Africa. In offering a number of "lessons learned", they emphasized the importance of openness and transparency for both the State and the international inspectorate. "A situation of mutual trust should and can be built up in a spirit of complete openness and co-operation by both sides," they said. "The international community should visibly support an impartial and independent IAEA — South Africa will surely do its part."

Safeguards in newly independent States

No fewer than 13 newly independent States of the former Soviet Union have substantial nuclear activities: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Khyrgistan, Latvia, Lithuania, Russia, Tajikistan, Urkraine, and Uzbekistan. With the exception of Russia, all have declared their intention either to become or to remain non-nuclear weapon States.

Since 1992, the IAEA has been working with newly independent States to help them establish or further develop their State Systems for Nuclear Accountancy and Control (SSACs), and to strengthen the physical protection of nuclear materials and facilities and the regime for import and export control. Mr. Thorstensen of the IAEA reported that the work has included 24 fact-finding missions/technical visits, 16 training events, and co-ordinated technical support in specific areas. He noted that several countries, including Canada, Finland, Germany, Hungary, Japan, Sweden, United Kingdom, and United States, have expressed their intention to help newly independent States improve their SSACs by supporting, for example, training and equipment needs.

"The IAEA is fulfilling a vital function in institution and capacity building in the newly independent States," reported Mr. Thorstensen. "Much remains to be done, but much is already under way."

The situation in Ukraine was updated by Messrs. A. Glukhov and N. Steinberg of the Ukrainian State Committee on Nuclear and Radiation Safety, whose responsibilities include the implementation of domestic and international safeguards. They noted the progress made on a comprehensive safeguards agreement with the IAEA covering all nuclear material in all peaceful nuclear activities. This agreement would remain in force until superseded by an agreement pursuant to the NPT once Ukraine fulfills its pledge to join the Treaty as a non-nuclear weapon State. (The agreement was concluded in June 1994, and now goes to the IAEA Board of Governors for approval.)

Improving technical capabilities

Early in 1995, the IAEA is expected to present results to its Board of Governors of a 2-year programme — known as "93+2" — to strengthen the safeguards system and make it more cost effective. In describing efforts, Mr. Richard Hooper, who is heading the IAEA programme, noted that a number of countries are hosting field trials of possible new elements, including environmental monitoring. The programme has two basic objectives. One is to strengthen the system's capability to detect undeclared facilities and activities in States having comprehensive safeguards agreements, in particular through the use of more sources of information and greater access for inspection. The other is to improve the cost effectiveness of conventional safeguards through the introduction of new technology and possible changes in approaches and procedures.

Among specific areas of emphasis for the future development of safeguards are advanced systems for information management and remote monitoring; environmental monitoring; and the use of commercial satellites.

Information management. Advanced tools for managing the large volume and diversity of safeguards information are being developed and evaluated. Extensive safeguards information is needed by the IAEA, noted Mr. John Rooney of the US Department of Energy. "The ability to acquire, review, store, analyze, validate, and retrieve large volumes of such information will provide a challenge to the existing IAEA information management system," he said. An enhanced system now is being designed for monitoring nuclear activities on a global scale by making better use of information obtained through safeguards inspections as well as from other sources, he said.

Remote monitoring. The technology for transmitting a wide variety of information to off-site locations, generally known as remote monitoring, is in widespread industrial use, and not new to safeguards. The fast pace of technological advances, however, has opened up possibilities, reported Messrs. Cecil S. Sonnier and Charles S. Johnson from Sandia National Laboratories in the United States. They specifically looked at the integration of video surveillance and electronic seals with a variety of monitors. Such advanced systems are installed in several nuclear facilities in France, Germany, Japan, the United Kingdom, and the United States, they noted. Remote monitoring systems are being tested in field trials involving the United States and Australia, and future trials are expected to involve several facilities in Europe, North America, and the Far East. The aims are to demonstrate that the systems can save inspection resources while maintaining safeguards effectiveness, and to promote international acceptance of such systems for safeguards applications. While the technology itself presents "a rather minimal challenge," they pointed out that the situation is "complicated by policy issues related to State rights, transparency, safeguards criteria, and other issues."

Environmental monitoring. In looking at the prospects of environmental monitoring for the detection of undeclared production of plutonium and highly enriched uranium, Mr. G. Andrew of the United Kingdom's Department of Trade and Industry drew upon the technical advice, recommendations, and conclusions of a consultants' group meeting convened by the IAEA in March 1993. The approach involves the analysis of environmental samples to detect releases of radionuclides and other signs that provide "signatures" of key nuclear fuel cycle activities. The results of such monitoring are then compared with known activities that have been declared by States. He pointed out that the evaluation of environmental monitoring techniques should take into account possible complicating factors. These include the presence of radionuclides in the environment from nuclear-weapons testing and from commercial nuclear operations.

"Environmental monitoring, and indeed other sources of information, is unlikely to be able to deliver definitive proof one way or the other as to the existence of undeclared activities," he cautioned. "While the techniques are powerful, they will not provide an absolute guarantee that no undeclared facilities exist in a State. Subject to confirmation by the IAEA's ongoing evaluation programme, environmental monitoring should, however, provide the Agency with a range of potentially powerful tools to allow reasonable questions to be raised, and hopefully resolved, with a State about its nuclear programme."

Commercial satellites. The photographic data from commercial satellites may be useful in safeguards, yet there are political and technical

Sweden and other countries have invited field trials under an IAEA safeguards project on environmental monitoring.
(Credit: Hosoya, IAEA)

questions that remain to be solved, according to Mr. W. Fischer, W.-D. Lauppe, B. Richter, and G. Stein of the Jülich Nuclear Research Centre in Germany, and Mr. B. Jasani of King's College in London. Currently, they reported, six countries, including the United States, France, Russia, India, and Japan, have launched and operated civil remote sensing satellites, with a combined nine long-term satellites in orbit. While their possible use for safeguards holds limitations, preliminary evaluation of some commercial satellite images has demonstrated that known nuclear facilities can be readily observed, which suggests a potential for detecting undeclared nuclear activities.

These are just some areas drawing attention in the ongoing research and development (R&D) side of IAEA safeguards. All told, the Agency's R&D needs comprise 66 main items that are primarily being met through Member State Support Programmes, reported Mr. V. Pouchkarev, who heads the Systems Studies Section of the IAEA Safeguards Division of Concepts and Planning. More than 200 specific tasks are under way.

Possible new verification tasks

Some new verification tasks for the IAEA are closer in view than others. Beginning this year, the United States intends to submit excess fissile material to safeguards under its voluntary offer agreement with the IAEA, reported Ambassador John Ritch III. He pointed out that this will be the first instance in which the IAEA will play a role in verifying certain aspects of the disarmament process. The material will be in various forms, including weapons components. The projected schedule foresees several tons in non-sensitive forms of highly enriched uranium at Oak Ridge submitted in 1994, followed by plutonium in non-sensitive oxide and metallic forms at Hanford and Rocky Flats. Approaches for future inspections of weapons components are under study. He also noted that the US and Russia have signed a joint declaration regarding the placement of excess weapons material under IAEA safeguards.

The Ambassador further outlined features of President Clinton's proposal of September 1993 for an international treaty prohibiting the production of highly enriched uranium and separation of plutonium for nuclear explosives, which the United Nations General Assembly endorsed in October 1993.

"The United States does not envisage the treaty as prohibiting the production of highly enriched uranium or the separation of plutonium for civil nuclear activities under safeguards, nor does it see the convention as requiring full-scope safeguards," he said. "It would, however, have the important effect of imposing a 'cap' on the fissile material available to the treaty's members — both nuclear-weapon States and non-nuclear weapon States — for nuclear explosives." In emphasizing the importance of verification, he said that the United States "sees the IAEA as the appropriate agency to carry out this role."

Non-proliferation policies

How the IAEA's safeguards system evolves during this decade will depend in no small measure on the outcome of the 1995 Conference on the review and extension of the NPT, which will take place in New York 17 April to 12 May 1995.

In reviewing major policy and institutional issues before the Conference, Mr. Mohamed ElBaradei, IAEA Assistant Director General, noted that most of the parties already have declared themselves in favour of the Treaty's indefinite extension, while others have advocated extension for a fixed period of time, accompanied by a mechanism to enable further extensions.

"The IAEA has a major interest in the outcome of the 1995 Conference because of the impact on the application of Agency safeguards," he said. "The majority of the safeguards agreements under which the Agency implements safeguards are those pursuant to the NPT...It is to be hoped that whatever the outcome of the Conference, it would be one that fosters the cause of non-proliferation and efforts for its universalization." ❐

The symposium was the seventh in a series on the subject that the IAEA has convened since 1965. The 1994 meeting was organized by the IAEA in co-operation with the American Nuclear Society, the European Safeguards Research and Development Association, the Institute of Nuclear Materials Management, and the Russian Nuclear Society. It had the twin objectives of encouraging and assisting safeguards-related R&D at the national level, and of providing an impartial, factual technical basis to help guide discussions and the formulation of nuclear non-proliferation policies by governments and international organizations. The IAEA expects to return to a 4-year frequency for safeguards symposia, with the next one foreseen for early 1998, unless developments call for an earlier schedule. Proceedings of the 1994 symposium are available for purchase from the IAEA or its sales outlets in Member States. See the Keep Abreast section for ordering information.

Paying tribute to 25 years of safeguards leadership

Over the past three decades, thousands of men and women have worked to build, develop, and implement what has become the world's first international system for on-site verification: the IAEA's system of nuclear safeguards. Today more than 800 nuclear facilities in some 60 States having significant nuclear activities are covered by IAEA safeguards, with inspectors typically conducting more than 2000 inspections each year.

Since the system's inception in the 1960s, six men have headed the IAEA's Department of Safeguards, which has the responsibility of carrying out the range of safeguards activities. Five of these leaders — Mr. Rudolph Rometsch of Switzerland from 1969-78; Mr. Hans Grümm of Austria from 1978-83; Mr. Peter Tempus of Switzerland from 1983-87; Mr. Jon Jennekens of Canada from 1987-93; and Mr. Bruno Pellaud of Switzerland, from 1993-present — joined in a lively panel discussion during the IAEA safeguard symposium for an exchange of views and experiences, followed by a reception. Tribute was paid to the sixth man, the late Mr. Alan McKnight of Australia, who headed IAEA safeguards from 1964-69. Moderated by Mr. Pellaud, the discussion offered insights into the organizational, financial, technical, and political challenges involved in establishing the system over the past quarter century. Excerpts of their remarks:

1969-78: The Blue Book safeguards

Mr. Rometsch: "The outstanding event in my first year at the IAEA was the meeting of the Committee of the Whole, called together to work out the structure and content of safeguards agreements in connection with the NPT (Treaty on the Non-Proliferation of Nuclear Weapons). That committee deliberated over a period of 11 months. It discussed and laid down in detail what is still known as the 'Blue Book' (INFCIRC/153).

"I remember particularly two points of the Committee discussions, points that have become some sort of dogma for safeguards work — and also caused problems.

"Firstly, the generally supported idea to design a technical system which would allow achieving the objective of safeguards in every State Party to the NPT in the same nondiscriminatory and objective manner. That meant subdividing and standardizing the safeguards measures, laying down rules on how the inspection staff would systematically collect facts on the whereabouts of nuclear material. At headquarters these facts would be combined

From left to right:
Mr. Jennekens, Mr. Tempus, Mr. Pellaud, Mr. Grümm, and Mr. Rometsch.
(Credit: Pavlicek, IAEA)

like pieces of a puzzle into conclusions. This technique made the safeguards effort in a country nearly proportional to the size of its nuclear activity... A few years later, a special division was established within the Safeguards Department with the task of analyzing continuously the effectiveness of safeguards operations and presenting the results yearly to the Board of Governors. It had an unexpected side effect. It showed that the means at the disposition of the Safeguards Department did not and could not grow in the same proportion as the rapidly increasing number of countries and facilities coming under safeguards in those years.

"The second basic point of discussion in the 1970 Committee of the Whole led also to a sort of dogma for field work — if not to a tabu. It was the question whether inspections should be designed also to detect undeclared facilities. The conclusion was clear at that time: looking for clandestine activities was out of the question and the inspection system was designed accordingly.

"Events have shown that both points require re-thinking. Maybe the same type of adaptations might be helpful for both. If means are not sufficient to collect all the parts of the puzzle, a peer review of the entire nuclear activities of a country might lead more directly to varied conclusions. The "entirety" approach is the modern word... A similar review of the interconnections between countries which would cover nuclear imports and exports could provide indications on the completeness of declared activities.

"In any case, to my mind it is extremely important that all parts of the good, old system are kept under review, are adapted to new situations in the changing world, and that the Safeguards Department be kept as young and as active as possible."

1978-83: Growing workload

Mr. Grümm: "The workload of the department increased tremendously as a consequence of the ratification of the NPT by Euratom and Japan. It was very hard to wrest from the Board an increase of the staff from 200 to 400 within 5 years. Concurrently, the quality of verification had to be strengthened through the creation of a training section, the improvement of instruments, the computerization of inspection reporting, and the introduction of stringent performance criteria...

"You are fully aware of another basic problem mentioned by Dr. Rometsch, the verification of the completeness of the initial inventory as submitted by the States. In 1979 we tried to discuss this question but met substantial resistance from various States. Only by bypassing them and other institutions did we succeed in incorporating suspicious terms like 'undeclared facility' and 'undeclared material' in the safeguards glossary, version 1980. It is regrettable that only an event like the Iraqi case was able to initiate the serious consideration of the Agency coping with clandestine fuel cycles separated from safeguarded facilities...This time nobody doubts that the Agency is entitled to pay attention to undeclared nuclear material and it has wide international support in this respect....A further problem which troubled us in the early 1980s seems to be settled by now. The principle of the so-called 'equality of misery' was strongly emphasized at that time by some States, which were very reluctant to accept safeguards. We had to apply safeguards without any consideration of particular situations in specific States. This led to undue concentration of inspection effort in countries with open democratic societies where, I dare to say, at that time the press would have reported any diversion before the Agency inspectors had even arrived."

1983-87: Consolidation and unity

Mr. Tempus: "When I came here to Vienna, my impression was that after the stormy years of rapid development after the NPT was concluded, big increase of the staff, negotiations with dozens of countries about safeguards agreements, and many successful and unsuccessful attempts to conclude subsidiary arrangements and facility attachments, the first leveling out of this development was felt. In my view, Hans Grümm had already started moves to consolidate the situation. Nevertheless, I had the feeling when I came that I inherited not a real department but a federation of safeguards divisions. I spent my 4 years in this way, in consolidation. It was an attempt to unify the activities of the divisions so that action of the department as a whole would come out...It was clear to me that computers would play a central role in safeguards in the future. The computers were not welcomed at all by the inspectors. They were afraid, after the first moves by Hans Grümm to computerize the inspection report, that they would be squeezed into a fixed scheme, not allowing them to do what they felt they should do at the facilities.

"Another important activity was to consolidate and unify the operational activities of the inspectors by working on the safeguards manual... the advantage was that the operation divisions started to work in the same manner. I must add that I was very lucky that during my 4 years there was no major turbulence in the political field.

"What is my perception today? The situation has changed dramatically. Iraq, the breakup of the Soviet Union, North Korea have, I think, in the public perception shaken the foundation of safeguards to some extent. It is not the feeling that NPT is obsolete. But it is a feeling that essential amendments are needed and necessary...It is clear that, with the present financial resources and staff, all the ideas cannot be realized, even if further improvements are made in efficiency and effectiveness of safeguards...As long as more money and staff are not available, the Agency is in danger of getting squeezed between the expectations raised and the reality of what can be done."

1987-93: Time for initiatives

Mr. Jennekens: "In 1988 the Department of Safeguards launched several initiatives, one of which was a continuation of the work that had been started by my predecessors: a department-wide effort to develop and to promulgate unified planning, implementation, and evaluation criteria. The second initiative was the development of what the department referred to as a more meaningful — that is to say, a more co-operative, more efficient, and more effective — set of arrangements with State Systems of Accounting and Control....In most instances the initiatives were welcomed and received positive support. In other instances...the initiatives met with disinterest, obfuscation, opposition, resentment, and even hostility. In fact, it was not until June 1991, some 3 years later, that we managed to achieve the broad agreement on the concept of a more meaningful set of partnership arrangements. On the IAEA safeguards criteria for 1991-95, it took a little longer to achieve the level of acceptance required....the acceptance of those unified planning, implementation, and evaluation criteria was a major factor in reaching agreement on revised safeguards approaches. It was those revised safeguards approaches which represented a major factor in the reduction of our person-days of inspection effort...

"The two terms 'streamlining' and 'strengthening' of safeguards have been mentioned repeatedly and incessantly during the last few years, in many instances by people who don't understand the issue and are not interested in understanding the issue... During this symposium, some extremely interesting presentations have been made, including those on new methods of measurement, detection, and analysis. Undoubtedly, the effort to explore and examine those will continue.

"Also, the events of the last few years have perhaps prompted us to look at the broader areas of arms control and the non-proliferation of all weapons of mass destruction....Conventional weapons that were used in 1991 in one part of the globe, and have been used the last 3 years in countries very close to us, are so-called 'conventional' but they are weapons of mass destruction. I think it's now time for our political masters, hopefully with our prompting, to begin to think in a larger context, of a more universal regime for arms control, reduction, and eventual elimination."

Beyond 1993: New challenges

Mr. Pellaud: "It seems clear from what we have just heard and from what we heard at this symposium that safeguards are at a crossroads. What does that mean? The major events have been Iraq, South Africa, DPRK. What is certain is that as a result we have what is called the strengthening and streamlining wave. That wave began to roll in 1992-93...What should it be? Change, yes, but what kind of change?...The safeguards system has been built over the past 25 years as a coherent system defined with approaches, with goal attainment, and with criteria...A cathedral has been built over the last 25 years. It's solid, it is well thought out. The way I look at the tasks in front of us in the next few years is that we may have to add a few little churches or chapels next to the cathedral. Specifically, we have to add new activities to the safeguards system because we are confronted with new challenges: in particular, undeclared facilities about which something has to be done. But I feel very strongly about keeping the solid basis we have. In other words, change for me does not mean in any way saying that we have to start all over again or question the way in which the safeguards system has been built."

Future directions for international safeguards

The IAEA Symposium on International Safeguards in March 1994 concluded with a panel of distinguished experts: Dr. Hans Blix, IAEA Director General; Ambassador Kamal Bakshi of India; and Mr. David Fischer, formerly Assistant Director General at the IAEA and an internationally recognized expert on safeguards. Chaired by Mr. Bruno Pellaud, IAEA Deputy Director for Safeguards, the panel addressed the future development of international safeguards and verification.

Presented here are edited excerpts of that discussion.

"A new era of new possibilities"

Dr. Blix: "With the end of the cold war, we have entered a new era which opens many new possibilities in nuclear arms control and disarmament and also raises some new dangers, all of them calling for effective verification to create confidence...From the media debate about non-proliferation, one could get the impression that the world is waiting for a whole new crop of nuclear-weapon States. It is true that there are some new risks at the present time. There are more developing countries which are, shall we say, graduating to a capacity to develop nuclear weapons. Iraq was the case that awoke us to that reality, and the case of the Democratic People's Republic of Korea (DPRK) is another. There is the further problem caused by the disintegration of the Soviet Union, where it is not quite certain how soon and how effectively Ukraine will move towards the NPT. And there is the risk, which we see very frequently mentioned and often exaggerated in the newspapers, of the trickling of nuclear material and know-how from the former Soviet Union to the rest of the world. We have not, in fact, seen any case where such trickling has raised serious non-proliferation concerns. That doesn't mean it could not happen, and we are watchful about it. The other problems in the non-proliferation field are the old ones: the situation in South Asia; the situation in the Middle East; and the Korean situation.

"These cases, these threats, partly new, partly old, must not obscure the substantial progress that has been made in the last few years and about which there is less media attention. I have in mind first of all the acceptance by Argentina and Brazil of comprehensive full-scope safeguards and the quadripartite agreement recently ratified by the Brazilian Parliament, and the perspective that Cuba has at least declared that it will not stand in the way of an entry into force of the Tlatelolco Treaty. There is a very good chance that the Tlatelolco Treaty, which preceded the Non-Proliferation Treaty, may enter into force perhaps even this year, or at any rate within the not too distant future. There is the tremendous progress in South Africa having joined the NPT, having been the first State to roll back from a nuclear-weapon status. And there is the declaration of Algeria that it, too, intends to join the Non-Proliferation Treaty, thereby opening the way for a treaty establishing a nuclear-weapon-free-zone in Africa...It seems to me, therefore, that there is very great and good momentum leading up to the NPT Conference next year.

"A nuclear-weapon-free world is still a distant vision, but we need to have some visions to know where we want to head. A *nearly* nuclear-weapon-free world is what I think we can strive for today, and we can begin to think about a world without nuclear weapons in the hands of individual States. For that vision, we need also to discuss a development of the constitutional architecture of the international community, or expressed more simply, the development of the rather primitive international institutions and rules with which we are now operating."

"New political directions"

Mr. Fischer: "Turning to the new political directions, three points have been mentioned: monitoring fissile material recovered from nuclear warheads to ensure that the process is irreversible; a cut-off of fissile material production; and a Comprehensive Test Ban Treaty, or CTBT. All three together would make a very appropriate epitaph on the nuclear arms race. A cut-off would be an important step in limiting 'vertical' proliferation. We have to be careful, however, in drafting a cut-off convention not to establish a new category of States recognized by treaty as having the right to maintain stocks of unsafeguarded fissile material and to do what they like with them. That would run contrary to the whole concept of the NPT...On the CTBT, there is every reason to concentrate in one international organization responsibility for verifying all measures of non-proliferation, vertical and horizontal. The cut-off, monitoring recovered fissile material, and CTBT are all naturally reinforcing.

"All the new directions we have examined postulate the continued existence of the NPT.

From left: **Ambassador Bakshi; Dr. Blix, Mr. Pellaud, and Mr. Fischer.** *(Credit: Pavlicek, IAEA)*

Without its continued existence reflecting the determination of the international community to put a stop to the spread of nuclear weapons and proposals to roll back the nuclear arsenals of the nuclear-weapon States, none of the other proposals we have in mind are likely to be viable in the long term.

"Finally, a cut-off, the verification of nuclear material retrieved from nuclear warheads, and the CTBT are all extremely desirable. But fundamentally they preserve the status quo in the sense that the discrimination between the nuclear-weapon States and non-nuclear weapon States remains. If our grand schemes are to be viable in the long term it is essential that we go beyond START-1 and START-2 and continue to roll back the nuclear arsenals of the five nuclear-weapon States, with the eventual aim of a completely nuclear-weapon-free world."

Lessons from experience

Ambassador Bakshi: "The concept of safeguards in relation to fresh initiatives, like the proposal for the cut-off of fissile material production and safeguards on plutonium and enriched uranium from dismantled weapon systems...are at a very preliminary stage. I think it is too early to speculate scientifically on their future, apart from expressing the hope that these initiatives would be universal, non-discriminatory, and that the required verification is simple. On the other hand, the initiative for a CTBT has emerged in more concrete form and is being discussed as such at Geneva.

"The second major question is the so-called case of Iraq on which, if I may say so, almost the entire thinking on the future of safeguards is based. I am going to be perhaps in the minority of one or two, but I am daring to speak in the presence of high priests and daring to take a minority opinion. I am going to submit to you that we can draw two concrete lessons from the case of Iraq.

First is a positive lesson. The IAEA safeguards system has been applied for over 38 years. Today the IAEA has safeguards agreements in over 160 countries. Today nuclear material under safeguards is reported to be 114 000 tonnes and today the IAEA performs 11 000 person/days of inspection in a given year. But in 38 years there has been only one case of a country that, in violation of international obligations voluntarily entered into, has gone the weapons route. I repeat, 38 years of inspection activity, 38 years of safeguards and one case. I am aware of the so-called case of North Korea, but the best or the worst we can say today about it is that there are suspicions, inconsistencies, and nothing more factual or proven. So the first lesson of Iraq is that the IAEA safeguards system has worked successfully with only one exception.

"Regarding the second lesson of Iraq....as some of you might know, I spent five-and-a-half years in Baghdad, as India's ambassador until after the Gulf war in July 1991, before coming to Vienna. Apart from any technical or scientific assessment, I know from personal experience that Iraq could not have advanced more than a few inches on the nuclear route if it was not supplied with nuclear equipment, nuclear technology, nuclear expertise, and, who knows, nuclear trained manpower for its weapons programme...The second lesson is very obvious. Many of those who are loudest in proclaiming their fidelity to non-proliferation were the ones who supplied this equipment and technology....

"Whatever lessons might have been derived from all of this...the Board of Governors and the IAEA Secretariat not only learned the lessons, but came up with appropriate responses. These can be seen in the decisions taken over the last 2 years and include the reiteration of special inspections, and their use in the case of North Korea, despite the fact that this has become a little problematical; proposals for early design information; and proposals for universal and voluntary reporting of exports and imports of sensitive technology and materials....Let us implement these measures. Let us see what practical difficulties come...I believe that the existing safeguards regime is good enough to give us sufficient scope for full implementation to ensure the achievement of our objectives. This does not mean we should not look at new approaches, but it does mean that we must first make, or continue to make, the best use of existing provisions before starting to implement untested ideas."

Intrusiveness of safeguards and the chemical weapons convention

Dr. Blix: "I wonder whether Ambassador Bakshi would say some words about what he thinks the limits are to intrusiveness. I am on record as having said that in my view the Agency, in its safeguards system, must be open to receive any information from anybody and hence even from national intelligence systems. However, all the information that is passed onto us must be examined critically...But there are other problems relating to intrusiveness. None of us is very keen on having his house searched. We want there to be limits on search warrants before anyone goes into a house, and sovereign States and governments are not keener to have outsiders in their houses. But how far do the present inhibitions go to stop States from accepting inspection? In the Chemical Weapons Convention (CWC), there is something called 'managed access', which relates to militarily sensitive areas. In the case of the DPRK, we have encountered objections that two sites are allegedly of a military kind. Does Ambassador Bakshi see some restrictions in how far we can go here?"

Ambassador Bakshi: "Intelligence information is a very tricky business. I know that the Director General has assured us that any information that comes to him and the Secretariat would be examined very thoroughly. But what happens if there is only one country that is capable of giving such information? I won't go into case history, but I, and many others, were attracted to the proposal made in this symposium that there are commercial satellites available, and data is collected from these satellites on a commercial basis, and it's possible to analyze this data and to come to specific conclusions. Now in that case it is not intelligence information. It is not given by one country. All nation States have their own foreign policy objectives, their own modus operandi, etc., including my own. So why depend upon one country?... We could depend upon commercially available information. We could analyze it and make use of it. I'm not saying this is feasible, practical, or cost-effective. That has to be examined.

"One word about the CWC and the safeguards regime. I wonder if it is possible for a 38-year-old adult like the IAEA to learn from a toddler, like the CWC. As I see it, if we want a greater degree of transparency, if we want a greater degree of openness, or even greater intrusiveness, then we must have a system like the CWC which is more broad based, supported more broadly, and which is a system based on equity."

Dr. Blix: "I think we can learn a few things from the toddler, the CWC, for the simple reason that verification measures of that convention were worked out after many years during which States were exposed to verification in the nuclear sphere...They have found that the system for nuclear inspection is tolerable and they have been ready to go further... When States have been able to accept a number of things under the CWC, they should be able to introduce them also to the older nuclear verification system."

Ambassador Bakshi: "There is a basic difference between the NPT and the CWC. In one case there are nuclear-weapon States, 'haves', and non-nuclear weapon States, 'have-nots'. In the other case, the case of the CWC, there are no 'chemical weapon States'. Therefore, these are two different animals we are talking about, and what is applicable to one is not necessarily applicable to the other."

Special inspections

Mr. Fischer: "One point that has been discussed from time to time is special inspections. We already see that they can be confrontational. This suggests that one should take another look at the challenge inspection procedures foreseen in the CWC. They will also be very confrontational, but the confrontation will be between State and State rather than State and international organization."

Dr. Blix: "The moment that you demand a special inspection, you are likely to have passed the stage of mild diplomacy and co-operative openness. Transparency holds important elements and will be part of the modern form of safeguards we are developing. There is an important difference between our special inspections and challenge inspections under the CWC, and it is too early to say which will be the most advantageous in the end. They both have their merits. If challenge inspections are used frequently, States may get used to them...A special inspection, on the other hand, will be requested only when the IAEA has reasons to believe that something exists which has not been declared and should have been declared. When we began to develop the idea of invitations from States to the Agency to go anywhere, at anytime, it was to have something short of special inspections, something not as dramatic. That functioned one time in the DPRK, but the second time it did not. The refusal on the second occasion was also perhaps an indication that we were running into something. In South Africa and Iran, we have also made use of the undramatic and low-key co-operative visits, to go to various places we wanted to go."

Priorities and resources

Mr. Fischer: "I fear that the impression of the man, or the journalist, in the street is that the IAEA is still focusing too much attention on nations or in regions where the dangers of proliferation are negligible, rather than on the hot spots of the world. There is a problem here. The IAEA as an international organization may not discriminate between States and it is, therefore, very difficult for it to redeploy its resources. In one sense, the new emphasis on clandestine facilities may help. For instance, the considerable safeguards effort that had to go into establishing that there was no clandestine stock of fissile material in South Africa was an indication of some shift of resources. But the bulk is still likely to go into safeguarding the industrialized States of the North. One has to try to find means of focusing more resources on smaller fuel cycles."

Dr. Blix: "We cannot be discriminatory in our safeguards methods. They must be applied equally. You cannot say that in a particular area, in particular parts of the world, we will increase the frequency of inspections. It has to be on some objective grounds that the frequency of inspection measures are applied."

Balancing the IAEA's activities

Dr. Blix: "Ambassador Bakshi has often championed in the Agency the idea of balancing the main activities. That means promotion of the peaceful use of nuclear energy, on the one hand, and verification for the prevention of the spread of nuclear weapons on the other. They go hand in hand. I'm fully with him on that, and very supportive of the Agency's activities in the promotional field. However, I do not think that the Statute of the Agency lays down that this is a dollar for dollar affair. Recently, in the discussion about the cut-off, and even more in the discussion of a CTBT, I hear that some States say, 'Well, it's risky to make use of the Agency in this context because you have to pay twice. First you have to pay for the verification system under a CTBT, and second you have to...pay an equal amount for promotional activities because there has to be a balance'. Is this a realistic objection by some States?"

Ambassador Bakshi: "I would not insist on dollar for dollar. The concern of the Group of 77 which I have attempted to voice, or to represent, is that this Agency, which was started as the international agency to promote the peaceful uses of nuclear energy, is today perceived by many as only a safeguards implementing agency...The first advantage of trying to suggest coming back to the main focus is that we do something for the vast mass of the people. And second, I find that much of the criticism of the Agency today in the western media is based so much on ignorance. It is based on a very faulty understanding that all the Agency does is to snoop around, you know, the concepts of watchdogs and nuclear policing, the catch phrases that journalists use...So in short what we are trying to say is, not that you spend 50% on safeguards and 50% on peaceful promotion of nuclear energy. No. We are saying, please, what has to be done, has to be done. But while doing so, please don't neglect the peaceful uses of nuclear energy."

Environmental monitoring & safeguards: Reinforcing analytical capabilities

The IAEA is planning a specially designed "clean" laboratory for analyzing environmental samples from safeguards inspections

by
David Donohue, Stein Deron, and Erwin Kuhn

Radiometric monitoring of rivers, streams, sediments, and other environmental pathways has become an important element of the IAEA's long-term verification of the nuclear programme in Iraq. At the same time, a number of countries voluntarily are participating in IAEA field trials to demonstrate the capability of environmental monitoring techniques for the detection of nuclear activities. The techniques allow for chemical and isotopic analysis of minute samples of water, soil, biota, and other environmental materials to detect "nuclear signatures" that are specific to certain types of facilities and operations.

The analysis of collected environmental samples and measurements is a highly specialized and exacting discipline, one that requires suitably equipped and designed facilities and a high level of analytical expertise. Environmental samples taken in Iraq, for example, have been measured with state-of-the-art analytical methods in specialized laboratories in several IAEA Member States; the detection limit for uranium or plutonium by these methods is around 10 million atoms.

For its part, the IAEA has established an extensive in-house capability for performing analytical chemistry measurements, whether in support of programmes for technical co-operation, human health, nuclear safety, or safeguards. Expertise in the measurement of radioactive elements in the environment exists at the Physics, Chemistry and Instrumentation Laboratory at the IAEA's Seibersdorf Laboratories; the Isotope Hydrology Laboratory at IAEA headquarters in Vienna; and the IAEA's Marine Environment Laboratory in Monaco. In addition, many qualified laboratories in IAEA Member States provide analytical services for safeguards purposes or participate in exercises to characterize materials for the IAEA's Analytical Quality Control Service.

Building upon this experience, the IAEA is moving to establish a "clean" laboratory at the site of its research laboratories in Seibersdorf, Austria, specifically dedicated to the analysis of environmental samples and measurements for safeguards purposes. The laboratory will serve to augment services being provided by the Safeguards Analytical Laboratory, which the IAEA set up in the 1970s and today handles more than 1000 samples of uranium, plutonium, and other types of nuclear material each year.

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Why a "clean laboratory" is needed

Why does the IAEA need a special clean laboratory? There are five basic reasons:

- Experience with the inspections of the IAEA Iraq Action Team has shown the importance of environmental sampling and analysis for the detection and elaboration of undeclared nuclear activities, and the indispensability of high-quality analytical capabilities. One of the main limitations on the use of ultra-sensitive monitoring techniques is maintaining the integrity of the sample — that is, preventing its contamination with spurious materials which could lead to disastrously wrong conclusions. This requires that the IAEA apply stringent measures to ensure that clean sampling materials are used and that the post-inspection handling and analysis of the samples is performed under conditions of extraordinary cleanliness. The IAEA faces a continuing need to apply such techniques in its ongoing long-term monitoring programme in Iraq under UN Security Council Resolution 715.

In addition, the IAEA has the right under INFCIRC/153-type safeguards agreements (those concluded pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons) to request special safeguards inspections in order to exclude the existence of undeclared nuclear activities. Environmental sampling and ultra-sensitive analysis techniques represent an essential part of such special inspections.

- Whenever a State enters into a comprehensive safeguards agreement with the Agency, the IAEA must carry out ad hoc inspections to verify the correctness and completeness of the State's initial declaration. This has been done recently in South Africa and remains under way in the Democratic People's Republic of Korea. Similar work will soon start in Argentina and Brazil under the quadripartite safeguards agreement and in several republics of the former Soviet Union which have signed comprehensive safeguards agreements, such as Kazakhstan.

In a number of instances, environmental monitoring has already been used with the approval of State authorities, and it is expected that this technique will continue to be used in ad hoc inspections as a confidence-building measure. This underscores the need to derive reliable conclusions from environmental monitoring measurements, and to prevent contamination of samples.

- In 1993, the IAEA Director General's Standing Advisory Group on Safeguards Implementation (SAGSI) presented its recommendations for strengthening the safeguards system and making it more effective and efficient. The IAEA has responded to these recommendations by formulating the safeguards programme known as "93+2" to study options for improving routine safeguards implementation. One task involves an evaluation of environmental monitoring techniques for the detection of undeclared nuclear activities at declared or unknown sites. There is a strong possibility that some form of environmental sampling and analysis will be incorporated into routine safeguards implementation, which could result in a large number of environmental samples being taken and handled by the IAEA. Handling such a large number of samples without cross-contamination will be a challenging task. In addition, efficient use of the existing analytical capacity in the Agency or in Member State laboratories will require the application of rapid, sensitive, and selective screening techniques to select those samples which warrant further analysis.

- It would not be cost-effective for the IAEA to duplicate the specialized analysis capabilities which exist in Member States. The best use of these laboratories must be made by distributing among them the environmental samples coming from ad hoc, special, or routine safeguards inspections. It is always desirable to submit replicate samples to different laboratories as a check on the accuracy of their results. This quality assurance function involves a number of other activities. These include the preparation and distribution of reference or control samples; the certification of clean sampling materials; and the proper documentation of sampling and analytical procedures. The IAEA cannot afford to delegate this quality assurance function. In order to execute it properly, there must be in-house analytical capabilities which are of comparable performance to those in national laboratories. This need not be a duplication of their efforts and can certainly not compete in terms of sample throughput. Rather, the IAEA would serve as a referee laboratory which is competent to control and assure the quality of the overall service.

Receipt of safeguards inspection material at the IAEA's Safeguards Analytical Laboratory.

- Finally, it should be stressed that the IAEA requires an *independent* analytical capability for these environmental or special samples. In many cases, the identity of the samples, their origin, and the inspector's knowledge of the sampling site must be factored into the scheme of analysis. This, as well as the need for rapid feedback to the inspectors, requires an in-house analytical capability which can provide the needed buffer between the Department of Safeguards and the Member State laboratories in order to maintain the safeguards confidentiality of the results.

What will the clean laboratory do?

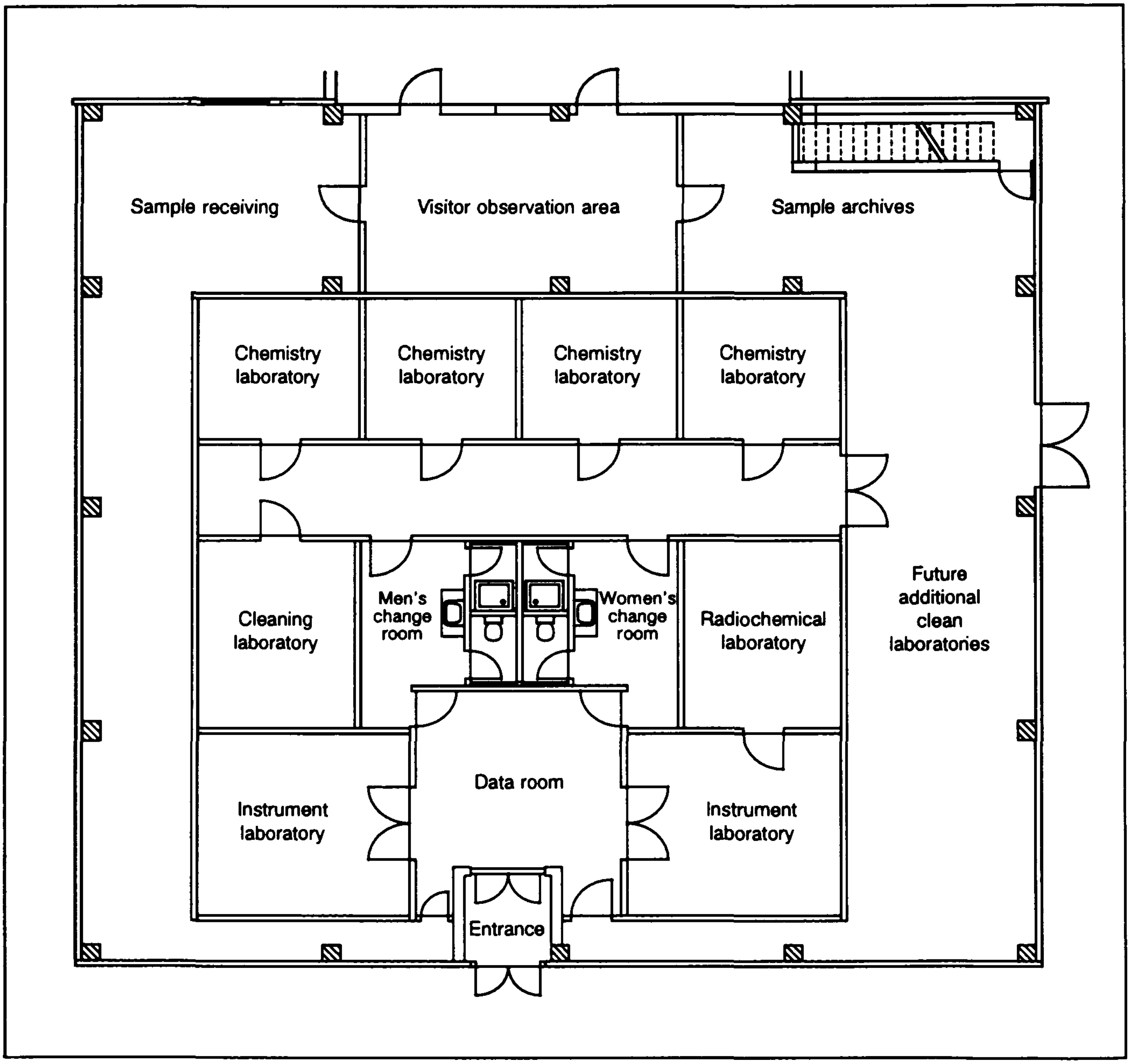
The design of the clean laboratory must provide for a number of activities, including:

- personnel access involving complete clothing change;

● transfer of samples, preliminary cleaning and replacement of the outer packaging;
● splitting, repackaging, and archival storage of samples;
● preliminary screening of samples by non-destructive techniques such as alpha counting, gamma spectrometry, or X-ray fluorescence spectrometry to determine the gross radioactivity and major elements present.
● chemical treatment of samples to concentrate analytes of interest such as uranium and plutonium. Sample types to be treated include water, soil, sediment, vegetation, biota, and swipes. High-purity isotopic spikes may be added to allow quantification of the important elements by isotope dilution mass spectrometry.
● measurement of the isotopic composition and concentration of uranium, plutonium, and other elements by thermal ionization mass spectrometry, equipped with ion-counting detection for high sensitivity. The detection limits for uranium and plutonium will be in the range of 10^7 atoms (several femtograms).
● preparation of reference or control samples for internal quality control and quality assurance of measurements performed in Member State laboratories.
● preparation and certification of the cleanliness of sampling materials such as bottles, bags, or swipe media.

The design should also allow room for expansion and the implementation of other in-

Proposed layout of the clean laboratory



strumental techniques, including scanning electron microscopy with electron probe attachment for the detection and measurement of microscopic particles and inductively-coupled plasma mass spectrometry for the measurement of trace elements in liquid samples at the parts-per-billion level.

The proposed physical layout of the clean laboratory includes four separate Class-100 chemistry laboratories equipped with laminar-flow fume cupboards where the dissolution or ashing of samples can be performed. *(See figure.)* Each laboratory will handle a different type of sample (water, soil/sediment, biota or swipes) to avoid cross-contamination problems. These laboratories must be maintained at the highest level of cleanliness because the samples are handled in the open and are most vulnerable to contamination.

Additional rooms are provided for the instrumental measurements by radiometric methods (alpha, gamma, or X-ray spectrometry) or mass spectrometry. These laboratories can be operated at a more modest level of cleanliness by using clean-air showers over the most sensitive areas. Samples will enter the clean laboratory through a special room where the outer packaging can be removed and replaced with clean materials. Also important will be a laboratory for the cleaning of glassware and equipment and the purification of chemical reagents by sub-boiling distillation. Archival storage of samples will be performed in a separate room equipped with freezers for the preservation of biological samples.

Financial and administrative challenges

The first consideration for the establishment of a new facility is the funding. The IAEA has already received an extrabudgetary contribution from the United States of $1 000 000 for the clean laboratory. Preliminary estimates have been solicited and received for the construction of a new building within the Seibersdorf Research Centre complex. The clean laboratory itself will take the form of modular rooms constructed of pre-fabricated wall and ceiling panels. The ceiling panels would contain the filters and ventilation fans required to supply air of Class-100 quality into the modules. The estimated cost of such modules for the working design would be US $200 000 to $300 000, with an additional cost of US $600 000 for the inlet air handling system (heating/cooling/humidity control and pre-filtering).

The analytical instrumentation to be installed in the clean laboratory represents another significant investment; the thermal ionization mass spectrometer has already been ordered using US $500 000 from the IAEA's regular budget, but the radiometric instrumentation remains to be purchased. Instruments such as the scanning electron microscope or inductively-coupled mass spectrometer would cost between US $300 000 and $500 000 each, which Member States have been invited to provide through additional extrabudgetary contributions.

The operation of the clean laboratory will involve certain running costs, including utilities, supplies, and replacement of equipment and, of course, staff salaries. Present plans call for a staff consisting of two professionals, two laboratory technicians, and one maintenance worker. The laboratory technicians will require extensive training in general practices for a clean laboratory and in the specific chemical or analytical procedures that will be applied.

The construction of the building to house the clean laboratory is expected to take 12 months, with the installation of the clean modules themselves requiring about 3 months. It is planned that the laboratory's operation would begin by late 1995. The overall management of this project is carried out by a high-level committee chaired by Mr. Bruno Pellaud, Deputy Director General for Safeguards, with representatives of the Department of Research and Isotopes and the Department of Administration. The daily supervision of the work is being handled by a task force of staff members from the three departments.

Reinforcing analytical capabilities

At a time when governments are seeking greater confidence in the absence of undeclared nuclear activities, the techniques of environmental monitoring are being seen as one valuable verification tool.

The IAEA's establishment of a clean laboratory for analyzing environmental samples thus responds to an important need. Although the IAEA's existing facilities provide a valuable resource, they do not include the extensive capabilities that are needed for the type of environmental analysis required for safeguards applications. Once in operation, the clean laboratory promises to play a central role in the IAEA's continuing development of its verification system. ❐

Nuclear inspections in Iraq: Removing final stocks of irradiated fuel

An unprecedented operation succeeds in safely removing all declared stocks of nuclear-weapons-grade material from Iraq

by Fernando Lopez Lizana, Robert Ouvrard, and Ferenc Takáts

When the last consignment of highly enriched uranium in spent fuel left Iraq's Habbayina airport in February 1994, a milestone was reached in the IAEA's monitoring and verification of the former Iraqi nuclear programme. Nearly 3 years earlier, on 12 April 1991, the United Nations Security Council had adopted Resolution 687 which *inter alia* demanded that Iraq "place all its nuclear-weapons-usable materials under exclusive control, for custody and removal, of the International Atomic Energy Agency, with the assistance of the United Nations Special Commission".

The operation to remove the spent fuel —carried out in two shipments on 4 December 1993 and 12 February 1994 — effectively completed the removal of declared stocks of nuclear-weapons-grade material from Iraq. Substantial technical problems had to be overcome to remove the fuel, some of which was buried under the rubble of a research reactor destroyed during the 1991 war.

The removal stands among a range of operations undertaken by the IAEA over the past 3 years under terms of UN Security Council resolutions. In 1991, following its initial inspections in Iraq, IAEA inspection teams removed gram quantities of plutonium that Iraq was found to have separated, and they supervised the removal of nuclear material, including fresh nuclear fuel, that was part of Iraq's declared nuclear inventory under IAEA safeguards. Though declared stocks of nuclear-weapons-grade materials now have been removed from Iraq, the IAEA's work in the country is continuing. It includes the implementation of a plan for long-term monitoring and verification of Iraqi nuclear activities.

In this article, the job of removing the spent fuel is described, most notably from the standpoint of technical challenges that were faced and considerations of safety and radiation protection that had to be taken into account.

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Preparing for the operation

In planning the operation, the IAEA requested various governments to assist with contractual arrangements for the removal, transportation, and disposal of all irradiated fuel assemblies located at research reactors in Iraq. In June 1993, a contract was signed between the IAEA and the Committee of International Relations on behalf of the Russian Ministry of Atomic Energy (Minatom) for the removal, transportation, and reprocessing of the irradiated fuel assemblies, and for the permanent storage in Russia of the wastes generated during the reprocessing process.

While Minatom was responsible for the overall operation, there were two main subcontractors: the Nuclear Assurance Corporation (NAC) of the United States for handling, cleaning, and packaging the irradiated fuel; and the air cargo company Touch and Go Ltd. of Russia for the transportation, by air, of the containers between Iraq and Russia. The technical and financial discussions to conclude the contract with Minatom (which was signed on 21 June 1993) took several months. Several missions to Iraq also were required to secure the necessary assistance of the Iraqi side and to monitor progress in preparation of the sites.

In technical terms the task included the following sequences of operations:

- gaining access to the fuel,
- cleaning the fuel to remove dirt and possible radioactive contaminants from its surface,

Spent fuel assemblies removed from Iraq

Type	Number
IRT-2M assemblies — tubular type (80% enrichment)	96
EK-10, EK-36, EK-NU assemblies (10%, 36%, natural)	74
Tamuz II MTR assemblies (93% enrichment)	32
Tamuz II control assemblies (93% enrichment)	6
Total	208

- verification of each assembly (type and serial numbers),
- loading in a transport cask,
- transfer of the cask by road from the loading place to the airport,
- transport of the casks by air from Baghdad to Yekaterinburg in the Russian Federation, and
- transport of the cask by road from Yekaterinburg to the Chelyabinsk reprocessing plant.

Preparations included:

- the manufacturing of some technological equipment (i.e. for cleaning fuel and storage water);
- manufacturing or procurement of equipment and spare parts which were considered to be necessary for the work, but which could not be purchased locally (container support structure, truck spare tires, crane spare parts etc.);
- licensing of the transport container by the Russian regulatory body; and
- preparing radiation protection equipment and a dose recordkeeping system by IAEA staff.

The preparatory work was accomplished during summer 1993. Actual field work began on 6 October 1993 and the last consignment of irradiated fuel left Iraq on 12 February 1994. Throughout this period, IAEA staff members were rotated in the field to supervise the contractual work and assure the co-operative link with Iraqi authorities.

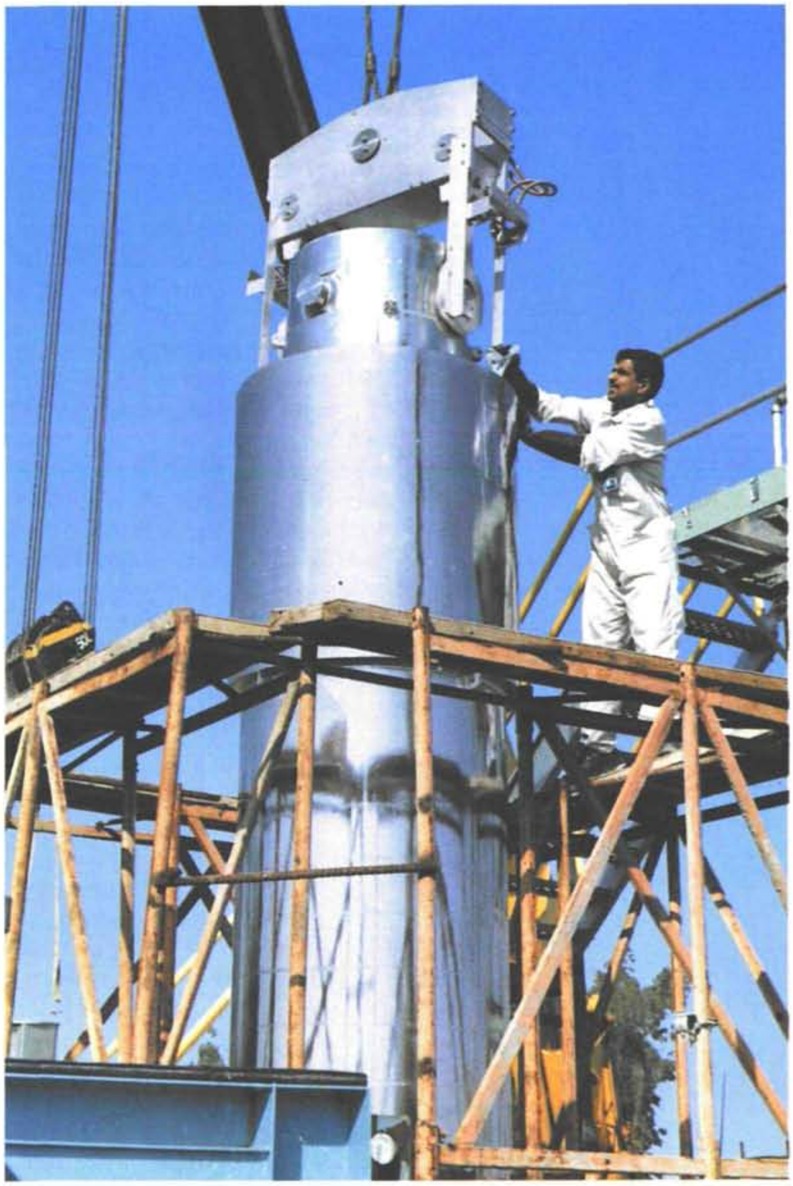
A great amount of work was done by the Iraqi counterparts. It included removal of debris and cleaning of the sites; supplying cranes, trucks, and other equipment; and constructing a transfer cask, concrete platforms, and two cleaning pools. In addition, the Iraqi counterparts provided operational and radiation protection staff, site offices, and all support activities necessary for the operations.

The sites of the spent fuel assemblies

The irradiated fuel assemblies removed from Iraq came from the two research reactors at the Tuwaitha Nuclear Research Centre. They were stored in two different locations, one at Tuwaitha and the other at Garf al Naddaf, a farming area not far from Tuwaitha. All told, more than 200 spent fuel assemblies had to be removed. *(See table.)*

The IRT-5000 research reactor. This water-cooled, pool-type reactor at the Tuwaitha Nuclear Research Center had an original power of 2 megawatts-thermal (MWth), which was increased to 5 MWth in 1978. There was fuel in the reactor pool, and in an auxiliary spent fuel storage pool.

The reactor as well as other nuclear facilities at Tuwaitha were destroyed by coalition air raids during the first days of the war in 1991. Fortunately, the pools were not directly hit, and the fuel assemblies were not damaged. However,



An Iraqi worker helps prepare a spent fuel cask for shipment. *(Credit: Iraq Atomic Energy Commission)* debris from the collapsed structures covered the reactor pool. Substantial clearing was necessary to get access to the pool before recovery operations could start. From this site, 76 fuel assemblies had to be removed.

Location B. During the first days of the war, the Iraqis moved some irradiated fuel assemblies stored at Tuwaitha to prevent their destruction from bombardments. They were taken to a site located about 5 kilometers north of the Tuwaitha Nuclear Research Center. The IAEA has named this site, located in the Garf al Naddaf district, as "Location B". It was far from being an ideal storage place for nuclear fuel. It is just an acre or so of farm land, has no built structures, and no support facilities, such as water or electricity. There is no road on the site, and the soil is soft clay, so it is difficult to move after heavy rains.

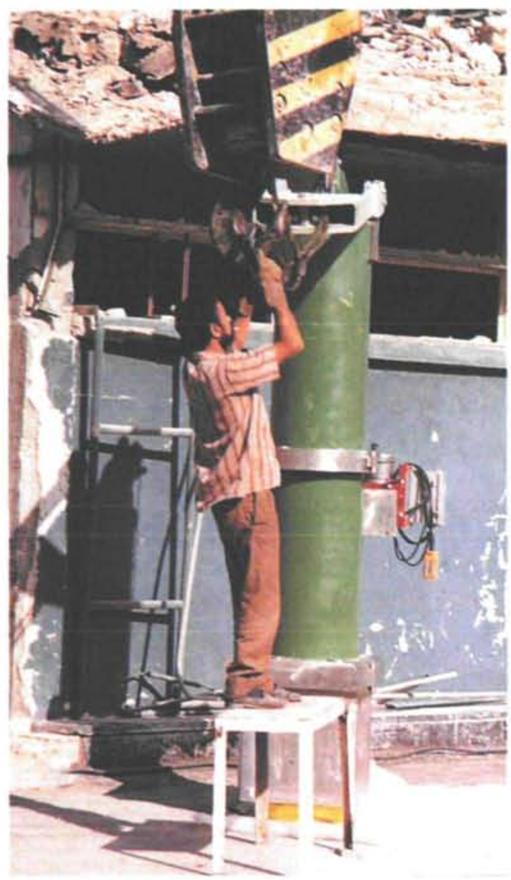
Sixteen concrete storage tanks were buried here in the open air and filled with water. Aluminum racks holding the irradiated fuel assemblies were placed in carbon steel drums. Each tank contained up to two drums. The tanks (which were, in fact, buried below the surface level) were covered with a reinforced concrete plate, with a hole in the center for water refilling. This was covered by a second, smaller concrete plate.

At the end of January 1992, following a period of flooding, the storage conditions had to be modified, for fear of leakage and groundwater contamination. Fourteen new concrete tanks were constructed to replace the original 16. The original inner drums of carbon steel were replaced with tin-plated steel drums. The 14 new tanks were buried so that the rim partially extended one meter above ground to avoid penetration of groundwater. From this site, 132 fuel assemblies of different types had to be removed.

Tools of the operation

The cleaning stations. Due to the presence of all kind of debris, stones, sand, and other materials, the fuel assemblies had to be cleaned before placing them in the transport cask. Two cleaning stations had to be installed, one on each site. They were about 4 meters deep, to allow safe handling of the irradiated fuel assemblies. The walls were made of concrete, covered with an additional steel liner to make it leakproof.

The cleaning stations were equipped with a handling tool (upender), into which individual assemblies were introduced for cleaning, and an appropriate water filtration system. The assemblies were turned upside down to let the bigger parts fall out, then the fuel was washed from above using pressurized water.



Scenes from the removal operation: **Over a period of 5 months in late 1993 and early 1994, the IAEA organized and supervised the removal of all declared stocks of nuclear-weapons-grade material from Iraq's Tuwaitha Nuclear Research Centre and a nearby storage site. All told, highly enriched uranium in the form of 208 assemblies of spent nuclear fuel were recovered, cleaned, loaded into 23-ton transport casks, sealed, and flown out of Iraq. Shown here are scenes from the complex and technically demanding operation, which involved 170 workers, including Iraqi personnel, IAEA experts, and US and Russian contractors.** *(Credits: R. Ouvrard, IAEA; Iraq Atomic Energy Commission)*

The transfer cask. To transfer the fuel assemblies from the storage locations into the cleaning station and then to the transport casks, a shielded transfer cask was used. The transfer cask, provided by NAC, had a lead shield thickness of 13.2 centimeters and a bottom ball valve. Its lower part was designed so as to fit either a lead collimator, when positioned on storage tanks, or a trolley when used on the cleaning station and on the transport cask adapter.

Different types of grapples controlled by compressed air were used to pick up the assemblies. The fuel was pulled into the cask or lowered down with an electric hoist.

The transport casks. The transport casks were designed and provided by NAC. They were of the type known as NAC-LWT packages normally used for the transport of one pressurized-water reactor fuel assembly or two boiling-water reactor assemblies. They were modified for the Iraqi operation in order to receive fuel assemblies from Iraqi research reactors (24 Tamuz-II fuel assemblies, and 28 IRT-5000 fuel assemblies). Inside the cask, the fuel assemblies were placed into two stainless steel fuel baskets on two levels.

The transport containers satisfy the requirements of the IAEA Safety Series No. 6, *International Regulations for the Transport of Radioactive Material* (1985 Edition, as amended 1990). Since the US Nuclear Regulatory Commission (NRC) had not yet adopted the current IAEA requirements, a license to use the NAC casks had to be obtained from the Russian regulatory body.

Each cask is made of stainless steel (total weight: about 23 tons). The gamma shielding, surrounding the fuel assemblies, is made of:

- lateral sides: 1.9 centimeter lead, 16.6 centimeter steel, 3.0 centimeter lead. The original neutron shielding, made of a tetra-borate potassium solution, had been drained out for this particular operation;
- lower side: 10.16 centimeter steel, 7.62 centimeter lead, 8.89 centimeter steel;
- upper side: 28.57 centimeter steel.

The fuel assemblies were introduced from the top; the transport casks were maintained in vertical position inside the container support structure.

Taking into account the airplane's loading capacity, four transport casks were needed for this operation. This meant that for all of the spent fuel, two air shipments were necessary.

According to the requirements of the IAEA transport regulations, the following dose rate limits were to be respected: 2 millisieverts per hour (mSv/h) at the surface of the cask; 0.1 mSv/h at 2 meters from the surface of the transport vehicle; and 0.02 mSv/h at the level of transport personnel.

Operational procedure

With minor differences, the same operational procedure was followed at both sites, and included the following steps:

Each individual assembly was transferred from its existing storage location to the cleaning station. The fuel assembly was first lifted from its storage location into the transfer cask, using a grapple tool attached to a cable. Then the bottom ball valve of the transfer cask was closed, the cask was lifted, moved to the cleaning station, and lowered onto an adapter directly above this cleaning station. The bottom ball valve was reopened and the fuel assembly lowered into the cleaning tool. Once the fuel assembly was correctly seated, the grapple was remotely disengaged and withdrawn into the transfer cask. The ball valve was closed and the transfer cask removed.

Each fuel assembly was first cleaned by high-pressure water to remove the rubble and slit within the fuel assembly. For this, the assembly had to be turned upside down, the high pressure stream being applied through the lower end fitting of the fuel assembly. The assembly was then uprighted to its original position and visually inspected. Whenever needed, the cleaning process was repeated.

The cleaned assembly was then transferred to the transport cask, using the transfer cask. Once loaded with the fuel assembly and closed, this cask was lifted and moved to the shipping area and lowered onto the adaptor plate, directly above the shipping cask. The bottom ball valve and the adaptor plate shield valve were then opened and the fuel assembly was lowered into the shipping cask. Once the assembly was correctly seated, the grapple was remotely disengaged and withdrawn into the transfer cask. The ball valve of the transfer cask and the adaptor plate shield valve were closed and the transfer cask removed.

The above operations had to be repeated until a whole shipping cask was completely loaded (in fact, cleaned assemblies were temporarily stored in the cleaning station, to allow continuous work between storage tanks and cleaning station). Then the shipping cask was transferred to a decontamination area, for cleaning to the required shipping levels.

The cask was then rotated to the horizontal position, fitted with its impact limiters, and secured into its ISO container. A final radiation survey was performed to verify that IAEA requirements were met and safeguards seals were installed.

Four shipping casks were so prepared during each of the two campaigns and then transported, under escort, to Habbaniya airport, where they were loaded into an Antonov-124 airplane for onward transport to Russia.

Safety considerations

Owing to the circumstances, the conditions at the two sites before the operation started could not be considered as normal from the safety point of view.

At the IRT reactor, the site was full of rubble, and what was left of the building threatened to collapse. However, the radiation levels were low.

Completely different was the situation at Location B. Although the general radiation levels were low, i.e. 10 to 30 micro-sieverts per hour (corresponding to normal levels at controlled areas), the dose rates were considerably higher on the top of each storage tank, where workers would have to operate. The dose rates further were strongly dependent on the water level above the fuel assemblies. (Radiation levels up to 10 mSv/h had been recorded during previous inspections.) Moreover, the manual pre-cleaning of the assemblies required the removal of the smaller upper concrete shielding plates. This would have exposed workers (even for a short time) to unacceptable radiation levels, namely, in some cases, up to 1 Sv/h (100 rem/h).

Therefore, considerable preparatory work was necessary before the actual removal operations could start. The work included supplying water and electricity to the site, installing offices and facilities, and reinforcing the ground for heavy load-bearing equipment.

Radiation protection measures

More important from the point of radiation protection was the preparation of additional concrete shielding to be used on the storage tanks. This shielding was made of two concrete frames (5 meters by 5 meters, 80 centimeters thick, and 60 to 77.5 centimeters high). They were designed to allow two of these frames to be stacked and to completely surround each tank.

In addition, two large concrete cover plates were prepared. In its center, each plate had a suitable hole, either to allow manual cleaning of the assemblies, or to accept a lead collimator on which the transfer cask had to sit. This additional shielding was sufficient to reduce the radiation exposure to an acceptable level, that is, to less than 0.2 mSv/h (20 millirem/h) at working position, and less than 0.02 mSv/h (2 millirem/h) around the shielded tank.

Two tanks were shielded at one time, in order to optimize the operations of the cranes. Before any transfer of irradiated fuel started, a check of radiation levels was always done and, as requested, water was added to the tanks. In addition, water samples from the tanks were taken to control possible water contamination with fission products, in order to detect at an early stage any breach of the fuel cladding's integrity. The gamma spectrometry analysis was done by the Iraqi health physics group.

For monitoring individuals, each worker was provided with a:

- thermoluminescent dosimeter (TLD), distributed at the beginning (October, January) and read at the end (December, February) of each of the two campaigns);
- an electronic personal dosimeter (EPD) read at the end of each working day.

Additionally, a computer program to record dose data, specially prepared for this purpose, was used in the field daily.

The removal operation was performed in two campaigns: from 6 October to 12 December 1993 and from 6 January to 12 February 1994. During each period there were activities at both sites.

In total, 170 persons were involved. The collective dose amounted to 0.11 man-Sv with an average individual dose equal to 0.66 mSv. The maximum individual dose was 8.5 mSv, which is about 17% of the annual dose limit.

Co-operative effort

The removal by air of irradiated fuel from Iraq —an unprecedented operation — was performed on schedule and without any significant problems. The individual radiation exposures were kept reasonably low, far below the level which could have been expected for such a difficult operation. This testifies to the co-operative preparatory work and high level of expertise involved in the operation.

The removed spent fuel was flown from Iraq in an Antonov-124 directly to Yekaterinburg in Russia. From there, it was transported to a reprocessing facility at Chelyabinsk. After dilution to lower enrichment at Chelyabinsk, the residual nuclear material will be available for sale under IAEA supervision for use in peaceful nuclear activities. ❐

Nuclear co-operation in South America: The Brazilian-Argentine common system of safeguards

An overview of the joint approach being followed by Brazil and Argentina to verify the exclusively peaceful use of nuclear energy

by Marco A. Marzo, Alfredo L. Biaggio, and Ana C. Raffo

Argentina and Brazil together make up a South American region of more than 11 million square kilometres, with some 200 million inhabitants and mutual trade worth about US $7 billion yearly. The combined gross domestic product (GDP) of the two countries exceeds US $540 billion and accounts for approximately 50% of the total GDP of Latin America and the Caribbean, while the population of the two countries represents 35% of the total for this geographical region. Both countries are part of "Mercosur", a project for economic and market integration that also includes Uruguay and Paraguay.

Nuclear co-operation between Argentina and Brazil started in the 1960s. It was greatly intensified after 1980, when the political conditions created by the settling of disputes over the use of water resources made possible the signing of an agreement between the two countries on peaceful uses of nuclear energy. The implementation of this agreement involves joint efforts in a number of fields, including cyclotron production of radioisotopes; development of isotopic standards; radiation protection and nuclear safety; and recycling of fuel elements.

As a natural extension of this co-operation, Brazil and Argentina have over the past 14 years set up a variety of bilateral mechanisms for co-operation in the nuclear field. They are aimed both at promoting development and at strengthening mutual trust and conveying an assurance to the international community that neither of the countries intends to develop or produce nuclear weapons.

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In this context, a number of commitments to the exclusively peaceful uses of nuclear energy have been assumed by both countries. These commitments were expressed in a series of Joint Declarations on Nuclear Policy made by the two Presidents at Foz do Iguaçú (1985), Brasilia (1986), Viedma (1987), Iperó; (1988) and Ezeiza (1988), and in the 1990 Joint Statement of Buenos Aires and Declaration of Foz do Iguaçú.

The policies set forth in these statements ultimately led to the Bilateral Agreement for the Exclusively Peaceful Use of Nuclear Energy, signed at Guadalajara, Mexico. It has been in force since 12 December 1991 following its ratification by the Brazilian and Argentine Congresses. The ratification resulted in the promulgation with force of law of the terms of the agreement, this law being equally binding on both Brazil and Argentina. The bilateral agreement sets up a system of full-scope safeguards and establishes the Common System of Accounting and Control of Nuclear Materials (SCCC) and the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC), whose function is to administer and implement the SCCC.

Both Brazil and Argentina have had safeguards agreements in force with the IAEA since the 1960s and 1970s. They derived from co-operation agreements that Brazil had signed with the United States and Germany, and Argentina with the United States, Germany, Canada, and Switzerland. These INFCIRC/66-type safeguards agreements dealt with specific cases of co-operation and did not cover the nuclear materials involved in each country's autonomous programmes, which are now under the full-scope safeguards established by the bilateral agreement, subject to the SCCC and verified and monitored by ABACC.

In addition, on the basis of the bilateral agreement, a quadripartite safeguards agreement was signed on 13 December 1991 between Argentina, Brazil, ABACC, and the IAEA. (This agreement entered into force on 4 March 1994).

The bilateral agreement

The basic undertakings of the bilateral agreement are:

- To use the nuclear material and facilities under their jurisdiction or control exclusively for peaceful purposes;
- To prohibit and prevent in their respective territories, and to abstain from carrying out, promoting or authorizing, directly or indirectly, or from participating in any way in: (1) the testing, use , manufacture, production or acquisition by any means of any nuclear weapon; and (2) the receipt, storage, installation, deployment or any other form of possession of any nuclear weapon;
- Bearing in mind that at present no technical distinction can be made between nuclear explosive devices for peaceful purposes, the Parties also undertake to prohibit and prevent in their respective territories, and to abstain from carrying out, promoting or authorizing, directly or indirectly, or from participating in any way in, the testing, use, manufacture, production, or acquisition by any means of any nuclear explosive device while the above-mentioned technical limitation exists;
- As a basic verification undertaking, the Parties undertake to submit all the nuclear materials in all nuclear activities carried out in their territories or anywhere under their jurisdiction or control to the SCCC.

The agreement also provides that any serious breach by one of the Parties entitles the other Party to terminate the agreement or to suspend its application as a whole or in part, notification thereof to be made by that Party to the Secretary General of the United Nations and the Secretary General of the Organization of American States.

The design and role of the SCCC

The agreement establishes the SCCC in accordance with the guidelines set out in Annex I, the objective of which is to verify that the nuclear materials used in all nuclear activities of the Parties are not diverted to uses not authorized under the terms of the agreement.

Design of the system. The SCCC was designed as a system of full-scope safeguards to be implemented by a central executive body (the permanent staff of ABACC), which receives financial and technical support from the Parties in carrying out its activities. The system requires a combination of efforts by operators, national authorities, and ABACC.

Geographical distribution of safeguards activities in Argentina and Brazil

National authorities have an important and special role to play in implementing the SCCC. In addition to carrying out the usual activities at State level, they serve as the natural channel through which ABACC requests the services it needs to conduct verification activities in the other country. Being designed in this way, the SCCC calls for well-developed national authorities, capable not only of fulfilling their obligations at the State level but also of providing all the support required for the activities of

ABACC. This unusual dual role of the national authorities is completely new in the area of safeguards and is the cause of continuous discussions and adjustments. The technical support available in both countries comprises inspectors, consultants, working groups, special studies, training, maintenance and calibration of equipment, preparation of standards, laboratory services, and any other service or study related to safeguards.

Basic documents for the SCCC. In addition to the bilateral agreement, the principal documents defining the SCCC are the General Procedures and Implementation Manuals for each category of installation, the latter being analogous to facility attachments.

The General Procedures set out the basic criteria and requirement of the SCCC. Chapter 1 contains the criteria and conditions for the starting point of, exemptions from, and termination of safeguards. It also includes general rules for establishing an appropriate level of accountability and control of nuclear materials — later to be defined in detail in the Implementation Manual for each installation or other location — taking into account the usual parameters (category of nuclear material, conversion time, inventory, or annual throughput). Chapter 2 lays down the requirements at the State level for the licensing of nuclear facilities or other locations and the requirements regarding information of relevance to the SCCC (records, physical inventory, and traceability of measurement systems). Chapter 3 describes procedures for implementation of the SCCC at the State level.

The provisions relating to the implementation of the SCCC by ABACC are contained in Chapter 4. This includes specifications for relevant information to be provided to ABACC (design information questionnaires, or DIQs; inventory change reports, or ICRs; material balance reports, or MBRs; physical inventory listing, or PIL; and notification of transfers out of or between States Parties). Chapter 4 also describes in general terms the purposes of inspections by ABACC and the scope of such inspections and discusses access for inspection and notification about inspections. The general provisions for evaluation of shipper-receiver differences and of material unaccounted for (MUF) are also included in this chapter.

The remaining chapters contain provisions relating to the following: Chapter 5, ABACC Inspectors; Chapter 6, Routine Communications; Chapter 7, Document Revision; Chapter 8, Transitional Arrangements; and Chapter 9, Definitions. There are also two annexes: Annex 1, containing accounting report forms and instructions for their use; and Annex II, containing the Basic System of Routine Communications.

The role of ABACC

To implement the SCCC in both countries, the agreement establishes ABACC, which has its headquarters in Rio de Janeiro. The agreement gives ABACC the status of an international organization, and its officials that of international civil servants. Their privileges and immunities are set out in an additional protocol to the agreement, in the relevant headquarters agreement signed with the Government of Brazil, and in a special agreement signed with the Government of Argentina.

The organs of ABACC are as follows: the Commission, a governing body empowered to issue the necessary regulations and consisting of four members, two being designated by each government; and the Secretariat, its executive body.

The principal functions of the Commission are to:

- monitor the functioning of the SCCC;
- supervise the functioning of the Secretariat;
- appoint the professional staff of the Secretariat;
- prepare a list of qualified inspectors from among those proposed by the Parties;
- inform the Party concerned of any anomalies which may arise in the implementation of the SCCC;
- inform the Parties of any non-compliance with the agreement.

Any discrepancy or potential anomaly detected through inspections or evaluation of reports and records must be reported by the Secretariat to the Commission, which must call upon the Party concerned to correct the situation. Under the Commission's rules of procedure, its decisions are adopted unanimously.

The Secretariat has the following functions:

- to implement the directives and instructions issued by the Commission;
- to perform the necessary activities for implementation and administration of the SCCC;
- to act as the representative of the ABACC;
- to designate and instruct the inspector who will carry out the inspections;
- to receive and evaluate the inspection reports;
- to inform the Commission of any discrepancy in the records of either of the Parties which emerges from the evaluation of the inspection results.

The Secretariat consists of a Secretary and a Deputy Secretary, whose nationalities alternate every year, and of the staff, currently made up of six senior technical officers (three from each country), two administrative officers, four auxiliary staff members and some 60 inspectors provided by the Parties (approximately 30 from each country). The inspectors are under the authority of the Secretariat during the performance of their inspection duties; they must maintain an appropriate level of confidentiality and are banned from receiving instructions from any other organization or individual in connection with their inspection activities. The agreement provides that Brazilian installations shall be inspected by Argentine inspectors and vice versa.

The inspectors are experts working for the national authorities or other official institutions in the two countries and are enlisted by the ABACC Secretariat when necessary. The inspectorate staff is made up not only of individuals with extensive experience in inspections at the national level, but also of experts in various areas of relevance to safeguards (non-destructive and destructive testing, design and operation of nuclear facilities, etc.).

The Secretariat consists of a technical unit and an administrative-financial unit. The former covers the following areas: nuclear material accounting; planning and evaluation; operations; and technical support.

The annual budget of ABACC currently stands at approximately US $2 million per year, not including salaries for inspectors and consultants (paid directly by the countries), or equipment purchases which are made under special headings.

Implementation status

During the first months of 1992, efforts were made to acquire the basic resources (premises, appointment of staff, financial support, etc.) and to prepare the regulations needed to operate ABACC. The resulting headquarters agreement between Brazil and ABACC was signed in March 1992. The Secretariat of ABACC commenced operations at its headquarters in Rio de Janeiro in July 1992.

Declarations of initial inventories by both countries were received in September 1992, and since then the inventories have been kept up to date systematically.

Since both countries have nuclear material under IAEA safeguards (INFCIRC/66-type agreements), the Secretariat decided to oversee the accounting of all nuclear material, but to give priority to verifying the design of facilities and controlling nuclear material not safeguarded by the IAEA. Activities in line with this priority were completed in December 1993, when the design information for such facilities and their total initial inventory had been verified and discussions on the respective implementation manuals were well advanced. It can therefore be said that, today, all the nuclear material in Brazil and Argentina is adequately safeguarded, either by ABACC or by the IAEA.

An ABACC inspector applying seals to nuclear material.
(Credit: ABACC)

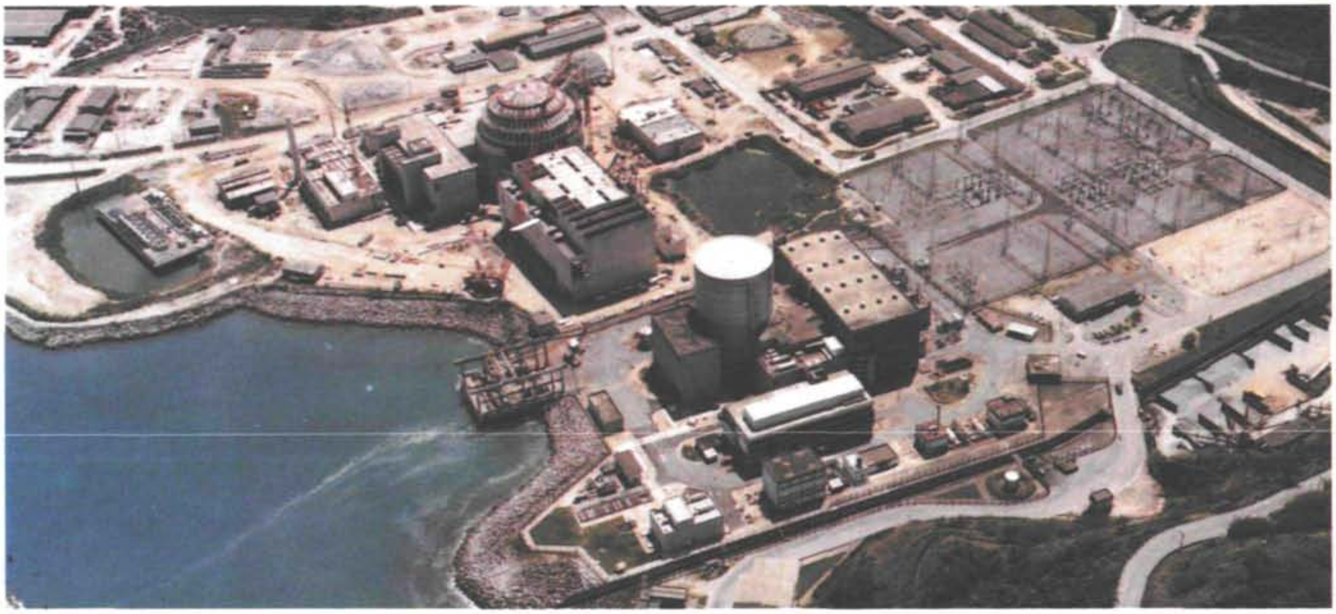
In order to achieve objectives, the following technical activities were carried out:

Accounting. A data bank has been set up to record the initial inventory and all subsequent changes.

Inspections. The system of inspections has been successfully launched. As of December 1993, 56 inspections had been carried out in the two countries. The ABACC's inspection effort at present amounts to around 30 person-days per month.

Training of inspectors. Two seminars for inspector training were carried out in 1992, one in Brazil and the other in Argentina. With the support of ABACC, the Argentine national authority also organized a one-month course for inspectors in June 1993. Inspectors from both countries attended the course.

Equipment. An equipment purchasing programme worth approximately US $1.5 million was drawn up. A first stage representing $150 000 in expenditures has been completed, and the second stage, amounting to $500 000, is now being carried out. Funding for the third stage has already been included in the 1994 budget. In addition, the necessary steps have been taken to ensure the calibration and maintenance of the equipment and preparation and registration of the ABACC seals.



The Angra nuclear power station in Brazil. *(Credit: FURNAS Centrais Electricas)*

Chemical and isotopic analysis of samples. Laboratories in both countries have already been pre-selected and are receiving on a regular basis samples taken during inspections; a programme has also been launched to establish a network of Brazilian and Argentine laboratories for sample analysis, with a corresponding intercomparison exercise (it is ABACC policy that samples taken in Argentine facilities should be analyzed in Brazil and vice versa).

On the basis of the practical experience obtained with the SCCC and ABACC, a number of special points seem worth mentioning:

- Since the corps of inspectors is made up not only of safeguards experts but also of specialists in facility design and operation, the Secretariat generally puts together inspection teams consisting of a safeguards specialist and a specialist in the type of facility that is to be inspected. This makes for more effective continuous verification that the facility is operating in conformity with the operator's initial declarations.
- An operation specialist carrying out an inspection in the other country gains a better understanding of the difficulties and inconvenience associated with the application of safeguards in a specific type of facility and, upon returning to his or her normal activities, will seek to improve the safeguards-related elements in similar types of facilities in his or her own country (recording and reporting systems, measurement systems, etc.), thus creating feedback that helps to improve the process of applying safeguards.
- The SCCC is part of a whole web of technical co-operation in the nuclear field between the two countries; as a result, the human resources involved in the various applications, including the most sensitive ones, and the activities under way in each country, are known to the other Party, which helps to increase the effectiveness of the safeguarding process.
- Most of the sites under safeguards are research or development facilities, laboratories or other locations which, by the nature of their activities, frequently change the processes employed, use a variety of different nuclear materials and generally lack continuity over time in their operations. Moreover many of these sites were not designed with safeguards in mind. Consequently, the effort that initially goes into inspecting these sites is not commensurate with the inventory of nuclear material, which is generally very small.
- As the inspectors do not work full time for the ABACC Secretariat, it is crucial that inspection reports should be extremely detailed and comprehensive, so that solutions found in the event of disputes or discrepancies can be reconstructed later and to ensure continuity of understanding of the situation at each site. Consequently, a considerable portion of the inspection person-days is spent at ABACC headquarters on pre- and post-inspection activities.

The quadripartite agreement

The bilateral Brazilian-Argentine agreement was supplemented by the quadripartite safeguards agreement, signed by the two governments, ABACC and the IAEA on 13 December 1991 in Vienna, Austria. Under this agreement, the IAEA also takes on the responsibility for applying comprehensive safeguards in Brazil

The Embalse nuclear power plant in Argentina. *(Credit: CNEA)*

and Argentina. (The agreement entered into force on 4 March 1994 and related IAEA verification activities have been initiated.)

The agreement's basic undertakings are the acceptance by the States Parties of safeguards, in accordance with the terms of the agreement, on all nuclear material in all nuclear activities within their territories, under their jurisdiction or carried out under their control anywhere, for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices.

In addition, the agreement states that the IAEA shall have the right and the obligation to ensure that safeguards will be applied on all nuclear material in all nuclear activities within the territories of the States Parties, under their jurisdiction or carried out under their control anywhere, for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices.

ABACC undertakes, in applying its safeguards on nuclear material in all nuclear activities within the territories of the States Parties, to co-operate with the IAEA, in accordance with the terms of the agreement, with a view to ascertaining that such nuclear material is not diverted to nuclear weapons or other nuclear explosive devices.

The agreement further states that the IAEA shall apply its safeguards in such a manner as to enable it to verify, in ascertaining that there has been no diversion of nuclear material to nuclear weapons or other nuclear explosive devices, findings of the SCCC. The IAEA's verification shall include, *inter alia*, independent measurements and observations conducted by the IAEA, in accordance with the procedures specified in the agreement. The IAEA, in its verification, shall take due account of the technical effectiveness of the SCCC. Moreover, the agreement states that the States Parties, ABACC, and the IAEA shall co-operate to facilitate the implementation of the safeguards provided for in the agreement; and that ABACC and the IAEA shall avoid unnecessary duplication of safeguards activities.

The fact that the implementation of the SCCC and the setting up of ABACC followed the signing of the quadripartite agreement has meant that, in developing them, it has been possible to take into account the future relationship and the need for complementarity between ABACC and the IAEA in applying the safeguards foreseen by the agreement.

Positive signs

The efforts made by Brazil and Argentina to establish a common system of accounting and control of nuclear materials, the development of ABACC to administer the system, and the extent to which it has been implemented in only a short period of time indicate that it is possible successfully to establish regional systems for the application of safeguards.

Furthermore, the signing of the quadripartite agreement and the progress made jointly with the IAEA in preparing for its implementation show that regional bodies can play an important role in making the international safeguards system work effectively. ❒

International convention on nuclear safety: A legal milestone

Governmental delegates adopt the first international legal instrument directly addressing the safety of nuclear power plants

By Odette Jankowitsch and Franz-Nikolaus Flakus

On 17 June 1994, representatives from 84 countries adopted without a vote the text of the Convention on Nuclear Safety. The action was taken at a Diplomatic Conference in Vienna which the Agency's Board of Governors had authorized the Director General to convene for 14-17 June 1994 at IAEA headquarters. Previously, in September 1993, the IAEA General Conference at its 37th regular session had expressed the desirability of convening a Diplomatic Conference as soon as possible to adopt the Convention. (resolution GC(XXXVII)/RES/615)

The Convention is the first international legal instrument which directly addresses the issue of safety of nuclear power plants.* In that sense, it represents "a milestone in the development of the international law of nuclear energy," in the view of Dr. Walter Hohlefelder of Germany, who was elected President of the Diplomatic Conference.

The Convention's scope of application (Article 3) provides that it "shall apply to the safety of nuclear installations". The Convention defines "nuclear installation" as "any land-based civil nuclear power plant...including such storage, handling, and treatment facilities for radioactive materials as are on the same site and are directly related to the operation of the nuclear power plant."

The issue of safety is addressed in a preventive and continuous manner comparable to some extent to agreements on safety of air or maritime transportation. The Convention, as stated in its Preamble, clearly reflects the importance to the international community "of ensuring that the use of nuclear energy is safe, well regulated and environmentally sound".

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The safe use of nuclear, as of other forms of energy, remains, however, essentially a national responsibility. The Convention, in its Preamble, underlines the view that responsibility for nuclear safety rests with the respective State. Nevertheless, international efforts in the area of safety have come increasingly to recognize the interdependence of all participants in the nuclear fuel cycle. As IAEA Director General Hans Blix noted in his opening statement to the Diplomatic Conference, an accident anywhere has the potential for direct transboundary radiation consequences and has global ramifications in terms of public confidence in nuclear power as a major energy source. "Through this Convention," he said, "States will bind themselves to a number of important safety rules, and accept to participate in and report to periodic peer review meetings to verify implementation of the Convention's obligations."

Chronology and background

In September 1991, an International Conference on the "Safety of Nuclear Power: Strategy for the Future" convened by the IAEA declared that "safety should be primarily enforced at national levels, by conscientious application of existing safety principles, standards and good practices at each plant, and within each national regulatory body, making best use of national legal frameworks and working practices." The Conference, however, also saw "a

*The two conventions adopted in 1986 — the *Convention on Early Notification of a Nuclear Accident* and the *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* — both apply "in the event of any accident..." The 1980 *Convention on the Physical Protection of Nuclear Material* applies to "nuclear material...while in international nuclear transport". The *Vienna Convention on Civil Liability for Nuclear Damage* is applicable to damages following incidents.

need to consider an integrated international approach to all aspects of nuclear safety including safety objectives for radioactive wastes — which would be adopted by all Governments." It requested the governing bodies of the IAEA to organize "the preparation of a proposal on the necessary elements of such a formalized international approach, examining the merits of various options and taking into account the activities and roles of relevant international and intergovernmental bodies and using the guidance and mechanisms already established in the IAEA."

Soon afterwards, the General Conference, supporting this idea, invited the Director General "to prepare, for the Board's consideration in February 1992, an outline of the possible elements of a nuclear safety convention, taking into account the activities and roles of relevant international and intergovernmental bodies and drawing on the advice of standing groups like INSAG (International Nuclear Safety Advisory Group), NUSSAG (Nuclear Safety Standards Advisory Group), and INWAC (International Waste Management Advisory Group), and also on expertise made available by Member States and competent international organizations". (GC(XXXV)/RES/553)

Pursuant to that resolution, the Director General convened a limited group of experts to advise on structure and contents of the possible elements of an international nuclear safety convention. The group met in December 1991, reconfirmed that there was a need for an international instrument on nuclear safety, and urged that preparatory work for the establishment of such an instrument begin as soon as possible. A decision on the structure of a convention would be taken after agreement had been reached on its scope and contents. It was considered that the convention should give emphasis to general principles and procedures rather than to technical details regarding nuclear safety.

In February 1992, the Board of Governors authorized the Director General to convene an open-ended group of legal and technical experts with the task of carrying out the necessary substantive preparations for a nuclear safety convention (the group soon came to be known as the "Group of Experts on a Nuclear Safety Convention").

The Group of Experts held its first meeting from 25 to 29 May 1992 and elected as its chairman Mr. Z. Domaratzki of Canada; 90 experts from 45 countries, the Commission of the European Communities (CEC), Nuclear Energy Agency of the Organization for Economic Cooperation and Development (NEA/OECD), and International Labour Organization (ILO) participated.

The experts agreed on a number of points, namely that:

- the main obligations of the parties to the envisaged convention would be based in large measure on the principles for the regulation and management of safety and the operation of nuclear installations contained in a draft NUSSAG document on safety fundamentals regarding the safety of nuclear installations. (The IAEA published the *Safety Fundamentals: The Safety of Nuclear Installations* in 1993 as Safety Series No. 110);
- the Convention would provide for an obligation of the Contracting Parties to report on its implementation, a review mechanism being established through a "meeting of the Parties"; and
- the IAEA would provide the meeting of the Parties with support services and technical expertise.

In September 1992, the General Conference took note of the work done by the Group of Experts for the drafting of a nuclear safety convention. It urged the Group to continue its work taking into account "the vital necessity of a continuing effort to raise the general level of nuclear safety worldwide". (GC(XXXVI/RES/582)

In October 1992, at the second meeting of the Group of Experts (attended by 100 experts from 43 countries, the CEC, NEA/OECD, and ILO), the experts agreed that the objective was to establish, at an early date, a convention with an "incentive character". In January 1993, the Group (123 experts from 53 countries, the CEC, and NEA/OECD) reviewed further draft texts with comments and annotations prepared by the IAEA Secretariat. At its fourth meeting in May 1993 (114 experts from 50 countries, the CEC, and NEA/OECD), the Group resolved the main outstanding issues, thus facilitating the drafting process and the establishment of a single text.

On the issue of scope of application, the experts agreed that the Convention should be limited to civil nuclear power plants, with the understanding that a concomitant political commitment would be made to initiate negotiations on an international instrument on the safety of waste management. The experts agreed that the Convention should also address the issue of so-called "existing situations", i.e. installations not in line with the obligations of the Convention.

At its June 1993 session, the IAEA Board invited the Director General to request Chairman Domaratzki to prepare, after such consultations as he thought necessary, a comprehensive reference text for discussion at the next meeting of the Group, in October 1993. In his statement at the 37th session of the General Conference, the Director General reported that a consensus about structure and contents of the Convention had

Selected obligations of States under the Convention on Nuclear Safety

States that become parties to the Convention on Nuclear Safety undertake important obligations. Among them are those pertaining to:

Reporting: "Each Contracting Party shall submit for review...a report on the measures it has taken to implement each of the obligations of this Convention." *(Article 5)* "The Contracting Parties shall hold meetings...for the purpose of reviewing the reports submitted..." *(Article 20.1)*

Existing nuclear installations: "Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shutdown may take into account the whole energy context and possible alternatives as well as the social, environmental, and economic impact." *(Article 6)*

Legislative and regulatory framework. "Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations. The legislative and regulatory framework shall provide for (i) the establishment of applicable national safety requirements and regulations; (ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a license; (iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of the licenses; (iv) the enforcement of applicable regulations and of the terms of licenses, including suspension, modification, or revocation. *(Article 7)*

Assessment and verification of safety: "Each Contracting Party shall take the appropriate steps to ensure that (i) comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body; (ii) verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions." *(Article 14)*

Emergency preparedness: "Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body. Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response." *(Article 16.1 and 16.2)*

Operation: Each Contracting Party shall take the appropriate steps to ensure that: (i) the initial authorization to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements; (ii) operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation; (iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures; (iv) procedures are established for responding to anticipated operational occurrences and to accidents; (v) necessary engineering and technical support in all safety related fields is available throughout the lifetime of a nuclear installation; (vi) incidents significant to safety are reported in a timely manner by the holder of the relevant license to the regulatory body; (vii) programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies; (viii) the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal." *(Article 19)*

Governmental delegates at the Diplomatic Conference. ***Above from left:*** Dr. Morris Rosen, IAEA Assistant Director General for Nuclear Safety; IAEA Director General Hans Blix; Dr. Walter Hohlefelder, elected the Conference President; and Dr. Lars Högberg, Chairman of the Committee of the Whole.
(Credit: F.-N. Flakus, IAEA)

emerged: the Convention would be limited in scope to nuclear power reactors; it would oblige the Contracting Parties to comply with fundamental safety principles based on NUSSAG's nuclear safety fundamentals document; an important feature would be an obligation of the parties to report at agreed intervals to meetings of the Contracting Parties on the implementation of the obligations laid down in the Convention; reporting by the Contracting Parties would be linked to a system of international peer review; and the IAEA would function as the Secretariat of the Convention and might be asked to assist Contracting Parties in the review process.

In October and December 1993, at its fifth and sixth meetings (attended by 120 experts from 50 countries, the CEC, and NEA/OECD), the Group reviewed the draft text prepared by the Chairman. The seventh and final meeting of the Group was held from 31 January to 4 February 1994 and approved the draft text of a Convention, thereby concluding its work.

In February 1994, the IAEA Board of Governors authorized the convening of the Diplomatic Conference, and it was held 14-17 June at the IAEA. In addition to electing Dr. Hohlefelder as President, the Conference elected Mr. Lars Högberg of Sweden as Chairman of the Committee of the Whole; Mrs. Thereza Maria Machado Quintella of Brazil as Vice-Chairperson; and Mr. A. Gopalakrishnan of India as Chairman of the Drafting Committee. The text of the adopted Convention is available in six languages: Arabic, Chinese, English, French, Russian, and Spanish. (INFCIRC/449)

Structure and content

The Convention on Nuclear Safety is structured as follows:

Preamble; Chapter 1 — Objectives, Definitions and Scope; Chapter 2 — Obligations: (a) General Provisions, (b) Legislation and Regulation, (c) General Safety Considerations, (d) Safety of Installations; Chapter 3 — Meetings of the Contracting Parties; and Chapter 4 — Final Clauses and Other Provisions. The Convention has no annexes.

The Convention applies to "nuclear installations", defined as "land based civil nuclear power plants". The obligations are based to a large extent on principles which present an international consensus on the basic concepts for the regulation, the management of safety, and the operation of nuclear installations. They include in particular the obligation of Contracting Parties to establish and maintain a legislative and regulatory framework for nuclear installations and the obligation to implement a number of measures based on general safety considerations regarding, for example, the availability of financial and human resources, the assessment and verification of safety, quality assurance, and emergency preparedness. Other obligations concern technical aspects of the safety of nuclear installations, including siting, design, construction and operation.

A principal feature of the Convention is the obligation of the Contracting Parties to submit reports on the implementation of the Convention for consideration at meetings of the Parties to be held at regular — approximately 3-year — intervals. In addition, the Convention provides that the Agency shall be the Secretariat of the Convention and the Director General its Depositary.

Implementation and peer review process

Generally, the Convention stipulates obligations for States Parties to take national measures and to report on the measures taken to implement each of the obligations.

After entry into force, implementation of the Convention will formally be pursued in setting up a peer review process. The form and scope of the peer review is the prerogative of the Contracting Parties, and definitive provisions for implementing the peer review system need to be elaborated in detail. Within 6 months of entry into force, a preparatory meeting of the Contracting Parties is to be convened to lay out the structure of the required national reports and the mechanism for the peer review. The peer review process will need to show a number of desirable features: it will have to be efficient, involve reasonable costs, and not place an undue burden on national reporting; it also has to be effective and transparent, demonstrating compliance with the Convention and informing how a Contracting Party has met its obligations. The process will have to function in an incentive manner, thereby triggering a learning and self-educating mechanism. The formal review is the culmination of a process, rather than a detailed review of national nuclear safety programmes.

Each Contracting Party will have to submit a concise national report for the purpose of informing how it has complied with the obligations stipulated in the Convention, and will have the opportunity to discuss and seek clarification of any report submitted by another Party.

Topics and issues to be addressed in the national report are to some extent of a general nature (relating to obligations under general safety considerations such as priority to safety, financial and human resources, human factors), but also cover more specific thematic areas (government organization and legislation; design; construction and siting; operation, including operational experiences).

As stipulated by the Convention, a concluding report, compiled by the Contracting Parties and adopted by consensus, will serve to communicate the final statements of the Meeting of the Contracting Parties to the public.

From the very beginning, the Convention had been envisaged as a catalyst, an incentive for countries to promote continuing progress in nuclear safety. Its implementation will foster — and intensify over time — the collective international involvement and commitment to nuclear safety, and thus steadily promote nuclear safety worldwide.

Also the need was affirmed — and included in the Preamble to the Convention — to develop as soon as possible an international convention on the safety of radioactive waste management. Progress made in developing safety fundamentals for nuclear waste management would pave the way for the early establishment of such a convention following the good example set by the work on the nuclear safety convention.

Outlook

The Convention will be open for signature on 20 September 1994 at IAEA headquarters in Vienna, in conjunction with the 38th regular session of the General Conference. It will enter into force after the deposit with the IAEA Director General of "the twenty-second instrument of ratification, including the instruments of seventeen States, each having at least one nuclear installation which has achieved criticality in a reactor core". (Article 31)

It is hoped that the ratification process will benefit from the same political will that made it possible for States to negotiate and adopt the Convention in such a short time and that the Convention will therefore enter into force in the near future.

As Dr. Blix stated in his concluding remarks to the Conference, "The promotion of safety in nuclear installations is an important national and international objective. This Convention will give many well-known principles the force of law. It will also establish innovative mechanisms to help us ensure that the letters of this law translate into safe nuclear reality". ❐

Nuclear techniques for food and agricultural development: 1964-94

A look at selected achievements of the Joint FAO/IAEA Division as it marks its 30th year of worldwide service this October

by Björn Sigurbjörnsson and Peter Vose

From research laboratories to farmers' fields, nuclear techniques play an increasingly valuable and often unique role in agricultural research and development. They are used in a wide range of applications, from food preservation to crop production to animal health studies.

In no small measure, the collaborative work of two global organizations — the IAEA and the Food and Agriculture Organization (FAO) of the United Nations — has been instrumental to the progress. Thirty years ago, in October 1964, the two agencies combined forces to form a Joint Division for Nuclear Techniques in Food and Agriculture. The new division unified FAO's atomic energy branch and IAEA's agricultural unit, and in the process created a common programme that avoided overlap and duplication of efforts.

Over the past 30 years, programmes of the Joint FAO/IAEA Division have helped countries solve practical, and costly, problems in areas of soil fertility, irrigation, and crop production; plant breeding and genetics; animal production and health; insect and pest control; agrochemicals and residues; and food preservation. The Division's overall objectives are to exploit the potential for application of isotopes and radiation techniques in agricultural research and development; to increase and stabilize agricultural production; to reduce production costs; to improve the quality of food; to protect agricultural products from spoilage and losses; and to minimize pollution of food and the agricultural environment. On the occasion of the Joint Division's 30th anniversary year, this article highlights selected achievements over the past three decades.*

Mr. Sigurbjörnsson is Director of the Joint FAO/IAEA Division and Mr. Vose is a former senior staff member of the Division. Both were among the founders of the Division in 1964.

Soil fertility and nitrogen fixation

Agricultural researchers have long suspected that a great deal of fertilizer is wasted by being wrongly applied and consequently never gets taken up by the crop. The problem drew the attention of experts of the Joint Division in the 1960s, but they realized that possible solutions could be expensive. The Division's first co-ordinated research programmes on rice and maize, however, demonstrated that the use of the isotopes phosphorus-32 and nitrogen-15 in worldwide field studies was economically feasible. The finding stimulated the widespread use of nitrogen-15 in agricultural research, and had a major influence on extending the use of isotope techniques to many developing countries.

In subsequent years, FAO/IAEA-sponsored experiments on rice fertilization in the Far East, Hungary, and Egypt helped solve critical problems concerning the proper placement of phosphorus and nitrogen fertilizers. It was found that phosphorus should be given on the surface, whereas that would be the worst possible circumstance for nitrogen, whose surface applications would not be taken up by the crop. While this had been suspected from years of traditional experimentation, it had not been proven before.

A co-ordinated programme with maize further showed that the uptake of phosphorus was increased when it was mixed with nitrogen fertilizer, and that application of some nitrogen at the time of tasselling resulted in very effective uptake and increased crop yield. Recommendations based on these experimental results have been adopted by the FAO fertilizer programme, as well as by many countries, thus helping to save millions of dollars in fertilizer costs.

*A more comprehensive report on the Joint FAO/IAEA Division and its work appears in the 1994 edition of the *IAEA Yearbook*

Similarly, for tree crops, the Joint Division's work showed that effective placement of fertilizer can offer savings over many years. While traditional fertilizer experiments with tree crops take years to perform and evaluate, the use of fertilizers labelled with isotopes can help researchers determine root activity. The Division's programme showed that traditional placement of fertilizers was not optimal in many cases.

More recently, research has been intensive on the subject of biological nitrogen fixation from the atmosphere. The work has been prompted by the high costs and often poor availability of nitrogen fertilizers in developing countries, plus the need to reduce fertilizer levels in developed countries. It is quite difficult to measure the amount of nitrogen fixed by a crop, but the Joint FAO/IAEA Division has been among the pioneers in the development of methods using nitrogen-15. These methods give good results and have been used in major co-ordinated research programmes determining the nitrogen fixing capacity of beans and other legumes, of pastures, of nitrogen-fixing leguminous trees, and of *Azolla*, the pond weed that supplies nitrogen to rice paddies.

Soil moisture and irrigation

The efficient use of water in irrigation systems requires continuous monitoring of the level of soil moisture and interpretation of these measurements. The use of nuclear techniques to measure soil moisture has enabled soil physicists to redesign irrigation regimes and better plan the use of scarce irrigation water. At the same time, the productive potential of the land can be maintained or improved.

FAO/IAEA co-ordinated research programmes have shown that traditional irrigation methods can be improved to save as much as 40% of total water use; the saved water can be used to irrigate other areas. Researchers in a number of countries have tested different practices to increase water conservation in rainfed areas, with results leading to immediate practical applications.

Mutation plant breeding

In 1964, mutation breeding was frequently derided. Long-established plant breeders had difficulty in believing that inducing mutants through radiation in an apparently random manner had any relevance to their classical procedures, with careful crossing of different parent plants and selection and re-selection of their progeny. But attitudes have greatly changed, in great part due to the Joint Division's programmes. In reality, mutation breeding has been one of the big success stories —1800 improved mutant cultivars released to date— with an impact so great that we don't attempt to assess its monetary value.

A turning point was probably an international conference sponsored by the FAO and IAEA in Rome in the Spring of 1964. At that time, the number of known released mutant cultivars was less than fifty. At the conference, it was agreed that co-operative work was needed to solve problems in effective mutation treatment conditions, and in the subsequent screening, selection, and application of mutants, among other areas.

There was a serious lack of knowledge about how to start a mutation breeding programme and how to incorporate a useful trait into the best existing varieties. This challenge was taken up by the new Division. The FAO/IAEA *Manual on Mutation Breeding* was the answer. This publication has had enormous influence, becoming a standard text for plant breeders. On the practical side, a very significant development was the design of a facility (SNIF—Standard Neutron Irradiation Facility) to provide plant breeders with a pure source of fast neutrons in pool-type reactors.

An early FAO/IAEA programme was concerned with testing mutant durum wheat cultivars in the Mediterranean and Near East. Mutant cultivars of durum wheat are now among some of the most successful grown, with almost 70% of the total acreage of durum in Italy under mutant varieties.

Pioneer mutation breeding also was done on barley, leading to a situation today where virtually all barley cultivars grown in northern and central Europe have induced mutations in their parentage, coming about through a "cascade" process of newer varieties.

Mutation breeding in rice has been extremely successful. Largely as a result of the 1964 conference, a major co-ordinated rice improvement programme using mutation techniques was developed under FAO/IAEA auspices. The result was a high number of improved new varieties bred with the help of induced mutations. Before the programme began, there were four released mutant cultivars of rice. Today there are more than 200. Worldwide, there are many millions of hectares under mutant rice cultivars and the impact has been enormous.

The Joint Division has addressed other problems as well, such as crop resistance to diseases and the protein content of cereal grains. From studies of the annual cereals like barley, wheat, and rice, research moved to grain legumes, fruits, and root and tuber crops. The programmes on grain legume improvement resulted in more than 100 improved cultivars.

Vegetatively propagated crops presented much greater problems — except for the multimillion dollar house plant market, which needed no help as mutants were very easily obtained. The answer seems to lie in the use of *in vitro* culture techniques, and the Joint Division — through its Agriculture Laboratory at the IAEA's Seibersdorf Laboratories — has been active in exploring unconventional breeding methods for improvement of tropical crops. Palms, tropical fruits, cassava, yam, and cocoa have been among the crops studied. For example, cultures of banana tissues significantly enhance the effective use of mutation treatments. Cultivars of bananas aimed at acquiring disease resistance are being tested. One of these, called "Novaria" and developed at Seibersdorf, has just been released in Malaysia.

Animal production and health

Livestock are an important component of most farming systems. Internal parasites result in huge losses of animals worldwide, shown both through reduced growth and from needless deaths. Quite early research showed that some internal animal parasites could be "attenuated" by irradiation — that is made harmless — to provide vaccines against a number of killing parasitic diseases. The earliest FAO/IAEA co-ordinated programme in animal sciences in 1966 was devoted to the effective control of internal parasites in domestic animals.

The reproduction of animals has been another focus of research. The reproductive status of female animals can be determined by measuring the level of the hormone progesterone in their blood or milk using radioimmunoassay (RIA) with iodine-125 as a label. The Seibersdorf Laboratory has developed RIA kits especially designed for use under difficult conditions. Using this method, very successful FAO/IAEA programmes on buffalo production in Asia, sheep and goats in Africa, and llamas and alpacas in Latin America have given unique information on the reproductive behaviour of indigenous species and the types of livestock raised by typical small farmers. They have led to the identification of animals with superior performance, and the acceptance of new management practices to improve breeding efficiency.

DNA probes that are isotopically labelled (using phosphorus-32 or iodine-131), and immunoassay methods that are similar in principle, enable diagnosis of diseases, assist in conducting disease surveys, and monitor disease control programmes. The immunoassay test (enzyme linked immunosorbent assay— ELISA) is used to detect and measure antibodies to particular infections. It therefore can be used to establish the extent of major diseases, such as rinderpest (the cattle plague), babesiosis and brucellosis. Moreover, it can monitor the effectiveness of control measures such as drug treatment or vaccination.

ELISA has been highly successful. Kits especially designed at the Seibersdorf Laboratory have been supplied worldwide, with many millions of assay units sent out to different projects. A major use of ELISA has been in the rinderpest vaccination campaign in Nigeria, and, more recently, in the Pan African Rinderpest Campaign, which cleared rinderpest from 14 countries. *(See the following article.)*

Problems of nutrition also continue to command attention. Mineral deficiency or imbalance is often a problem in livestock, but frequently it is not easy to recognize that a problem exists until growth of the animals is seriously affected. Isotope methods for diagnosing copper, selenium, zinc, and phosphorus deficiency have provided a quicker way of determining the status of these essential elements, and were a feature of early FAO/IAEA work.

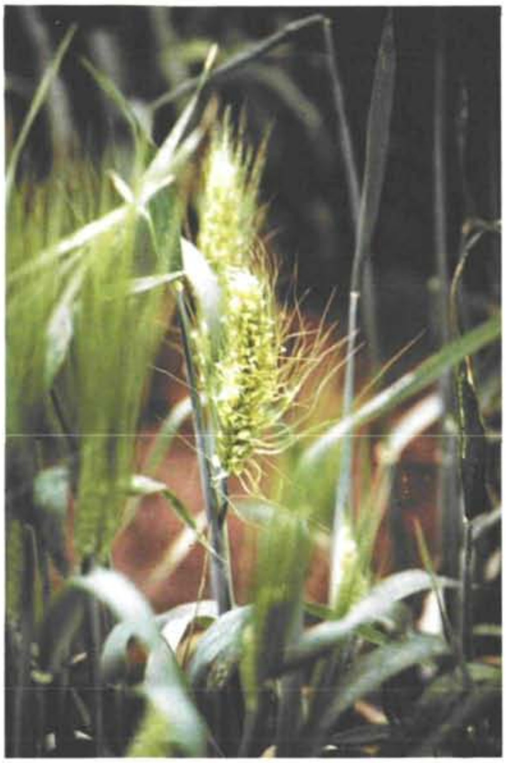
One co-ordinated programme used nitrogen-15 in studies of non-protein nitrogen sources, such as urea, as a supplementary feed for ruminants. This led to the use of cheap non-protein nitrogen to meet the protein needs of ruminants, because they can convert the inorganic nitrogen to protein.

Joint FAO/IAEA work in the 1980s focused on finding the best ways of using fibrous fodders like straw and crop residues, and byproducts of food processing industries such as bagasse, for feeding buffaloes, sheep, and goats. An artificial rumen, named Rusitec, was designed and used to study microbial degradation of feeds using isotope labelling. The acquired information has led to the formulation of new diets based on locally available feeds for ruminant animals in developing countries.

The worldwide scope of these programmes has contributed substantially to concepts now common among animal nutritionists in establishing the value of feeds and the nutrient requirements of livestock.

Insect control

There are major insect pests of crops, livestock, and humans whose impact is so great that the social development and economies of entire regions may be affected. They include the screwworm, which affects humans and warm-blooded animals (principally cattle), the



Facing page: Cattle farming in Africa; a farmer winnows rice, of which some 200 mutant cultivars have been developed; a market square in Guatemala; a scientist prepares an experiment at the Agriculture Laboratory in Seibersdorf; research at the Seibersdorf Laboratory on controlled release formulations of herbicides. *This page:* a close-up of a mutant of barley; a medfly trap in Central America. (Credits: FAO; M. Maluszynski, IAEA; J. Marshall, IAEA)

Mediterranean fruit fly (medfly), and the tsetse fly, which affects both livestock and humans.

Over the years, the FAO and IAEA have jointly convened eight major symposia on the application of radiation techniques to insect problems. The meetings have particularly influenced development of the Sterile Insect Technique (SIT). This technique involves rearing insects, which are then sterilized by radiation and later released in the infested areas. Their mates do not produce offspring, and with repeated releases the population is reduced and eradicated.

The medfly, *Ceratitis capitata*, is virtually ubiquitous wherever there is citrus and soft fruit grown. The economic consequences are profound as the fruit is seriously damaged, and consequently exports are greatly reduced. Researchers at the Seibersdorf Laboratories have developed artificial diets and highly successful rearing methods for the medfly, so that mass-rearing of millions of flies can be done cheaply. Though it sounds simple, it took a lot of research to make it so.

Two especially important developments occurred at Seibersdorf. The first was the creation of a genetic sexing strain of medfly in which the female pupae are white and the males brown, thus permitting easy separation and enabling the release of only male flies. A further very clever piece of research has involved the insertion of a differential heat-sensitive gene, induced by a chemical mutagen, onto the sex-determining Y-chromosome, by means of a radiation induced chromosome translocation; a technical "tour de force". The resulting medfly strain permits sex segregation at an earlier stage — the eggs are heated to 35°C, whereupon eggs carrying females are killed, while the males survive. This means that it is necessary to rear only half the larvae, thus halving food costs, a major expense of the SIT method. Moreover, releasing only males means that fruit is not punctured by females laying sterile eggs.

One of the big medfly success stories has been the eradication campaign in Mexico, for which the Joint FAO/IAEA Divison provided advice, training, and assistance in designing the eradication project and the fly "factory". In the end, a massive programme funded by Mexico and the United States could produce 500 million sterile flies per week. As a result the pest was eradicated from the infested area, and an enormous loss to the Mexican economy was prevented.

The New World Screwworm is a pernicious, unpleasant pest of all warm-blooded animals. Eggs are laid on the backs of animals and the resulting larvae bore through the hide into the flesh. In 1988, it was found that the insect had established itself in Libya, and an urgent national and international effort, co-ordinated by FAO and supported by IAEA, was mounted to prevent its spread to livestock and wildlife in North Africa, sub-Saharan Africa and the Mediterranean Basin. By 1992, eradication was achieved, preventing the enormous losses which would have occurred if the infestation had been allowed to spread.

Tsetse flies, *Glossina spp.*, effectively "sterilize" almost two-thirds of the land area of sub-Saharan Africa. The tsetse fly feeds on the blood of animals and transmits the Trypanosomas organism which is responsible for human sleeping sickness and the "Ngana" condition in cattle. About 50 million people are at risk in an area the size of the entire farmland of the United States.

Researchers at the Seibersdorf Laboratories have worked steadily towards making SIT a reality for tsetse, including development of methods of rearing on artificial membranes with a blood diet. At the start, it was not known if self-sustaining colonies could be kept for a long period in the laboratory, and still have progeny that would later function in the wild. This has now been achieved.

In Nigeria, an operation known as the BICOT pilot project was carried out by the FAO and IAEA in 1984-86. It successfully eradicated the tsetse fly from an area of 1500 square kilometers. At the present time, a number of pilot scale projects are being run to build upon the experience acquired during that project.

Agrochemicals and the environment

Public concern about the potential contamination of food is not new. Prior to 1964, the FAO had collected information on the amount of radioactivity from fallout found in soil, vegetation, and food. The data was reported to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). In 1969, these results were put into perspective at a seminar on Agricultural and Public Health Aspects of Environmental Contamination by Radioactive Materials jointly sponsored by the FAO, IAEA, and World Health Organization (WHO).

The Chernobyl accident revived the earlier international concern about the contamination of the environment by radioactive fallout. It led to a major FAO/IAEA report, *Radioactive Fallout in Soils, Crops and Food* in 1989. This was accompanied the same year by an international symposium on Environmental Effects Following a Major Nuclear Accident, which was convened by the FAO, IAEA, WHO, and United Nations Environment Programme.

A body of information exists to help evaluate the extent and magnitude of any future environmental contamination from radionuclides. The 1994 publication, *Guidelines for Agricultural Countermeasures Following an Accidental Release of Radionuclides*, will assist in devising methods of monitoring and limiting the short- and long-term effects on agriculture, food, and human health.

Nitrates in drinking water sources have become a political issue as well, as levels are sometimes close to or exceed WHO limits. A Joint FAO/IAEA Division programme in the 1970s used nitrogen-15 tracers to show beyond doubt that the nitrate found in the water table was almost exclusively due to agricultural inputs. The results were disseminated in a series of publications (1974, 1975, 1984) which have become standard references in the field.

The discharge of mercury waste to rivers and estuaries has caused localized outbreaks of poisoning in consumers of fish. Additionally, the use of organo-mercury compounds in agriculture as a seed dressing against seed-borne fungal diseases has caused the death of many birds and accidents to people. In collaboration with WHO and the International Labour Organization (ILO), the Joint FAO/IAEA Division has evaluated the impact of mercury on the environment. A monograph was issued which became a major source of information, and subsequently resulted in heavy restrictions on the use and release of mercury.

In the field of pesticides, radioisotope labelling has not only provided exceptionally accurate analysis of minute amounts (parts per billion) of pesticide residues, but has also provided the means to determine metabolic pathways, and the fate of the compounds in nature. Moreover, a considerable fraction of a pesticide-derived residue in soils and plant products cannot be extracted by conventional analytical solvents, and would therefore not be detected except by radioisotope labelling.

The fate of residues is a determining factor in deciding how a pesticide should be used, or on banning certain compounds as being ecologically harmful, or even determining that a compound that may be potentially harmful in one situation may be quite suitable for use in another.

For example, the use of DDT and lindane has been widely cut back or banned in temperate climates because of their persistence in the environment. A wide reaching study initiated by the Joint FAO/IAEA Division found that substances such as DDT and lindane dissipated much faster in tropical environments with high temperature and high humidity, so that local accumulation of residues was prevented.

One current approach of the Joint Division to a more environmentally friendly and efficient use of herbicides and pesticides is to make them available to the crop over a longer period, but in lesser concentration, by means of so-called controlled release compounds. These last for a longer time and release the active pesticide or herbicide over a longer period. Radioisotope tracers are invaluable in the research, development, and testing of such formulations.

Food preservation by irradiation

As much as one-third of the total world harvest may be lost due to spoilage and infestation on its way to the consumer. Food irradiation offers a safe and reliable way to reduce wastage. Decades of research have shown conclusively that there are no adverse effects from the consumption of irradiated foods. They do not become radioactive in any way nor does irradiation leave any harmful residues.

Food irradiation is valuable for disinfestation of stored products, such as grain, spices, dried fruit and vegetables; for the sprout inhibition of long-stored potatoes and onions, thus reducing the need for chemical inhibitors of doubtful safety; for the elimination of food-borne diseases, especially *Salmonella* in poultry, red meat, and seafood; for the disinfestation of tropical fruits from the fruit fly and other pests, for which it is an effective residue-free treatment; and for the extension of the shelf life of mushrooms, strawberries, and tropical fruits.

The FAO/IAEA Symposium on Food Irradiation at Karlsruhe in 1966 was a landmark in defining the possibilities of the technology. Nevertheless, from the strictly economic point of view, preserving food by irradiation has so far made only modest impact, despite its advantages. However, the development of enabling technology and legislation has made considerable progress during the last 30 years, and the work of the Joint FAO/IAEA Division has been largely responsible for this.

Despite economic handicaps and the resistance of some consumer groups, the number of facilities for food irradiation has steadily grown, and there are now about 65 facilities worldwide, of which about 50 might be called commercial.

During the period 1971-81, the FAO, IAEA, and WHO appointed groups of experts to evaluate the studies of the wholesomeness of irradiated foods. As a result of the stimulation and co-ordination of the Joint Division, it became possible in 1983 for the Codex Alimentarius Commission to adopt and publish an international standard for food irradiation.

At present, an International Consultative Group on Food Irradiation (ICGFI) operates under the aegis of the FAO, IAEA and WHO, with the FAO/IAEA acting as its Secretariat. It evaluates global developments and provides Member States with advice. Training has always been an integral part of the effort and the first FAO/IAEA course was held in Michigan, in the United States, in 1967 and was the first of its kind. Later, several hundred persons were trained during the 10 years of an international food irradiation project in Wageningen, Netherlands. Today, training is encouraged by ICGFI, which organizes Irradiation Process Control Schools, where certificates are earned by successfully trained operators. Its curriculum is being endorsed by an increasing number of food control authorities.

Training and research for development

Training and applied research via co-ordinated programmes and the Seibersdorf Laboratory have always been a prominent feature of Joint Division activities. During the past 30 years, there have been 2200 participants in 122 inter-regional training courses. Moreover, 2609 IAEA fellowships have been awarded in agriculture; 380 of the fellows worked directly at Seibersdorf. From the beginning, the Agriculture Laboratory at Seibersdorf has been central to the Joint Division's work and impact. Without it, some of the most successful programmes could hardly have taken place, as it has done pioneer work not done elsewhere. Its role has been to develop methods and test them, to pursue new lines of approach, and to perform the essential backup for the co-ordinated research and other field programmes.

Originally housed in a pre-fabricated building bought for US $25 000 earned from a contract (how could a building be so cheap?), the agriculture laboratory has grown to a useful, though still too small, size as a wing of the main laboratory.

Similarly, the FAO/IAEA training courses at Seibersdorf used to cause great internal strains because of the lack of space. A new training centre has greatly improved conditions for course participants, fellowship trainees, and the Laboratory staff alike. It has been a fine investment in the future. ❒

From 17-21 October 1994 in Vienna, the FAO and IAEA are jointly convening an International Symposium on Nuclear and Related Techniques in Soil/Plant Studies on Sustainable Agriculture and Environmental Preservation.

Animal health: Supporting Africa's campaign against rinderpest

IAEA and FAO scientists have played catalytic roles in helping African countries save their livestock from a life-threatening disease

by Martyn H. Jeggo, Roland Geiger, and James D. Dargie

Rinderpest, or cattle plague, is a devastating viral disease of cattle and wildlife. It can affect all animals in a herd and kill up to 90% of them. When exposed to infection, susceptible animals develop an eye discharge followed by the formation of ulcerative necrotic lesions in the mouth and nose. Within a few days these lesions spread to the intestines resulting in severe diarrhoea and frequently death. Although mild strains of the rinderpest virus exist, most infected animals die and the only effective protection is through vaccination. Fortunately, today's vaccines protect animals against all known strains of rinderpest virus and one inoculation protects them for life.

At the turn of the 20th century, the application of basic zoo-sanitary measures eradicated the disease from Europe. In Africa and Asia, however, rinderpest has continued to cause the death of millions of animals. Between 1979 and 1983, more than 100 million head of cattle were affected in Africa. In Nigeria alone during this period, 500 000 cattle died, at an overall economic cost to the country of an estimated US $1.9 billion.

Over the past 8 years, the IAEA and the Food and Agriculture Organization (FAO) have worked together through their Joint Division in Vienna to help African countries protect their livestock — and by extension their agricultural economies — from the severe consequences of rinderpest. They have supported an extensive African campaign to eradicate rinderpest. Since 1987, when the campaign began, the disease was found in 14 African countries. Today, rinderpest is restricted to relatively isolated pockets in just two African countries — an indication of just how effective efforts have been. This article reports on this campaign, specifically looking at the impact of projects carried out by the IAEA and its Joint FAO/IAEA Division. It further addresses key aspects of this work that may provide valuable lessons for the future.

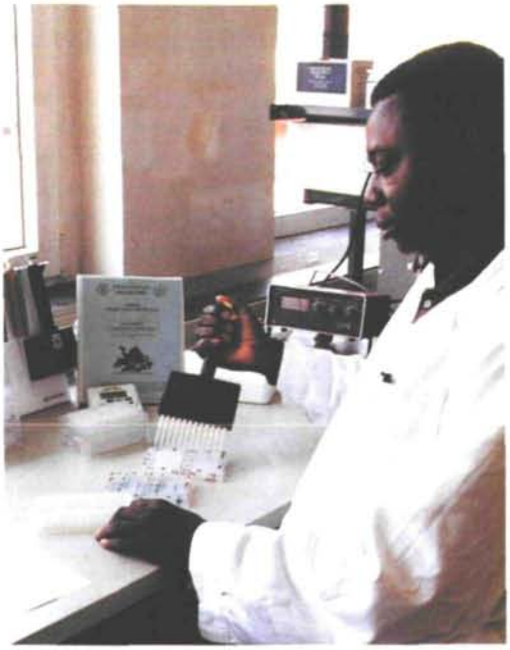
Mr. Jeggo is a senior staff member, and Mr. Dargie is the Head, of the Animal Production and Health Section of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. Mr. Geiger is seconded to this Division as an IAEA Technical Co-operation Regional Expert in Animal Health.

Strategy of control and eradication

Under the first major effort to eliminate rinderpest from the region (the so-called JP 15 Campaign in the mid-1960s), millions of cattle in 22 African countries were vaccinated at a cost of US $51 million. The disease all but died out. Cattle owners and veterinary authorities, no longer fearing the disease, became complacent, however. They ceased vaccination and national cattle populations again became susceptible. Unfortunately, residual pockets of virus activity remained in some countries and the movements of infected cattle by nomads and commercial operators consequently led to the devastating epidemics of the late 1970s and early 1980s.

Since then, it has been recognized that the rinderpest virus cannot survive if 85% or more of the cattle are effectively vaccinated. With this in mind, and realizing that success in eradicating the disease would require substantial strengthening of veterinary services in Africa, the Organization of African Unity (OAU) took action. In 1986, through its Inter-African Bureau of Animal Resources (IBAR), it embarked on the largest ever eradication programme for animal disease, the Pan African Rinderpest Campaign (PARC). This programme is funded primarily by the European Economic Community (EEC) but a consortium of other international and bilateral donors is also involved. *(See figure.)*

This new campaign incorporated several elements so as to be certain that countries achieved adequate levels of vaccination to ensure eradication. In addition to mass annual vaccination cam-



Scenes from campaigns to eradicate rinderpest, a life-threatening disease for cattle and wildlife.

paigns, each country would need to establish a system to determine the effectiveness of their national vaccination programmes and ascertain that 85% or more of their cattle populations were immune. Once this had been attained, countries could cease vaccination but would then continue to monitor animals carefully to identify any remaining pockets of virus infection. The Office International des Epizooties (OIE) — the veterinary analogue to the World Health Organization — would officially register countries free of rinderpest, once surveillance procedures had shown this to be true. The OIE registration would thus place a seal of international acceptance of eradication for each country and pave the way for freer livestock movements and trade.

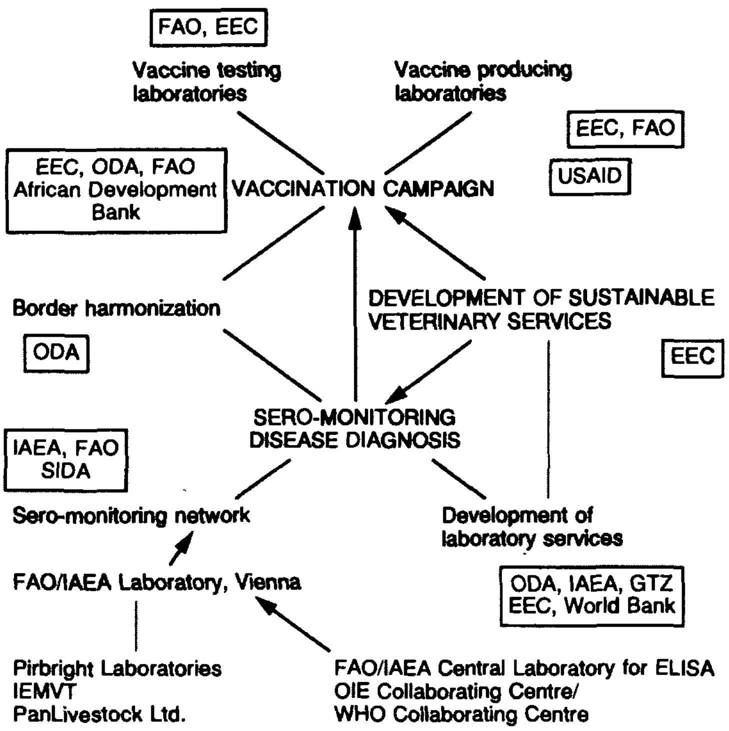
Yet how would the required level of seromonitoring and disease surveillance be established and maintained on a routine basis in each country? Until PARC started, the only recognized approach for determining whether animals were successfully vaccinated against rinderpest was to collect blood samples for examination. They would be examined for the presence of anti-rinderpest antibodies using a method called virus neutralization. This is a lengthy procedure requiring considerable expertise, equipment, and logistic support — well outside the means of most African laboratories. Moreover, the procedure cannot be standardized between countries. Therefore, some other kind of test was needed. After much discussion, a panel convened by the FAO and IAEA decided that an immunoassay-based method called the ELISA (enzyme-linked immunosorbent assay) offered the ideal solution to the problem.

ELISAs can be used to diagnose a wide range of different diseases. They identify the causative organism and detect the antibody response to different organisms. They are therefore in principle suited to measuring both the response to rinderpest vaccination and to detecting any remaining foci of virus activity following a cessation of vaccination. ELISAs are relatively simple and, because the reagents are used in minute amounts, also very inexpensive. Another major advantage is that the procedure is fast. Many samples can be tested in a short time, which means that analysis of test results can be computerized. The assays can be easily checked through internal and external quality control procedures, removing all subjectivity and providing assurance of results. Finally, ELISAs can be produced in a "kit" with the reagents prepared in such a way that they can withstand the rigours of prolonged travel.

Developing the approach

IAEA has the task of promoting the peaceful uses of nuclear energy and in agriculture its programme is developed and technically implemented by the Joint FAO/IAEA Division. In the early days of immunoassays, radioisotopes were the labels of choice and today these are still used extensively in radioimmunoassays (RIA) for

Pan-African Rinderpest Campaign of the OAU/IBAR



OAU = Organization of African Unity; IBAR = Inter-African Bureau for Animal Resources; ODA = Overseas Development Adminsitration (UK); EEC = European Economic Community; GTZ = Deutsche Gesellschaft für Technische Zusammenarbeit; SIDA = Swedish International Development Authority; OIE = Office International des Epizooties; IEMVT = Institut d'Elevage et de Medicine Veterinaire des Pays Tropicaux; WHO = World Health Organization; USAID = United States Agency for International Development

Structural organization of PARC

measuring reproductive hormones and as labels for other diagnostic procedures involving molecular methods.

However, in the 1980s, enzymes became recognized as more appropriate labels for diagnostic tests based on immunoassay where the need was for high throughput and a "yes/no" answer. Nevertheless, in the process of developing and purifying reagents for ELISA tests and for validating their specificity and sensitivity, isotopes are extensively used. While the final test does not contain an isotope, ELISAs would be difficult to develop without isotopes, and they are clearly nuclear-based techniques. Indeed the very first immunoassay-based serological test for rinderpest was an RIA using antibodies labelled with iodine-125.

Against this background, it was logical for the IAEA to expand its programme to encompass ELISA for diagnosing livestock diseases. It was also logical, in view of the critical food security situation in Africa, that the first target of such a programme would be to develop a cheap and reliable test for rinderpest — a disease which is capable of killing large numbers of animals which provide a basic source of food and traction for millions of Africans.

At the outset, some key decisions had to be made on how to implement the task — in particular whether to provide veterinary centres with the capability to produce their own kits for particular diseases, whether to supply kits from a commercial source, or whether the IAEA itself should produce them. Although it may have been politically desirable to provide each diagnostic centre with the capability to develop and produce its own ELISA test, this was considered technically and economically unrealistic. Commerical kits also posed problems. While the supply appeared to be a simple solution, the kits are prohibitively expensive and are seldom designed for use in developing countries. Moreover, they are not available for rinderpest or many of the diseases which exist in developing countries. A further important consideration was that commercial companies do not provide training or technical backstopping on the use of their diagnostic products in developing countries. Consequently, the validity of the obtained results is often suspect.

Having weighed the pros and cons of each option, the IAEA and FAO decided to establish the FAO/IAEA Central Laboratory for ELISA and Molecular Techniques for Animal Disease Diagnosis, located at the IAEA's Seibersdorf Laboratories. Within this Central Laboratory, tests for a variety of diseases affecting livestock could be developed and refined and quality assurance programmes for the various tests could be co-ordinated. Its establishment and subsequent recognition by OIE and WHO as official collaborating centres for ELISA were critical — not only from the standpoint of providing the springboard for the development of the IAEA's programme but also for promoting international standardization of reagents and test protocols for diagnostic tests. As far as PARC was concerned, this approach satisfied the requirement for all PARC countries to use a standardized system of sero-monitoring. In that way, results could be compared from country to country, validation data could be produced which would meet stringent OIE requirements, and adequate internal and external control procedures could be introduced to assure all parties that the results being reported were indeed correct.

In providing support for the introduction and use of ELISA-based technology for sero-monitoring into PARC countries, two basic types of IAEA support programmes were utilized: the Research Contract Programme and the Technical Co-operation Programme. But crucial to the success of the IAEA's assistance was the overall integration and co-ordination of these resources by the Joint FAO/IAEA Division.

Setting up the network

Co-ordinated research programmes. FAO/IAEA research contracts are awarded on an annual basis (for up to 5 years) to institutes in developing countries for the purpose of using nuclear-based methods to study or solve a problem in a particular field of activity or region. These contracts can be grouped to form a Co-ordinated Research Programme (CRP), under which a number of research agreements are also awarded to institutes in developed countries that have established expertise in the problem being tackled. CRPs, which are funded by the IAEA's regular budget or by external donors, also involve holding Research Co-ordination Meetings (RCMs) at regular intervals.

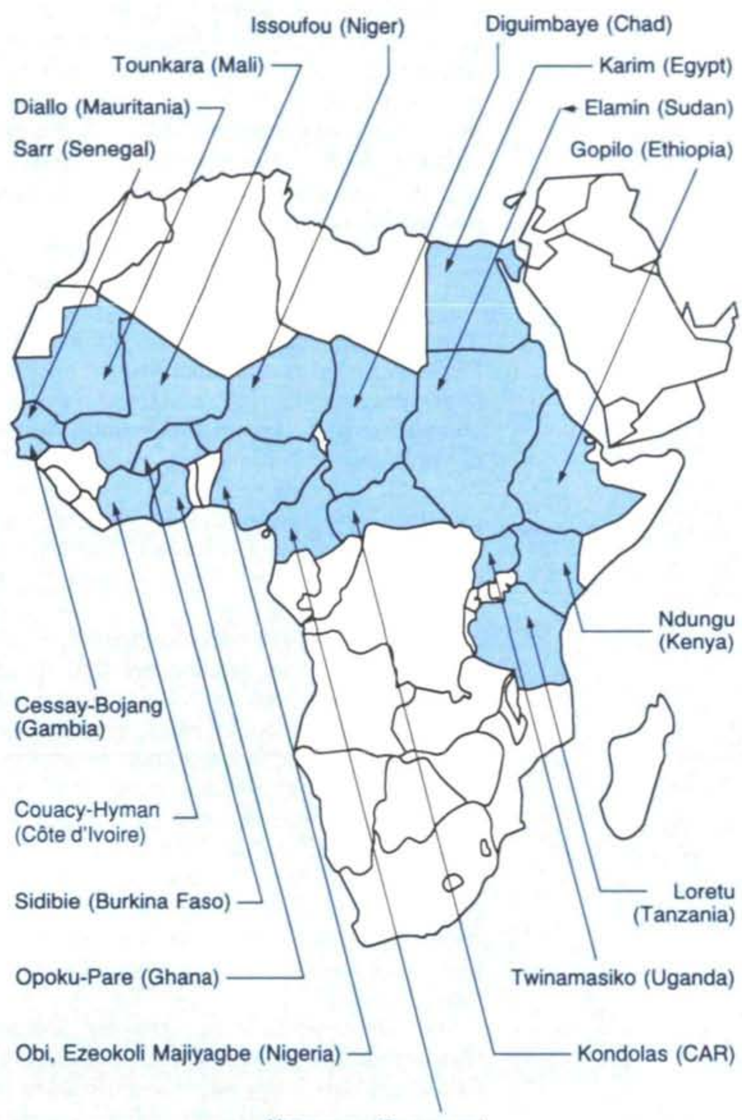
CRPs were an ideal mechanism for establishing a "network approach" for introducing an ELISA test for rinderpest sero-monitoring. They responded to the need for a simple, cheap, and reliable system to monitor and if necessary improve the effectiveness of the expensive national vaccination programmes envisaged under PARC, and to the need for a system which could be easily run in a standardized fashion throughout the region. CRPs further would allow validation of the ELISA under a wide variety of conditions and localities in Africa; "fine tuning" of the ultimate test to be used; and field testing of the computer software programs necessary for quick analysis of the many thousands of sera that would be tested.

Against this background, the IAEA approached the Swedish International Development Authority (SIDA) for funding. In 1986, it agreed to provide funds to the Joint FAO/IAEA Division for a 5-year programme to introduce an ELISA test (developed by the Pirbright Laboratories in the United Kingdom in collaboration with the FAO/IAEA Central Laboratory) into 21 national veterinary laboratories in 19 African countries charged with the task of sero-monitoring rinderpest.

By the early 1990s, the initial objective of having a fully validated and standardized ELISA test running routinely in Africa was achieved. The stage was then set to train staff in the veterinary centres supporting PARC's activities to use the test as a monitoring tool within the framework of their national campaigns and to establish systems of feedback of results to national PARC co-ordinators and to officials responsible for regional co-ordination at OAU/IBAR. During these follow-up activities, which were also generously funded by SIDA, the ELISA kit for rinderpest was modified to give the higher levels of sensitivity and specificity needed to identify residual areas of virus activity. An external quality assurance (QA) programme also became operational under which each participating laboratory was required to test 40 sera each year to assure that the results obtained were valid. Standardized systems for designing sampling strategies for each country were written and two FAO/IAEA computer software programs were developed to assist in data generation, storage, and manipulation.

Throughout the entire period of SIDA support (from 1986-1993), RCMs were held annual-

FAO/IAEA Sero-monitoring Network of National Veterinary Laboratories in Africa



ly at which research contract holders presented details of their national sero-monitoring programmes, the results obtained, and their plans for the next 12 months. These co-ordination meetings proved vital in maintaining the programme's impetus. During the past 3 years, national sero-monitoring results from the entire region have been published by IAEA on an annual basis to provide national authorities, OAU, and all donors with an up-to-date account of PARC progress, and to provide individual countries with the basis for declaring freedom from rinderpest.

Technical co-operation projects. The IAEA's Department of Technical Co-operation was another important avenue of support. Through national and regional projects, the Department helps countries to develop their human resources and infrastructures so that they are better able to use nuclear methods for the development of different sectors of the economy, including agriculture. These projects usually involve a partnership between the IAEA and relevant national institutes. The institute provides basic infrastructural resources and the Agency provides appropriate equipment, training in the technology for counterpart staff, and outside experts who periodically visit the institute and assist with the technology transfer. Such projects may last for 3 to 5 years.

For PARC, IAEA-supported national and regional projects provided intensive training in technical skills and knowledge to national staff belonging to the testing laboratories (through regional courses and individual fellowships), the equipment and rinderpest kits needed to do the testing, and the services of both short-term experts and a regional expert to technically support the activities.

For technical officers, primary concerns typically include ensuring that recommended activities are technically viable, contribute to the socio-economic development of the countries (that is, have "impact"), and are able to run independently of donor support. Administrators are also interested in these aspects, but they additionally want information on costs and cost-effectiveness, including justification for the way in which technical officers utilize the financial resources. A number of questions therefore inevitably arise when a particular Agency activity is evaluated: What did it achieve? Has it had impact? What did it cost? Can it now run on its own without further external inputs?

Achievements, costs, and impacts

Before the IAEA's rinderpest programme was initiated, national vaccination programmes against the disease in sub-Saharan Africa could not be monitored effectively by the veterinary services. This was because they lacked an appropriate test, an appropriate and reliable animal sampling framework for using the test, and systems for reporting and feedback of results. They also lacked the equipment and know-how to conduct sampling and testing in a way which was acceptable to OAU/IBAR, to the OIE and to the donors supporting PARC. These countries, therefore, were unable to show that they were free of rinderpest or the virus which causes it. As a result, there were restrictions on animal movements and trade. The veterinary services were also locked into costly and indefinite annual vaccination programmes to avoid adverse economic and agricultural consequences arising from the cattle deaths, reduced meat and milk production, and loss of traction animals caused by outbreaks of rinderpest.

The Agency's programme has helped to introduce a new scenario — one in which an internationally accepted test has been developed, validated, and made available with quality assurance to the majority of African countries involved in PARC. The test works well and national veterinary authorities and all major donors and organizations involved in the PARC programme firmly believe and trust its reliability. It can now be used for other national and regional programmes being developed by FAO in concert with major donors.

But developing the test and providing the internationally accepted FAO/IAEA test kits and the equipment to conduct the assays were perhaps the least of the challenges. Having developed this powerful test, the first challenge was to decide how it should be used to assist in "decision making" — both within the national testing laboratories and by those supervising field staff responsible for cattle vaccinations and for collecting blood samples for testing. The next challenge was to develop the linkages needed to make the strategy work.

Two further major achievements of the programme were that it served to catalyze discussion and eventual agreement between all those with a stake in PARC on the steps that countries would take in the process of moving along a pathway which would culminate in a declaration of freedom from rinderpest. It also put into place within 19 countries a verifiable and transparent system for doing this. Thus, apart from developing and providing the essential "tool" for verification, the IAEA's programme introduced the quality assurance and epidemiological systems necessary to ensure international acceptability and reporting of data obtained by national testing laboratories. Importantly, the programme also helped to ensure that a constant flow of information took place between these centres and the people making the decisions in the field so that vaccinations were targeted at susceptible cattle populations. Such a comprehensive and standardized system of national and regional testing and reporting has never been achieved before — either in the developed or developing world.

Behind all this lies considerable human endeavour and commitment. Many development projects provide training abroad for national counterparts and the services of full-time consultants in recipient countries to assist project activities. All too often these activities collapse because the counterparts leave their posts following training or the consultant leaves the country.

During this programme, only three of the several dozen people trained through FAO/IAEA-sponsored courses, workshops, fellowships, and other mechanisms (which were conducted almost exclusively within Africa) moved to other positions and were replaced. National counterparts were supported initially by consultants from outside Africa who made only short visits to the countries concerned (typically for 1 to 2 weeks), but always with a clear objective in mind — for example, to check assay results or help with data analysis. Accountability for doing the testing and for interpreting and reporting results was always with the national counterparts, and the reagents for running the external quality assurance of assay results were prepared and distributed from an African centre.

Without doubt, therefore, and in addition to the technical and conceptual developments which underpinned the Agency's assistance, the major achievement (and critical factor in making this support effective) was the high levels of technical ability, knowledge, and motivation attained by the national counterpart staff. This was made possible by using the comparative advantages of the different IAEA support mechanisms. One spin-off from this is that counterparts who started off as IAEA trainees are now providing the bulk of the technical support for rinderpest sero-monitoring in Africa and are being hired as consultants by the IAEA and FAO in support of rinderpest eradication activities elsewhere in the world.

Economic impacts. The impact of PARC and of the IAEA's programme is already evident at a number of levels. The first of these is economic. Here it must be emphasised that while the funds provided by the Agency were critical to the success of PARC, they were complementary to other inputs and would have been ineffective without the mobile veterinary force and laboratory personnel or the vehicles, fuel, spare parts, etc., needed in each country to vaccinate cattle and collect blood samples.

The cost of carrying out the original basic research to develop the reagents for use in the standardized FAO/IAEA kit were covered by the United Kingdom through its support to the Pirbright Laboratories. Additionally, the reagents and the consultancy services needed to help establish the technical capability to produce the kits at the FAO/IAEA Central Laboratory were provided by the UK's Department of Energy. Thus, essentially all the original research and development costs were met from sources outside the IAEA.

The programme then moved progressively through the stages of technology transfer (equipping and training of staff in counterpart laboratories), applied research to validate the rinderpest test (including further training and technical backstopping by IAEA experts and the holding of co-ordination meetings), and ultimately to the final stage of routine use of the test within national vaccination programmes and reporting of results to regional PARC co-ordinators and donors. During these stages, SIDA provided US $1 million for applied research in Africa and at Seibersdorf, while the IAEA's Technical Assistance and Co-operation Fund (TACF) provided US $2.7 million primarily for training, equipment and kits, and technical backstopping. When considered in relation to the number of countries involved and the timescale of the programme (1986-1994), these outlays represent annual expenditures of less than US $20 000 per country over the period covered. In fact, due to the extremely high level of sustainability which now exists in this programme, the Agency's contribution to the entire PARC sero-monitoring in 1994 fell to US $80 000, or about US $4500 per country. In 1995, no further inputs are foreseen from the TACF.

The costs of vaccination and blood collection and testing vary considerably from country to country. Figures from a number of Member States indicate average costs of US $0.8 per head and US $3 per sample, respectively. Thus in Egypt, for example, where 4.2 million cattle were vaccinated in 1992-93, the cost of vaccination was US $3.3 million. Based on the sero-monitoring and disease surveillance results which cost US $30 000 to obtain, this country was able to stop vaccinating and therefore saved more than US $3 million. However, to meet OIE recommendations, countries must continue to sero-monitor for 5 years following cessation of vaccination, which in Egypt's case will cost about US $150 000; nevertheless, savings on vaccinations over that period will exceed US $16 million. The Gambia has also stopped vaccinating and a further six West African countries (Mali, Senegal, Ghana, Burkina Faso, Côte d'-Ivoire and Mauritania) will do so by the end of 1994 with annual savings totalling US $6 million. Sero-monitoring in these countries costs US $60 000 per year, or US $300 000 during the 5 years following vaccination. For this group of countries, total savings over 5 years after accounting for the costs of sero-monitoring will therefore be just under US $30 million. Even in a rinderpest-infected country like Ethiopia with a cattle population of 35 million, vaccination has now stopped in large areas and the scarce resources are used to focus on the endemic areas. The confidence of the veterinary authorities to cease vaccination in these countries is largely based on the sero-monitoring results.

These figures go some way towards illustrating the enormity of the economic resources expanded on PARC and they also demonstrate the great cost-effectiveness of the IAEA's support. Yet they do not give the total picture. Eight years ago rinderpest was present in 14 African countries. It is now restricted to relatively isolated pockets in only two countries. Major outbreaks of rinderpest such as those which occurred before PARC normally last for about 5 years and result in an average mortality of 30%. With a total cattle population of 120 million in sub-Saharan Africa, this represents about 8 million cattle per year. At an estimated value perhead of US $120, the total cost of another rinderpest pandemic would be US $960 million per annum. Under PARC, approximately 45 million cattle are vaccinated annually at a cost of US $36 million. This gives an annual cost-benefit ratio for the vaccination campaign of around 25 to 1. The net annual economic benefit to sub-Saharan Africa of the campaign is therefore in the region of US $920 million, excluding other benefits, such as the value of animal traction. By analogy, the cost of renewed epidemics of rinderpest would be around US $1 billion per year. There can therefore be no doubt that PARC is economically justifiable and that the Agency's assistance has contributed substantially to the economic impact of the campaign by putting into place the technology and decision-making apparatus to enable countries to appropriately target and monitor their vaccination programmes, and then to eventually stop vaccination .

The second major impact is political. Rinderpest eradication is given top priority by the OAU for livestock development in Africa and this organization has campaigned vigorously to secure donor and national support for both vaccination and sero-monitoring. The undoubted success of both activities in terms of economic benefits to individual farmers and countries, and in establishing effective linkages between farmers and field and laboratory personnel has given the veterinary services a high profile in PARC countries. This in turn has opened up opportunities for improved control or eradication of other diseases and enhanced prospects for privatization and sustainability — a point underlined at the 4th OAU Council of Ministers meeting held recently in Addis Ababa where the principles developed and strategies undertaken in implementing the IAEA's support for PARC were considered as a model for other diseases.

The major impact of the IAEA's programme is still to come. The resources established for rinderpest can now be used to encourage flow of animal disease data from the herd level to veterinary investigation centres and from there to national authorities. In that way, appropriate policies and cost-effective campaigns may be developed to control or eradicate other diseases affecting livestock and food security in Africa. A start to this has already been made through national technical co-operation projects under which assistance is being provided to support control programmes on African Horse Sickness in Morocco, brucellosis in Zambia, Mali, Côte d'Ivoire and Ghana, and contagious bovine pleuropneumonia in Namibia, Uganda, Cameroon and Côte d'Ivoire. Also, a network similar to that in operation for rinderpest was recently established to monitor trypanosomiasis control programmes in 14 African countries. With the rapid move towards liberalization of trade and internationally standardized approaches to establishment of disease status as agreed under the General Agreement on Tariffs and Trade (GATT), the approach that has evolved through the IAEA's assistance to PARC will prove crucial in the long term to improving African livestock productivity and giving producers a better chance in the international market place.

Sustainability

Throughout the developed world, governments have embarked on the progressive privatization of industries and even of essential services like health, public transport, and education. In these countries, most aspects of animal welfare are in the hands of private veterinary practioners who are licensed to undertake routine vaccinations, on-farm testing, and clinical inspections. Nevertheless, national governments and government veterinary officers retain control over significant parts of disease reporting and control programmes including the running of essential support services, such as veterinary investigation and animal disease research centres. These continue to be funded from taxes generated from agriculture, but much more significantly from the industrial and service sectors simply because they are considered as politically and economically essential to the countries concerned.

In Africa, agriculture is the backbone of the economy and livestock are both essential and substantial components. At present the veterinary services are almost exclusively government-run. Current moves to liberalize their involvement, through new policy and financial frameworks being prepared and implemented through PARC, will reduce but not eliminate government responsibility for planning and monitoring control or eradication programmes for many diseases and for running support services.

The IAEA's assistance to PARC has covered a period of 8 years and the activities of the network which was established will continue to be supported technically by the Joint FAO/IAEA Division, OAU/IBAR, and FAO using funds now being made available by the EEC.

The need to maintain external funding for this activity will probably be seen by some as a sign of failure because it implies "non-sustainability". Yet the financial resources required to maintain the rinderpest sero-monitoring network now amount to less than US $5000 per country, primarily to supply FAO/IAEA kits (which cost US $2000 to test 10 000 samples in duplicate), some consumables and *ad hoc* consultancy services.

These inputs are small when considered in relation to the initial investments made in research, development, equipment, and training; they are minimal in comparison to the investment being made by the countries themselves; and they represent a fraction of the benefits accruing to the African livestock and agricultural sectors. But small as these inputs may be, external funding must be maintained either until the job is completed (in which case there will be no further need for kits), or the policies now being put in place produce comprehensive customer-client relationships. As pointed out earlier, in no country in the world are any of the facets which society considers vital to its well-being and development truly self-sustainable if defined in purely narrow sectorial terms. The African veterinary services are no exception.

The future

In all the countries covered by the IAEA's programme, the capacity now has been developed to use immunoassay technology to monitor rinderpest vaccination. As immunity levels in national cattle herds reach 85% and countries cease vaccination, they will continue to carry out intense serological and disease surveillance to identify and remove any remaining pockets of disease or virus activity which were not detected because of vaccination programmes. The funds now earmarked by the EEC will be used to cover the requirements of countries which have not yet benefitted from Agency support and to establish in all national laboratories a second ELISA test which will enable actual diagnosis of rinderpest as opposed to detecting antibodies to the virus. This kind of test is essential for countries that stop vaccinating so that appropriate remedial action can be taken in the event of a suspected outbreak of the disease.

Eradication programmes similar to PARC are being planned by FAO and the EEC for other parts of the world infected with rinderpest, most notably in the Arabia peninsula under a West Asian Rinderpest Eradication Campaign (WAREC), and in Asia through a South Asia Rinderpest Eradication Campaign (SAREC). Also, FAO recently launched its Global Rinderpest Eradication Programme (GREP) to provide a co-ordinated approach to global rinderpest eradication — a target which it is believed can be achieved by the year 2010.

These programmes will attempt to emulate the undoubted success of PARC. In all cases, rinderpest sero-monitoring and surveillance using the test and strategies developed and introduced by the IAEA for PARC have been pinpointed by FAO and the EEC as crucial to the success of this global effort. The funds required for the testing programme to support SAREC have already been earmarked for establishing an FAO/IAEA co-ordinated research programme operated by the Joint Division, and in many WAREC countries a number of national IAEA technical co-operation projects are now providing support for rinderpest sero-surveillance along the lines provided to PARC.

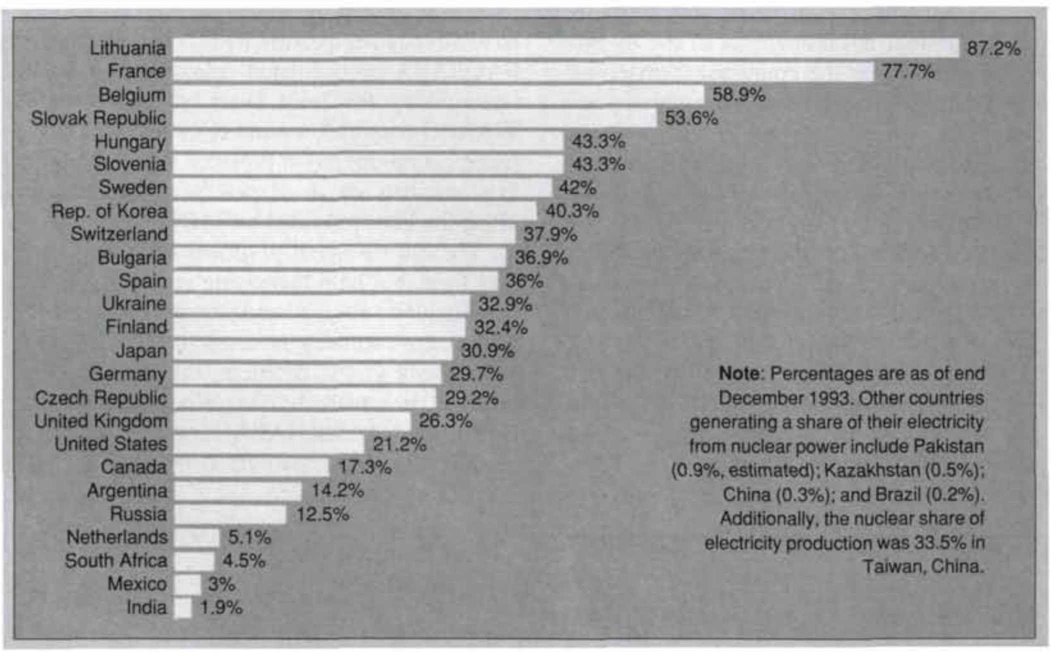
The ultimate goal of global eradication will take time, but with increasing realization of the benefits to be attained and a commitment on the part of the countries affected to face up to the seriousness of the problem, the goal that has been set is a realistic one. When rinderpest is finally eradicated the IAEA's contribution to this unique effort will have been considerable. ❑

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
Belgium	7	5 527		
Brazil	1	626	1	1245
Bulgaria	6	3 538		
Canada	22	15 755		
China	2	1 194	1	906
Cuba			2	816
Czech Republic	4	1 648	2	1 824
Finland	4	2 310		
France	57	59 033	4	5 815
Germany	21	22 559		
Hungary	4	1 729		
India	9	1 593	5	1 010
Iran			2	2 392
Japan	48	38 029	6	5 645
Kazakhstan	1	70		
Korea, Rep. of	9	7 220	7	5 770
Lithuania	2	2 370		
Mexico	1	654	1	654
Netherlands	2	504		
Pakistan	1	125	1	300
Romania			5	3 155
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	7 101		
Sweden	12	10 002		
Switzerland	5	2 985		
United Kingdom	35	11 909	1	1 188
Ukraine	15	12 679	6	5 700
USA	109	98 784	2	2 330
World total*	430	337 718	55	44 369

* The total includesTaiwan, China where six reactors totalling 4890 MWe are in operation.

Nuclear share of electricity generation in selected countries



IAEA General Conference in Vienna, 19-23 September

The 38th regular session of the IAEA's General Conference is taking place at the Austria Center in Vienna from 19-23 September 1994. High-level governmental delegates from more than 100 countries are participating.

The provisional agenda includes more than 20 items related to various aspects of the IAEA's work. They include items related to technical co-operation, nuclear safety, radiological protection, and radioactive waste management; strengthening the effectiveness and improving the efficiency of the safeguards system; implementation of safeguards in the Democratic People's Republic of Korea; application of IAEA safeguards in the Middle East; an African nuclear-weapon-free zone; strengthening the IAEA's main activities; and the IAEA's programme and budget for 1995 and 1996.

In conjunction with the Conference, a number of events are being organized. These include a special scientific programme, as well as traditional meetings of senior regulatory officials on nuclear safety and group meetings in respect of IAEA regional co-operative programmes in Latin America, Asia and the Pacific, and Africa.

During the Conference, the International Convention on Nuclear Safety will be opened for signature. The Convention was adopted in June 1994 by governmental delegates from 84 countries. *(See article on page 36.)*

Preceding the Conference, the 35-member IAEA Board of Governors is scheduled to consider various matters related to safeguards and other subjects at meetings beginning on 12 September.

IAEA Board of Governors' June meetings. At its meetings from 6-10 June 1994, the Board *inter alia* discussed a number of safeguards-related matters, including the conduct of safeguards inspections in the Democratic People's Republic of Korea *(see related item)*; technical co-operation; nuclear safety and radiological protection; and the Agency's programme and budget.

Safeguards-related matters. The Board took note of the IAEA's Safeguards Implementation Report (SIR) for 1993. SIR reported that, on the basis of all the information available to the Agency, it is considered reasonable to conclude that, with one exception, the nuclear material and other items which had been placed under Agency safeguards remained in peaceful nuclear activities or were otherwise adequately accounted for. The Board also commended efforts to evaluate measures for the strengthening and cost-efficiency of IAEA safeguards being carried out through a 2-year development programme, and looked forward to receiving proposals for the Board's consideration in time for its first session of 1995. The Board reiterated the importance of maintaining an appropriate balance between strengthening and cost-efficiency measures in the programme.

Technical assistance and co-operation. The Board received a report on the IAEA's programme during 1993 and welcomed improvements in the provision of technical assistance. Altogether 1373 technical co-operation projects were operational in 1993, which included the organization of 2798 expert assignments and 172 national, regional, and inter-regional training courses for some 1450 participants.

Nuclear safety, radiological protection, and waste management. The Board took note of the IAEA's annual *Nuclear Safety Review*, which will be distributed at the General Conference. It further discussed measures to resolve international waste management issues and considered matters related to liability for nuclear damage.

Programme and budget for 1995. The Board approved the report of its Administrative and Budget Committee which, among other things, recommended an IAEA regular budget in 1995 of US $211.6 million at an exchange rate of 12.70 Austrian schillings to the US dollar, and a target of US $61.5 million for voluntary contributions to the Technical Assistance and Co-operation Fund for 1995.

Chairman of the IAEA Board of Governors Ambassador Ronald Walker *(left)* and IAEA Director General Hans Blix.

Board adopts resolution on safeguards in the DPRK

The IAEA Board of Governors in June 1994 adopted a resolution calling upon the Democratic People's Republic of Korea (DPRK) to immediately extend full co-operation to the IAEA in efforts to carry out required safeguards activities in the country. The resolution *inter alia* stated that the DPRK is continuing to widen its non-compliance with its safeguards agreement by taking actions which prevent the Agency from verifying the history of the core of its 5-MWe experimental reactor and from ascertaining whether nuclear material from the reactor had been diverted in past years. The Board further decided to suspend non-

Resolution on DPRK safeguards adopted by the Board on 10 June 1994

The Board of Governors,

a) Recalling its resolutions GOV/2636 of 25 February 1993, GOV/2639 of 18 March 1993, GOV/2645 of 1 April 1993, GOV/2692 of 23 September 1993 and GOV/2711 of 21 March 1994 and General Conference resolution GC(XXXVII) RES/624 of 1 October 1993 finding the Democratic People's Republic of Korea (DPRK) to be in non-compliance with its safeguards agreement (INFCIRC/403),

(b) Taking account of the fact that the DPRK remains a party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and is therefore bound by its safeguards obligations,

(c) Recalling also that on 1 April 1993 and 22 March 1994, in accordance with the Agency's Statute and the safeguards agreement between the DPRK and the Agency, it reported the DPRK's non-compliance to the United Nations Security Council as the organ bearing the main responsibility for the maintenance of international peace and security,

(d) Noting with deep regret the Director General's written and oral reports of 2 June 1994 and 3 June 1994 and his statement to the Board on 7 June 1994, in which he reported that the limited opportunity which remained for the Agency to select, segregate and secure fuel rods from the DPRK's five megawatt reactor for later measurements in accordance with Agency standards had been lost and that the Agency's ability to ascertain, with sufficient confidence, whether nuclear material from the reactor had been diverted in the past had also been lost,

(e) Recalling further the 30 May 1994 statement by the President of the Security Council, and particularly the request to the Director General to keep Agency inspectors in the DPRK in order to monitor activities at the five-megawatt reactor, and

(f) Noting also that the Agency has been able to perform certain safeguards activities in the DPRK and the Director General's reaffirmation that the Secretariat remains available to conduct inspection activities as required by the safeguards agreement with the DPRK or as requested by the United Nations Security Council,

1. Deplores the DPRK's failure to implement essential elements of resolutions of the Board and the General Conference concerning its non-compliance with its safeguards agreement (INFCIRC/403);
2. Finds that the DPRK is continuing to widen its non-compliance with its safeguards agreement by taking actions which prevent the Agency from verifying the history of the reactor core and from ascertaining whether nuclear material from the reactor had been diverted in past years;
3. Strongly supports and commends the tireless efforts of the Director General and the Secretariat to implement the safeguards agreement;
4. Calls on the DPRK immediately to extend full co-operation to the Agency's Secretariat, in particular by providing access to all safeguards-relevant information and locations;
5. Encourages the Director General to continue his efforts to implement fully the safeguards agreement, and in particular to retain all Agency safeguards measures effectively in place and make available inspectors and equipment for safeguards in the DPRK as requested by the United Nations Security Council;
6. Decides, in conformity with the provisions of Article XII.C of the Statute, to suspend non-medical Agency assistance to the DPRK;
7. Requests the Director General to transmit this resolution to all Members of the Agency and to the Security Council and the General Assembly of the United Nations; and
8. Remains seized of the matter and requests the Director General to report promptly to the Board on all relevant developments regarding this issue.

Selective chronology regarding safeguards in the DPRK

APRIL 1992: The comprehensive NPT-type safeguards agreement with the DPRK enters into force on 10 April 1992, permitting verification that all nuclear material and all nuclear facilities in the DPRK are used exclusively for peaceful purposes and assessment of whether the initial declaration of material and facilities (received on 4 May 1992) is complete and correct. The DPRK declared holdings of plutonium of less than 1 kilogram. During 1992 the Agency's analysis of samples from the reprocessing plant indicated inconsistencies that led the IAEA to conclude more plutonium exists: whether grams or kilograms is unknown.

LATE 1992/EARLY 1993: The Agency requests access to and samples from two non-declared sites apparently related to nuclear waste. This is declined and the DPRK declares the sites to be non-nuclear and military.

MARCH 1993: On 12 March 1993 the DPRK announces its intention to withdraw from the NPT. The IAEA Board strongly backs the Director General's continuing efforts in resolutions adopted on 18 March and 1 April 1993.

APRIL/MAY 1993: The matter is referred to the Security Council in April 1993. The Council endorses the Agency's position, urges the DPRK to co-operate, urges the Director General to seek consultations with the DPRK, and urges Member States to seek to promote a solution. Throughout 1993, the United States especially has many contacts with the DPRK aimed at finding some settlement which would take account of security concerns of the DPRK and seek full nuclear transparency on the part of the DPRK.

JUNE 1993: The DPRK declares on 11 June 1993 that it has "suspended the effectuation of its withdrawal" from the NPT.

FEBRUARY 1994: On 15 February 1994, after lengthy talks between the DPRK and IAEA, a detailed understanding is reached about conducting inspections that the IAEA had requested — with the exception of the two non-declared, apparently waste-related sites.

MARCH 1994: In the DPRK, an IAEA inspection is performed at declared nuclear facilities in March 1994, but is blocked on very important points at the reprocessing plant. The IAEA reports the matter to the Security Council, which endorses the IAEA position.

APRIL/MAY 1994: After further talks between the DPRK and other States, the DPRK accepts IAEA inspection of the points earlier blocked. These inspections are performed in May and analysis of the results begins. The DPRK further informs the IAEA that it intends to refuel the 5-MWe Experimental Nuclear Power Reactor, loaded in 1986 and operated since 1987. The IAEA immediately informs the DPRK that — as it had told DPRK authorities already in February 1993 — it wished during such refuelling to select a number of fuel rods, segregate them from the others, secure them so that they would not be replaced by others, and examine them. This was requested because an examination of the rods might show how long they had been in the reactor. This presupposes availability of a representative sample of rods and knowledge of exactly where they had been located. If it were found that some or all the rods in the reactor had been there for a shorter time than 8 years, then there could exist non-declared nuclear material, spent fuel, or perhaps plutonium and waste.The DPRK first ignores the IAEA's request and then states that the Agency could verify that the discharged fuel would not be diverted. Later it answers that such selection and segregation is incompatible with the DPRK's "unique status".

MAY/JUNE 1994: When the discharge of fuel continues without agreement and the IAEA sees the possibility of this particular path to verifying the DPRK's nuclear inventory closing, it reports the situation to the Security Council and the Board of Governors in June 1994. Preceding these reports, in late May, the IAEA sends officials to the DPRK for talks, as communications indicate that the DPRK is ready to consult about the issue of inspections. IAEA officials again explain the urgency of the measures requested by the Agency, but again meet complete rejection of the measures because of DPRK's "unique status". At this stage, when already well over half of the fuel in the reactor had been discharged, the DPRK describes a method which it claims would enable the Agency in the future — after the DPRK had reached a package agreement with the United States and abandoned its "unique status" — to select rods, to identify the exact position which they had had in the reactor, and to measure them. In the judgement of the IAEA's experts and other experts consulted, the proposed method is found to be unworkable; IAEA officials explain this to DPRK authorities. By late June, the reactor is practically empty and the IAEA must conclude that, without any technical or safety reasons, the DPRK — referring simply to its alleged "unique status" — has prevented a valid future examination which could have confirmed or negated its claim that the discharged fuel was the first fuel in the reactor and that no earlier fuel had been taken out for possible reprocessing and plutonium separation. The IAEA does not say this has been the case, but it cannot exclude it. On 10 June, the IAEA Board adopts a resolution which *inter alia* states the DPRK is widening its non-compliance with the safeguards agreement; suspends non-medical IAEA technical assistance to the DPRK; and urges the DPRK's full co-operation for implementation of safeguards. Effective 13 June 1994, the DPRK withdraws its membership of the IAEA.

JUNE/JULY 1994: IAEA inspectors remain in the DPRK to conduct safeguards activities at the 5-MWe reactor and reprocessing plant. On 22 June, US President Clinton announces that the DPRK has agreed to "freeze" its nuclear programme, following a private meeting between former US President Carter and the DPRK President Kim Il Sung. A new round of talks between the United States and DPRK begins as scheduled on 8 July in Geneva; further, a summit meeting of the Presidents of the DPRK and Republic of Korea is envisaged for late July. The death of DPRK President Kim Il Sung on 8 July leads to the temporary suspension of the Geneva talks and postponement of the bilateral Summit. On 9 July, the IAEA confirms that its inspectors in the DPRK are continuing their work at Yongbyon.

medical Agency assistance to the DPRK. *(See boxes on the previous pages for the text of the resolution and a selective chronology of events. Also see the item on the G-7 summit on page 64.))*

Shortly after adoption of the resolution, the DPRK decided to withdraw as a member of the IAEA. In its capacity as depositary of the IAEA's Statute, the United States transmitted to the IAEA a letter of 13 June 1994 in which the DPRK Minister of Foreign Affairs communicated the government's decision to withdraw from the IAEA as of 13 June 1994.

The validity of the safeguards agreement concluded between the DPRK and the IAEA pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is not affected by the DPRK's withdrawal from the IAEA. That agreement entered into force in April 1992.

Conference on nuclear power option

As the world's population grows, the demand for electric power will accelerate, requiring governmental decisions on energy production and related issues. To help governments assess their energy futures, the IAEA is convening a Conference on the Nuclear Power Option from 4-8 September 1994. It is intended to provide a forum for discussion on nuclear power's present and future role for electricity generation. It will give an extensive overview of plans for global electricity production involving nuclear power in IAEA Member States, as well as regional overviews. A second part of the conference will review the experience gained over the past 40 years in operating the world's 430 existing nuclear power plants, an experience now exceeding 7000 accumulated years of operation. Papers will deal with experience in operations and maintenance, as well as construction, quality assurance, and decommissioning. Other papers will focus on issues affecting the nuclear power option, such as public acceptance, irradiated fuel and waste management, safety, economics, environmental protection, and legal liability. In a concluding session, papers will be presented on the prerequisites for a good nuclear power programme, including human resources, training, research, government oversight, and clear energy strategies.

The conference brings together senior decision-makers in energy planning, environmental agencies, regulatory authorities, and representatives from industry. More information may be obtained from the IAEA Division of Nuclear Power.

Conference on radiation and society

At the invitation of France and with support from the French Institute for Protection and Nuclear Safety (IPSN), the IAEA is organizing a major International Conference on Radiation and Society: Comprehending Radiation Risk. It is taking place 24-28 October 1994 in the recently established conference facility at the Louvre in Paris.

The conference is expected to draw the interest and participation of policy makers, nuclear experts, and the media from a number of countries. Participants will examine a number of case studies including the nuclear weapons legacy, cancer and leukaemia clusters, radioactive waste disposal and the environment, and Chernobyl health effects. It will then go on to examine various aspects of the interplay between expert advice, public and media perceptions, and the decision-making process.

The programme's technical sessions will cover various topics, including assessment of radiation exposure levels; assessment of radiation health effects; impact of radiation on the environment; perception of radiation risk; and managing radiation risk. Fora for the media and policymakers particularly will examine communication aspects of radiation risk, including discussions of controversial case studies. More information may be obtained from the IAEA Division of Nuclear Safety or from the communication service of IPSN in Paris, France (telephone 33-1-46-5486-38 or facsimile 33-1-46-5484-51).

Symposium on spent fuel storage

From 10-14 October in Vienna, the IAEA is organizing an international symposium on spent fuel storage. The symposium is intended to provide a forum for the exchange of information on the state-of-the-art and prospects for spent fuel storage with emphasis on safety, engineering and environmental aspects. Among topics to be discussed are national approaches to the safe storage of spent fuel, selection of different spent fuel storage technologies, design, planning, and siting of storage facilities, methods for increasing storage capacities and others.

The total amount of spent fuel accumulated worldwide at end 1993 was 140 thousand tonnes heavy metal (tHM) and projections until the end of the century indicate the amount may reach 225 thousand tHM. The first geological repositories for the final disposal of spent fuel are not expected to be in operation before 2010 so the use of interim storage — at-reactor (AR) or away-from-reactor (AFR) — will be the primary spent fuel management option for the next 20 years in many countries. It has been demonstrated that spent fuel can be safely stored for long periods of time, and some spent fuel has now been stored for more than 30 years. There is also scientific consensus that the present technologies of spent fuel storage give adequate protection to the population and the environment, but there is also strong interest in seeing whether further reductions in risk and additional radiological safety can be achieved. More information about the symposium may be obtained from the IAEA Division of Nuclear Fuel Cycle and Waste Management.

Isotope techniques in radioactive waste disposal

Experts from Australia, Austria, Canada, China, Czech Republic, Japan, France, Germany, Italy, Poland, Russia, Sweden, Switzerland, United Kingdom, and United States met in Vienna from 27-30 June 1994 on the use of isotope techniques in the hydrological appraisal of radioactive waste disposal sites. The advisory group meeting was organized by the IAEA's Isotope Hydrology Section.

Specific issues that were discussed included investigations of residence times in low permeability rocks; identification of origin of waters and recharge conditions; fluid rock interactions and transport of radionuclides in groundwater. Scientific papers were presented to illustrate various experiences of the participating countries. Participants also addressed the assessment of the performance of potential geologic repositories for nuclear waste from the standpoint of the understanding it requires of groundwater flow and radionuclide migration under low permeability conditions.

Emphasis was also placed on the influence on water and pollutant movements of climatic changes, sea level rise, recharge and discharge fluctuations, and water density. Isotope geochemistry and hydrology were considered to be important tools to investigate these parameters. Discussions on these topics need to be intensified among hydrologists and scientists responsible for waste management and disposal. More information may be obtained from the Isotope Hydrology Section in the IAEA Division of Physical and Chemical Sciences.

Safety of Soviet-designed nuclear power plants

An update on the safety of Soviet-designed nuclear power plants was recently presented at the British Nuclear Industry Forum held in London on 6 July 1994. The presentation was made by IAEA Assistant Director General for Nuclear Safety, Dr. Morris Rosen.

In reviewing the overall situation, Dr. Rosen said that generic safety issues common to the three principal Soviet reactor types — the 440-MWe WWER pressurized water reactor, the 1000-MWe WWER, and the graphite-moderated RBMK — cannot be entirely resolved. However, he said that many issues can be dealt with through international assistance projects. He noted that the IAEA's role has been to identify and prioritize the issues, and to provide the necessary backup technical documentation. "The efforts are aimed at bringing about an international consensus on what is necessary for an acceptable safety level," he said. "In the final analysis, it is the national governments who will decide on what is required."

In noting the complexity of the situation, he said there are a number of major issues associated with each of the three reactor types which are difficult to manage. Additionally, there are unique plant-specific features which must be individually considered, as well as problems specific to each country's political, economic, and social condition.

The first generation 440-MWe WWER plants do not have low leakage containment and many experts believe these reactors should be shut down, he said. The second generation of this reactor type has significantly improved safety features but still suffers from the common generic deficiences; these reactors are expected to continue operation as improvements are gradually introduced. He noted that reactors of the 1000-MWe WWER-type have many features common to Western designs. These plants will continue to operate while some under construction may incorporate improved core designs and instrumentation and control systems. The third type, the RBMK, has unresolved safety issues such as the lack of containment and a single shut-down system, he said. For the more modern RBMKs, the identified major issues appear to be solvable. At older RBMKs, however, the situation is more uncertain, he said, and any improvements that are made will need to be evaluated to determine whether they have resulted in higher safety levels.

Dr. Rosen also noted that the Convention on Nuclear Safety, which will be open for signature at the IAEA General Conference in September, contains a number of items relevant to the current situation with Soviet-designed reactors. He pointed out that it calls for existing reactors with deficiences to be urgently upgraded or shut down. The Convention also obliges States to prepare a report to be discussed at periodic review meetings, which will include in-depth studies of all national reports to identify problems, concerns, and uncertainties or omissions. Copies of Dr. Rosen's address are available from the IAEA Division of Nuclear Safety.

In Memoriam: Mr. James Daglish

When Mr. James Daglish passed away in his native New Zealand at the age of 55 on Whitsunday, 22 May 1994, the international community lost a friend and dedicated colleague. Much of his work still serves as a benchmark for nuclear communicators, and at the IAEA, where he served for a number of years, his knowledge and skills came to the fore when responding to the massive press coverage following the Chernobyl accident in 1986. More than one journalist with a post-Chernobyl book to his credit has acknowledged the support and contributions that Jim tirelessly provided along the way.

Jim served in the IAEA's Public Information Division twice between the years 1969 and 1990. From 1969-72, he edited the *IAEA Bulletin* quarterly journal, taking it far along its evolutionary path of providing topical information to the journal's thousands of readers. From 1983-90, he served as press officer, writer, and editor, producing a range of quality products on subjects of nuclear safety, radiological protection, and radiation issues. His background was impressive and varied, both as a journalist with the United Kingdom Press Association and the *Times*, and as a nuclear science and engineering specialist who edited *Atom*, the flagship magazine of the United Kingdom Atomic Energy Authority. Very much his own man, Jim will be remembered by those who knew him for his sound technical knowledge, lucid writing style, sardonic wit, and resonant voice that so authoritatively handled hundreds of interviews.

Jim is deeply missed by his family, friends, and colleagues. At the IAEA, his contributions will be long remembered, and deeply appreciated.—*The Editor, with Mr. David Kyd, Director of the IAEA Division of Public Information.*

Russia: Director General addresses technical conference in Obninsk

Speaking at the Fifth Annual Scientific and Technical Conference of the Nuclear Society in Obninsk, Russia on 27 June, marking the 40th anniversary of nuclear power in Russia, IAEA Director General Hans Blix said nuclear scientists, engineers, and administrators have an important role to play in making the world safer. Dr. Blix said the most obvious task is to devise ways in which nuclear weapons can safely be reduced and eventually eliminated. He particularly appealed to the nuclear community to accelerate its study and discussion on the best ways to take care of the large volumes of plutonium and highly enriched uranium recovered through the dismantlement of nuclear warheads. He pointed out that, before the excess nuclear material is peacefully used or disposed of, its storage and management must be such that it does not go back into new and possibly more modern nuclear weapons. In this connection, he noted that the United States has declared that it will place nuclear material recovered from weapons under IAEA safeguards. The IAEA could perform the same safeguards service for nuclear material recovered from weapons in Russia, if requested, he said.

Dr. Blix added that, in a situation where tens of thousands of nuclear warheads are waiting to be dismantled, a prohibition of the production of further nuclear material for weapons seems natural. He said if a cut-off of production of fissionable material for weapons were made universal, it would also put a cap on any further production of such material in the so-called threshold States. He said another measure that the world nuclear community must now help to bring about is a ban on all nuclear testing. The conclusion and universal acceptance of a complete test ban would be a powerful signal that the the era of nuclear weapon development is over, he said, and it would give a powerful boost to the Treaty on the Non-Proliferation of Nuclear Weapons, which will be up for prolongation next year. The full text of the Director General's address is available upon request from the IAEA Division of Public Information.

Ukraine: Safeguards agreement

The Government of Ukraine and the IAEA have agreed *ad referendum* to a draft comprehensive safeguards agreement during negotiations held from 27-28 June 1994 in Vienna. Under the draft safeguards agreement, Ukraine undertakes to use the nuclear material and facilities under its jurisdiction or control exclusively for peaceful purposes. It also provides for the application of safeguards by the IAEA to all nuclear material in all peaceful nuclear activities of Ukraine. It is expected that the agreement will be submitted for consideration by the IAEA Board of Governors at its meetings in September 1994.

United States: Falling nuclear costs

Nuclear power plants in the United States produced electricity at slightly lower costs in 1993 than they did in 1992, reports the Utility Data Institute (UDI), a research arm of McGraw-Hill based in Washington, DC. In 1993, US nuclear plants produced electrical power at an average costs of $21.52 per megawatt-hour, compared to $21.61 in 1992. UDI credited the decline to the industry's focus on improving availability and generation, and stabilizing operations and maintenance cost.

The country's top 10 plants, in terms of production costs, produced electricity at costs ranging from $12.90 per megawatt-hour to $15.26 per megawatt-hour. All told, 71 US nuclear plants were surveyed. More information may be obtained from UDI, 1200 G. Street NW, Suite 250, Washington, DC 20005.

Republic of Korea: OSART mission

An IAEA team of international experts recently completed a three-week review of the Ulchin nuclear power plant in the Republic of Korea under the Operational Safety Review Team (OSART) programme. Major results of the mission were presented to officials from the Ulchin plant, the Korean Electric Power Corporation (KEPCO), the Ministry of Science and Technology, and the Korea Institute of Nuclear Safety. The OSART mission included experts from Belgium, Finland, France, Germany, Japan, Switzerland, and the United Kingdom, plus IAEA safety officials and observers from Brazil, Pakistan, and the Slovak Republic.

Overall results showed that the Ulchin management team is committed to further improving the plant's existing good performance and to assuring acceptable levels of safety. The OSART team made a number of recommendations whose implementation will further contribute to management's intention to maintain and enhance the plant's safe operation. Eight areas were subjected to review: management; organization and administration; training and qualifications of staff; operations; maintenance; technical support; radiation protection; and emergency planning and preparedness. The mission was conducted 6-24 June 1994.

Future OSART missions. Remaining OSART missions and follow-up visits in 1994 include those to the Leibstadt plant in Switzerland (21 November to 10 December 1994); Cernavoda in Romania (September 1994); Krsko in Slovenia (24-28 October 1994); and Gravelines in France (7-10 November 1994).

Croatia, Kazakhstan, Slovenia, & Zambia: Safeguards agreements

The IAEA Board of Governors in June 1994 authorized the IAEA to conclude safeguards agreements with Croatia, Kazakhstan, Slovenia, and Zambia. All four agreements are being concluded pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

As of December 1993, IAEA safeguards agreements pursuant to the NPT were in force with 100 States. All told, the IAEA had 194 safeguards agreements in force with 116 States at the end of 1993.

Italy: G-7 Summit concludes in Naples

Meeting in Naples, Italy the weekend of 8 July 1994, leaders of the seven major industrialized countries, known as the Group of Seven, reinforced their commitments to nuclear non-proliferation and safety. As reported by the Associated Press and Reuter, they:

- pledged an additional amount of US $200 million toward the cost of shutting down the Chernobyl nuclear plant in Ukraine.
- urged the Democratic People's Republic of Korea (DPRK) to provide "total transparency in its nuclear programme through full and unconditional compliance with its non-proliferation obligations and to remove, once and for all, the suspicions surrounding its nuclear activities". They stressed the importance of the DPRK ensuring the continuity of IAEA safeguards and maintaining the freeze on its nuclear programme.
- underscored their commitments against the spread of weapons of mass destruction. They called upon all States that have not yet done so to accede to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) as non-nuclear weapon States, and they declared their unequivocal support for the indefinite extension of the NPT in 1995. They underlined the importance of continuing nuclear arms reduction, and confirmed their commitment to achieve universal, verifiable, and comprehensive treaties to ban nuclear tests and the production of fissile material for nuclear weapons. They further agreed to co-operate to prevent nuclear smuggling, and reaffirmed their work for effective export controls.

The Group of Seven countries are Canada, France, Italy, Germany, Japan, UK, and USA.

1994 Edition of the IAEA Yearbook

Global developments in the fields of nuclear safety and the verification of nuclear energy's peaceful uses are among topics featured in the 1994 edition of the *IAEA Yearbook*, a comprehensive overview of nuclear power's global development. The latest edition, which will be published shortly, reviews the status and trends of the world's nuclear power programmes, the nuclear fuel cycle, and waste management. Additionally featured is a global overview of programmes and projects in key areas of nuclear safety and radiological protection; nuclear safeguards statistics for 1993; and reports on the IAEA's safeguards system and on its activities related to the transfer of nuclear technologies and applications. Among special topics explored is the impact of nuclear applications in food and agriculture over the past 30 years, in commemoration of the 30th anniversary of the Joint Division of the IAEA and Food and Agriculture Organization of the United Nations.

The Yearbook's specialized sections, some of which are available separately, provide information and data on the nuclear fuel cycle, from uranium resources to the management of radioactive waste; the safety and operation of nuclear power plants; the application of safeguards, particularly from the standpoint of measures being taken to strengthen the system; and examples of nuclear techniques and research in medicine, industry, agriculture, and other fields. The *IAEA Yearbook* is available for purchase from the IAEA or its sales outlets in Member States. See the *Keep Abreast* section for ordering information.

RADIOACTIVE WASTE MANAGEMENT. A new report on radioactive waste management in Central and Eastern European countries has been issued by the IAEA Division of Public Information. The booklet includes basic background information on radioactive waste management and presents status reports of programmes in Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovak Republic, Slovenia, and Croatia. It further reviews initiatives of the IAEA under its radioactive waste management programme. Copies of the booklet may be obtained from the IAEA Division of Public Information.

HUMAN DEVELOPMENT AND THE PEACE DIVIDEND. The 1994 edition of the *Human Development Report,* issued by the United Nations Development Programme (UNDP), takes a close look at the "peace dividend", namely the savings from military spending that were being earmarked for social and human development needs. It calls the reduction in military expenditure in recent years a "hopeful sign", but adds that there "clearly is a long way to go". Between 1987 and 1991, global military spending declined from US $995 billion to $855 billion, an amount that equals the income of nearly half the world's people. The report estimates the global "peace dividend" at $935 billion — industrial nations appear to have cumulatively saved some $810 billion and the developing nations $125 billion. It is difficult, however, "to track where these funds went", the report states. More information may be obtained from UNDP, 1 UN Plaza, New York, New York, 10017 USA.

FEEDBACK ON ASSET SAFETY SERVICES. The IAEA has received positive feedback from users of its nuclear plant safety service known as ASSET, which stands for Assessment of Safety Significant Events Team. At a meeting of ASSET users in May 1994, participants recognized the direct and positive contribution of ASSET missions and seminars to the improvement of nuclear safety. The services were welcomed by the plants and were seen as being beneficial to both external safety experts and plant personnel. They further noted that better co-ordination of ASSET and other IAEA safety services is essential to ensure that countries were offered a comprehensive and efficient service; existing ASSET options should be extended by adding other specialized missions, in keeping with the needs of participating countries. More information is available upon request from the Safety Assessment Section in the IAEA Division of Nuclear Safety.

POSTS ANNOUNCED BY THE IAEA

RADIATION PROTECTION OFFICER (94-031), Department of Nuclear Energy and Safety. This P-4 post requires a master's degree in one of the physical sciences, with 10 years experience in radiation safety or associated disciplines. Also required is experience in producing documents and preparing material for training purposes, and experience carrying out complex technical projects. Applicants must have oral and written command of English, and the ability to draft technical reports in English. *Closing date: 7 October 1994.*

PRINTED MEDIA SPECIALIST (94-032), Department of Administration. This P-3 post requires a university degree with at least 6 years of experience in the field of public information at the national or international level, and with some scientific background. Also required is familiarity with electronic publishing systems. *Closing date: 7 October 1994.*

SAFEGUARDS ANALYST (94-033), Department of Safeguards. This P-4 post requires an advanced university degree or equivalent in nuclear engineering or industrial engineering with more than 10 years of experience in the nuclear energy field, preferably in safeguards or nuclear material control. *Closing date: 7 October 1994.*

TRANSPORT SAFETY SPECIALIST (94-034), Department of Nuclear Energy and Safety. This P-5 post requires a Ph.D. or equivalent in a field of science or engineering appropriate to the duties of the post with at least 15 years of experience in work related to the management of transportation of radioactive materials, and with adequate experience in a senior supervisory position. Also required is practical knowledge of the development and application of the Agency's transport regulations and supporting documents at the national and international level. *Closing date: 7 October 1994.*

IAEA SAFEGUARDS INSPECTOR (94/SGO-4), Department of Safeguards. This P-4 post requires a university degree in chemistry, physics, engineering or electronics/instrumentation or equivalent with at least 10 years relevant experience with the nuclear fuel cycle, processing of nuclear materials, material accounting or non-destructive analysis, preferably under plant operation conditions. Also required is national or international safeguards experience, demonstrated experience in the use of personal computers, and proven supervisory ability. *Closing date: 31 December 1994.*

IAEA SAFEGUARDS INSPECTOR (several positions) (94/SGO-3), Department of Safeguards. These P-3 posts require a university degree or equivalent with emphasis in a nuclear discipline, and at least 6 years of relevant experience in the nuclear field, preferably in the operation of nuclear facilities. Also required is demonstrated experience in the use of personal computers. *Closing date: 31 December 1994.*

WEST ASIAN SECTION HEAD (94-035), Department of Technical Co-operation. This P-5 post requires an advanced university degree in science and technology and basic knowledge of the various peaceful applications of nuclear energy. At least 15 years of managerial and administrative experience in programming, formulation and implementation of scientific /technical projects, and ability to lead a diverse team of professional and support staff also required. *Closing date: 28 October 1994.*

SENIOR FRENCH TRANSLATOR (94-036), Department of Administration. This P-4 post requires a university degree or equivalent. Applicants must have French as their mother tongue or principal language of education and be able to write clearly and concisely. They should have at least 10 years experience and acquired mastery of the terminology of several areas in the atomic energy field. *Closing date: 28 October 1994.*

SECTION HEAD (94-037), Department of Safeguards. This P-5 post requires an advanced university degree in informatics, nuclear technology or related field. At least 15 years experience in the nuclear industry, nuclear research, nuclear-related international or governmental service or informatic field. This experience must include experience in nuclear material accountancy, computerized data processing and supervisory or management assignments. Closing date: *28 October 1994.*

HEAD, ISOTOPE HYDROLOGY LABORATORY (94-038), Department of Research and Isotopes. This P-4 post requires a Ph.D. or equivalent in physics, physical chemistry or analytical chemistry, with at least 10 years experience in mass spectrometric analysis of environmental stable isotopes and also low-level counting of radioactive isotopes. Also required is research experience in interpretation of isotope data in hydrological and environmental studies. *Closing date: 28 October 1994.*

PLASMA PHYSICIST (94-039), Department of Research and Isotopes. This P-4 post requires a Ph.D. or equivalent in physics, with 10 years extensive experience in the field of plasma physics and controlled thermonuclear fusion research. Also required is experience in either theoretical or experimental research in the field of plasma physics and controlled thermonuclear fusion and a broad knowledge of worldwide activities in this field. *Closing date: 7 November 1994.*

MATHEMATICIAN (94-703), Department of Research and Isotopes. This P-4 post requires a Ph.D. in mathematics, familiarity with the major areas of mathematics, and at least 10 years experience in research and training at a national and international level. Extensive experience and involvement in the development of research in mathematics in developing countries; significant research contributions of a high level; and ability to communicate with and provide guidance to mathematicians are other essential qualifications. *Closing date: 7 November 1994.*

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, Box 100, A-1400 Vienna, Austria.

ON-LINE COMPUTER SERVICES. IAEA vacancy notices for professional positions, as well as application forms, now are available through a global computerized network that can be accessed directly. Access is through the Internet Services. The vacancy notices are located in a public directory accessible via the normal Internet file transfer services. To use the service, connect to the IAEA's Internet address NESIRS01.IAEA.OR.AT (161.5.64.10), and then log on using the identification *anonymous* and your user password. The vacancy notices are in the directory called *pub/vacancy_posts*. A *README* file contains general information, and an *INDEX* file contains a short description of each vacancy notice. Other information, in the form of files that may be copied, includes an application form and conditions of employment. 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.

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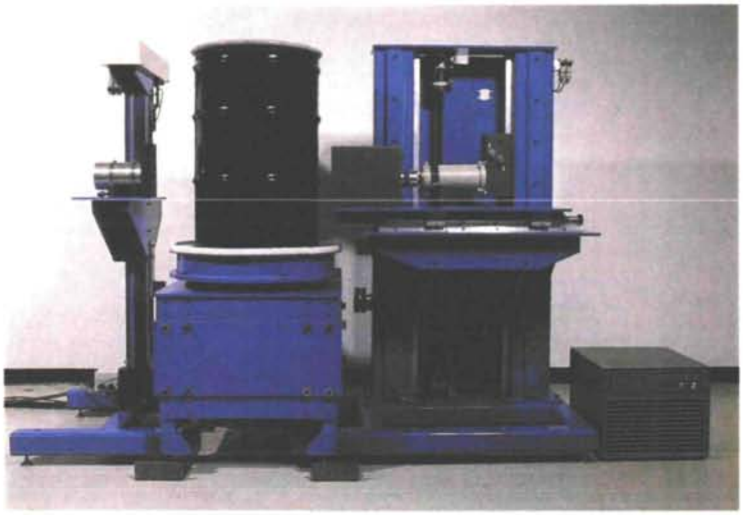

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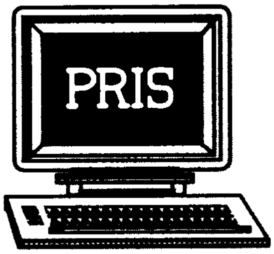


Database name
Power Reactor Information System (PRIS)

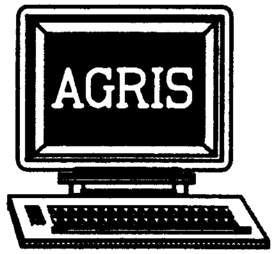
Type of database
Factual

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) 2360
Telex (1)-12645
Facsimile +43 1 234564
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

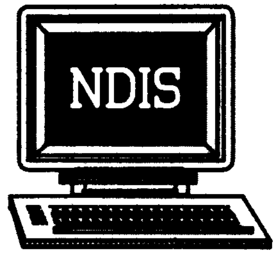
Producer
Food and Agriculture Organization of the United Nations (FAO) in co-operation with 172 national, regional, and international AGRIS centres

IAEA contact
AGRIS Processing Unit
c/o IAEA, P.O. Box 100
A-1400 Vienna, Austria
Telephone (43) (1) 2360
Telex (1)-12645
Facsimile +43 1 234564
Electronic mail via BITNET/INTERNET to ID: FAS@IAEA1.IAEA.OR.AT

Number of records on line from January 1993 to date
more than 130 000

Scope
Worldwide information on agricultural sciences and technology, including forestry, fisheries, and nutrition.

Coverage
Agriculture in general; geography and history; education, extension, and information; administration and legislation; agricultural economics; development and rural sociology; plant and animal science and production; plant protection; post-harvest technology; fisheries and aquaculture; agricultural machinery and engineering; natural resources; processing of agricultural products; human nutrition; pollution; methodology.



Database name
Nuclear Data Information System (NDIS)

Type of database
Numerical and bibliographic

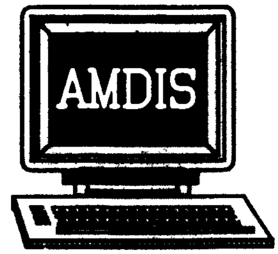
Producer
International Atomic Energy Agency in co-operation with the United States National Nuclear Data Centre at the Brookhaven National Laboratory, the Nuclear Data Bank of the Nuclear Energy Agency, Organisation for Economic Co-operation and Development in Paris, France, and a network of 22 other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

IAEA contact
IAEA Nuclear Data Section, P.O. Box 100
A-1400 Vienna, Austria
Telephone (43) (1) 2360
Telex (1)-12645
Facsimile +43 1 234564
Electronic mail via BITNET/INTERNET to ID: RNDS@IAEA1.IAEA.OR.AT

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 87 IAEA Member States and 16 other international organizations

IAEA contact
IAEA, INIS Section, P.O. Box 100, A-1400 Vienna, Austria
Telephone (43) (1) 2360 2842
Telex (1)-12645
Facsimile +43 1 234564
Electronic mail via BITNET/INTERNET to ID: ATIEH@NEPO1.IAEA.OR.AT

Number of records on line from January 1976 to date
more than 1.5 million

Scope
Worldwide information on the peaceful uses of nuclear science and technology; economic and environmental aspects of other energy sources.

Coverage
The central areas of coverage are nuclear reactors, reactor safety, nuclear fusion, applications of radiation or isotopes in medicine, agriculture, industry, and pest control, as well as related fields such as nuclear chemistry, nuclear physics, and materials science. Special emphasis is placed on the environmental, economic, and health effects of nuclear energy, as well as, from 1992, the economic and environmental aspects of non-nuclear energy sources. Legal and social aspects associated with nuclear energy also are covered.

UPCOMING CO-ORDINATED RESEARCH PROGRAMMES

Comparative international studies of osteoporosis using isotope techniques
To undertake pilot studies of bone density in selected human study groups in each participating country using DEXA (dual energy X-ray absorptiometry) and other nuclear-related techniques. Additional measurements of trace elements in bone (and possibly also teeth) are foreseen using neutron activation analysis and other appropriate techniques. The purpose is to obtain data relating to the aetiology and prevention of osteoporosis.

Characterization and evaluation of high-dose dosimetry techniques for quality assurance in radiation processing
To understand the effect of various parameters on the performance of several routine dosimeters presently in use. To facilitate the extension of the Agency's International Dose Assurance Service (IDAS) to low energy (<4 MeV) electron beams and X-ray sources.

The standardization of iodine-131 treatment for hyperthyroidism with an intent to optimize radiation dose and treatment response
To standardize iodine-131 treatment for hyperthyroidism (diffuse toxic goitre) with the objective of optimizing radiation dose and treatment response, and identifying important factors which influence the outcome of the treatment.

Nuclear techniques for diagnosis of bacterial and viral infections (African region)
To develop expertise in the African region in the use of DNA probe hybridization and polymerase chain reaction amplification methods in diagnosis of diseases such as AIDS, viral hepatitis, and tuberculosis and evaluate different primers and probes which work best for the pathogen strains in the region.

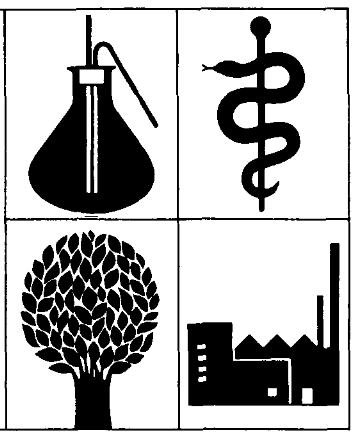
Clinical application of radiosensitizers in cancer radiotherapy
To enhance radiation-induced therapeutic gain by introducing the effective hypoxic cell radiosensitizer in treatment management.

Development of reference input parameter library for nuclear model calculations of nuclear data (Phase I: Starter file)
To develop a starter file of the input parameter library. The file is designed to provide necessary input for nuclear reaction model calculations of nuclear data for incident energies up to about 30 MeV.

Radiative cooling rates of fusion plasma impurities
To establish a comprehensive recommended database for the radiative power losses of the most important plasma impurities in the range of plasma parameters relevant for presently operating and next generation fusion devices.

Validation of accident and safety analysis methodology
To promote research and the exchange of information on validation of accident and safety analysis methodology covering the aspects of design basis accidents (DBAs) and beyond DBAs (so-called severe accidents).

These are selected listings, subject to change. More complete information about IAEA meetings can be obtained from the IAEA Conference Service 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.



SYMPOSIA & SEMINARS

OCTOBER 1994

Seminar on Radioactive Waste Management Practices and Issues in Developing Countries, ***Beijing, China*** (10-14 October)

International Symposium on Spent Fuel Storage — Safety, Engineering and Environmental Aspects, ***Vienna, Austria*** (10-14 October)

FAO/IAEA International Symposium on Nuclear and Related Techniques in Soil/Plant Studies on Sustainable Agriculture and Environmental Preservation, ***Vienna, Austria*** (17-21 October)

International Conference on Radiation, Health and Society: Comprehending Radiation Risks, ***Paris, France*** (24-28 October)

MARCH 1995

Symposium on Isotopes in Water Resources Management, ***Vienna, Austria*** (20-24 March)

MAY 1995

Seminar on Management of Ageing in Research Reactors, ***Hamburg, Germany*** (8-12 May)

Symposium on Environmental Impact of Radioactive Releases, ***Vienna, Austria*** (8-12 May)

JUNE 1995

Symposium on Induction of Mutations and Use of Molecular Techniques in Breeding for Crop Improvement, ***Vienna, Austria*** (19-23 June)

AUGUST 1995

Symposium on Tomography in Nuclear Medicine, Present Status and Future Prospects, ***Vienna, Austria*** (21-25 August)

Seminar on the Requirements for the Safe Management of Radioactive Waste, ***Vienna, Austria*** (28 August - 1 September)

Seminar on the Advancements in the Implementation of the New Basic Standards (Experience in Applying the 1990 Recommendations of ICRP), ***Vienna, Austria*** (Preliminary)

SEPTEMBER 1995

International Conference on Advances in Operational Safety at Nuclear Power Plants, ***Vienna, Austria*** (4-8 September)

Seminar on the Use of Isotope Techniques in Marine Environmental Studies, ***Vienna, Austria*** (9-13 October)

IAEA BULLETIN

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Viet Nam
Yugoslavia

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Iran, Islamic Republic of
Luxembourg
Mexico
Philippines
Sudan

1959

Iraq

1960

Chile
Colombia
Ghana
Senegal

1961

Lebanon
Mali
Zaire

1962

Liberia
Saudi Arabia

1963

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Libyan Arab Jamahiriya
Syrian Arab Republic
Uruguay

1964

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Gabon
Kuwait
Nigeria

1965

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Cyprus
Jamaica
Kenya
Madagascar

1966

Jordan
Panama

1967

Sierra Leone
Singapore
Uganda

1968

Liechtenstein

1969

Malaysia
Niger
Zambia

1970

Ireland

1972

Bangladesh

1973

Mongolia

1974

Mauritius

1976

Qatar
United Arab Emirates
United Republic of Tanzania

1977

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1983

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1984

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1986

Zimbabwe

1991

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Lithuania
Yemen, Republic of

1992

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Estonia
Slovenia

1993

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Slovakia

1994

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Marshall Islands
Uzbekistan

Eighteen ratifications were required to bring the IAEA's Statute into force. By 29 July 1957, the States in bold face 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.

IAEA headquarters, at the Vienna International Centre.

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PDM-173	40 keV ~	0.01 ~ 99.99 mSv	General use, photon
PDM-107	20 keV ~	1 ~ 9,999 μSv	Low energy, photon
PDM-303	thermal ~ fast	0.01 ~ 99.99 mSv	Neutron
ADM-102	40 keV ~	0.001 ~ 99.99 mSv	With vibration & sound alarm, photon

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